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Trade interdependence and the international business cycle

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A stochastic, general equilibrium model of the world economy is developed to analyze the contribution of trade interdependence to international business cycles. We test some of the implications of the model using data from ten major industrial countries and a variety of detrending techniques to calculate the cyclical component of output. We find that the significance of trade in the transmission of economic disturbances across countries is not robust to the choice of the detrending method. In general, the role of trade interdependence is moderate and seem to have been stronger in the period before 1973.

1. Introduction

The term 'world' or 'international' business cycle refers to the existence of common elements in aggregate cyclical behavior across countries.[1] Similarities in economic performance in any set of countries can be accounted for by two distinct factors. The first one is significant international economic interdependence. It is commonly accepted that a development in any one country may, depending on relative size and the degree of openness, be transmitted rapidly to other countries. Both current account transactions in

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[1]For an empirical documentation of the existence of world business cycles, see Dellas (1985), Gerlach (1988), Backus and Kehoe (1989, Baxter and Stockman (1989).

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goods and services and capital account transactions in assets can serve as the channel for the transmission of economic fluctuations across countries [Choudri and Cohen (1980); Huffman and Lothian (1984); Cantor and Mark (1988); Cole and Obstfeld (1989)].

The second factor is common 'exogenous' external or internal disturbances such as an oil shock that affects simultaneously all oil-dependent economies, similar economic policies, common technological advances, etc. [Stockman (1988)]. The emphasis in this case is on the generation (source) rather than on the transmision of economic shocks. While both factors can produce similar patterns of economic fluctuations, it is the former (the 'imported' business cycle or the 'locomotive' theory) that has received considerably more attention in economic theory in the subjects of stabilization policy, the optimal exchange rate regime, etc. in the analysis of historical episodes ranging from the Great Depression (Smoot–Haley Tariff Act) to the world-wide recession of the early 1980s and also in the current debate concerning the integration of financial markets in Europe in 1992.

Dellas (1986) studied the international aspects of the cyclical behavior of the United States, the United Kingdom, Germany and Japan from 1960 to 1982 and found, among other things, that macroeconomic aggregates in these four countries roughly move together over the business cycle. However, the main source of this positive covariance in economic activity seems to have been common disturbances rather than trade interdependence; that is, trade links did not seem to matter for the international business cycle. Since this result is clearly at odds with the view that trade has important macroeconomic effects (a view popular in the theoretical literature on the transmission of economic disturbances as well as in large macro models such as LINK), Dellas offered a number of reasons that could have possibly accounted for the insignificance of trade flows in explaining international economic fluctuations over the sample period for these four countries. The list included the presence of common external supply (oil) shocks, the adoption of similar economic policies to cope with these shocks, the fact that capital account transactions have become important in the sample under consideration due to asset market integration; and finally that trade links among these countries may not have been sufficiently strong both because these countries were only moderately open for most of the sample under consideration and because they do not represent major trading partner pairs.

In this paper we examine the significance of trade interdependence in a sample that includes smaller, more trade-dependent economies as well as countries with strong bilateral trade ties. In light of the real business cycle model developed in this paper, which emphasizes the importance of productive (capital) goods in the transmission and propagation of economic disturbances [for a similar point, see Long and Plosser (1983) and King and Plosser (1984)] we also carry out the analysis with data on trade of intermediate (production) inputs. Finally, given that the construction of cyclical elements requires detrending – currently a very controversial issue – we employ several detrending techniques. The statistical analysis relies on correlation, spectral and VAR methods.

The results tend to differ significantly across the various detrending methods which makes it hard to draw any general conclusions and also raises doubts about the feasibility of building a consensus view of what the facts really are. For example, the quantitative assessment of the cyclical interdependences across various GNP series is strikingly different depending on the detrending procedure employed. Similarly, the significance of common factors in driving output variability across countries depends on the detrending method used. In general, we find that trade in goods has moderate cyclical macroeconomic effects. This is true even in those cases when the variance decomposition of a VAR model indicates that external shocks account for a significant fraction of the variance of domestic output in the long run. We also find that the role of trade in the transmission of economic disturbances was stronger in the past than in the most recent years. A possible explanation for the latter finding is that the post 1973 period has been dominated by world-wide shocks (the two oil shocks), and also the integration of the capital markets has given financial innovations great importance. It is worth emphasizing that the imported business cycle theory can give a strong empirical content to real business cycle theories, in the sense that it identifies a very plausible real source of economic fluctuations [see also Mendoza (1988) and Backus, Kehoe and Kydland (1989)].

Real business cycle theories have been criticized on the ground that they require the occurrence of implausibly large and frequent technological (supply) shocks. While such a criticism may have some validity in a closed economy, neither large nor frequent shocks are required to generate business cycles in a trade-dependent economy. As demonstrated in the paper, a country-specific disturbance can lead to strong, prolonged fluctuations because its initial impact can be amplified by feedback effects operating through the trade account. Similarly, the possibility of imported business cycles can drastically reduce the frequency of the occurrence of required supply shocks for any individual country.[2] Finally, note that the imported business cycle theory can provide some support for the claim that gains from diversification in international asset markets are small [Cole and Obstfeld (1989)], by providing and alternative channel through which diversification of country-specific shocks may occur.

The paper is organized as follows. In section 2 a simple theoretical model is constructed to analyze the relationship between GNP and trade flows. In

[2]Backus, Kehoe and Kydland (1989) find that in open economy extension of the Kydland and Prescott (1982) paper, the technological shock's explanations of output variance increases from 66 to 82 percent.

section 3 we present some empirical results. The last section offers a summary of the main conclusions and suggestions for extensions.

2. The model

Many studies of the generation and transmission of disturbance across countries have emphasized the role of real trade links in the world economy. Traditional Keynesian analysis of interdependence has focused on how changes in domestic aggregate demand affect the demand for imports and subsequently foreign income, which in turn feeds back on domestic exports and income [Dornbusch (1980)]. Jonung (1981), for example, explains the transmission of the depression from the United States to Sweden in the 1930s using this absorption approach. Similarly, the recovery in Europe in the last few years has been related to a U.S. import demand stimulus. On the other hand, owing to the recent resurgence of interest in supply (mainly oil) shocks and real business cycles, international production interdependence – that is, the fact that countries employ imported productive inputs – has been identified as a potentially important channel in the transmission of business cycles [Marion and Svensson (1981); Dellas (1985)].

In this section we develop a simple dynamic, stochastic, general equilibrium model of the world economy that highlights the role of supply links. Since the objective is to produce an example of how economic fluctuations are related to bilateral trade dependence we have simplified the asset side of the model by assuming the existence of complete asset markets and a perfectly pooled equilibrium. Another way of focusing on real trade links would be to assume the absence of any asset (capital) flows and balanced trade. We chose to have complete asset markets solely for the sake of tractability. In this case changes in relative price do not affect the international distribution of wealth and this facilitates the solution of the model. The empirical analysis presented in section 3, however, does not require any assumption about the structure of asset markets.

The set-up, which extends those appearing in Dellas (1985) and Stockman and Svensson (1987) is as follows. The world consists of two identical countries, home and foreign. Each country is inhabited by an infinitely lived representative individual. The home country completely specializes in the production of a single good Y_1 and the foreign in the production of a different good Y_2.[3] Each good can be either consumed or used as an input in the production of either good. In other words

[3]The qualitative features of the model would remain intact if we allowed Y_1 and Y_2 to be vectors of outputs with possibly some common elements. In such a case, the degree of trade openness – which is endogenously determined as a function of the production and consumption structure – would be affected. Nevertheless, since our objective is *not* to explain the trade pattern and the degree of openness but rather to demonstrate how openness and trade matter for the transmission of international economic fluctuations, we have chosen to ignore this complication.

$$Y_{it} = C^{\mathrm{d}}_{it} + C^{\mathrm{f}}_{it} + X_{i1t} + X_{i2t}, \tag{1}$$

where Y_i = total output of commodity i, $C^{\mathrm{d}}_i(C^{\mathrm{f}}_i)$ is domestic (foreign) consumption of good i, and X_{ij} is the amount of good i used in the production of good j.

The utility function of the domestic individual is

$$U^{\mathrm{d}} = U(C^{\mathrm{d}}_{1t}, C^{\mathrm{d}}_{2t}), \tag{2}$$

and the production function is given by

$$Y_{1t+1} = f(X_{11t}, X_{21t}, \theta_{1t+1}), \tag{3}$$

where θ is a productivity shock that follows a stationary stochastic process. The production process takes one period to be completed, and the exact value of period $t+1$'s productivity shock is not known when investment decisions are undertaken in period t. Moreover, to facilitate the analysis, we assume that the rate of capital depreciation equals unity (inputs are completely perishable). This last assumption affects the degree of persistence of the business cycles, but it is of no consequence for their transmission.

Since individuals in both countries are identical in every respect (except for the fact that the production activities are country specific) and they are risk averse, they will be willing to pool their production risks. If trade in Arrow–Debreu contingent securities is allowed before the individuals find out which country they will reside in, they will choose to start from a position of equal wealth;[4] the resulting equilibrium is a perfectly pooled one similar to that described in Lucas (1982).

There are several asset structures that can support this perfectly pooled equilibrium. The simplest one is as follows. The domestic firm issues assets z_{i1}, $i=1,2$, and z^{d}. The first two assets are contracts obligating the owner of the assets to deliver X_{i1t}, $i=1,2$, $t=0,1,2\ldots$ units of capital good i to the domestic firm in period t (a negative dividend). The third asset, z^{d}, pays as a dividend each period the domestic firm's receipts from selling goods that period. The foreign firm issues similar assets z_{i2}, $i=1,2$, and z^{f}.

Formally, the domestic individual maximizes expected lifetime utility

$$W^{\mathrm{d}} = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t U(C^{\mathrm{d}}_{1t}, C^{\mathrm{d}}_{2t}) \tag{4}$$

[4]The assumption of a perfectly pooled equilibrium with equal allocation is not necessary. For a more general case with unequal wealth, see Stockman and Dellas (1989).

where $\beta \in (0,1)$ is a discount factor and E is the expectations operator, subject to the sequence of budget constraints

$$z_t'(q_t+\delta_t)=C_{it}^{\mathrm{d}}+p_t C_{2t}^{\mathrm{d}}+z_{t+1}'q_t, \quad t=0,1,2,\ldots, \tag{5}$$

where

$$z'=(z_{11},z_{12},z_{21},z_{22},z^{\mathrm{d}},d^{\mathrm{f}}),$$

$$\delta'=(-X_{11},-X_{12},-pX_{21},-pX_{22},Y_1,pY_2)'$$

is the dividend vector, q is the price vector of the z assets in terms of good Y_1 and p is the relative price of good Y_2 in terms of good Y_1.

The F.O.C. are

$$U_{it}=\lambda_t, \tag{6}$$

$$U_{2t}=\lambda_t p_t, \tag{7}$$

$$\lambda_t q_{it}=\beta \mathrm{E}[\lambda_{t+1}(q_{jt+1}+\delta_{jt+1})], \tag{8}$$

where δ_{jt+1} and q_{jt+1} are the jth elements in the δ and q vectors, respectively, and λ is the Lagrange mulitplier. In the perfectly pooled equilibrium the representative domestic agent chooses to hold $\frac{1}{2}z$. A similar set of conditions holds for the foreign resident.

The optimization problem of the domestic firm is as follows. The domestic firm is defined as a set of assets $(z_{11},z_{21},z^{\mathrm{d}})=(1,1,1)$. The value of the firm is thus $q_{1t}+q_{3t}+q_{5t}$. Using (6) we have that the value of the domestic firm (ex-dividend) at date t is

$$V_t^{\mathrm{d}}=\frac{1}{\lambda_t}\mathrm{E}_t\sum_{s=t+1}^{\infty}\beta^{s-t}\lambda_s(\delta_{1s}+\delta_{3s}+\delta_{5s})$$

$$=\frac{1}{\lambda_t}\mathrm{E}_t\sum_{s=t+1}^{\infty}\beta^{s-t}\lambda_s[f(X_{11s-1},X_{21s-1},\theta_s)-X_{11s}-P_sX_{21s}]. \tag{9}$$

Maximization of V_t^{d} with respect to X_{11t} and X_{21t} for $s=t+1,t+2,\ldots$ satisfies the following conditions:

$$\begin{aligned}&\mathrm{E}_t\beta(\lambda_{t+1}f_{11t+1}-\lambda_t)=0, \quad t=0,1,2,\ldots,\\ &\mathrm{E}_t\beta(\lambda_{t+1}f_{21t+1}-\lambda_t p_t)=0,\end{aligned} \tag{10}$$

where $f_{i1t+1} = \partial f / \partial X_{i1t+1}$, $i=1,2$.

The foreign firm is defined as a set of assets $(z_{12}, z_{22}, z^f) = (1,1,1)$. At date t, the foreign firm chooses a complete contingency plan for investment to maximize its value $V_t^{\mathrm{f}} = q_{2t} + q_{4t} + q_{6t}$. This plan satisfies the conditions

$$\begin{aligned} &\mathrm{E}_t \beta(\lambda_{t+1} p_{t+1} f_{12t+1} - \lambda_t) = 0, \\ &\mathrm{E}_t \beta(\lambda_{t+1} p_{t+1} f_{22t+1} - \lambda_t p_t) = 0. \end{aligned} \tag{11}$$

Equilibrium prices and quantities in the economy are determined by eqs. (6)–(8), (10), (11) and the market-clearing conditions

$$\begin{aligned} &C_{it}^{\mathrm{d}} + C_{it}^{\mathrm{f}} + X_{i1t} + X_{i2t} = Y_{it}, \quad i=1,2 \text{ and } t=1,2,\ldots, \\ &z_t' = (1,1,1,1,1,1). \end{aligned} \tag{12}$$

If the productivity shocks follow a white noise process, *equilibrium* allocations at date t will be stationary functions of the two state variables of the system, Y_{1t} and Y_{2t}, and hence $X_{jit} = m_{ji}(Y_{1t}, Y_{2t})$.[5] The properties of m depend on the properties of the utility and production functions. Substituting the solution for X_{ijt} in the production functions yields

$$\begin{aligned} Y_{it+1} &= f[m_{1i}(Y_{1t}, Y_{2t}), m_{2i}(Y_{1t}, Y_{2t}), \theta_{it+1})] \\ &= g_i(Y_{1t}, Y_{2t}, \theta_{it+1}), \quad i=1,2. \end{aligned} \tag{13}$$

To see how production interdependence affects the level and the variance–covariance matrix of national outputs, it is useful to specialize (2) and (3) to

$$U(C_{1t}, C_{2t}) = \phi_1 \ln C_{1t} + \phi_2 \ln C_{2t}, \tag{2'}$$

$$f(X_{iit}, X_{jit}, \theta_{it+1}) = \ln \theta_{it+1} + \sum_{j=1}^{2} \alpha_{ji} \ln X_{jit}, \quad j,i=1,2, \tag{3'}$$

where $0 \leqq \phi_1, \phi_2 \leqq 1$ and $\sum_{j=1}^{2} \alpha_{ij} < 1$. The solution to the problem is then given by

$$C_{it} = (\phi_i \mid \gamma_i) Y_{it}, \quad i=1,2,$$

[5]The white noise specification for productivity shocks is clearly unrealistic [see Backus, Kehoe and Kydland (1989) or Crucini (1990)]. It is adopted here solely for the purpose of constructing an illustrative analytical example.

$$X_{jit}=(\beta\gamma_i\alpha_{ji}\,|\,\gamma_j)Y_{jt},\quad i,j=1,2,\tag{14}$$

$$\gamma_i\ =\phi_i+\beta\sum_{i=1}^{2}\gamma_j\alpha_{ji},\quad i,j=1,2.$$

Substituting (14) into (3′) yields the following vector autoregressive (VAR) representation for the log of outputs:

$$\begin{pmatrix}y_{1t+1}\\ y_{2t+1}\end{pmatrix}=\begin{pmatrix}c_1\\ c_2\end{pmatrix}+\begin{bmatrix}\alpha_{11} & \alpha_{21}\\ \alpha_{12} & \alpha_{22}\end{bmatrix}\begin{pmatrix}y_{1t}\\ y_{2t}\end{pmatrix}+\begin{pmatrix}u_{1t+1}\\ u_{2t+1}\end{pmatrix}$$

or (15)

$$y_{t+1}\quad =B+Ay_t+\varepsilon_{t+1},$$

where

$$c_1=\alpha_{11}[\ln(\beta\alpha_{11})]+\alpha_{21}[\ln(\beta\alpha_{21}\gamma_2/\gamma_1)];$$

$$c_2=\alpha_{12}[\ln(\beta\alpha_{12}\gamma_1/\gamma_2)]+\alpha_{22}[\log(\beta\alpha_{22})];$$

$$y_{it+1}=\ln Y_{it+1},u_{it+1}=\ln\theta_{it+1}$$

and the covariance matrix of the u_{t+1}'s is given by $V=\{v_{ij}\}$.

From (15) it is clear that covariations in outputs occur for two distinct reasons. One is the existence of a high contemporaneous correlation in the shocks across countries (i.e. $p_{ij}=v_{ij}/\sqrt{v_{ii}v_{jj}}\rightarrow 1$). The second is the existence of large non-diagonal elements in the matrix A. Dellas (1986) discusses the economic implications of these two alternative sources of covariation. Most of the existing literature has concentrated attention on the first source of covariation to explain the features of international business cycles [see, for example, Backus, Kehoe and Kydland (1989), Costello (1989) or Crucini (1990)]. In this paper we examine the importance of the second source of covariations, i.e. the imported business cycle hypothesis.

From (15) it is then straightforward to see that $\mathrm{d}y_{it+1}/\mathrm{d}y_{jt}$ is positive because the α's are all positive. An increase in current output in the foreign country will increase foreign exports. Since part of foreign exports (domestic imports) is employed in the domestic productive activities, domestic output will increase too. Hence, trade in productive inputs will make outputs covary positively across countries, with the size of this covariance depending on the strength of bilateral trade ties [the functions m_{ij} in (13)]. It is also easy to show that the unconditional variance of w_{t+1} is given by $(I-A)^{-1}V(I-A)^{-1\prime}$, so that

$$\operatorname{Var} y_{1t+1} = \frac{(v_{11}(1-\alpha_{22})^2+(v_{21}+v_{12})\alpha_{21}(1-\alpha_{22})+\alpha_{12}^2 v_{22})}{(\det|I-A|)^2},$$

$$\operatorname{Var} y_{2t+1} = \frac{(v_{11}\alpha_{21}^2+(v_{21}+v_{12})\alpha_{12}(1-\alpha_{11})+(1-\alpha_{11})^2 v_{22})}{(\det|I-A|)^2},$$

$$\operatorname{Cov}(y_{1t},y_{2t}) = \frac{\begin{array}{c} v_{11}\alpha_{12}(1-\alpha_{22})+v_{12}(1-\alpha_{11})(1-\alpha_{22}) \\ +v_{21}\alpha_{21}\alpha_{12}+(1-\alpha_{11})v_{22}\alpha_{21} \end{array}}{[\det(1-A)]^2}.$$

To sign $\partial\operatorname{Var}(y_{1t})/\partial\alpha_{21}$, $\partial\operatorname{Var}(y_{2t})/\partial\alpha_{12}$, $\partial\operatorname{Cov}(y_{1t},y_{2t})/\partial\alpha_{12}$ and $\partial\operatorname{Cov}(y_{1t},y_{2t})/\partial\alpha_{21}$ requires simplifying assumptions. For example, if we set $v_{iy}=0$, i.e. cross-country productivity shocks are contemporaneously uncorrelated, all these quantities will be positive (so that production–trade interdependence contributes positively to the variability of national outputs and to the international business cycles) if $\det(I-A)>0$. This condition will be satisfied if the production functions display decreasing returns to scale.[6]

To summarize: under reasonable assumptions, the model predicts that outputs will be correlated and, if the correlation is due to the transmission of independent shocks, the correlation will be higher the larger is the share of foreign goods in production. Similarly, we expect the variability of outputs to be strictly related to trade in productive inputs. Therefore, the stronger are trade links across countries the higher will be the interdependence and the longer the feedback mechanism will last.

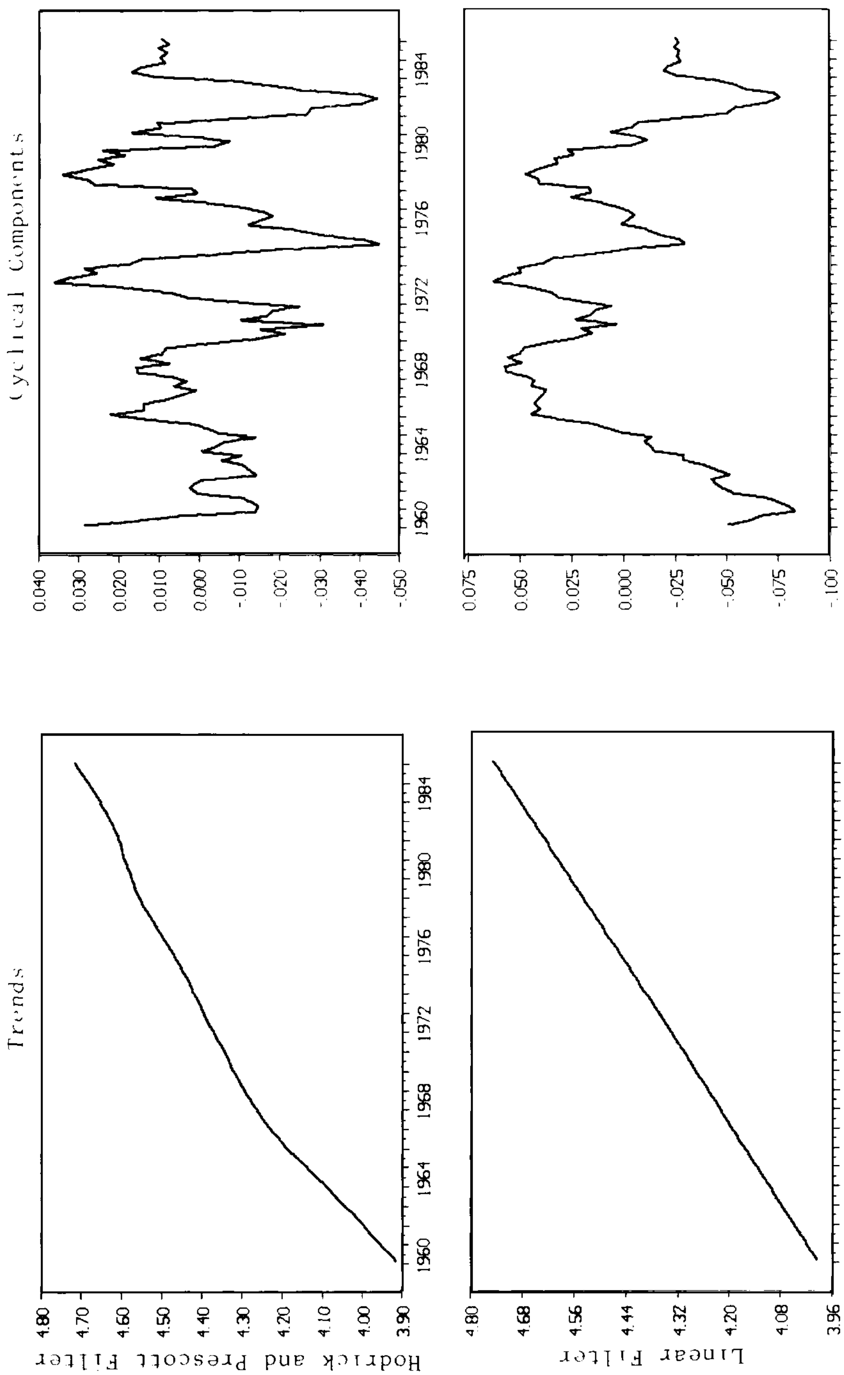
We examine these implications in the next section.

3. Empirical analysis

Most of the recent literature on international business cycles has been conducted within calibrated artificial economies [see, for example, Backus, Kehoe and Kydland (1989); Baxter and Crucini (1990); Costello (1990) or Stockman and Tesar (1990)]. In this paper we rely instead on the standard statistical tools of the macroeconometric literature [see, for example, Sims (1980)] because of their greater robustness within our model.[7]

[6]Some support for this assumption can be found in table 2 where common shocks are shown to be insignificant in explaining output variability using two different detrending methods and in table 3 where the pairwise cross correlation of shocks is shown to be small.

[7]The parameterization of the matrix A is problematic owing to data availability; moreover, the calibrated time series may be oversensitive to the parameterization of V as the results of Backus, Kehoe and Kydland have revealed.


Trends
Cyclical Components
Hodrick and Prescott Filter
Linear Filter
1960
1964
1968
1972
1976
1980
1984
4.80
4.70
4.60
4.50
4.40
4.30
4.20
4.10
4.00
3.90
4.68
4.56
4.44
4.32
4.20
4.08
3.96
0.040
0.030
0.020
0.010
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-.010
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0.075
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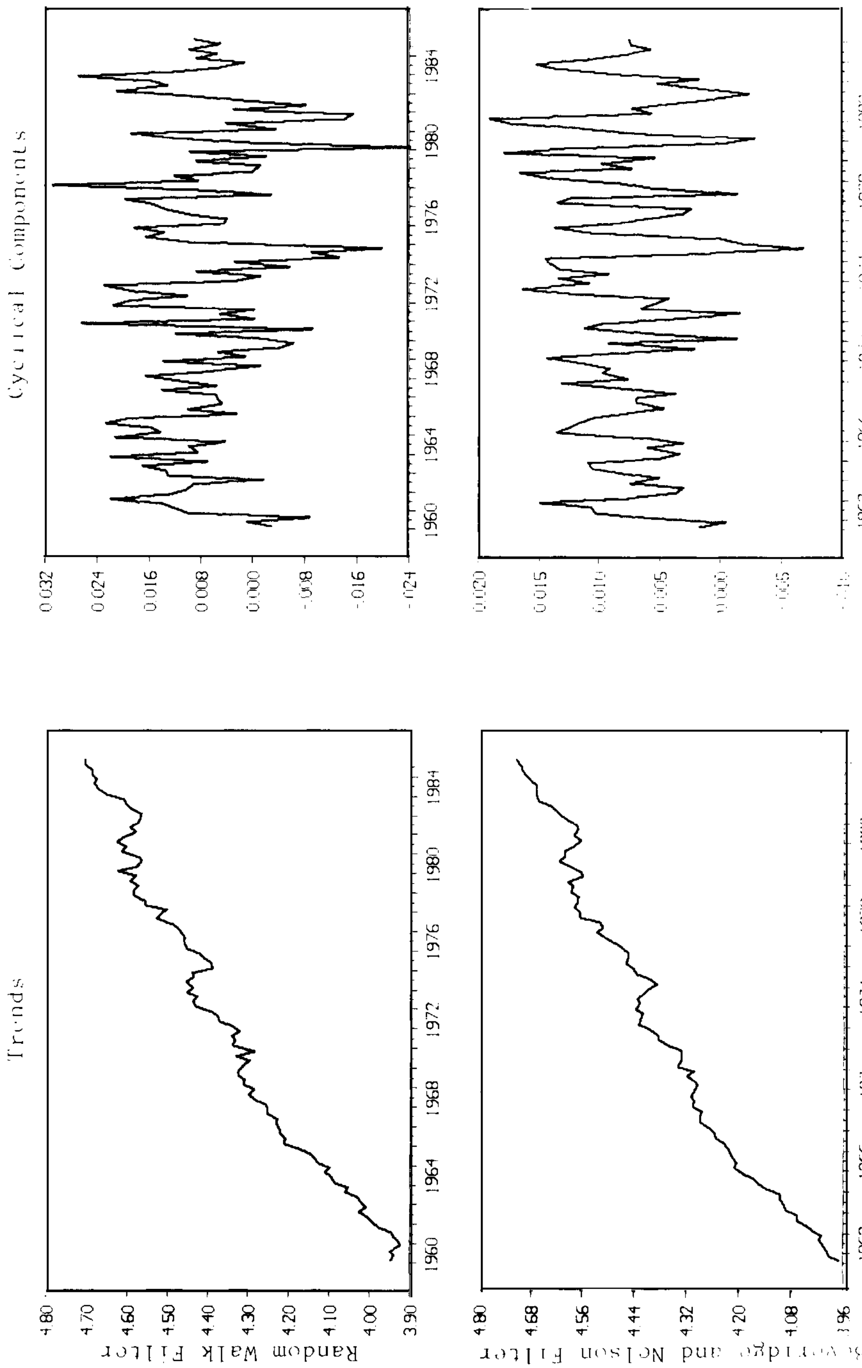

Fig. 1. Trends and cyclical components.

The analysis of business cycles requires the construction of cyclical components via detrending of the actual economic time series of interest. However, since in the model of section 2 outputs have no trend, economic theory cannot be used to guide us in the choice of detrending procedure. Also, different detrending methods make different assumptions about the underlying economic structure which may result in different distributional properties (moments, correlations) for the derived cyclical components and possibly conflicting descriptions of the empirical evidence [see Canova (1991) for such an account]. Given the low power of the tests designed to inform us about the long-run properties of economic time series, there exists no consensus view in the profession with regard to the appropriate statistical choice of trend removal. Rather than imposing our prior views on this matter, we have decided to adopt an agnostic approach and report the results under four alternative detrending specifications. We have generated the cyclical component of outputs assuming that the trend was (1) a log random walk with no drift uncorrelated with the cyclical component (RW), (2) a deterministic linear process uncorrelated with the cyclical component (LT), (3) a smooth stochastic process uncorrelated with the cyclical component [Hodrick–Prescott (HP) detrending], and (4) a log random walk perfectly correlated with the cyclical component [Beveridge–Nelson (BN) detrending). A description of these methods can be found in appendix A. To illustrate the differences existing across detrending methods, fig. 1 plots the U.S. GNP series, the four trends and the four cyclical components.[8]

The sample used in this study consists of the following 10 industrial countries for which quarterly data are available: Austria (AUS), Canada (CAN), France (FRA), Germany (GER), Italy (ITA), Japan (JP), South Africa (SFA), Sweden (WE), the United Kingdom (UK) and the United States (USA); the data are seasonally adjusted quarterly observations extending from 1960:1 to 1986:2 (with the exception of France and Sweden where the starting points are 1965:1 and 1969:1, respectively). All GNP (or GDP) data were taken from the IFS tapes and were converted into indices using 1980 values.[9] Bilateral trade data for imports and exports were taken from the DOT tapes. Bilateral trade variables in intermediate goods consist of fuels, metals, minerals, machinery and transport equipment and are taken from *The UN Commodity Trade Data Base*, Geneva.

First, we provide some evidence on the existence of international business

[8]Although the plots presented in fig. 1 look alike, one should note that the variability and the serial correlation properties of the detrended series are different. Canova (1991) provides extensive documentation of this fact. Also, while for the United States and the United Kingdom the plots of the cyclical components obtained with different detrending methods are similar, for all other countries the plots of four cyclical components display substantial differences.

[9]Austrian data were originally seasonally non-adjusted. To maintain consistency with the other series, they were seasonally adjusted using the frequency domain masking procedure suggested by Sims (1974).

Table 1

Percentage of the variance of 24 step ahead forecasts due to own innovations; 90% confidence bootstrap intervals; quarterly data: 10 countries 1969: 1–1986: 2.

Detrending method	RW	LT	HP	BN
GNP 80 USA	[88, 93]	[17, 42]	[43, 61]	[86, 92]
GNP 80 GER	[64, 87]	[66, 82]	[43, 64]	[71, 87]
GNP 80 JP	[67, 88]	[17, 32]	[43, 65]	[67, 86]
GDP 80 UK	[47, 67]	[32, 48]	[37, 59]	[50, 68]
GDP 80 FRA	[70, 88]	[12, 27]	[23, 41]	[64, 83]
GDP 80 ITA	[64, 79]	[12, 23]	[25, 39]	[63, 81]
GDP 80 SWE	[57, 78]	[41, 59]	[37, 61]	[62, 81]
GDP 80 AUT	[49, 74]	[8, 22]	[34, 57]	[48, 72]
GNP 80 CAN	[45, 76]	[18, 33]	[29, 51]	[50, 78]
GNP 80 SFA	[65, 84]	[6, 15]	[41, 59]	[62, 85]

Table 2

Analysis of variance; significance level of F-statistics; quarterly data, 10 countries, 1969:1–1986:2.

Detrending method	RW		LT		HP		BN	
	Ind.	Time	Ind.	Time	Ind.	Time	Ind.	Time
	0.98	0.51	0.74	0.00	0.99	0.00	0.00	0.38

cycles. Table 1 gives a 90 per cent bootstrap interval for the percentage of the variance at the 24 step (quarter) ahead forecast due to its own innovations.[10] If business cycles are born in individual countries but get transmitted abroad, then one will expect small entries in the table. In general, foreign innovations seem to matter in explaining the variance of the forecasts, therefore supporting the concept of international cyclical interdependence. However, the most striking feature of the table is the lack of robustness in the quantitative assessment of cyclical interdependence across the various detrending methods. This finding raises serious questions about the validity of the various 'stylized facts' that have been reported in the business cycle literature primarily with the aid of the HP filter. For instance, the contribution of foreign innovations to domestic economic conditions (and hence the size of cross-country linkages) are much larger (smaller) under LT (BN) than under HP.

Table 2 provides additional evidence on the existence of an international business cycle. There we compute an analysis of the variance of the cyclical

[10]The qualitative results remain unaffected if France and Sweden are dropped from the sample to increase the number of observations. Shocks are identified using a block Wold casual chain with four blocks (the United States and Canada, Japan, South Africa, European countries). Among European countries the contemporaneous ordering puts Germany first, France and the United Kingdom second, Italy fourth, Austria and Sweden last. The size of the bootstrap confidence intervals is not sensitive to the ordering in this block.

Table 3

Highest and lowest cross-country pairwise correlation of output innovations; quarterly data, 10 countries, 1969:1–1986:2.

Detrending method	RW	LT	HP	BN
Low	0.44E-05	−0.0001	−0.0002	0.38E-06
High	0.0109	0.1879	0.0918	0.0017

component of outputs obtained with various detrending methods. The individual effect measures the importance of country-specific cycles in generating cyclical fluctuations in output. The time effect represents a measure of the common (across countries) fluctuations over time in the cyclical component of outputs. The numbers reported in the table are the significance level of the F-statistics for the hypothesis that each effect is individually insignificant. Once again the results depend on the detrending procedure employed. The common time effect is strong when LT or HP are used, while the individual country effect is significant only when BN is used. Note also that the significance level of the time effect for each detrending procedure is consistent with the magnitude of the entries of the corresponding column of table 1.[11]

To examine whether international business cycles are generated by common shocks or by a transmission mechanism of independent shocks, we run bivariate ARMA models for pairs of countries' cyclical component of outputs and computed an estimate of the cross-country correlations of the innovations.[12] Uniformly small correlations favor the 'transmitted' business cycle hypothesis while large ones the 'common shocks' one. Table 3 reports the highest and the lowest of these pairwise correlation coefficients for each detrending method.[13] The correlations turn out to be positive, but in most cases they are small and insignificant. This result agrees with Stockman and Tesar's (1990) finding that the cross-country correlations of solow residuals are much smaller than those of outputs.

From this evidence one may conclude that while there are some common shocks, one must look for endogenous transmission mechanisms to explain the correlation pattern of actual outputs; trade is a natural candidate.

Next, we examine how trade interdependences affect the cyclical compo-

[11]That is, if a detrending method picks up the presence of common factors, then it also picks up a significant transmission mechanism of shocks.

[12]One can also try to estimate a more general version of (3′) (more lags, allowing for serial correlation in the productivity shocks, etc.) as a direct test of the theory [as in Dellas (1986)]. We have not pursued this line becuase the estimated coefficients tend to be rather uninformative for our purposes as they tend to capture many other links beside trade (such as fiscal and monetary policies, asset markets effects, etc.).

[13]The results obtained using subsamples for this and for the previous experiment are available on request from the authors.

nent of output. Let Y^c_{it} be the cyclical output in country i in period t; σ_{it} be the annual volatility of the cyclical component of output (constructed as the standard deviation of Y^c_{it} in the four quarters comprising year t); Cov_{ijn} be the correlation between the cyclical component of outputs i and j, n periods apart; and Cov^s_{ijn} is the correlation of σ_{it} and σ_{jt}, n periods apart (so that Cov^s_{ijn} is the contemporaneous correlation and so forth). We construct two measures of bilateral trade dependence, one based on total imports of goods and the other based on imports of intermediate productive goods.[14] Let $m_{ij}(h_{ij})$ be the average share of imports (intermediate imports) from country j in total average imports (total intermediate imports) of country i, weighted by the country's import to GNP (or GDP) ratio. The totals are computed over the countries in the sample and averaged over time. Then $\overline{m_{ij}}=\max\{m_{ij}; m_{ji}\}$ and $\overline{h_{ij}}=\max\{h_{ij}, h_{ji}\}$ are our measures for bilateral trade links across countries.[15] Note also that although in practice the true m_{ij}'s may be endogenous, our measure of trade links does not face any serious endogeneity problem because we are using very long averages to compute a single value of these parameters. Table A.1 contains the average (over 1960–1986) percentage (of the total) bilateral trade variables for imports, while table A.2 contains the average percentage bilateral trade variables for intermediate imports employed in the exercise.[16] Recall that, according to the model, $\partial \mathrm{Cov}_{ijn}/\partial m_{ij}>0$ and $\partial \mathrm{Cov}_{ijn}/\partial h_{ij}>0$, i.e. the higher is the degree of trade interdependence, measured in terms of imports or in terms of intermediate imports, the stronger is the covariation of cyclical outputs. Similarly $\partial \mathrm{Cov}^s_{ijn}/\partial m_{ij}>0$ and $\partial \mathrm{Cov}^s_{ijn}/\partial h_{ij}>0$.

The world economic environment has changed substantially in the years after 1973 (an exchange rate regime switch, oil shocks, etc.) and the features of the international business cycles may have been altered after that date [see Gerlach (1988)]. To capture this change we carried out the analysis in the full sample (F) and also in the pre-1973 subsample (1973) and the after 1973 subsample (1986). In these two cases the bilateral trade variables are averages over the respective subsamples. Tables 4 and 5 examine the two predictions of the model.[17] Several features stand out in these tables. First, the finding that trade interdependence matters for the cyclical covariation of outputs is somewhat robust to all the detrending methods and is most

[14]Tables B.1 and B.2 in appendix B report results using an alternative measure of trade interdependence that uses the share of trade in GNP.

[15]The m_{ij}'s have the following interpretation. Let $j=1,\ldots,n$ in eq. (3′) with $j=1$ representing the production share of the domestic input and $j=2,\ldots,n$ representing the production shares of the foreign inputs. Then m_{ij} corresponds to $\alpha_{i,j}$, $j=2,\ldots,n$ in (3′) under the normalization $\sum_{j=2}^{n}\alpha_{i,j}=q$, where q is the import share of GNP.

[16]The use of $m_{ij}(h_{ij})$ or $m_{ji}(h_{ji})$ in place of $\bar{m}_{ij}(\bar{h}_{ij})$ and also of measures based on exports rather than imports did not affect our results.

[17]Since all the variables used are estimated, there is an additional component of the standard error of the correlations due to these estimates. In constructing tests for the significance of the correlations, we explicitly take into account the existence of these standard errors.

Table 4

Cross-correlation of bilateral trade ties/correlation of cyclical component of output; quarterly data, 10 countries, 1960:1–1986:2.

Detrending method	Sample	Import ties ($\bar{m}_{ij}$)			Intermediate import ties ($\bar{h}_{ij}$)		
		Lag 1	Lag 0	Lead 1	Lag 1	Lag 0	Lead 1
RW	60–86	−0.09	0.08	−0.06	−0.04	0.06	−0.13
	60–73	−0.16	0.24**	−0.08	−0.09	0.21	−0.15
	73–86	−0.03	0.26*	−0.06	0.01	0.19	−0.00
LT	60–86	0.11	0.10	0.06	0.09	0.08	0.06
	60–73	0.20	0.28*	0.20	0.17	0.19	0.13
	73–86	0.12	0.20	0.24**	0.18	0.24**	0.25**
HP	60–86	0.16	0.19	0.10	0.10	0.08	0.02
	60–73	0.07	0.26*	0.23**	0.08	0.17	0.15
	73–86	0.03	0.10	0.15	0.03	0.06	0.10
BN	60–86	−0.04	0.19	0.06	0.01	0.13	−0.15
	60–73	−0.06	0.24**	−0.08	−0.09	0.21**	−0.15
	73–86	0.04	0.07	0.09	0.02	0.04	0.01

*Significant at 5% confidence.
**Significant at 10% confidence.

Table 5

Cross-correlation of bilateral trade ties/correlation of annual standard error of cyclical component of output; quarterly data, 10 countries, 1960:1–1986:2.

Detrending method	Sample	Import ties ($\bar{m}_{ij}$)			Intermediate import ties ($\bar{h}_{ij}$)		
		Lag 1	Lag 0	Lead 1	Lag 1	Lag 0	Lead 1
RW	60–86	−0.13	−0.06	0.08	−0.15	0.06	0.09
	60–73	0.05	−0.30*	0.19	−0.04	−0.42*	0.12
	73–86	−0.00	−0.03	−0.06	0.11	−0.15	−0.15
LT	60–86	−0.07	−0.23**	−0.07	0.00	−0.20	−0.11
	60–73	0.01	−0.29*	−0.16	−0.03	−0.28*	−0.25**
	73–86	0.00	−0.06	−0.09	−0.15	−0.10	0.05
HP	60–86	−0.22**	−0.27*	−0.21**	−0.14	−0.22**	−0.36*
	60–73	0.03	−0.22**	−0.16	−0.03	−0.28*	−0.25**
	74–86	0.13	0.19	0.03	−0.12	0.11	0.16
BN	60–86	0.07	−0.03	0.17	0.12	0.00	0.11
	60–73	0.27*	0.03	0.27*	0.17	0.03	0.17
	73–86	0.15	0.10	0.19	0.18	0.16	0.26*

*Significant at 5% confidence.
**Significant at 10% confidence.

significant when the HP filter is used. Second, trade interdependences are slightly more important when total imports (as opposed to intermediate imports) are used. Third, the evidence concerning the effect of trade interdependences on the variability of output is weak and the results vary

Table 6

Cross-correlation of bilateral trade ties correlation of output innovations; quarterly data, 10 countries, 1960:1–1986:2.

Detrending method	Sample	Import ties ($\bar{m}_{ij}$)	Intermediate import ties ($\bar{h}_{ij}$)
RW	60–86	−0.011	−0.03
	60–73	0.398*	0.43*
	73–86	0.032	−0.05
LT	60–86	0.174	0.151
	60–73	0.171	0.199
	73–86	0.011	0.091
HP	60–86	−0.04	−0.076
	60–73	−0.08	−0.006
	73–86	0.01	0.011
BN	60–86	−0.07	−0.097
	60–73	0.39*	0.437*
	73–86	−0.03	0.082

*Significant at 5% confidence.

significantly across detrending methods. The correlations turn out to have a meaningful sign and to be somewhat significant only when the data are filtered with HP or BN. Finally, the contribution of trade interdependence to the international business cycle seems to have been greater in the past rather than in the most recent years. This is not surprising given the world wide oil shocks of the 1970s, the internationalization of the capital markets and the convergence in policies across countries.

The pairwise coefficients of innovations correlations obtained from bivariate ARMA models can also be used to confirm the claim that trade interdependence matters for the international business cycle. Suppose that there are only two sources of international comovements – common shocks and trade links – and suppose that the countries with the strongest trade links are also the ones with the highest correlation of innovations (i.e. with the stronger common shocks). If that were the case the relationship observed in tables 4 and 5 could be spurious, reflecting the relationship between common shocks and trade ties. Fortunately, this turns out not to be the case. As can be seen from table 6 there is little systematic relationship between the size of trade links and the occurrence of common shocks.

The analysis of the relationships between trade links and the cyclical comovements of outputs so far has been restricted to contemporaneous or almost contemporaneous output comovements. However, it is possible that the transmission of economic disturbances takes a long time to appear. It is, then, of interest to investigate how economic fluctuations are related across countries over the business cycle. There are two ways to study this type of effect. One is to examine how the off-diagonal entries of the variance

Table 7

Contemporaneous correlation: Entries of the variance decomposition at 24 steps/bilateral trade ties; quarterly data, 10 countries, 1969:1–1986:2.

Detrending methods	RW		LT		HP		BN	
	$\bar{m}_{ij}$	$\bar{h}_{ij}$	$\bar{m}_{ij}$	$\bar{h}_{ij}$	$\bar{m}_{ij}$	$\bar{h}_{ij}$	$\bar{m}_{ij}$	$\bar{h}_{ij}$
	0.068	0.045	0.388*	0.354*	0.210*	0.239*	0.089	0.056

*Significant at 5% confidence.

decomposition at long horizons relate to the size of bilateral trade links between any country pair i,j. If economic disturbances get transmitted across countries via trade in goods, we expect the correlation between the off-diagonal elements of the variance decomposition and the size of the bilateral trade links to be positive. Table 7 reports the correlation coefficient between the median value of the 90 per cent confidence internal of the variance decomposition at 24 steps and bilateral trade links. Although their significance varies with the detrending procedure employed, they are broadly consistent with the prediction of the model.

Alternatively, one could directly examine the comovements of outputs at business cycle frequencies and their relationship with bilateral trade links. This can be conveniently accomplished by employing spectral analysis techniques. As has been emphasized in the literature [see, for example, Priestley (1981)], spectral analysis decomposes the variance of a stochastic process by frequency. This decomposition ascribes certain portions of the total variance to components of various frequencies (periods). Consequently, spectral analysis is particularly suited to the study of the cyclical characteristics of economic time series since it can determine how the variation of any economic time series is affected by cyclical movements and what the period of these cycles is.

As a measure of cyclical output comovements over the business cycle we calculate the coherence coefficient for pairs of national outputs averaging the coherence over business cycle frequencies (COH1 for 3–5 years and COH2 for 2–6 years). The coherence coefficient measures the proportion of the variance in one economic series that is accounted for by variation in another series at some frequency. We take averages to eliminate spurious results at specific frequencies owing to small sample biases. Table 8 reports the correlation coefficients between the coherence variable and the bilateral trade variable. As before the results tend to differ depending on which filter is applied to the data. The only significant relationship between trade interdependence and business cycle appears when the BN filter is used in the analysis, and it is supportive of the theory. Note also the evident distortion in the coherence at business cycle frequencies introduced when outputs are

Table 8

Correlation average coherence at business cycle frequencies/bilateral trade ties; quarterly data, 10 countries, 1960:1–1986:2.

Detrending method	Sample	Import COH1	Ties ($\bar{m}_{ij}$) COH2	Intermediate COH1	Import ($\bar{h}_{ij}$) COH2
RW	60–86	−0.113	−0.027	−0.142	−0.050
	60–73	−0.049	−0.036	−0.040	−0.023
	73–86	0.053	0.018	0.020	0.003
LT	60–86	−0.043	0.075	−0.060	0.043
	60–73	0.272**	0.256**	0.236**	0.223**
	73–86	−0.269**	−0.121	−0.233**	−0.133
HP	60–86	0.088	0.255**	0.044	0.120
	60–73	0.132	0.085	0.088	0.025
	73–86	−0.073	0.255**	−0.019	0.074
BN	60–86	−0.012	−0.018	0.041	0.054
	60–73	−0.129	−0.135	−0.163	−0.166
	73–86	−0.022	−0.034	0.109	0.102

Note: The first and third columns refer to correlation with the average coherence for 3–5 year cycles. The second and the fourth columns refer to correlations with average coherence for 2–6 years cycles.

**Significant at 10% confidence.

Table A.1

Average percentage of bilateral import ties; sample 1960–1986.

	AUS	CAN	FRA	GER	ITA	JAP	SAF	SWE	UK	USA
AUS		0.002	0.005	0.027	0.025	0.004	0.006	0.012	0.005	0.002
CAN	0.006		0.009	0.015	0.012	0.120	0.022	0.006	0.054	0.215
FRA	0.044	0.011		0.104	0.101	0.031	0.033	0.042	0.051	0.025
GER	0.404	0.023	0.163		0.151	0.074	0.142	0.205	0.078	0.056
ITA	0.080	0.009	0.070	0.080		0.023	0.032	0.032	0.032	0.026
JAP	0.014	0.033	0.014	0.022	0.010		0.073	0.025	0.025	0.120
SAF	0.004	0.003	0.006	0.009	0.014	0.044		0.002	0.025	0.010
SWE	0.018	0.005	0.017	0.031	0.015	0.011	0.017		0.034	0.010
UK	0.040	0.059	0.058	0.052	0.046	0.047	0.234	0.134		0.053
USA	0.053	0.684	0.089	0.103	0.111	0.292	0.170	0.088	0.106	

Table A.2

Average percentage of bilateral intermediate import ties; sample 1960–1986.

	AUS	CAN	FRA	GER	ITA	JAP	SAF	SWE	UK	USA
AUS		0.005	0.011	0.055	0.035	0.005	0.012	0.013	0.011	0.005
CAN	0.013		0.008	0.013	0.013	0.047	0.008	0.022	0.052	0.412
FRA	0.032	0.006		0.137	0.187	0.026	0.054	0.053	0.105	0.068
GER	0.396	0.007	0.242		0.212	0.049	0.110	0.135	0.129	0.071
ITA	0.067	0.032	0.139	0.101		0.010	0.059	0.032	0.063	0.045
JAP	0.011	0.035	0.009	0.021	0.014		0.200	0.014	0.022	0.145
SAF	0.008	0.003	0.014	0.023	0.017	0.037		0.012	0.055	0.018
SWE	0.053	0.002	0.028	0.059	0.028	0.013	0.004		0.080	0.020
UK	0.020	0.025	0.099	0.083	0.098	0.044	0.128	0.119		0.083
USA	0.072	0.901	0.087	0.141	0.134	0.641	0.308	0.133	0.165	

detrended with the HP filter [see King and Rebelo (1989) for a similar argument].

To check the robustness of our conclusions, we also analyzed annual data in two larger samples of countries. The first data set consists of 42 countries and we ask how the overall degree of openness [measured as the average share of imports (exports) in GNP (or GDP) over the sample period] affects individual country average output growth, its volatility and its correlation with world economic conditions [see also Kormendi and Meguire (1985)]. World output was constructed using a weighted average of the output of the 42 countries with weights equal to the shares of their output in the total. The second sample consists of 17 European countries plus the United States, Canada, Japan and South Africa (and hence it includes major trading partners pairs) and asks whether strong bilateral trade ties imply similar cyclical output behaviour and similar variability. A detailed description of the samples and of the test performed is contained in appendix B. Tables B.1 and B.2 contain the result of the exercises. While the results are somewhat weakened, the qualitaive conclusions are unaffected.

4. Conclusions

Business cycles are an international phenomenon in the sense that economic conditions tend to be highly correlated across countries. A question arising from this empirical observation is whether it is possible to identify the cross-country linkages that serve as important mechanisms in the internationalization of economic developments. Trade flows are a natural candidate. However, despite the popularity of views attributing the transmission of economic disturbances to the flow of goods (the imported business cycle theory, the United States as a 'locomotive' for the rest of the world, the impact of the world-wide recession on trade revenue and hence debt servicing in developing countries, etc.), little statistical effort has been expended to document the existence of trade-based cycles. For instance, no serious attempt has been made to evaluate the claims that the severity and the transmission of the Great Depression to Europe was largely due to the introduction of the Smoot–Haley Tariff Act in the United States and the subsequent European retaliation that disrupted trade flows.[18] In this paper we have made a first step in establishing a relationship between trade interdependence and cyclical macroeconomic behavior. The sign of the relationship was found to be positive but its significance depended on the detrending procedure employed. The question is whether the reasons offered by Dellas (1986) (see the introduction) are important in accounting for the moderate significance of trade interdependences. We feel that this may still be

[18]Krugman (1990) has recently argued that this was not the case.

the case because the role of trade interdependence in accounting for international business cycles seems to have been more significant before rather than after 1973; the latter is the period which witnessed the emergence of oil shocks, of common policy responses and of increased financial market integrations. This evidence, however, makes further research in identifying the sources and channels of transmission of international business cycles a worthwhile project to undertake.

Appendix A: Detrending methods

In this appendix we describe the four statistical procedures used to extract trends from the observable time series. All these methods assume that the trend and the cycle are unobservable, but use different identifying assumptions to extract the two components. Let the logarithm of the observable time series be denoted by y_t, its trend (permanent component) by y_t^{p} and its cyclical component by y_t^{c} and let $y_t = y_t^{\mathrm{p}} + y_t^{\mathrm{c}}$.

A.1. Linear detrending

This procedure is the simplest one. It assumes that the trend and the cyclical component of the log of a series are uncorrelated and that the trend is a deterministic process which can be approximated by a simple linear function of time. The model for y_t^{p} takes the form

$$y_t^{\mathrm{p}} = a + b(t - t_0),$$

where t_0 is a scaling factor. The permanent component can be estimated by fitting y_t to a constant and a linear function of time and by taking the predicted value of the regression. An estimate of the cyclical component is then $\hat{y}_t^{\mathrm{c}} = y_t - \hat{y}_t^{\mathrm{p}} = y_t - \hat{a} - \hat{b}(t - t_0)$.

A.2. Hodrick–Prescott detrending

The two main hypotheses underlying the Hodrick and Prescott (1980) decomposition are that the trend is stochastic but moves smoothly over time and that trend and cycle are independent. An estimate of the permanent component of the series can be obtained by solving the following constraint minimization problem:

$$\min_{\{y_t^{\mathrm{p}}\}_{t=1}^{T}} \left\{ \sum_{t=1}^{T} (y_t - y_t^{\mathrm{p}})^2 + \lambda \sum_{t=1}^{T} [(y_t^{\mathrm{p}} - y_{t-1}^{\mathrm{p}}) - (y_{t-1}^{\mathrm{p}} - y_{t-2}^{\mathrm{p}})]^2 \right\},$$

where λ is a parameter which penalizes the variability of the trend. The optimal value of λ can be shown to be $\lambda=\sqrt{\sigma_1^2/\sigma_2^2}$, where σ_1 and σ_2 are the standard deviations of the cyclical component and of the trend of y_t. Hodrick and Prescott do not estimate this parameter from the data, but instead assume a priori it to be 1,600, which implies that the standard error of the cycle is 40 times larger than the standard error of the trend. [See Canova (1990) for the consequence of this assumption on some of important summary statistics.] The cyclical component can then be obtained using $\hat{y}_t^c = y_t - \hat{y}_t^p$.

A.3. RW detrending

The two basic assumptions of this procedure are that the trend is a random walk with no drift, while the cyclical component is stationary and that trend and cycle are uncorrelated. Under these assumptions y_t has a unit root which is entirely due to the permanent component of the series, and therefore

$$y_t^p = y_{t-1}^p + \varepsilon_t$$

and an estimate of y_t^c can be obtained as

$$\hat{y}_t^c = y_t - y_{t-1}.$$

A.4. Beveridge–Nelson detrending

The procedure proposed by Beveridge and Nelson (1981) also assumes that y_t has a unit root and that the trend accounts for it, but it assumes that the trend and the cyclical components are perfectly correlated and driven by the same shock. The model for y_t is $\phi(L)(1-L)y_t=(\theta(L)\varepsilon_t+\mu'$. An estimate of the trend of the series can be obtained using

$$\hat{y}_t^p = \left[\sum_k \hat{w}_t(k) - k\mu\right] + y_t,$$

where $\hat{w}_t(k)=\mathrm{E}[w_{t+k}\,|\,y_t, y_{t-1}\ldots]$, $\mu=\mu'/\phi(L=1)$, and $w_t=y_t-y_{t-1}$. Therefore, an estimate of the cyclical component of y_t is

$$\hat{y}_t^c = \sum_k \hat{w}_t(k) - k\mu.$$

Appendix B: Annual data

We analyze annual data in two samples. The observations range from

Table B.1

Correlation of overall measure of openness/average growth; S.E. of growth of output and world output growth; annual data, 42 countries.

	Cov (G_i, MDO)	Cov (S_D, MDO)	Cov (r_{iw}, MDO)
F	−0.24490	0.07621	0.07380
1973	0.01202	−0.15791	−0.23741
1986	−0.8979	0.13650	0.24845

Note: r_{iw} is a measure of world output computed as weighted average of the output of 42 countries. The weights are given by the share of that country output in constant prices in total world output in constant prices.

Table B.2

Cross-correlation measure of openness/output correlations; annual data, 21 countries.

Detrending method	RW		LT	
	Cov (r_{ij}, m_{ij})	Cov (r_{ij}, h_{ij})	Cov (r_{ij}, m_{ij})	Cov (r_{ij}, h_{ij})
F	0.17378*	0.08941	0.04214	0.01372
1973	0.02824	0.02293	0.08724	0.06432
1986	0.15230*	0.05455	0.00537	0.01003
Detrending method	HP		BN	
	Cov (r_{ij}, m_{ij})	Cov (r_{ij}, h_{ij})	Cov (r_{ij}, m_{ij})	Cov (r_{ij}, h_{ij})
F	0.13472	0.0972	0.18732*	0.1011
1973	0.10362	0.0846	0.00370	0.0272
1986	0.12464	0.0956	0.14972*	0.1173

Note: r_{ij} is the contemporaneous correlation between the cyclical components of output in country i and j. m_{ij} and h_{ij} are average percentage bilateral import ties and intermediate import ties, respectively.
*Significant at 5% confidence.

around 1950 (some countries start at 1946 some in late 1950) to 1985. The first sample consists of the following 42 countries: Australia, Austria, Belgium, Bolivia, Burma, Canada, Colombia, Denmark, Dominican Republic, Ecuador, El Salvador, Finland, France, Germany, Greece, Guatemala, Honduras, Iceland, Ireland, Italy, Japan, Korea, Mexico, Netherlands, New Zealand, Nicaragua, Norway, Paraguay, Peru, Philippines, Portugal, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Thailand, Turkey, Uruguay, the United Kingdom, the United States and Venezuela.

We ask whether the overall degree of openness for country i (MDO_i), constructed as $MDO_i = 1/N\sum_{t=1}^{N}(\text{Imports}_t/GNP_t)_i$ is related to the average growth rate of output, G_i, its standard deviation (sd_i) and to the correlation between average domestic and average world output growth (r_{iw}) (one observation for each country i used here). Table B.1 reports the results. The correlations are statistically insignificant.

The second sample consists of the following 17 countries, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, Turkey, the United Kingdom plus the United States, Canada, Japan and South Africa.

We ask whether the degree of bilateral trade ties between countries i and j, m_{ij}, h_{ij}, (constructed as in section 3) are related to the size of the cyclical comovements of outputs between i and j, r_{ij}. Table B.2 reports the contemporaneous correlations. Once again the results depend on the detrending procedure employed. With RW and BN the correlations are significant, while with the other two methods they are not. Also, one can notice that the significance of the correlations increases after 1974.

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