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

Jean Goggin and Iulia Siedschlag

Abstract: This paper examines patterns and factors underlying the international transmission of business cycles between Ireland and its trading partners over the period 1980-2007. We estimate a model of simultaneous equations using a panel of cross-country annual data where trade integration, 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. The adoption of the euro has led to more synchronised business cycles between Ireland and its euro area trading partners.

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1. Introduction

The increased international economic integration over the past two decades has stimulated a growing academic and policy interest in the analysis of the synchronisation of business cycles and their international transmission. (Stockman, 1988; Canova and Marrinan, 1998; Kose, et al., 2003; Baxter and Kouparitsas, 2003, 2005; Bordo and Helbling 2003; Imbs, 2004). 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).

This paper identifies and explains the pattern and factors underlying the transmission of business cycles between Ireland and its main trading partners over the period 1980-2007. In particular, we analyse the effects of trade integration, sectoral specialisation, financial integration, fiscal policy, competitiveness and monetary integration on bilateral correlations of business cycles. We estimate a model of simultaneous equations 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 integration, sectoral specialisation and financial integration are likely to have both direct and indirect effects on business cycle correlations. In the simultaneous equations model these indirect effects are captured by separate structural equations for trade, 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 fixed effects.

To our knowledge this is the first in-depth analysis of international transmission of business cycles between Ireland and its trading partners. Our contribution to the literature is twofold. First, in contrast to existing studies which estimate single-equations, we estimate a system of simultaneous equations to test the effect of determinants on 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 time invariant country-specific unobserved characteristics that may affect the bilateral correlations.

The main findings of this paper are as follows. 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 differences in GDP per capita. The adoption of the euro has led to more synchronised business cycles between Ireland and its euro area 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 Background

Existing theoretical and empirical literature on the international transmission of business cycles suggests complex interactions between trade openness, sectoral specialisation, financial integration, similarity of economic policies and business cycle synchronisation.

First, it has been suggested that trade openness results in highly correlated business cycles (McKinnon, 1963). Frankel and Rose (1998), Artis and Zhang (1997), Clark and Wincoop (2001) and Imbs (2004), among others, investigated the relationship between trade intensity and 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, e.g. if one is specialised in agricultural products while the other in manufacturing, a common, industry-specific shock results in asymmetric effects so that business cycles are less correlated. However, the 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 with one-digit industries and two-digit manufacturing industries and could verify the argument of low business cycle correlation between countries which are highly specialised. Traistaru (2004) found that similarity of sectoral structures (6 sectors) had a positive effect, *ceteris paribus*, on business cycle correlations in the enlarged 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. The 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 similarity 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) postulate from their findings 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. Existing empirical evidence suggests that the group of the largest countries are more correlated in comparison to small countries.

3. Model Specification and Estimation Issues

In Section 2 we proposed that business cycle correlations between Ireland and its trading partners can be explained by 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.

It is highly likely that a number of explanatory factors are interrelated with each other. First, neoclassical trade theory suggests that countries specialise when trading. To the extent that trade leads to more specialisation, the positive effect of trade on business cycle correlations should be lower. If trade is largely based on intra-industry trade, the positive effect on business cycle correlation should dominate (Fidrmuc 2004). Second, financial integration could foster specialisation via the reallocation of capital in line with comparative advantages of countries. We account for these types of endogeneity by estimating a simultaneous equations model. This allows us to model both direct and indirect effects of trade integration, sectoral specialisation and financial integration on business cycle correlations.

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. The definitions of variables and data sources are explained in Table A1 in the Appendix.

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

$$CORRY_{it}^{IE} = \alpha_1 TRADE_{it}^{IE} + \alpha_2 SPEC_{it}^{IE} + \alpha_3 FIN_{it}^{IE} + \alpha_4 FDDIF_{it}^{IE} + \alpha_5 REERDIF_{it}^{IE} + \lambda_i + \mu_t + \varepsilon_{1,it}^{IE} \quad (1)$$

$$TRADE_{it}^{IE} = \beta_1 SPEC_{it}^{IE} + \beta_2 I_{1,it}^{IE} + \lambda_i + \mu_t + \varepsilon_{2,it}^{IE} \quad (2)$$

$$SPEC_{it}^{IE} = \delta_1 TRADE_{it}^{IE} + \delta_2 FIN_{it}^{IE} + \delta_3 I_{2,it}^{IE} + \lambda_i + \mu_t + \varepsilon_{3,it}^{IE} \quad (3)$$

$$FIN_{it}^{IE} = \gamma_1 TRADE_{it}^{IE} + \gamma_2 SPEC_{it}^{IE} + \gamma_3 I_{3,it}^{IE} + \lambda_i + \mu_t + \varepsilon_{4,it}^{IE} \quad (4)$$

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

IE refers to Ireland; $i = 1, \dots, 23$ is the index of trading partners of Ireland; $t = 1, 2, 3$ is the time 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 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* 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. Each observation in t 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

¹ Imbs (2004) 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. In contrast to Imbs, we use a panel data model allowing for time invariant unobserved country fixed effects.

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 is determined by an exogenous variable contained in the vector I_1 . We use the following exogenous variables to explain bilateral trade intensity suggested by the gravity trade models: the distance between Dublin and the capital cities of Ireland's 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 development².

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.

² Imbs and Wacziarg (2003) provide empirical evidence supporting this fact.

4. Data and Variables

In this paper we use a panel of annual cross-country observations for Ireland and 23 of its trading partners³ over the period 1980-2007. A full list of variables and their data sources is given in Table A1 in the Appendix.

In order to examine the synchronisation of business cycles between Ireland and its trading partners, real GDP data were collected for the period 1980-2009.⁴ 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”. 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 components of GDP were obtained for the years 1983-2006 inclusive. 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. In addition, the correlations were calculated for eight year rolling windows over the period 1983-2006.

Bilateral trade intensity was calculated using the following formula:

$$TRADE_{it}^{IE} = \frac{1}{T} \sum_{t=1}^T \frac{x_{it}^{IE} + m_{it}^{IE}}{x_t^{IE} + m_t^{IE} + x_{it} + m_{it}}$$

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 . The trade data were obtained from the United Nations Commodity Trade Statistics Database.

³ 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.

⁴ The real GDP series are denominated in national currency. 2008 and 2009 data are forecasts.

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:

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

Where s_{nt}^{IE} is the share of sector n in total value added of Ireland at time t , and s_{int} is the share of sector n in total value added of trading partner i at time 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.⁵

Our measure of *financial integration* is compiled 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 dataset 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. Therefore, financial integration is calculated as:

$$FIN_{it}^{IE} = \left| \left(\frac{NFA}{GDP} \right)_t^{IE} - \left(\frac{NFA}{GDP} \right)_{it} \right|$$

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.

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

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

Where d_t^{IE} is net borrowing or lending as a percentage of GDP (the general government deficit) in Ireland at time t , and d_{it} is net borrowing or lending as a percentage of GDP in trading partner i at time t . To account for potential endogeneity,

⁵ 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.

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:

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

Where r_t^{IE} is the real effective exchange rate⁶ in Ireland at time t , and r_{it} is the real effective exchange rate in trading partner i at time 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 the 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 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

Prior to estimating the system of equations, we examine the descriptive statistics of each of the core variables.

Business Cycle Correlations

Looking firstly at the business cycle correlations, Table 1 indicates that the average correlation between Ireland and its trading partners over the whole 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. Figure 1 shows the average correlation between Ireland and its trading partners for each eight year rolling

⁶ Real effective exchange rate index based on relative changes in consumer prices.

window, and indicates that the average correlation reached a high of 0.58 in the 1993-2000 sub-period. The lowest correlation value is observed in one of the earliest periods, 1984-1991.

Turning to individual country performances, Figure 2 shows the ten highest and lowest correlations over the entire period, 1983-2006. Eight of the ten countries displaying the highest correlations are euro area members, while six of them rank among Ireland's top ten trading partners, in terms of their share of overall Irish trade.⁷ Figures 3, 4 and 5 show the highest and lowest correlations in each sub-period. While the top ten countries vary in each period, the Netherlands, Belgium-Luxembourg and Finland are among the top ten in each of the three sub-periods analysed.

Looking at the euro area as a whole, Figure 6 shows the average correlation between Ireland and its trading partners in the euro area over the entire period, and in each sub-period. It is clearly shown that the correlation between Ireland and these countries is at its highest in the most recent sub-period, 1999-2006, the third stage of EMU.

Finally, Figure 7 shows the correlations between Ireland and its five main trading partners (UK, US, Belgium-Luxembourg, Germany and France) in each eight year rolling window over the period 1983-2006. Looking at the final period, 1999-2006, the cyclical GDP component of each of these trading partners has become more correlated with that of Ireland since the first period, 1983-1990. In each case, the correlations fell significantly in the periods 1991-1998 and 1992-1999. Ireland's two leading partners, the UK and the US, both display their highest levels of correlation in the period 1993-2000. In the most recent period, 1999-2006, the average correlation between Ireland and these two countries was 0.35. In the same period, the correlations between Ireland and its main trading partners within the euro area were particularly high, averaging at 0.71.

Bilateral Trade Intensity

Figure 8 shows the average values of trade intensity between Ireland and its trading partners in the whole period analysed, and in each sub-period. It is clearly shown that trade intensity has increased on average over time, and that it increased by a larger amount between the second and third sub-periods. Figure 9 shows the ten largest and smallest bilateral trade intensity levels, again over the whole period and in each sub-

⁷ These rankings are based on OECD trade statistics, and represent the years 1993-2004 inclusive.

period. It can be seen clearly that the highest intensity levels in each period correspond to the UK, Ireland's most important trading partner. A number of the euro area countries repeatedly feature amongst the highest trade intensity levels, in particular Belgium-Luxembourg, the Netherlands, France and Germany. Figure 10 shows the average trade intensity between Ireland and its trading partners in the euro area over the entire period and in each sub-period. The trade intensity level between Ireland and these countries has risen in each period, rising substantially in the third stage of EMU.

Sectoral Specialisation

The sectoral specialisation variable is measured in such a way that smaller values imply a larger similarity between Ireland and its trading partners in the share of sectors in total value added. A larger value indicates a higher sectoral specialisation in Ireland with respect to its trading partner. Figure 11 shows the average value of the sectoral specialisation index in the whole period, and in each of the three sub-periods. Again it is shown that that sectoral specialisation has increased over time, suggesting a reduction, on average, in the similarity between Ireland and its trading partners, in terms of sectoral shares in the total economy. Figure 12 displays the ten highest and lowest sectoral specialisation levels in each period. Norway, Australia, Cyprus and the US feature among the highest levels in each sub-period, suggesting a lack of similarity between Ireland and these countries in the share of sectors in total value added. Euro area countries feature among the lower levels, although Figure 13 shows that the sectoral specialisation index for Ireland and its euro area trading partners has increased over time, particularly in the third stage of EMU, suggesting the emergence of different sectoral shares in Ireland compared to the euro area countries.

Financial Integration

Figure 14 shows the average level of financial integration between Ireland and its trading partners in each time period while Figure 16, shows the level of financial integration between Ireland and its euro area trading partners. As expected, financial integration has increased in the Third Stage of EMU. Figure 15 shows the ten highest and lowest financial integration levels for each period. Switzerland and Singapore feature in the top three highest levels in each period, suggesting that Ireland is most integrated financially with these countries.

Fiscal Policy

Figure 17 shows the average level of the fiscal deficit differential between Ireland and its trading partners in each period. This differential was clearly at its highest in the early period, falling significantly in the second period and remaining around that level into the final period. Figure 18 shows a similar pattern for the differential between Ireland and its euro area trading partners. The peak in the early period is not altogether surprising, considering Ireland ran a large budget deficit throughout the economic difficulties of the 1980's.

Competitiveness Differential

A similar pattern is displayed in Figure 19, which shows the average level of the real effective exchange rate differential in each period. Again, the differential is highest in the earliest period, suggesting that Ireland and its trading partners became more similar over time, in terms of relative price competitiveness. Figure 20 shows that price competitiveness differential between Ireland and its euro area trading partners fell substantially between the first and second periods, before rising slightly in the final period.

6. Empirical Analysis

This section reports the three-stage least squares estimates for the system of simultaneous equations used in our analysis. Before turning to the three-stage least squares results, we report the results for the core explanatory variables in bivariate regressions.

Partial Correlations

In Figure 21, bilateral trade intensity is plotted against business cycle correlation, with the vertical axis representing the correlations and the horizontal axis representing trade. This bivariate regression reveals an upward-sloping trend, suggesting a positive relationship between trade intensity and business cycle synchronisation – the more intensive the trade between Ireland and its trading partner, the more synchronous the business cycle.

Figure 22 plots sectoral specialisation against business cycle correlation. In this case, we would expect to see a negative relationship between the two variables. Two

economies producing the same types of goods should be subjected to common shocks, and therefore, a low specialisation level would be associated with a high degree of business cycle synchronisation. The negative-sloping trend line in Figure A.22 confirms this relationship on a bivariate basis.

The measure of financial integration is plotted against business cycle correlation in Figure 23, and reveals a downward-sloping trend. The theory and literature on the effects of financial integration on the synchronisation of business cycles are somewhat ambiguous. Kalem-Ozcan et al (2003) argue that countries with a high degree of financial integration are more specialised industrially, which in turn can lead to lower levels of synchronisation. On the other hand, however, many empirical findings, including those of Imbs (2004), suggest that financial integration and increased capital flows are directly associated with higher a correlation of business cycles. We will look to the simultaneous equation approach to disentangle the direct and indirect effects.

Turning to our policy variables, Figure 24 plots the fiscal deficit differential against business cycle correlation. More similar fiscal policies correspond to increased correlation between business cycles, as implied by the negative slope of the trend line. In Figure 25, our national competitiveness indicator, the real effective exchange rate differential is plotted against business cycle correlation, and again the negative slope suggests that the lower the differences in national competitiveness, the larger the degree of cycle correlation.

Three-Stage Least Squares Results

The results of the three-stage least squares estimations are presented in Table 2. 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 both the main explanatory variables and the structural variables, and with regard to direct and indirect effects.

The first column of Table 2 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 have a positive and significant direct effect on business cycle correlations. Sectoral specialisation has a negative and significant

direct effect on business cycle correlations. Sectoral specialisation has however 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 GDP per capita 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 product 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 lower values of sectoral specialisation, that is, their economic structures are more similar. Furthermore, as expected in the financial integration equation, lagged financial integration has a positive effect on financial integration.

The second column of Table 2 presents the results for the second specification, in which the euro dummy was included in the primary equation. We find that the adoption of the euro has fostered the synchronisation of business cycles between Ireland and its euro area 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 integration. However, the negative coefficient on the financial integration variable in the system's third equation is not significant in this specification. All of the structural variables remain significant, again with only minor changes in magnitude.

Robustness Checks

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 take account of this they suggest the following transformation of the dependent variable:

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

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

Table 3 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.

7. Conclusions

This paper examined patterns and factors underlying the international transmission of business cycles between Ireland and its trading partners over the period 1980-2006.

In particular, we analyse 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 1980-2006 time period. Although the average correlation fell in the second sub-period, its highest level is 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, Finland and Belgium-Luxembourg are the countries with which Ireland is most synchronised over the entire period, displaying consistently high levels of correlation in each sub-period.

We estimate a 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 allows 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 construct a panel data including three eight year sub-periods and control for time invariant unobserved region 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 GDP per capita 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.

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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'Informations 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	SI
Spain	ES
Sweden	SE
Switzerland	CH
United Kingdom	UK
United States	US

Table 1: Summary statistics for main variables**Growth cycle correlation**

	Obs	Mean	Std. Dev.	Min	Max
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
1983-1990	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

Sectoral specialisation

	Obs	Mean	Std. Dev.	Min	Max
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
1983-1990	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
1983-1990	23	6.366	3.170	2.472	14.808
1991-1998	23	3.515	2.791	0.945	13.179
1999-2006	23	3.453	2.167	0.770	8.497

Real effective exchange rate differential

	Obs	Mean	Std. Dev.	Min	Max
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

Figure 1: Average correlations in each rolling window

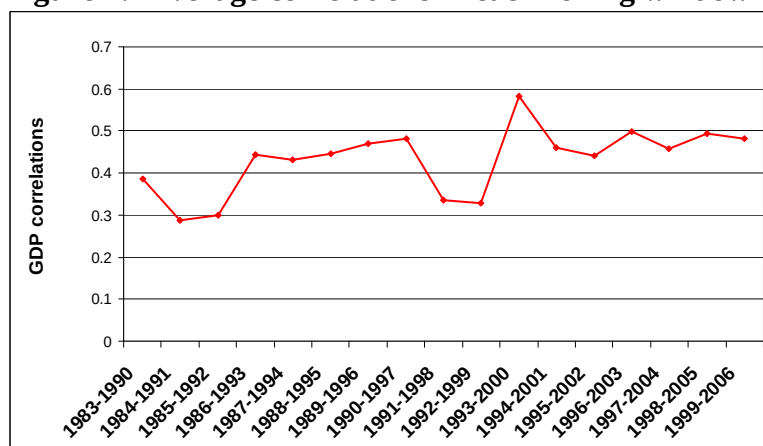


Figure 2: Ten highest and lowest correlations, 1983-2006

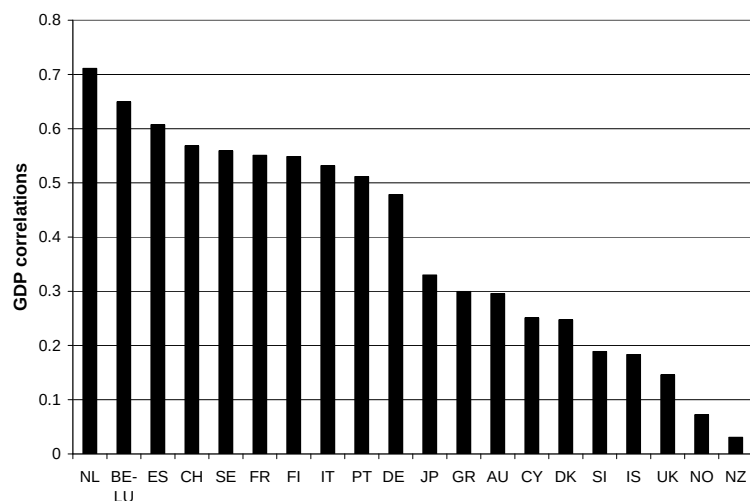


Figure 3: Ten highest and lowest correlations, 1983-1990

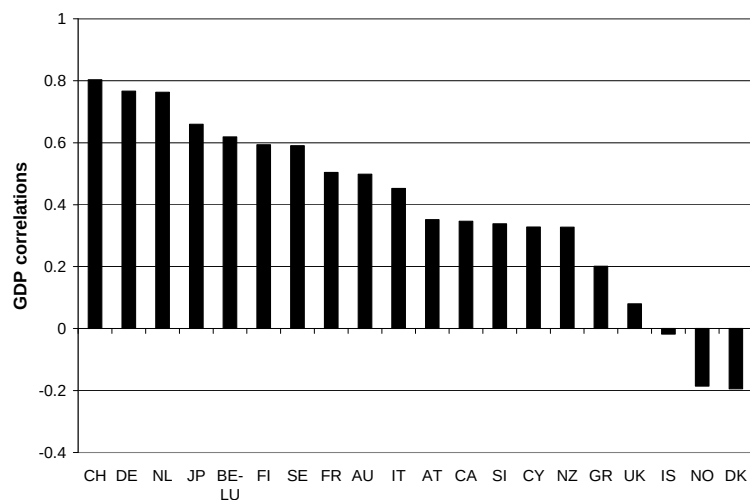


Figure 4: Ten highest and lowest correlations, 1991-1998

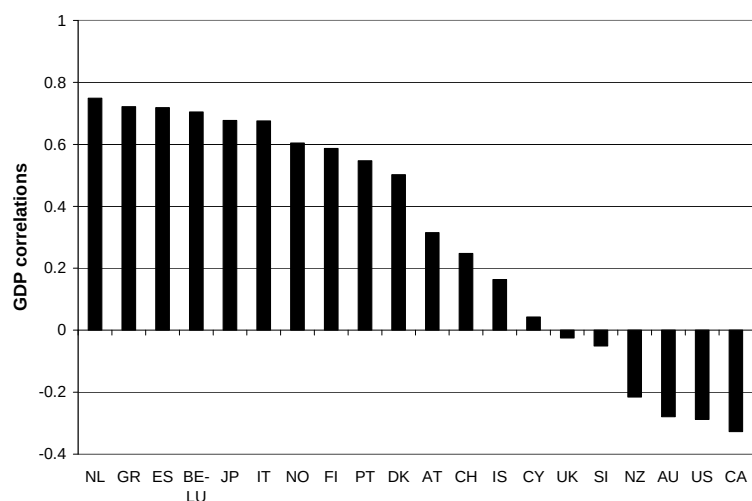


Figure 5: Ten highest and lowest correlations, 1999-2006

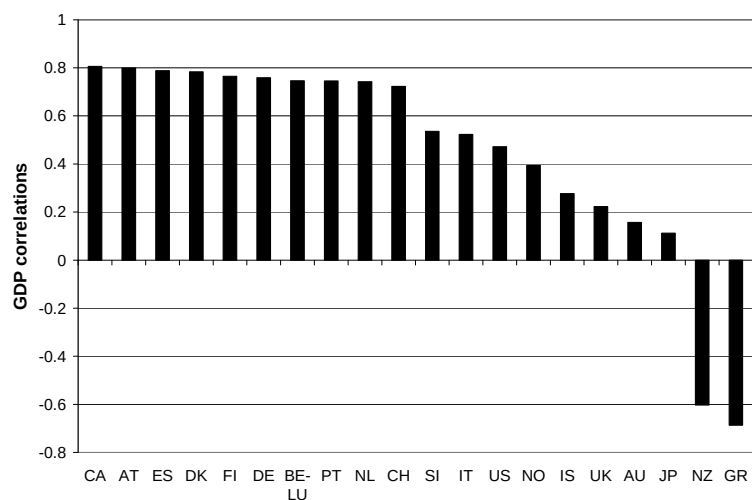


Figure 6: Correlation between Ireland and its euro area trading partners

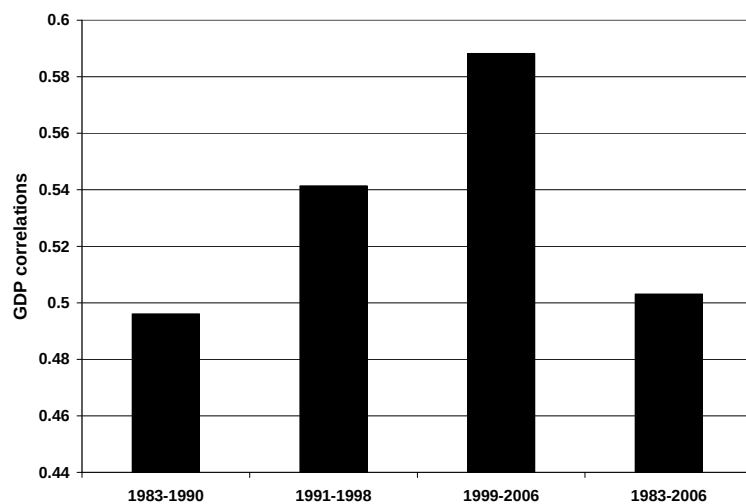
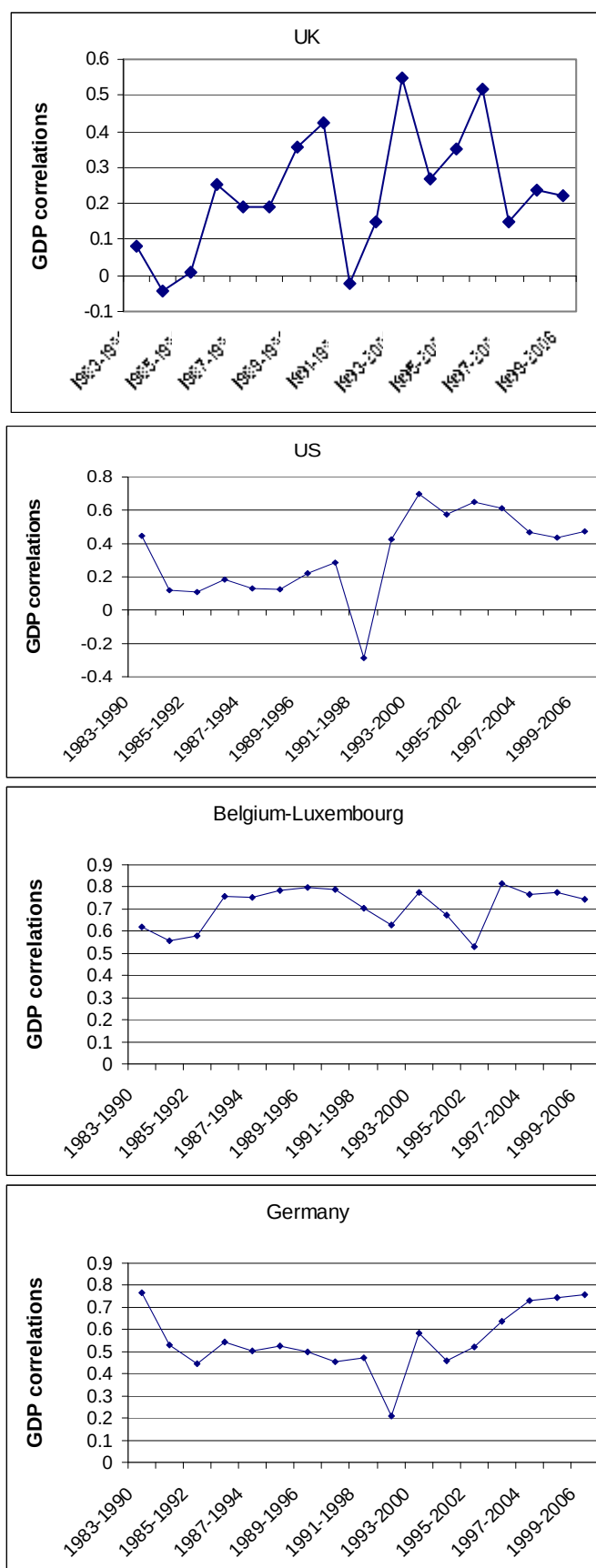


Figure 7: Correlations between Ireland and its five main trading partners



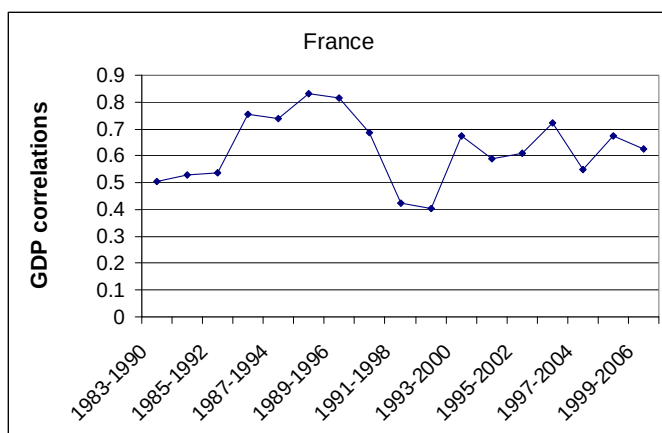


Figure 8: Average trade intensity

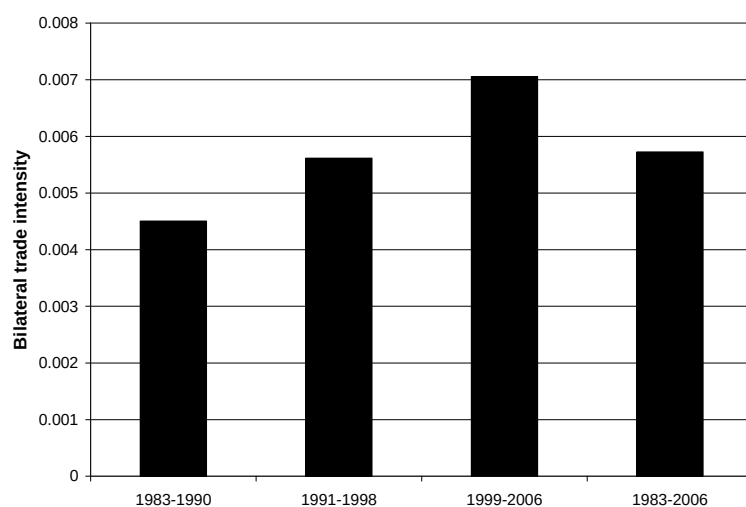
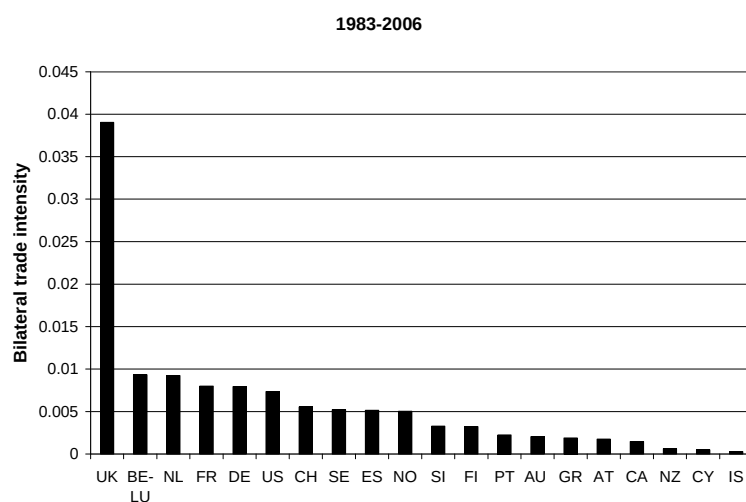


Figure 9: Ten highest and lowest trade intensity levels



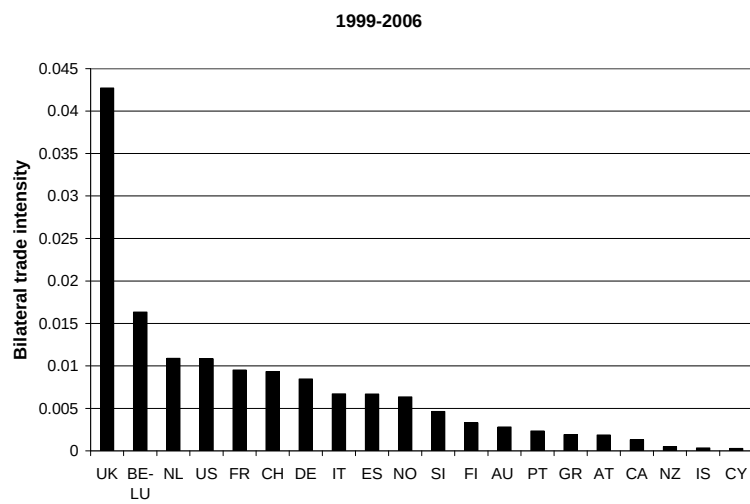
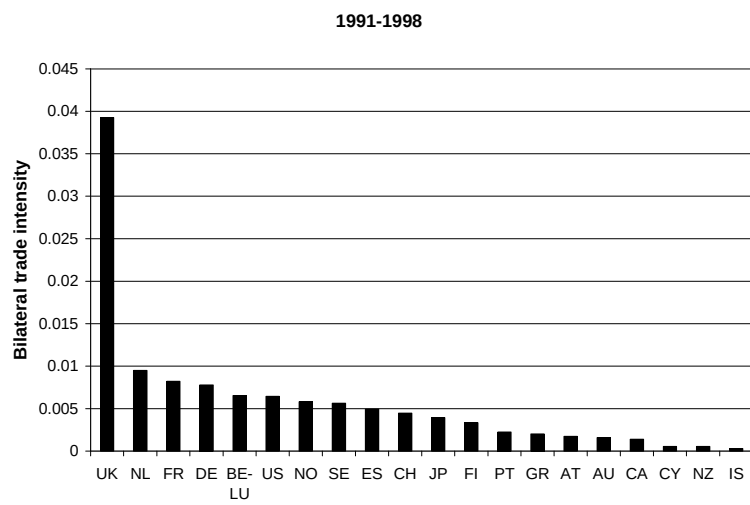
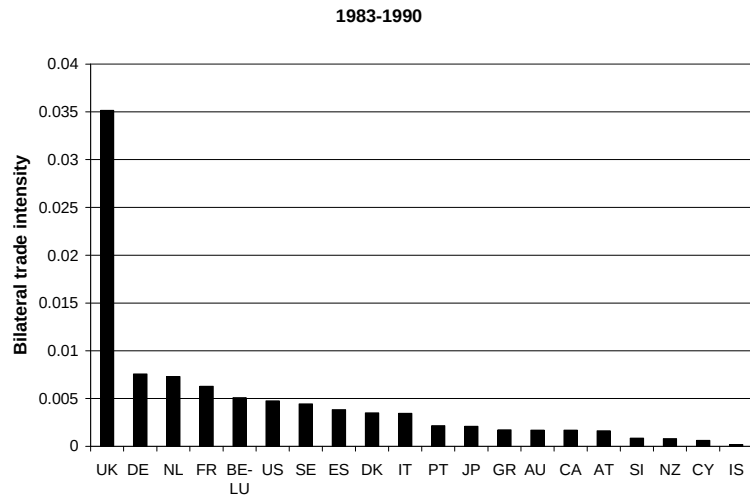


Figure 10: Trade intensity between Ireland and its euro area trading partners

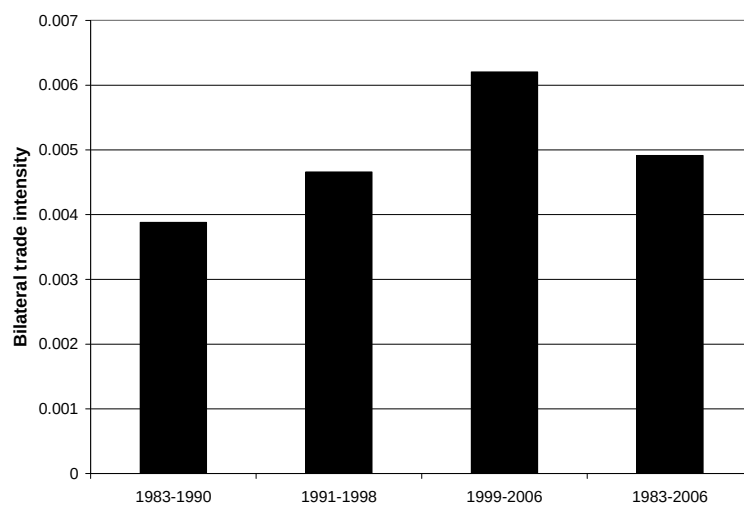


Figure 11: Average sectoral specialisation

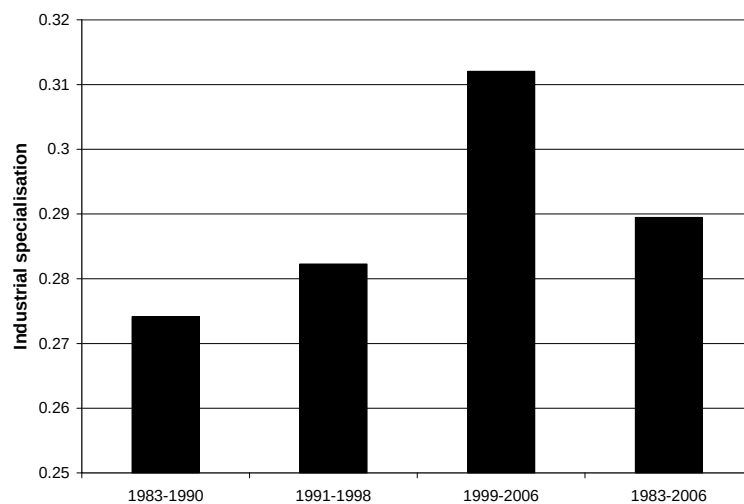
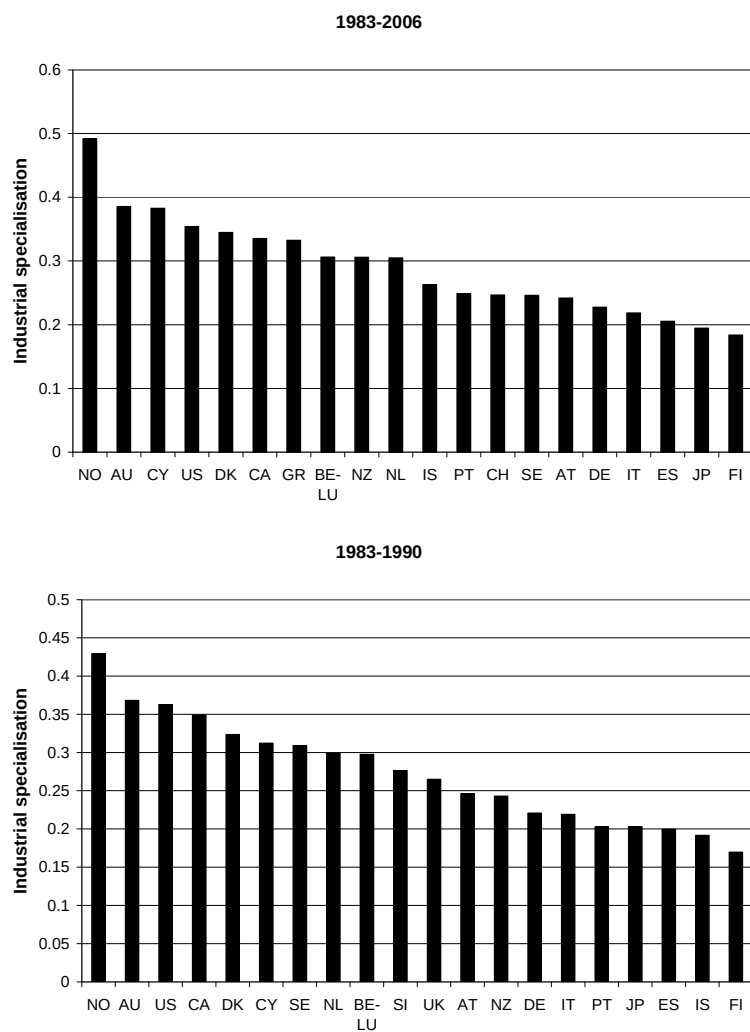


Figure 12: Ten highest and lowest sectoral specialisation levels



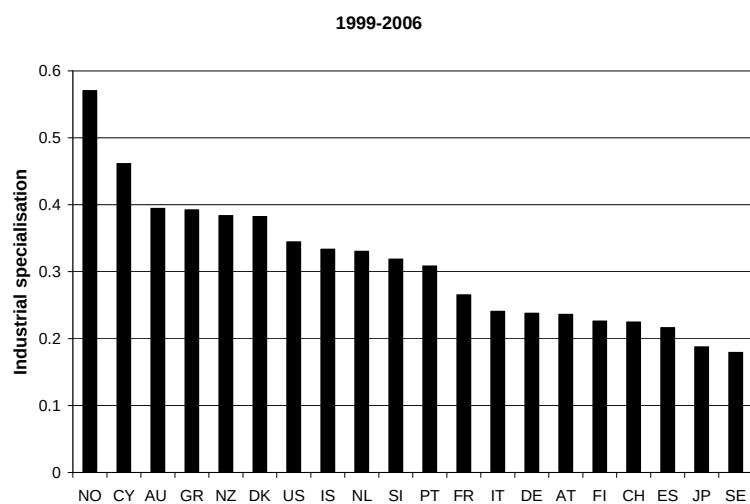
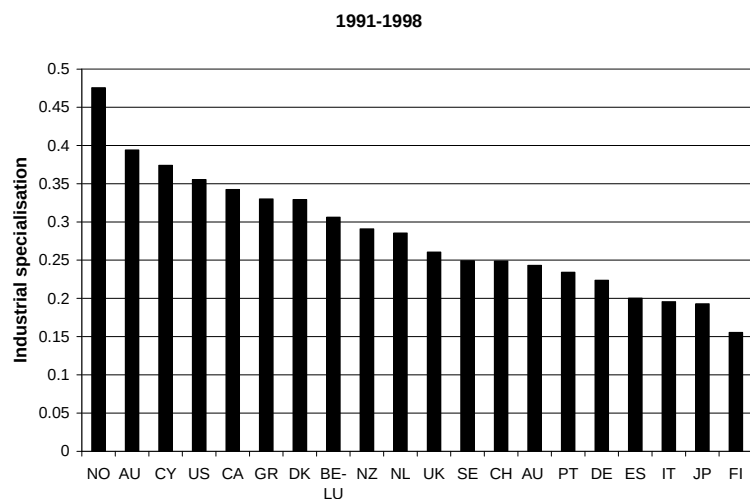


Figure 13: Sectoral specialisation, Ireland and its euro area trading partners

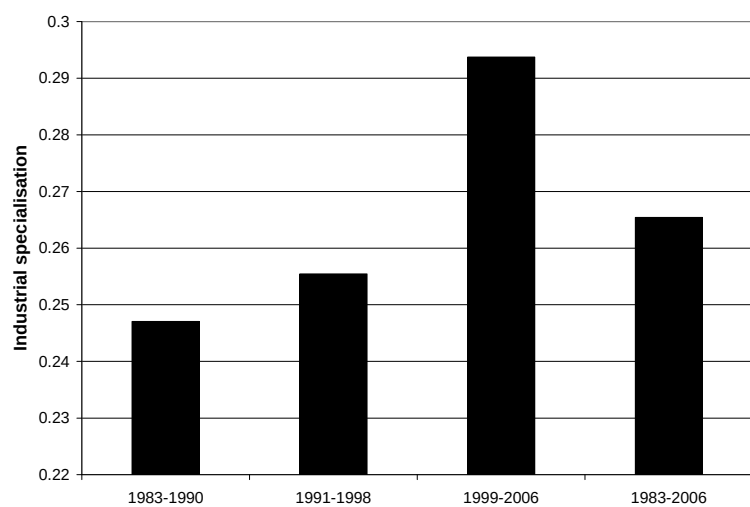


Figure 14: Average financial integration

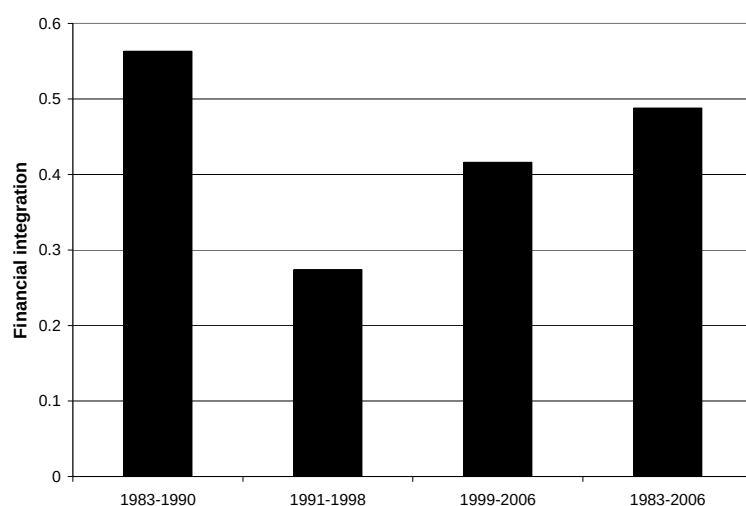
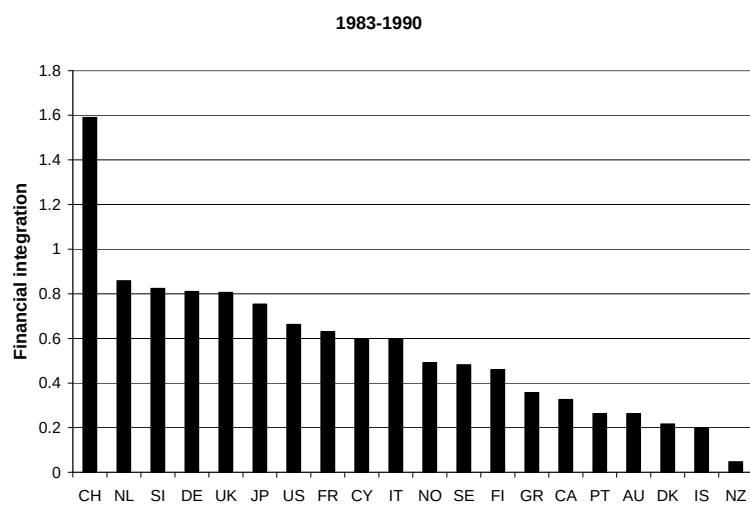
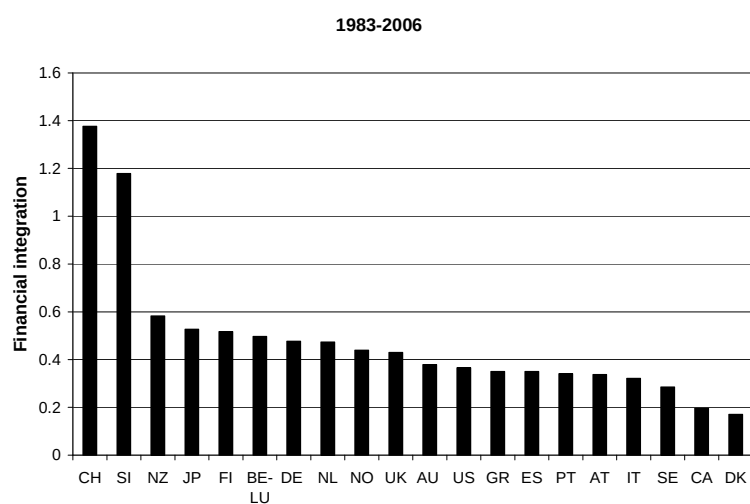


Figure 15: Ten highest and lowest financial integration levels



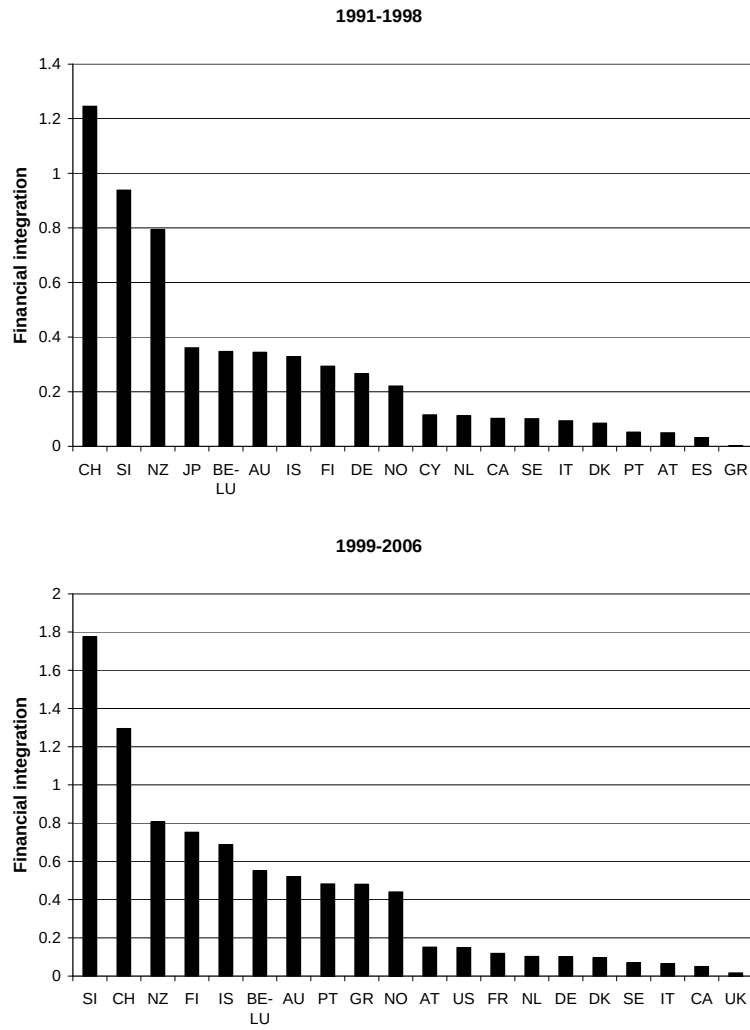


Figure 16: Financial integration between Ireland and its euro area trading partners

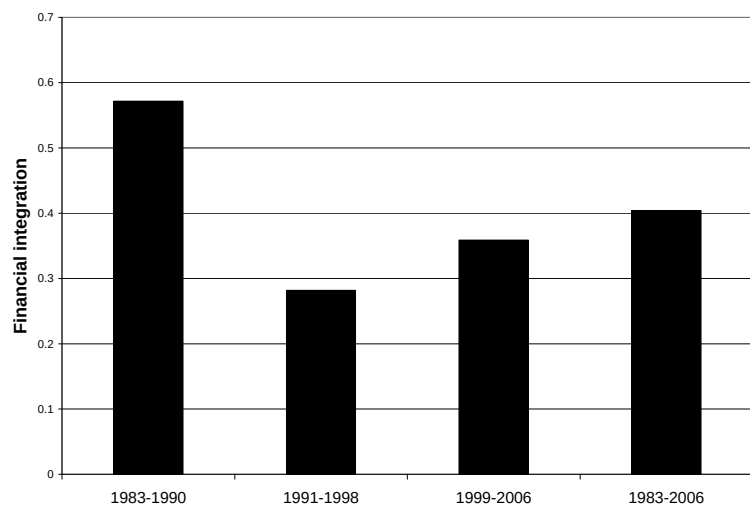


Figure 17: Average fiscal deficit differential

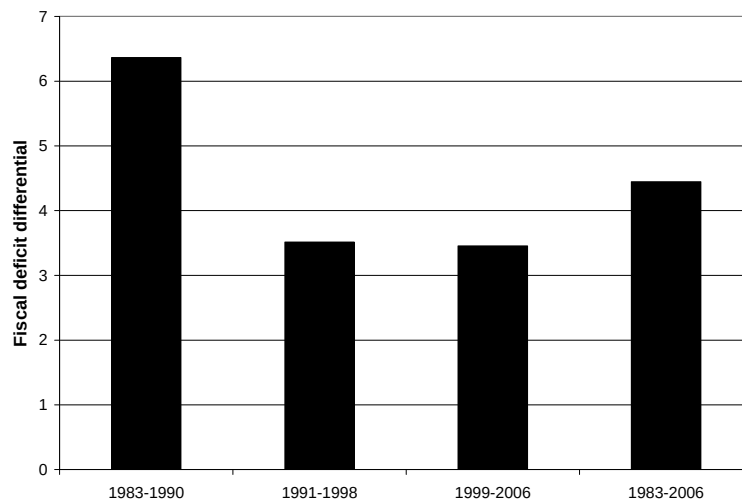


Figure 18: Fiscal deficit differential between Ireland and its euro area trading partners

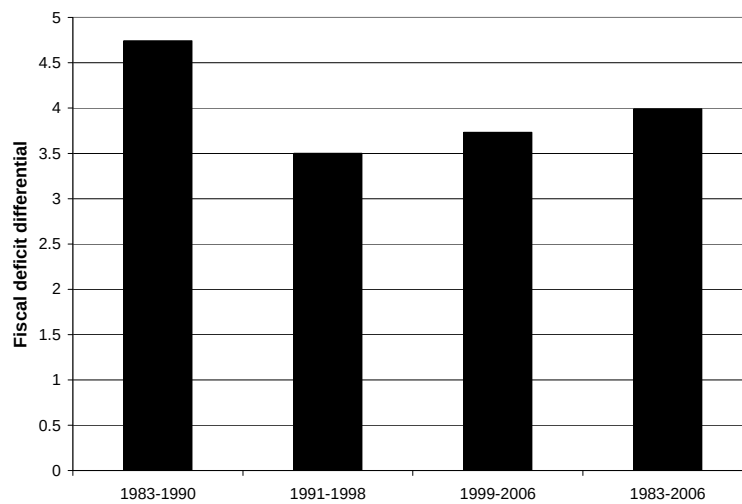


Figure 19: Average real effective exchange rate differential

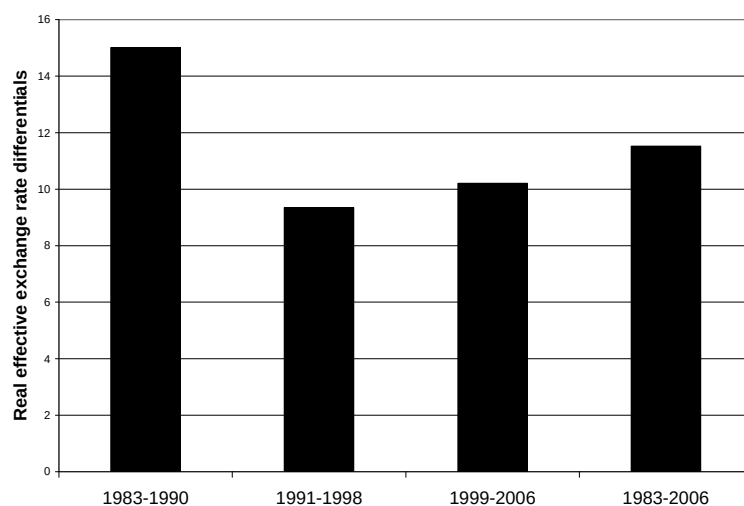
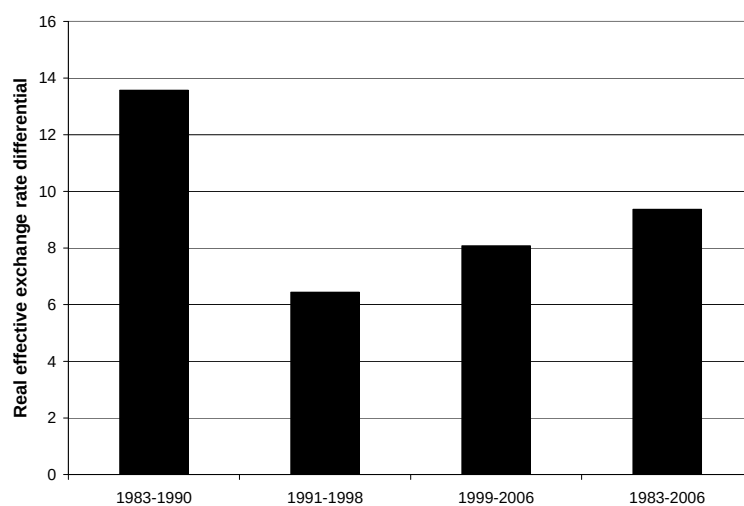


Figure 20: Real effective exchange rate differential between Ireland and its euro area trading partners



Bivariate Regressions

Figure 21: Trade intensity and business cycle correlation

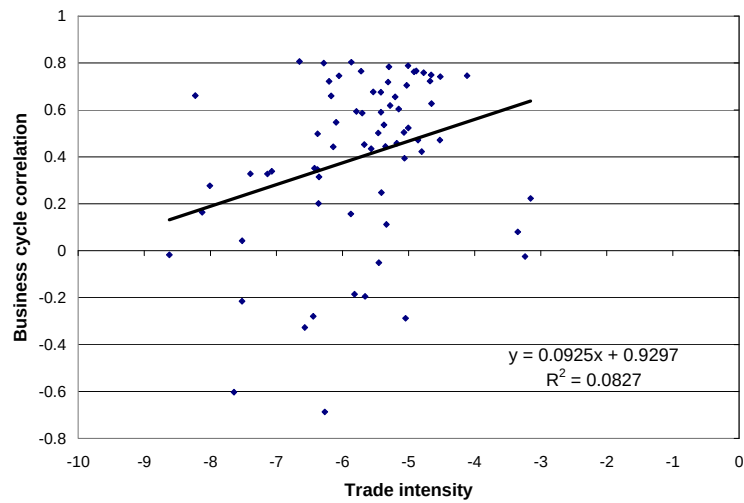


Figure 22: Sectoral specialisation and business cycle correlation

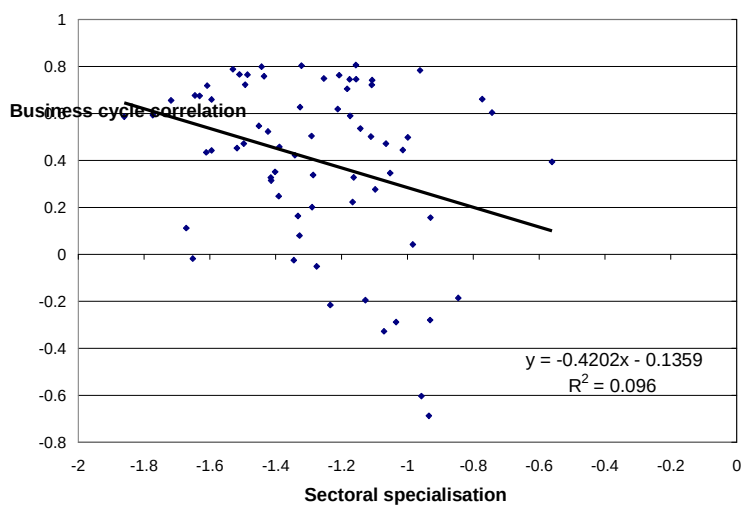


Figure 23: Financial integration and business cycle correlation

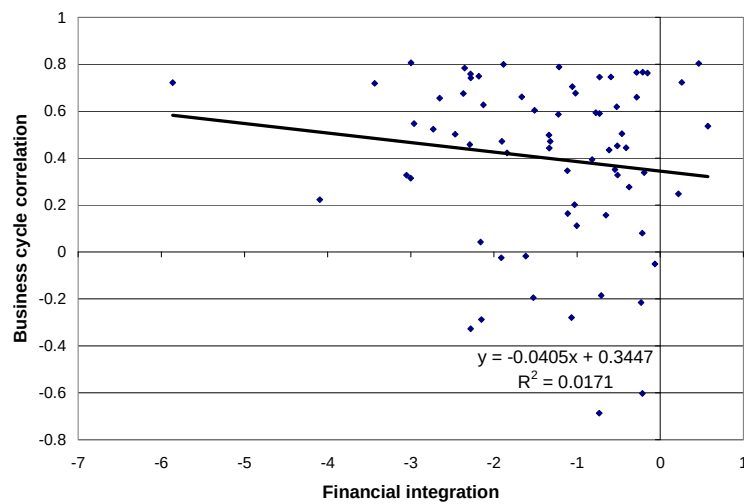


Figure 24: Fiscal deficit differential and business cycle correlation

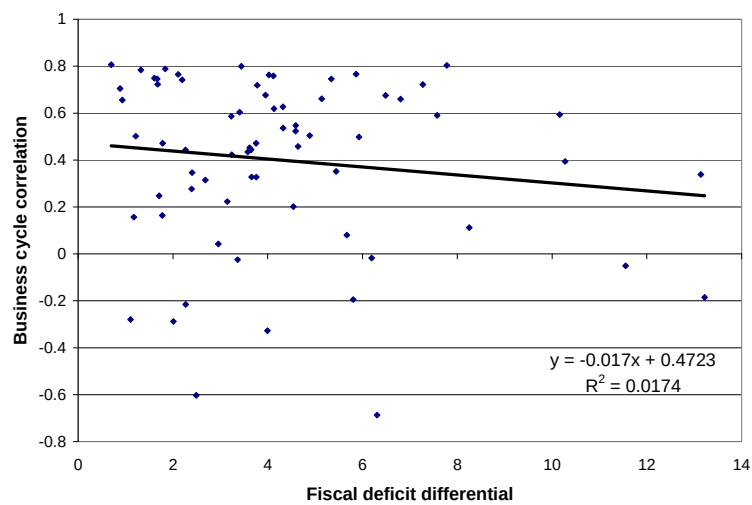


Figure 25: Real effective exchange rate differential and business cycle correlation

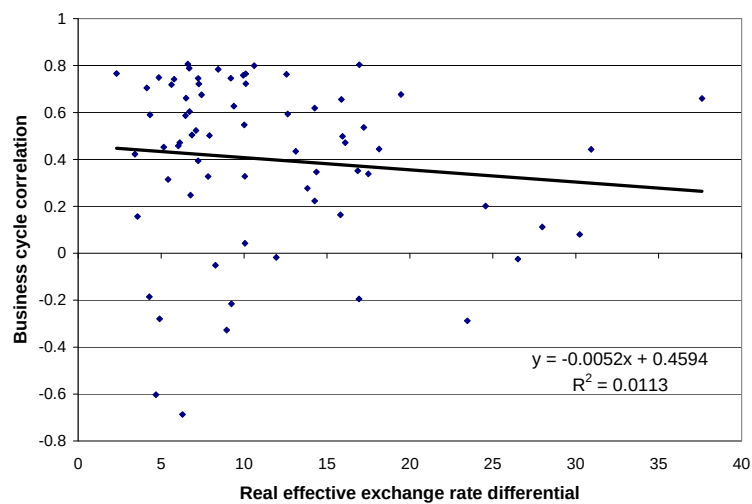


Table 2: Three-stage least squares estimates of business cycle correlations

	Model 1	Model 2
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

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 3 Three-stage least squares estimates of business cycle correlations with transformed dependent variable

	Model 1	Model 2
Correlation (transformed)		
Trade intensity	0.070** (0.033)	0.056* (0.032)
Sectoral specialisation	-0.984*** (0.156)	-0.879*** (0.153)
Financial integration	0.123** (0.055)	0.152*** (0.052)
Euro dummy		0.343** (0.129)
Fiscal deficit differential	-0.014 (0.016)	-0.013 (0.016)
Real effective exchange rate differential	-0.013* (0.007)	-0.010 (0.008)
N	69	69
R ²	0.54	0.54
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

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

- 267 Resonances from *Economic Development* for Current Economic Policymaking
Frances Ruane
- 266 The Impact of Wage Bargaining Regime on Firm-Level Competitiveness and Wage Inequality: The Case of Ireland
Seamus McGuinness, Elish Kelly and Philip O'Connell
- 265 Poverty in Ireland in Comparative European Perspective
Christopher T. Whelan and Bertrand Maître
- 264 A Hedonic Analysis of the Value of Rail Transport in the Greater Dublin Area
Karen Mayor, Seán Lyons, David Duffy and Richard S.J. Tol
- 263 Comparing Poverty Indicators in an Enlarged EU
Christopher T. Whelan and Bertrand Maître
- 262 Fuel Poverty in Ireland: Extent, Affected Groups and Policy Issues
Sue Scott, Seán Lyons, Claire Keane, Donal McCarthy and Richard S.J. Tol
- 261 The Misperception of Inflation by Irish Consumers
David Duffy and Pete Lunn
- 260 The Direct Impact of Climate Change on Regional Labour Productivity
Tord Kjellstrom, R Sari Kovats, Simon J. Lloyd, Tom Holt, *Richard S.J. Tol*
- 259 Damage Costs of Climate Change through Intensification of Tropical Cyclone Activities:
An Application of FUND
Daiju Narita, *Richard S. J. Tol* and *David Anthoff*
- 258 Are Over-educated People Insiders or Outsiders?
A Case of Job Search Methods and Over-education in UK
Aleksander Kucel, *Delma Byrne*
- 257 Metrics for Aggregating the Climate Effect of Different Emissions: A Unifying Framework
Richard S.J. Tol, Terje K. Berntsen, Brian C. O'Neill, Jan S. Fuglestedt, Keith P. Shine, Yves Balkanski and Laszlo Makra

- 256 Intra-Union Flexibility of Non-ETS Emission Reduction Obligations in the European Union
Richard S.J. Tol
- 255 The Economic Impact of Climate Change
Richard S.J. Tol
- 254 Measuring International Inequity Aversion
Richard S.J. Tol
- 253 Using a Census to Assess the Reliability of a National Household Survey for Migration Research: The Case of Ireland
Alan Barrett and Elish Kelly
- 252 Risk Aversion, Time Preference, and the Social Cost of Carbon
David Anthoff, Richard S.J. Tol and Gary W. Yohe
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