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International Transmission of Business Cycles Between Ireland and its Trading Partners*

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Abstract: Given its high degree of integration into the world economy, Ireland has been affected by the current turmoil in financial markets and global recession. We estimate a model of simultaneous equations using a panel of cross–country annual data where trade intensity, sectoral specialisation, and financial integration are considered endogenous. Our results suggest that deeper trade and financial integration had strong direct positive effects on the synchronisation of Irish business cycles with its trading partners. Sectoral specialisation and national competitiveness differentials were sources of cyclical divergence. Sectoral specialisation had however an indirect positive effect on business cycle synchronisation via its positive effect on trade and financial integration. Business cycles between Ireland and its euro area trading partners have become more synchronised.

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International Transmission of Business Cycles

Between Ireland and its Trading Partners

1 INTRODUCTION

There has been renewed interest recently in the analysis of international transmission of business cycles notably in relation to the current global financial and economic crisis. In an increasingly integrated world economy, understanding the extent to which business cycles propagate across countries and their underlying factors is highly important to investors and policy makers.

Given its high degree of integration into the world economy, Ireland has been affected by the current turmoil in financial markets and global recession. Yet to date, empirical evidence on the extent of the co-movement of economic activity between Ireland and its trading partners is limited. To our knowledge there is no evidence on the factors underlying the transmission of business cycles between Ireland and its trading partners.

To fill this gap, this paper identifies and explains the patterns and factors underlying the transmission of business cycles between Ireland and its main trading partners over the past three decades. Have business cycles between Ireland and its trading partners become more synchronised? Which factors drive business cycle synchronisation? Has the euro led to more synchronised business cycles with the euro area countries?

In particular, we analyse the effects of bilateral trade intensity, sectoral specialisation, financial integration, fiscal policy, competitiveness and monetary integration on bilateral correlations of business cycles. We estimate a structural model using a panel of cross–country annual data where trade integration, sectoral specialisation and financial integration are considered simultaneously as explanatory factors of business cycle correlations. As argued previously in the literature (Frankel and Rose, 1998; Imbs, 2004) these factors are likely to be endogenous, in the context of economic and monetary integration. Furthermore, due to their complex interactions, trade intensity, sectoral specialisation and financial integration are likely to have both direct and

indirect effects on business cycle correlations (Imbs, 2004). In the simultaneous equations model these indirect effects are captured by separate structural equations for trade intensity, sectoral specialisation and financial integration. This statistical model addresses both the simultaneity and endogeneity in the relationships between business cycle correlations, trade integration, sectoral specialisation and financial integration. In order to capture changes over time of these relationships we construct a panel data including three eight year sub-periods and control for time invariant unobserved country specific effects which may affect business cycle correlations.

To our knowledge this is the first in-depth analysis of international transmission of business cycles between Ireland and its trading partners. We use an improved methodology to account for econometric issues which have not been addressed in a systematic way in previous studies. First, in contrast to existing studies which estimate single-equation models, we estimate a system of simultaneous equations to uncover determinants of Ireland's business cycle correlations with its trading partners suggested by theory and account for endogeneity and simultaneity in the underlying relationships. Second, we go beyond most existing cross-section studies by using panel data and account for changes over time and time invariant country-specific unobserved characteristics that may affect the bilateral correlations.

The main findings of this paper are as follows. Over the past three decades the transmission of business cycles between Ireland and its trading partners has increased. Deeper trade and financial integration had strong direct positive effects on the synchronisation of Irish business cycles with its trading partners. Sectoral specialisation and national competitiveness differentials were sources of cyclical divergence. Sectoral specialisation had however an indirect positive effect on business cycle synchronisation via its positive effect on trade and financial integration. While the effect of sectoral specialisation on business cycle synchronisation appears independent of trade and financial integration, it reflects differentials in development stages. Business cycles of Ireland and its euro area trading partners have become more synchronised which implies that the fit of the common monetary policy has increased.

Our results suggest that while domestic shocks are likely to be important, understanding economic developments in Ireland's trading partners is highly important for policy making. On the basis of our empirical evidence, we argue that in

the current context, there is a strong case for co-ordination of policy responses to the global financial and economic crisis in Ireland and its trading partners.

The remainder of this paper is organized as follows: Section 2 discusses the theoretical and empirical background for our analysis and derives testable hypotheses about the international transmission of business cycles between Ireland and its trading partners. Section 3 presents our model specification and estimation issues. Section 4 discusses our data and variables. Section 5 presents summary statistics of business cycle correlations and the main explanatory variables. Section 6 presents the results of our econometric analysis and Section 7 concludes.

2 THEORETICAL AND EMPIRICAL FOUNDATIONS

The increased international trade, financial and monetary integration over the past two decades has stimulated a growing academic and policy interest in the analysis of the synchronisation of business cycles (Artis and Zhang, 1997; Canova and Marrinan, 1998; Kose, et al., 2003; Baxter and Kouparitsas, 2003, 2005; Bordo and Helbling 2003; Imbs, 2004; Calderón, et al., 2007; Inklaar, et. al., 2008; Artis and Okubo, 2008). In particular, the impact of monetary integration on the business-cycle synchronisation has received increasing attention recently (Frankel and Rose, 1998; Artis et al., 2003; Barrios et al., 2003; Traistaru, 2004; Bergman, 2005; Schiavo, 2008)[1]. Existing theoretical and empirical literature on the international transmission of business cycles suggests complex interactions between trade intensity, sectoral specialisation, financial integration, similarity of economic policies and business cycle synchronisation (Imbs 2004).

First, it has been suggested that trade openness results in highly correlated business cycles (McKinnon, 1963). In theory the effect of trade intensity on correlations of business cycles is ambiguous. To the extent that increased trade leads to more inter-industry specialisation and industry specific shocks, the effect would be negative. If increased trade is the result of intra-industry specialisation, demand shocks would be propagated across countries leading to more correlated output correlations. Frankel and Rose (1998), Artis and Zhang (1997), Clark and Wincoop (2001) and Imbs (2004), among others, investigated the relationship between trade intensity and

[1] Haan et al. (2008) review recent research on the synchronisation of business cycles in the European Economic and Monetary Union and its underlying factors.

business cycle correlation for industrial countries and found that deeper trade integration was associated with higher business cycle correlations. In this paper, we test the hypothesis that trade integration has had a positive effect on the co-movement of Irish economic activity and its trading partners.

Second, following Kenen (1969), business cycle synchronisation will be lower in two economies if they have different economic structures. If that is the case, an external demand or supply shock will hit the two economies to a different extent. With differences in economic structures, a common, industry-specific shock results in asymmetric effects so that business cycles are less correlated. However, existing empirical evidence related to these arguments is inconclusive. Clark and Wincoop (2001) looked at various indicators of dissimilarity in economic structures (bilateral dissimilarity in industry sectors, manufacturing sectors, non-manufacturing sectors) and found that it can explain a low cross-country correlation of employment growth in the US and the EU. However, dissimilarity does not explain the low correlation of GDP growth. Imbs (2004) used a specialisation index based on one-digit industries and two-digit manufacturing industries and find that highly specialised countries had low business cycle correlations. Traistaru (2004) found that similarity of sectoral structures had a positive effect, *ceteris paribus,* on business cycle correlations in the enlarged European Economic and Monetary Union (EMU). Given the theoretical arguments on the role of specialisation for business cycle synchronisation, we test the hypothesis that sectoral specialisation has led to lower bilateral business cycle correlations.

The third source of business cycle synchronisation which we address here is financial integration. In theory, the effect of financial integration on co-movement of economic activity is ambiguous. On the one hand, financial linkages could heighten cross-country spillover effects of macroeconomic fluctuations and lead to more synchronised business cycles. On the other hand, international financial integration facilitates the reallocation of capital in line with comparative advantages of countries which could result in more specialisation in production and thus a higher exposure to industry and country-specific risks and less synchronisation of business cycles. However, international integration of capital markets could help to diversify consumption risks across countries and result in a stronger co-movement of consumption across countries. While Imbs (2004) and Jansen and Stockman (2004)

find empirical evidence for a positive effect of financial integration on business cycle synchronisation, Baxter and Kouparitsas (2005) and Inklaar et al (2007) find no significant effects.

The fourth source of business cycle synchronisation which we examine is policy linkages. In particular, we analyse the effect of fiscal policy convergence. It has been argued that less idiosyncratic policy shocks lead to more business cycle synchronisation. However, existing empirical evidence is inconclusive. While Inklaar et al (2007) and Darvas et al (2005) find support for this view, Clark and van Wincoop (2001) and Camacho et al (2006) find no significant effects of fiscal convergence on business cycle synchronisation.

Further, we examine the effect of national competitiveness differentials on the transmission of business cycles. Countries which are more similar in terms of their relative price competitiveness are likely to adjust to international shocks in a more similar way and have more synchronised business cycles. Böwer and Guillemineau (2006) find empirical support for this view. We test the hypothesis that similarilty in relative price competitiveness has led to more synchronised business cycles.

Finally, we investigate the effect of monetary integration on business cycles synchronisation. Frankel and Rose (1998) suggest that members of a monetary union would *ex post* fulfil the Optimum Currency Area (OCA) criteria since a common currency reduces transaction costs and thus leads to more trade and more business cycle synchronisation. Benalal et al (2006), Böwer and Guillemineau (2006) and Schiavo (2008) find that the introduction of the euro has had a positive effect on synchronisation of business cycles in the euro area.

3 MODEL SPECIFICATION AND ESTIMATION ISSUES

As discussed in Section 2 we analyse correlations of business cycles between Ireland and its trading partners as a function of trade intensity, sectoral specialisation, financial integration, fiscal policy, competitiveness and monetary integration. Most of the existing studies look at the impact of different determinants of business cycle correlation using a single-equation approach. In contrast, we estimate the direct and indirect effects of these determinants using a system of simultaneous equations. This approach takes into account both the complex interlinks between business cycle correlations, trade intensity, sectoral specialisation and financial integration

controlling for both simultaneity and endogeneity. We expect that while trade, financial and monetary integration are sources of business cycle synchronisation, sectoral specialisation and dissimilarity with respect to fiscal policy and competitiveness are sources of cyclical divergence.

Most of previous empirical studies have estimated cross-section models of business cycle correlations. In this paper we estimate time-varying correlations of business cycles calculated over three eight year sub-periods. This panel data allows us to control for country specific time invariant unobserved characteristics and period specific common shocks. The definitions of variables and data sources are explained in Appendix A1.

Our baseline model specification contains the following 4 equations (Eq. 1 to 4) to be estimated simultaneously.[2]

$$CORRY_{i\tau}^{IE} = \alpha_1 TRADE_{i\tau}^{IE} + \alpha_2 SPEC_{i\tau}^{IE} + \alpha_3 FIN_{i\tau}^{IE} + \alpha_4 FDDIF_{i,\tau-1}^{IE} + \alpha_5 REERDIF_{i,\tau-1}^{IE} + \\ + \lambda_i + \mu_\tau + \varepsilon_{1,i\tau}^{IE} \tag{1}$$

$$TRADE_{i\tau}^{IE} = \beta_1 SPEC_{i\tau}^{IE} + \beta_2 I_{1,i\tau}^{IE} + \varepsilon_{2,it}^{IE} \tag{2}$$

$$SPEC_{i\tau}^{IE} = \delta_1 TRADE_{i\tau}^{IE} + \delta_2 FIN_{i\tau}^{IE} + \delta_3 I_{2,i\tau}^{IE} + \varepsilon_{3,i\tau}^{IE} \tag{3}$$

$$FIN_{i\tau}^{IE} = \gamma_1 TRADE_{i\tau}^{IE} + \gamma_2 SPEC_{i\tau}^{IE} + \gamma_3 I_{3,i\tau}^{IE} + \varepsilon_{4,i\tau}^{IE} \tag{4}$$

$$I_{1,i\tau}^{IE} \neq I_{2,i\tau}^{IE} \neq I_{3,i\tau}^{IE}$$

IE refers to Ireland; $i = 1,\ldots 23$ is the index of trading partners of Ireland; $\tau = 1,2,3$ is the period index. *CORRY* refers to the correlation between the cyclical components of real GDP in Ireland and its trading partners. *TRADE* is the bilateral trade intensity between Ireland and its trading partners. It measures the importance of transmission of country-specific demand shocks through trade linkages. *SPEC* is an index of dissimilarity/specialisation of Ireland's sectoral structure with respect to its trading partners. It measures the importance of transmission of sector specific shocks. *FIN*

[2] This model builds on Imbs (2004). He estimates a model of four simultaneous equations to identify the direct and indirect effects of trade intensity, industrial specialisation and financial integration on business cycle correlations using a cross section of 22 OECD countries. Our innovation is to estimate a panel data model allowing for time invariant unobserved country fixed effects. In addition, our model specifications include additional explanatory and instrumental variables.

denotes bilateral financial integration. λ is a vector of country fixed effects which controls for time invariant unobserved country specific effects. μ is a vector of time fixed effects. *CORRY, TRADE, SPEC* and *FIN* are endogenous variables. $I_1 \neq I_2 \neq I_3$ are vectors that contain the exogenous determinants of equations (2), (3) and (4). They need to be different in order to identify the system. *FDDIF* measures the similarity of fiscal policy and *REERDIF* measures similarity in relative price competitiveness. Both variables are lagged by one period to account for potential endogeneity.

Each observation in τ relates to an eight year sub-period as follows: 1983-1990, 1991-1998, 1999-2006.

Equations (2), (3) and (4) contain the indirect effects on *CORRY* working via the endogenous variables. For example, *SPEC* has a direct effect on *CORRY* but also an indirect one through its effect on *TRADE* and FIN.

Eq. (2) relates trade and sectoral specialisation. Neoclassical trade theory suggests that economies producing specialised goods trade with each other. In contrast, the new trade theory suggests that economies with similar industry structures have intensive intra-industry trade. We expect a positive coefficient β_1 if higher inter-industry specialisation leads to more trade.

Finally, trade intensity is determined by exogenous variables contained in the vector I_1. We use the following exogeneous variables to explain bilateral trade intensity suggested by the gravity trade models: the distance between Dublin and the capital cities of Ireland' trading partners (DIS); the log of the product of the real GDP in Ireland and its trading partners (GDP); a dummy for countries using English (LANG).

Eq. (3) captures the argument that a country's specialisation increases following trade and financial integration. As exogenous variables we include the product of the GDP per capita in Ireland and its trading partners (GDPPC) and the GDP per capita differential between Ireland and its trading partners (*GAP).* Here we consider the argument that countries have different specialisation patterns depending on their stages in economic development[3].

[3] Imbs and Wacziarg (2003) provide empirical evidence supporting this fact.

Finally, Eq. (4) relates financial integration to trade and specialisation. As an exogenous variable contained in vector I_3, we consider a lagged measure for financial integration.

To estimate the above mentioned system of simultaneous equations, a Three-Stage Least Square (3 SLS) estimator is used, combining a simultaneous estimation with instrumental variables in order to separate the components of the endogenous variables.

The estimation is carried out in two steps:

a) the system is estimated equation by equation using Two-Stage Least Squares (2SLS); the covariance matrix of the equations disturbances is then retrieved;

b) using the covariance matrix from the first step, the system is estimated with a Generalized Least Square (GLS) estimator.

4 DATA AND VARIABLES

In this paper we use a panel of annual cross-country observations for Ireland and 23 of its trading partners[4] over the past three decades. A full list of variables and their data sources is given in Appendix A1.

In order to examine the synchronisation of business cycles between Ireland and its trading partners, real GDP data were collected for the period 1980-2009.[5] The cyclical components were obtained by applying the Baxter-King band-pass filter (Baxter and King, 1999). The filtering procedure uses the classical definition of a business cycle given by Burns and Mitchell (1946). It therefore isolates real GDP fluctuations lasting between 2 and 8 years. This de-trending technique removes both the low frequency long-term trend growth and the high frequency irregular components and retains intermediate components, "business cycles"[6]. This filter was applied in STATA, using the common settings for annual data, i.e. lag length k = 3, shortest cycle pass p = 2 and longest cycle pass q = 8. By setting the lag length equal to 3, the cyclical

[4] The 23 trading partners are: Australia, Austria, Belgium-Luxembourg, Canada, Cyprus, Denmark, Finland, France, Germany, Greece, Iceland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, UK, USA. Due to data availability Belgium and Luxembourg were grouped as one. These trading partners account for about 90 percent of the Irish trade. Data availability restricted us to these trading partners.

[5] The real GDP series are denominated in national currency. 2008 and 2009 data are forecasts.

[6] The Baxter – King filter is based on the theory of spectral analysis of time series data. It improves upon alternative detrending methods. For a detailed discussion on alternative detrending methods see Stock and Watson (1999).

components of GDP were obtained for the years 1983-2006 inclusive[7]. Using these cyclical components, Pearson correlation coefficients between Ireland and each trading partner were calculated. The correlations were calculated for the entire period, and for the three sub-periods.

Bilateral trade intensity was calculated as follows:

$$TRADE_{i\tau}^{IE} = \frac{1}{T}\sum_{t=1}^{T}\frac{x_{it}^{IE} + m_{it}^{IE}}{x_{t}^{IE} + m_{t}^{IE} + x_{it} + m_{it}} \qquad (5)$$

Where x_{it}^{IE} is total exports from Ireland to trading partner *i* in year *t*, m_{it}^{IE} is total imports to Ireland from trading partner *i* in year *t*, x_{t}^{IE} (m_{t}^{IE}) represents total exports (imports) of Ireland in year *t* and x_{it} (m_{it}) represents total exports (imports) of trading partner *i* in year *t*. *T* refers to the total number of years in the sub-period. The trade data were obtained from the United Nations Commodity Trade Statistics Database.

The *sectoral specialisation* indicator is measured by the absolute difference between the average share of a particular sector in the total economy in Ireland and its trading partner:

$$SPEC_{i\tau}^{IE} = \sum_{n=1}^{N}\left[\frac{1}{T}\sum_{t=1}^{T}\left|s_{nt}^{IE} - s_{\text{int}}\right|\right] \qquad (6)$$

Where s_{nt}^{IE} is the share of sector n in total value added of Ireland in year *t*, and s_{int} is the share of sector *n* in total value added of trading partner *i* in year *t*. The value added data were obtained from the National Accounts section of the United Nations Statistics Division, and they cover seven sectors of the economy.[8]

Our measure of *financial integration* is computed using a dataset constructed by Lane and Milesi-Ferretti (2006), which reports cumulated external positions for a large sample of countries. The logic behind this measure is that two countries with massively positive (negative) net foreign asset holdings will both tend to be issuers (recipients) of capital flows, and should therefore experience less bilateral flow than two economies where one is in surplus and the other in deficit (Imbs, 2004).

[7] The Baxter-King filter is based on a moving average centred on twelve-quarters which implies that cyclical components of real GDP growth are obtained for 1983-2006.

[8] The sectors are classified as follows: Agriculture, hunting, forestry and fishing; Mining and utilities; Manufacturing; Construction; Wholesale, retail trade, restaurants and hotels; Transport, storage and communication; and Other activities.

Following on this logic, financial integration is calculated as:

$$FIN_{i\tau}^{IE} = \frac{1}{T}\sum_{t=1}^{T}\left|\left(\frac{NFA}{GDP}\right)_{t}^{IE} - \left(\frac{NFA}{GDP}\right)_{it}\right| \qquad (7)$$

Where *NFA* denotes the net foreign asset position in a given country, and is computed using accumulated current accounts and the sum of net positions in foreign direct investment, equities and debt. A high value for $FIN_{i\tau}^{IE}$ implies diverging external positions between Ireland and country *i* and a high degree of financial integration.

Data from the IMF World Economic Outlook Database were used to calculate the *fiscal deficit differential* variable as follows:

$$FDDIF_{i\tau}^{IE} = \frac{1}{T}\sum_{t=1}^{T}\left|d_{t}^{IE} - d_{it}\right| \qquad (8)$$

Where d_{t}^{IE} is net borrowing or lending as a percentage of GDP (the general government deficit) in Ireland in year *t*, and d_{it} is net borrowing or lending as a percentage of GDP in trading partner *i* in year *t*. To account for potential endogeneity, fiscal deficit differentials between Ireland and its trading partners used in estimations are one-period lagged values.

The *real effective exchange rate differential* variable, which is used as a national competitiveness indicator, was calculated in a similar manner:

$$REERDIF_{i\tau}^{IE} = \frac{1}{T}\sum_{t=1}^{T}\left|r_{t}^{IE} - r_{it}\right| \qquad (9)$$

Where r_{t}^{IE} is the real effective exchange rate[9] in Ireland in year *t*, and r_{it} is the real effective exchange rate in trading partner *i* in year *t*. Data on real effective exchange rates were taken from the IMF International Financial Statistics. To account for potential endogeneity, real effective exchange rate differentials between Ireland and its trading partners used in estimations are one-period lagged values.

The instruments used to determine bilateral trade intensity are standard gravity variables: the geographic distance between the two countries' capital cities (*DIS*), the product of their GDP levels (*GDP*), and a binary variable to capture a common

[9] Real effective exchange rate index based on relative changes in consumer prices.

language between the two countries (*LANG*). The exogenous determinants of specialisation used here are the product of the two countries' GDP per capita levels (*GDPPC*), and the gap between these GDP per capita levels (*GAP*). Finally, to instrument financial integration, we use a lagged financial integration variable (*LAGFIN*).

5 DESCRIPTIVE STATISTICS

Table 1 shows summary statistics of the main variables. The average correlation between Ireland and its trading partners over the analysed period was 0.40. The average correlation was lowest in the 1991-1998 sub-period, at 0.32. This rose to a high of 0.48 in the most recent sub-period, 1999-2006. Bilateral trade intensity and sectoral specialisation have increased over the analysed period. Over the analysed period, net foreign asset positions, fiscal stance and competitiveness have become more similar between Ireland and its trading partners.

Given the relevance of business cycle synchronisation for the transmission of the common monetary policy, we further analyse descriptive statistics of the main variables for the euro area shown in Table 2. It is worth noting that on average, business cycle correlations between Ireland and its trading partners in the euro area were higher with the highest at 0.6 in the most recent sub-period corresponding to the third stage of EMU. Bilateral trade intensity and sectoral specialisation increased over the analysed period but they were lower than the averages for all trading partners. Similarity of the net foreign asset positions, fiscal policy and competitiveness increased and was greater between Ireland and its euro area trading partners in comparison to the averages for all trading partners.

Table 3 shows the three highest and lowest values for the endogenous variables in the system. It appears that business cycles in Ireland were highly correlated with those in the Netherlands and Belgium-Luxembourg due to high trade intensity. High output correlations between Ireland and Spain might be explained by similarity of economic structures, in particular in recent years. High bilateral financial integration explain the high output correlation between Ireland and Switzerland. It is worth noting that while trade intensity with the United Kingdom was the highest, business cycle correlations were among the lowest. This suggests the importance of a multivariate analysis of

business cycles correlations as well as appropriate conditioning and accounting for simultaneity in the underlying relationships.

6 EMPIRICAL RESULTS

This section reports the three-stage least squares estimates for the system of simultaneous equations used in our analysis.

The results of estimations are presented in Table 4. The set of simultaneous equations was estimated twice, with the second specification including a dummy variable for the euro area trading partners. The following discussion will address the results of the two specifications, with regard to the main explanatory variables and with regard to both direct and indirect effects.

The first column of Table 4 presents the results for the estimation of our baseline model, without the euro dummy, and these can be summarised as follows.

Trade intensity and financial integration had a positive and significant direct effect on business cycle correlations. The point estimates suggest that if the average trade intensity between Ireland and its trading partners doubled, the average correlation of business cycles would increase from 0.40 to 0.44[10]. A doubling of bilateral financial integration intensity would result in a higher increase of the average business cycle correlation by 0.08. Another way to interpret the results is in terms of changes in business cycle correlations due to one standard deviation increases in the explanatory variables. While a standard deviation increase in the average bilateral trade intensity would not lead to any change in the average business cycle correlations, an increase by one standard deviation of the bilateral financial integration would be associated with an increase of the average business cycle correlation by 0.03[11].

Sectoral specialisation had a negative and significant direct effect on business cycle correlations. A doubling of bilateral sectoral specialisation would be associated with a decrease of the average output correlation by 0.55. Put another way, an increase of the average bilateral sectoral specialisation by one standard deviation would result in a

[10] The increase in the average bilateral business cycle correlation due to a doubling of the average bilateral trade intensity is obtained by multiplying the point estimate for bilateral trade intensity and ln(2).

[11] The increase in the average bilateral business cycle correlation due to a one standard deviation increase of the average bilateral trade intensity is obtained by multiplying the point estimate and the standard deviation of bilateral trade intensity.

decrease of bilateral business cycle correlations from 0.40 to 0.34. However, sectoral specialisation had a positive indirect effect on business cycle correlations via its positive effect on trade and financial integration. Further, the effect of sectoral specialisation appears independent of trade and financial integration and it reflects differences in stages of development between Ireland and trading partners.

In the trade equation all three gravity variables have the expected impact on trade intensity: Distance (-), GDP product (+), Language (+). We find that the product of GDP per capita has a negative effect on sectoral specialisation. This result is in line with expectations – pairs of wealthy countries, or countries at a similar stage of development tend to have more similar economic structures. Furthermore, as expected, in the financial integration equation, financial integration is positively affected by the degree of past financial integration.

The second column of Table 4 presents the results for the second specification, in which the euro dummy was included in the primary equation as an explanatory variable. We find that business cycles correlations between Ireland and its euro area trading partners were higher in comparison with the other trading partners, as expected. The direction of the effects of trade, specialisation and financial integration are unchanged from the first specification, with only minor changes noted in magnitude. The real effective exchange rate differential variable is no longer significant.

The positive indirect effect of specialisation is also present in the second specification, via its positive effect on trade and financial integration. All of the explanatory variables in structural equations which were significant in the first model specification remain significant with only minor changes in magnitude.

Robustness Checks

We test the robustness of our results with regard to two econometric issues: (i) the possibility that the error terms might not be normally distributed; (ii) the effects of outliers.

Inklaar et al (2007) point out that the fact that the Pearson's correlation coefficient is bound between -1 and 1 implies that the error terms in the regression models of the determinants of business cycle synchronisation might not be normally distributed. To

account for this econometric issue they suggest the following transformation of the dependent variable:

$$C = \tfrac{1}{2} \ln((1+C)/(1-C)) \quad (5)$$

where C is the pairwise correlation coefficient for each country pair.

Table 5 shows the estimates of the two model specifications with using the above transformation for our dependent variable *CORRY*. We find that the results are qualitatively similar with those obtained with the bound dependent variable which suggests that the deviation from a normal distribution is sufficiently small.

We further checked the robustness of our estimates to the effects of outliers. Table 6 shows the results of estimates obtained by omitting the pairs of Ireland with the following trade partners: United Kingdom (highest trade intensity), Cyprus (lowest trade intensity), Norway (most dissimilar economic structure), Finland (most similar economic structure), Switzerland (highest financial integration), Denmark (lowest financial integration).

The results are qualitatively invariant to omitting these country pairs. For example, the point estimates suggest that if the average trade intensity between Ireland and its trading partners doubled, the average correlation of business cycles would increase from 0.41 to 0.47, when United Kingdom was omitted, from 0.40 to 0.45 when Cyprus was omitted, from 0.41 to 0.45 when Norway was omitted, from 0.39 to 0.43 when Finland was omitted, from 0.39 to 0.42 when Switzerland was omitted, and from 0.40 to 0.44 when Denmark was omitted. Further, a doubling of bilateral financial integration would lead to an increase of the average correlation of business cycles to 0.47 when we excluded the pairs with United Kingdom, Cyprus, Finland, Switzerland, and Denmark, to 0.48 when Norway was excluded and to 0.49 when Denmark was omitted. A doubling of bilateral sectoral specialisation would be associated with a decrease of the average output correlation by 0.59 when United Kingdom and Cyprus were omitted, by 0.58 when Finland was omitted, by 0.56 when Switzerland was omitted, by 0.55 when Norway was omitted and by 0.54 when Norway was omitted.

7 CONCLUSIONS

This paper examined patterns and factors underlying the international transmission of business cycles between Ireland and its trading partners over the past three decades. In particular, we analysed the effects of trade integration, sectoral specialisation, financial integration, fiscal policy, price competitiveness and monetary integration on bilateral correlations of business cycles.

The analysis of business cycle correlations suggests that Ireland has, on average, become more synchronised with its trading partners over the past three decades. Although the average correlation fell in the second sub-period, its highest level was recorded in the most recent sub-period, 1999-2006. The level of correlation between Ireland and its euro area trading partners rose in each of the three sub-periods, reaching almost 0.6 most recently. The Netherlands, Belgium-Luxembourg, and Spain are the countries with which Ireland is most synchronised over the entire period, displaying consistently high levels of correlation in each sub-period.

We used an improved methodology to account for endogeneity and simultaneity in the underlying relationships and changes over time. To this purpose, we estimated a structural model of simultaneous equations using a panel of cross –country annual data where trade integration, sectoral specialisation, financial integration are considered endogenous. The simultaneous equations model allowed us to capture both direct and indirect effects of trade, sectoral specialisation and financial integration on business cycle correlations. In order to capture changes over time of these relationships we constructed a panel data including three eight year sup-periods and control for time invariant unobserved country fixed effects.

Our results suggest that deeper trade and financial integration had strong direct positive effects on the synchronisation of Irish business cycles with its trading partners. Sectoral specialisation and national competitiveness differentials were sources of cyclical divergence. Sectoral specialisation had however an indirect positive effect on business cycle synchronisation via its positive effect on trade and financial integration. Further, while the effect of sectoral specialisation appears to be independent of trade and financial integration it reflects differences in stages of development between Ireland and its trading partners. The adoption of the euro has led to more synchronised business cycles with Ireland's euro area trading partners.

This latter result suggests that the fit of the common monetary policy in Ireland has increased.

Our estimates are robust to a possible deviation of error terms from a normal distribution and to outliers. Finally, our findings suggest that while domestic shocks are likely to be important, understanding economic developments in Ireland's trading partners is highly important for policy making. In the current context, there is a strong case for co-ordination of policy responses to the global financial and economic crisis in Ireland and its trading partners.

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APPENDIX A1: VARIABLES AND DATA SOURCES

Variable	Description	Data Source
CORRY	Correlation coefficient of business cycles	IMF World Economic Outlook (April 2008); own calculations
TRADE	Bilateral trade intensity	United Nations Commodity Trade Statistics; own calculations
SPEC	Sectoral specialisation	United Nations Statistics Division – National Accounts; own calculations
FIN	Financial integration	Lane and Milesi-Ferretti (2001); own calculations
FDDIF	Fiscal deficit differential	IMF World Economic Outlook (April 2008); own calculations
REERDIF	Real effective exchange rate differential	IMF International Financial Statistics; own calculations
DIS	Geographical distance	Centre d'Etudes Prospectives et D'Infomations Internationales
GDP	Product of two countries' GDP levels	IMF World Economic Outlook (April 2008); own calculations
LANG	Common language dummy	
GDPPC	Product of two countries' GDP per capita levels	IMF World Economic Outlook (April 2008); own calculations
GAP	Gap between two countries' GDP per capita levels	
LAGFIN	Lagged financial integration	
EURO	Euro Area dummy	

APPENDIX A2: COUNTRY CODES

Australia	AU
Austria	AT
Belgium-Luxembourg	BE-LU
Canada	CA
Cyprus	CY
Denmark	DK
Finland	FI
France	FR
Germany	DE
Greece	GR
Iceland	IS
Italy	IT
Japan	JP
Netherlands	NL
New Zealand	NZ
Norway	NO
Portugal	PT
Singapore	SG
Spain	ES
Sweden	SE
Switzerland	CH
United Kingdom	UK
United States	US

Table 1: Summary statistics for main variables

Business cycle correlation

	Obs	Mean	Std. Dev.	Min	Max
1983-2006	23	0.400	0.243	-0.164	0.751
1983-1990	23	0.398	0.276	-0.194	0.803
1991-1998	23	0.323	0.369	-0.327	0.749
1999-2006	23	0.479	0.416	-0.687	0.807

Trade intensity

	Obs	Mean	Std. Dev.	Min	Max
1983-2006	23	0.006	0.008	0.0002	0.039
1983-1990	23	0.005	0.007	0.0002	0.035
1991-1998	23	0.006	0.008	0.0003	0.039
1999-2006	23	0.007	0.009	0.0003	0.043

Industrial specialisation

	Obs	Mean	Std. Dev.	Min	Max
1983-2006	23	0.289	0.073	0.184	0.492
1983-1990	23	0.274	0.065	0.170	0.429
1991-1998	23	0.282	0.074	0.157	0.476
1999-2006	23	0.312	0.093	0.179	0.571

Financial integration

	Obs	Mean	Std. Dev.	Min	Max
1983-2006	23	0.418	0.293	0.132	1.377
1983-1990	23	0.563	0.317	0.047	1.590
1991-1998	23	0.274	0.312	0.003	1.245
1999-2006	23	0.416	0.433	0.017	1.775

Fiscal deficit differential

	Obs	Mean	Std. Dev.	Min	Max
1983-2006	23	4.444	1.943	2.358	10.105
1983-1990	23	5.830	2.952	2.266	13.219
1991-1998	23	3.457	2.397	0.883	11.552
1999-2006	23	3.544	2.388	0.698	10.277

Real effective exchange rate differential

	Obs	Mean	Std. Dev.	Min	Max
1983-2006	23	11.522	5.694	6.080	28.356
1983-1990	23	15.015	8.972	2.312	37.617
1991-1998	23	9.344	6.123	3.419	26.507
1999-2006	23	10.207	5.403	3.576	27.987

Table 2: Summary statistics for main variables: Euro Area trading partners

Business cycle correlation

	Obs	Mean	Std. Dev.	Min	Max
1983-2006	11	0.542	0.190	0.079	0.751
1983-1990	11	0.496	0.177	0.201	0.767
1991-1998	11	0.541	0.217	0.043	0.749
1999-2006	11	0.589	0.431	-0.687	0.799

Trade intensity

	Obs	Mean	Std. Dev.	Min	Max
1983-2006	11	0.005	0.003	0.0005	0.009
1983-1990	11	0.004	0.002	0.0006	0.008
1991-1998	11	0.005	0.003	0.0005	0.009
1999-2006	11	0.006	0.005	0.0003	0.016

Industrial specialisation

	Obs	Mean	Std. Dev.	Min	Max
1983-2006	11	0.265	0.060	0.184	0.383
1983-1990	11	0.247	0.048	0.170	0.312
1991-1998	11	0.255	0.064	0.156	0.374
1999-2006	11	0.294	0.078	0.216	0.462

Financial integration

	Obs	Mean	Std. Dev.	Min	Max
1983-2006	11	0.336	0.091	0.252	0.502
1983-1990	11	0.572	0.173	0.263	0.858
1991-1998	11	0.139	0.115	0.003	0.347
1999-2006	11	0.299	0.231	0.065	0.753

Fiscal deficit differential

	Obs	Mean	Std. Dev.	Min	Max
1983-2006	11	4.119	1.107	2.358	6.064
1983-1990	11	5.144	2.349	2.472	10.821
1991-1998	11	3.437	2.276	0.945	7.968
1999-2006	11	3.775	1.566	1.524	6.380

Real effective exchange rate differential

	Obs	Mean	Std. Dev.	Min	Max
1983-2006	11	9.363	2.976	6.133	16.058
1983-1990	11	13.570	8.311	2.312	30.931
1991-1998	11	6.441	2.150	3.419	10.053
1999-2006	11	8.078	1.776	5.786	10.613

Table 3: Selected minima and maxima (three highest and lowest values)

	Three highest values		Three lowest values	
Business cycle correlations				
1983-2006	0.711	NL	0.146	UK
	0.649	BE-LU	0.072	NO
	0.607	ES	0.031	NZ
1983-1990	0.803	CH	-0.018	IS
	0.767	DE	-0.186	NO
	0.763	NL	-0.194	DK
1991-1998	0.749	NL	-0.279	AU
	0.722	GR	-0.288	US
	0.719	ES	-0.327	CA
1999-2006	0.807	CA	0.112	JP
	0.799	AT	-0.603	NZ
	0.788	ES	-0.687	GR
Trade intensity				
1983-2006	0.039	UK	0.0006	NZ
	0.009	BE-LU	0.0005	IS
	0.009	NL	0.0003	CY
1983-1990	0.035	UK	0.0008	NZ
	0.008	DE	0.0006	CY
	0.007	NL	0.0002	IS
1991-1998	0.039	UK	0.0005	CY
	0.010	NL	0.0005	NZ
	0.008	FR	0.0003	IS
1999-2006	0.043	UK	0.0005	NZ
	0.016	BE-LU	0.0003	IS
	0.011	NL	0.0003	CY
Sectoral specialisation				
1983-2006	0.492	NO	0.205	ES
	0.386	AU	0.195	JP
	0.383	CY	0.184	FI
1983-1990	0.429	NO	0.200	ES
	0.368	AU	0.192	IS
	0.363	US	0.170	FI
1991-1998	0.476	NO	0.196	IT
	0.394	AU	0.193	JP
	0.374	CY	0.156	FI
1999-2006	0.571	NO	0.216	ES
	0.462	CY	0.188	JP
	0.395	AU	0.179	SE
Financial integration				
1983-2006	1.377	CH	0.286	SE
	1.179	SG	0.196	CA
	0.582	NZ	0.171	DK
1983-1990	1.590	CH	0.217	DK
	0.858	NL	0.198	IS
	0.824	SG	0.047	NZ
1991-1998	1.245	CH	0.050	AT
	0.939	SG	0.032	ES
	0.795	NZ	0.003	GR
1999-2006	1.775	SG	0.065	IT
	1.295	CH	0.050	CA
	0.807	NZ	0.017	UK

Table 4: Three-stage least squares estimates of business cycle correlations

	Baseline Model	Augmented Model
Business Cycle Correlation		
Trade intensity	0.052** (0.026)	0.044* (0.025)
Sectoral specialisation	-0.789*** (0.125)	-0.717*** (0.124)
Financial integration	0.109** (0.044)	0.127*** (0.042)
Euro dummy		0.244** (0.104)
Fiscal deficit differential	-0.011 (0.013)	-0.011 (0.013)
Real effective exchange rate differential	-0.010* (0.006)	-0.008 (0.005)
N	69	69
R^2	0.55	0.55
Trade Intensity		
Sectoral specialisation	0.867*** (0.313)	0.841*** (0.310)
Distance	-0.974*** (0.058)	-0.976*** (0.058)
GDP	0.273*** (0.037)	0.271*** (0.039)
Language	1.036*** (0.218)	1.052*** (0.217)
N	69	69
R^2	0.99	0.99
Sectoral Specialisation		
Trade intensity	0.031 (0.029)	0.032 (0.028)
Financial integration	-0.033 (0.040)	-0.020 (0.040)
GDP per capita product	-0.073*** (0.024)	-0.072*** (0.024)
GDP per capita differential	0.032 (0.047)	0.034 (0.048)
N	69	69
R^2	0.95	0.95
Financial Integration		
Lagged financial integration	0.237* (0.130)	0.280** (0.130)
Trade intensity	0.023 (0.092)	-0.010 (0.092)
Sectoral specialisation	0.677* (0.382)	0.790** (0.380)
N	69	69
R^2	0.59	0.59

Notes: Standard errors in parentheses. *** significant at 1% level, ** significant at 5% level, * significant at 10% level. Explanatory variables are in logs, with the exception of the Euro dummy and the language dummy.

Table 5: Three-stage least squares estimates of business cycle correlations with transformed dependent variable

	Baseline Model	Augmented Model
Business Cycle Correlation (transformed)		
	0.070** (0.033)	0.056* (0.032)
Trade intensity	-0.984*** (0.156)	-0.879*** (0.153)
Sectoral specialisation	0.123** (0.055)	0.152*** (0.052)
Financial integration		0.343** (0.129)
Euro dummy	-0.014 (0.016)	-0.013 (0.016)
Fiscal deficit differential	-0.013* (0.007)	-0.010 (0.008)
Real effective exchange rate differential		
	69	69
N	0.54	0.54
R^2		
Trade Intensity		
Sectoral specialisation	0.876*** (0.314)	0.846*** (0.310)
Distance	-0.973*** (0.058)	-0.976*** (0.058)
GDP	0.274*** (0.037)	0.272*** (0.037)
Language	1.024*** (0.218)	1.052*** (0.217)
N	69	69
R^2	0.99	0.99
Sectoral Specialisation		
Trade intensity	0.030 (0.028)	0.031 (0.028)
Financial integration	-0.034 (0.040)	-0.020 (0.040)
GDP per capita product	-0.073*** (0.024)	-0.072*** (0.024)
GDP per capita differential	0.032 (0.047)	0.034 (0.048)
N	69	69
R^2	0.95	0.95
Financial Integration		
Lagged financial integration	0.235* (0.131)	0.279** (0.130)
Trade intensity	0.024 (0.092)	-0.010 (0.092)
Sectoral specialisation	0.677* (0.382)	0.790** (0.380)
N	69	69
R^2	0.59	0.59

Notes: Standard errors in parentheses. *** significant at 1% level, ** significant at 5% level, * significant at 10% level. Explanatory variables are in logs, with the exception of the Euro dummy and the language dummy.

Table 6: Three-least squares estimates of business cycles correlations with omitted country pairs – Baseline Model

Omitted pair	IE-UK	IE-CY	IE-NO	IE-FI	IE-CH	IE-DK
Business Cycle Correlation						
Trade intensity	0.086*** (0.028)	0.073** (0.029)	0.058** (0.026)	0.059** (0.027)	0.049* (0.026)	0.050* (0.026)
Industrial specialisation	-0.855*** (0.122)	-0.853*** (0.133)	-0.800*** (0.130)	-0.834*** (0.137)	-0.806*** (0.131)	-0.774*** (0.126)
Financial integration	0.081* (0.046)	0.095** (0.043)	0.106** (0.043)	0.116** (0.045)	0.109** (0.048)	0.131*** (0.044)
Fiscal deficit differential	-0.008 (0.013)	-0.012 (0.013)	-0.009 (0.015)	-0.010 (0.014)	-0.017 (0.013)	-0.008 (0.013)
Real effective exchange rate differential	-0.004 (0.006)	-0.010* (0.005)	-0.011* (0.006)	-0.011* (0.006)	-0.011** (0.006)	-0.009* (0.006)
N	66	66	66	66	66	66
R^2	0.58	0.58	0.57	0.51	0.54	0.53
Trade Intensity						
Industrial specialisation	0.724** (0.350)	1.163*** (0.321)	0.926** (0.367)	1.111*** (0.337)	0.865*** (0.319)	0.884*** (0.326)
Distance	-1.011*** (0.071)	-0.905*** (0.065)	-0.971*** (0.064)	-0.955*** (0.059)	-0.973*** (0.060)	-0.974*** (0.060)
GDP	0.283*** (0.039)	0.264*** (0.039)	0.281*** (0.039)	0.287*** (0.038)	0.271*** (0.037)	0.276*** (0.038)
Language	1.139*** (0.273)	0.900*** (0.225)	1.019*** (0.241)	1.002*** (0.220)	1.050*** (0.221)	1.037*** (0.227)
N	66	66	66	66	66	66
R^2	0.99	0.99	0.99	0.99	0.99	0.99
Industrial Specialisation						
Trade intensity	0.034 (0.032)	0.061* (0.030)	0.019 (0.026)	0.029 (0.027)	0.031 (0.030)	0.028 (0.029)
Financial integration	-0.034 (0.041)	-0.015 (0.039)	-0.057 (0.037)	-0.009 (0.039)	-0.017 (0.045)	-0.021 (0.041)
GDP per capita product	-0.069*** (0.025)	-0.059** (0.023)	-0.075*** (0.022)	-0.069*** (0.023)	-0.072*** (0.025)	-0.079*** (0.025)
GDP per capita differential	0.027 (0.049)	0.023 (0.047)	0.023 (0.044)	0.028 (0.046)	0.034 (0.050)	0.046 (0.050)
N	66	66	66	66	66	66
R^2	0.95	0.96	0.96	0.96	0.95	0.95
Financial Integration						
Lagged financial integration	0.208 (0.128)	0.258* (0.135)	0.247* (0.133)	0.237* (0.131)	0.145 (0.135)	0.212 (0.132)
Trade intensity	0.094 (0.094)	-0.012 (0.107)	0.040 (0.097)	-0.025 (0.095)	0.011 (0.092)	0.007 (0.093)
Industrial specialisation	0.363 (0.395)	0.801* (0.428)	0.589 (0.400)	0.935** (0.400)	0.880** (0.382)	0.753* (0.385)
N	66	66	66	66	66	66
R^2	0.59	0.59	0.59	0.60	0.62	0.58

Notes: Standard errors in parentheses*** significant at 1% level, ** significant at 5% level, * significant at 10% level. Explanatory variables are in logs, with the exception of the language dummy.

Year	Number	Title / Author(s) ESRI Authors / Co-authors *Italicised*
2009		
	278	Optimal Global Dynamic Carbon Taxation *David Anthoff*
	277	Energy Use and Appliance Ownership in Ireland *Eimear Leahy* and *Seán Lyons*
	276	Discounting for Climate Change *David Anthoff, Richard S.J. Tol* and Gary W. Yohe
	275	Projecting the Future Numbers of Migrant Workers in the Health and Social Care Sectors in Ireland *Alan Barrett* and Anna Rust
	274	Economic Costs of Extratropical Storms under Climate Change: An application of FUND Daiju Narita*, Richard S.J. Tol, David Anthoff*
	273	The Macro-Economic Impact of Changing the Rate of Corporation Tax *Thomas Conefrey* and *John D. Fitz Gerald*
	272	The Games We Used to Play An Application of Survival Analysis to the Sporting Life-course *Pete Lunn*
2008		
	271	Exploring the Economic Geography of Ireland *Edgar Morgenroth*
	270	Benchmarking, Social Partnership and Higher Remuneration: Wage Settling Institutions and the Public-Private Sector Wage Gap in Ireland *Elish Kelly, Seamus McGuinness, Philip O'Connell*
	269	A Dynamic Analysis of Household Car Ownership in Ireland *Anne Nolan*
	268	The Determinants of Mode of Transport to Work in the Greater Dublin Area *Nicola Commins* and *Anne Nolan*

267 Resonances from *Economic Development* for Current Economic Policymaking
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