Borders and Business Cycles [*]

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Abstract

Does the presence of a national border affect the synchronization of business cycles across regions or countries that are separated by this border? If so, has the importance of the border declined over time, and what accounts for the border effect? These are the questions we address in this paper, using data for: (i) U.S. states and Canadian provinces, (ii) regions in France and Germany, and (iii) European countries and U.S. Census regions. We find that the U.S.-Canada border has, at most, a weak effect on business cycle correlations between states and provinces. On the other hand, there is a large and statistically significant European border effect. We consider the role of three factors that have received a lot of attention in the context of the debate about EMU: sectoral specialization, the level of trade, and exchange rate volatility. We find that these can account for some, but not all, of the European border effect.

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1 Introduction

National economies across the globe are becoming more integrated as barriers to trade, capital flows, migration and technology dissemination are falling. Intranational economics can provide valuable insights about where this process may lead us since barriers are much weaker across regions within a country. In this paper we ask to what extent barriers posed by national borders affect the synchronization of business cycles across regions and countries that are separated by this border. We use evidence for regions located in the same country as a benchmark. We address three specific questions. First, is there evidence of a border effect when comparing within-country to cross-country correlations? Second, has the role of the border diminished over time? And finally, what accounts for the border effect?

Our approach, particularly with regards to the first question, is similar to that followed in literatures that have compared trade and the volatility of relative prices across regions in the same country to that across regions in different countries.[1] Those literatures are careful to control for "exogenous" factors that are unrelated to national borders, particularly distance and size. In the same spirit as those literatures, here we will control for these exogenous factors by regressing business cycle correlations on a common border dummy and measures of distance and size. Distance is an important barrier, which raises the cost of transportation and communication, but is not specifically related to the border. It is similarly important to control for size as larger regions (and countries) are generally more diversified and therefore have more correlated business cycles.

In comparing within-country to cross-country correlations we will consider three sets of data. The first is a U.S.-Canada data set, where the within country-correlations are among U.S. states and Canadian provinces, while the cross-country correlations are between states and provinces. The second is a France-Germany data set, where within-country correlations are among regions within France and within Germany, while cross-country correlations are between French and German regions. The third is a U.S.-European Union data set, where the within-country correlations are among nine Census regions in the U.S., while the cross-country correlations are among fourteen EU countries. The first data set provides information on the role of the U.S.-Canada border, while the other data sets provide information on the role of European borders.

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[1] For the trade literature see McCallum (1995), Helliwell (1997,1998), Wei (1996), and Wolf (1999). For the relative price literature see Engel and Rogers (1996,1999).

Our analysis extends and complements two previous literatures. The first directly compares within-country to cross-country correlations. Bayoumi and Eichengreen (1993, 1996) and Wynne and Koo (1997) compare correlations across regions in the U.S. to countries in Europe. Using data for regions in European nations, Fatás (1997) compares correlations between regional and national growth rates to correlations between regional and Europe-wide growth rates. The second literature, surveyed by Clark and Shin (1999), decomposes the sources of variation into international, nation-specific, region-specific, and industry-specific components. Forni and Reichlin (1997) is a recent example of a study comparing U.S. and European results. The findings of both of these literatures suggest that borders matter. Business cycle correlations across regions in the U.S. are much higher than across European countries. Consistent with that, in the decomposition literature common shocks are more important in the U.S. than in Europe.

Our approach has two advantages over these previous literatures. First, by explicitly controlling for exogenous factors that are unrelated to national borders (distance and size) we are able to more accurately measure the role of the border in affecting business cycle comovements. Second, our approach naturally lends itself to addressing what may account for the border effect. We will focus on three aspects that have received considerable attention in the debate about EMU: sectoral specialization, trade and monetary policy. As a result of trade and industrial policy the extent of industrial specialization and the level of trade may be higher within a country than across countries. Monetary policy may matter because regions within a country share the same currency, while countries do not. We evaluate the importance of these factors by including in the regression measures of production structure similarity, trade and exchange rate volatility.

The remainder of the paper is organized as follows. In section 2 we discuss the general methodology and econometric issues. Section 3 describes the data and reports results on the role of the border and on how much the border effect has changed over time. We also compare our results to that of the related literatures. Section 4 explores what accounts for the border effect, focusing on the role of sectoral specialization, trade and exchange rate volatility. The final section concludes.

2 Methodology and Interpretation

In this section we discuss econometric issues associated with regressing business cycle correlations on a set of explanatory variables, and the correct interpretation of the border dummy coefficient.

2.1 Econometric Issues

We begin by directly comparing within-country to cross-country business cycle correlations. Let ρ denote the vector of unique population correlations of interest, $\hat{\rho}$ the vector of estimated correlations and v the sampling error for the estimated vector:

$$\hat{\rho} = \rho + v. \tag{1}$$

We estimate the variance of the estimated correlation vector, which is the same as the variance of the sampling error, using the standard GMM methods described in Ogaki (1993). In this approach, GMM is used to estimate the vector of first and second moments of the data and the variance–covariance matrix of the moment parameter estimates. The variance–covariance matrix of the correlations, which are a nonlinear function of the first and second moments of the data, is then estimated using the delta method. The resulting variance estimator is denoted by $\frac{1}{T}\hat{\Sigma}_v$, where $\hat{\Sigma}_v$ is the estimate of the asymptotic variance–covariance matrix and T is the number of time–series observations used to estimate the correlations. This variance estimator incorporates the Newey and West (1987) correction for serial correlation in the data, using 2 lags for annual data and 8 lags for quarterly data. Since the average within-country correlations, average cross-country correlations, and their difference (the border effect) are all just linear combinations of the sample correlations, their variance is easily computed as $var(\delta'\hat{\rho}) = \delta'(\frac{1}{T}\hat{\Sigma}_v)\delta$.

We proceed to estimate a cross-section regression of the estimated correlations on a set of explanatory variables. Formally, we estimate by OLS the equation

$$\hat{\rho}_i = x_i'\beta + e_i. \tag{2}$$

In our baseline specification, the variables in x_i include a constant, a border dummy that is 1 when regions are located in the same country, the log of distance, and a population-based measure of the size of regions j and k. In further investigating what might explain any border effects, the set of explanatory variables is expanded to include measures of production structure similarity, trade, and exchange rate volatility.

In estimating standard errors for the parameters of (2), we depart from the practice of estimating the variance–covariance matrix of $\hat{\beta}$ using just the standard White (1980) correction for heteroskedasticity, as in Frankel and Rose (1998) and Imbs (1998a). In a footnote, Frankel and Rose argue that the resulting estimator takes appropriate account of the sampling uncertainty in the estimated correlation $\hat{\rho}_i$ — that is, the fact that the dependent variable in (2) is a generated variable. But, if the sampling error in one correlation $\hat{\rho}_i$ is correlated with the sampling error in another correlation $\hat{\rho}_l$, there will be dependencies across the residuals e_i of (2) that the White correction fails to adjust for. Such dependencies are likely to be important, and ignoring them seems likely to lead to understated standard errors. Indeed, in our analysis, White–adjusted standard errors based on the simple cross–section regression are generally lower, often much lower, than those we report.

We base our estimate of the variance–covariance matrix of $\hat{\beta}$ on the time–series sampling error in the estimated correlations. Although we treat the sample correlation $\hat{\rho}_i$ as stochastic (due to sampling error), we assume that the population coefficient ρ_i is *not* a random variable. We suppose that the population correlation ρ_i is a deterministic function of a wide range of variables, of which we only observe a subset. Formally, we may write $\rho = X\beta + Z\gamma$, where Z is orthogonal to X. β measures both the direct effect on the correlation, and the indirect effect through variables with which it is correlated.[2] Substituting (1) yields

$$\hat{\rho} = X\beta + Z\gamma + v. \tag{3}$$

OLS yields an unbiased estimate of β. Using the time–series estimate $\hat{\Sigma}_v$, the estimated variance–covariance matrix of $\hat{\beta}$ is

$$\operatorname{var}(\hat{\beta}) = (X'X)^{-1}X'(\frac{1}{T}\hat{\Sigma}_v)X(X'X)^{-1}. \tag{4}$$

While the assumption that ρ_i is deterministic may seem strong, our method produces standard error estimates that are clearly the "right" ones in the simple case where we only regress on a border dummy and a constant. The standard error associated with the border dummy coefficient computed using (4) is the same as that corresponding to the difference between average within-country and cross-country correlations discussed above. In the more complicated case where other regressors are included, our standard error estimates are computed in a way that is methodologically consistent with the simple approach.

In the results reported below, we use both full time–series of the data and sub–samples of the data. In computing variance estimates for the sub–samples, we use an

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[2] For example, distance may only affect the correlation indirectly through its effect on trade. Similarly, size may only affect the correlation indirectly though its effect on diversification.

estimate of the asymptotic variance matrix that is based on the full–sample of data, rather than the sub–samples. We use the same $\hat{\Sigma}_v$ estimate of the asymptotic variance–covariance matrix in the full–sample and sub–sample analyses for a given set of regions. To obtain an appropriate estimate of the sample variance of the correlations estimated with a given T observations, we just scale $\hat{\Sigma}_v$ by T. Our rationale for basing inference on the full–sample estimate of the asymptotic covariance matrix is that small samples of data will give highly imprecise variance estimates. Abstracting from serial correlation for simplicity, the GMM variance matrix $\hat{S}$ essentially corresponds to the sample fourth moment matrix of the data. As noted by Davidson and MacKinnon (1983), such high–order sample moments will be inefficient estimates of the population moments. The Monte Carlo results in Burnside and Eichenbaum (1996) and Christiano and den Haan (1996) on the finite–sample properties of hypotheses tests involving second moments and correlations highlight some serious precision problems.

In some cases we will also estimate (2) jointly for two sub-samples. In that case we compute the variance of v for each of the sub-samples as discussed above, while we assume that the sampling error is uncorrelated across the sub-samples.

2.2 Interpretation of the Border Effect

The coefficient on the border dummy from the regression (2) provides an estimate of how much the average correlation between regions of different countries would change if barriers specific to the border were eliminated, so that these regions become equally integrated — along all dimensions — as regions belonging to the same country. However, some care is required in interpreting the coefficient on the border dummy, particularly when it comes to drawing conclusions about the extent of economic integration among the regions involved. There is not necessarily a one-to-one relationship between the extent of integration among a set of regions and the correlation between their business cycles. "Integration" is itself a very multi-dimensional concept. An increase in trade between regions would probably increase the business cycle correlation between those regions. On the other hand, an increase in capital and labor mobility across regions may reduce the business cycle correlation. A region experiencing a favorable demand or supply shock can be expected to experience capital and labor inflows, at the expense of other regions, reinforcing the asymmetry of the original shock.

A higher level of integration along all dimensions therefore does not necessarily imply a higher business cycle correlation. The border coefficient could be zero, even though regions within the same country are more integrated than regions located in different countries. It is therefore important to realize that the common border coefficient itself is not a good measure of these barriers.

One has to be similarly careful when comparing changes in the common border coefficient over time. It is quite possible that the border coefficient declines over time, even though trade, capital mobility, labor mobility, and other factors of integration between regions of different countries remain unchanged. As an example, let us say that higher trade integration among regions belonging to the same country initially leads to a positive border coefficient. Later the border coefficient can drop due to increased labor and capital mobility among regions belonging to the same country, even when barriers resulting from the national border do not change, and therefore the extent of integration among regions located in different countries does not change. It is therefore important to know whether the decrease in the border coefficient is the result of increased cross-country correlations or decreased within-country correlations.

3 Evidence on the Role of the Border

In this section we first discuss the data sets. After that we describe the evidence on the role of national borders, and on the change in the role of national borders over time. At the end of the section we compare our results to related evidence in the literature.

3.1 Data

We apply the methodology described above to three basic combinations of regions: (1) 51 U.S. states and 10 Canadian provinces; (2) 8 regions in France and 8 regions in Germany; and (3) 8 U.S. Census regions and 14 EU countries.[3] Because U.S. states are generally much smaller than European nations, the states are aggregated to the nine Census regions for the purpose of comparing within–U.S. correlations to correlations across EU countries, although we more formally control for size in the regressions. We use the same set of French and German regions as Fatás (1997), who reduces the total of 11 German NUTS-1 regions to 8 regions in order to avoid using regions that are

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[3] In combination (1), we are actually using the 50 U.S. states plus the District of Columbia. For simplicity, we simply refer to this set as the 51 U.S. states.

composed of only large cities.[4]

For all combinations of regions, we use the available broad measures of economic activity. Specifically, we use both employment and GDP, except in the U.S.–Canada comparison. Canadian provincial GDP data are available for too short a time period to permit reliable inference.[5] Because of limitations in the availability of quarterly data, all analysis of European economies is based on annual data. In the case of the U.S.–Canada comparison, however, we are able to analyze both quarterly and annual employment data.

To isolate fluctuations at business cycle frequencies, we transform the data in three different ways: (1) taking simple percent changes; (2) passing the data through the filter proposed by Hodrick and Prescott (1997); and (3) passing the data through the Baxter and King (1995) filter. In applying the Hodrick–Prescott (HP) filter, we set the filter's smoothing parameter λ at 1600 for quarterly data and 10 for annual data. While many studies of annual data, such as Backus and Kehoe (1992), set λ at 100, Baxter and King suggest that a value of 10 is more appropriate for annual data.[6] In applying the Baxter–King filter, we set their parameters 'up', 'down', and 'K' at 2, 8, and 3, respectively, for annual data and 6, 32, and 12 for quarterly data. In the tables reported below, in the interest of brevity we omit results for Baxter–King filter because they are very similar to those for percent changes and HP–filtered data.

As detailed in the appendix, we use simple measures of distance and size. For the U.S.–Canada analysis distance is measured as the log of geographic distance – that is, taking the earth's curvature into account – between capital cities. For the U.S. Census regions distance is measured as the log of the population–weighted average of distances between the states within each Census region. Similarly, distances between the French and German regions and between the EU-14 countries are population–weighted averages of geographic distances between very small NUTS-3 regions. Size is defined as the sum

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[4] We experimented with adding Italian and UK regions to the second data set, as in Fatás (1997). The problem is that in that case it is hard to control for distance. Distances between UK regions and regions of other countries, and between Italian regions and those of other countries, are generally much larger than within-country distances, so that the distance variable starts to acts as a border dummy. For France and Germany there is substantial overlap between within-country and cross-country distances.

[5] Reflecting a major break in the series, provincial GDP data are only available back to 1984.

[6] We find that, in some cases, data filtered with $\lambda = 100$ produces counterintuitive results. In particular, the average correlation among U.S. states is higher in quarterly HP filtered data than in annual data filtered with $\lambda = 100$.

of the log populations of regions j and k, measured in a single year.[7]

3.2 Evidence Based on the Entire Sample

Table 1 reports some basic correlation results for our three data sets. It reports average within-country and cross-country correlations, as well the difference (border dummy). Standard errors are in parentheses.

For all three data sets the average within-country correlation is larger than the cross-country correlation, and this difference is statistically significant. This is particularly so for the France-Germany and U.S.-EU data sets. The average correlation of annual employment growth across the 9 U.S. Census regions is 0.51 higher than the average correlation across the 14 EU countries. The number is only slightly lower for output growth and HP-filtered data. This difference in correlations is strongly significant, suggesting that business cycles of the EU countries would become substantially more synchronized if European countries became equally integrated as the U.S. regions. It is worth noting that limiting ourselves to the countries of the current Euro zone leaves the average correlation across European countries practically unaltered. It rises by 0.02 for both output and employment growth rates.

The France-Germany data set also leads us to conclude that the border matters. On average the correlation of annual employment growth rates between a region in France and a region in Germany is 0.42 lower than between regions located in the same country. The national border between Germany and France appears to play an important role. This result is again strongly significant, and is also confirmed by the other business cycle measures.

In comparison to the European data, the evidence for the U.S. and Canada indicates that eliminating the border between these countries does not lead to a large increase in the correlation between them. The difference between the average within-country and the average cross-country correlation ranges from 0.14 to 0.22, dependent on the choice of the business cycle variable. While the border effect is statistically significant, it is much less so than for the European data. Moreover, the average correlation of annual employment growth rates between states and provinces (0.40) is much higher than between regions in Germany and France (0.19) and between European countries (0.20).

As stressed in the introduction, correlations alone cannot definitively tell us how

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[7] We chose not to use GDP as a measure of size because of possible endogeneity problems.

much business cycle correlations across countries would change if barriers specific to the border were eliminated. In order to assure ourselves that national borders matter we need to control for “exogenous” factors that are unrelated to the presence of borders. A lower correlation among regions of the same country can simply be the result of lower average distance than between regions of different countries. Similarly, it is possible that the correlations between the 9 Census regions is higher than between European countries because of somewhat larger size.

Table 2 shows the role of the border after controlling for distance and size. It shows the result of regressions of the business cycle correlation on a common border dummy, the log of distance, and size. For all data sets and business cycle measures distance has a negative coefficient. It is generally strongly significant. In all but one regression size has the expected positive coefficient, and is generally significant as well.

A comparison of Tables 1 and 2 shows that controlling for distance and size mainly affects the common border coefficient for the U.S.-Canada data set. The border effect, which was already small, becomes even smaller and is insignificant for annual data. To some extent the lower raw cross-country correlations (state-province) can be attributed to a larger distance than between regions of the same country (30% on average) and a smaller size.[8] Once we control for distance and size the border effect therefore declines.

The results for the U.S.-EU data set show that the significance of European borders remains almost unchanged after controlling for distance and size. Even though distance and size are both significant in the regressions, for three of the four business cycle measures the common border coefficient in Table 2 is exactly the same as the difference in average correlations in Table 1. The average distance between the U.S. regions (1938 miles) is larger than between the EU countries (1421 miles), while the average size of the U.S. regions (27.6 million people in 1990) is somewhat larger than that of the European countries (24.9 million people in 1994). The larger distance lowers the correlation across the U.S. regions relative to the EU countries by about the same amount as the larger size raises it. Simultaneously controlling for distance and size therefore does not change the estimated border effect.

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[8] The population of states is on average 79% higher than that of Canadian provinces. Within country correlations are dominated by state-state correlations, while cross-country correlations always involve a Canadian province.

3.3 Changes Across Sub-Samples

So far we have established a strong role of national European borders, and a weak role for the U.S.-Canada border, in the synchronization of business cycles across regions. We will now ask whether the significance of national borders has changed over time. Tables 3 and 4, and Figures 1 to 3, shed light on this. For each of the three data sets we break the sample into two periods of equal length. It may be desirable to make the periods even shorter, for example 5-year intervals, but the standard errors associated with average correlations based on such short periods are much too large to allow for meaningful analysis.

Table 3 reports the same results as in Table 2, but for the two sub-samples. It shows how the border effect has changed from the first to the second half of the sample, after controlling for distance and size.[9] Table 4 reports the raw correlations for both subsamples, providing insight in the change in both within-country and cross-country correlations. Finally, Figures 1 to 3 show the cross-country correlations (squares) and within-country country correlations (diamonds) as a function of distance, comparing for each data set the first half to the second half of the sample.

Table 3 shows that there is a drop in the importance of the border for all three data sets. For all data sets the border effect was about 0.20 lower during the second half than during the first half of the sample. However, as already pointed out, we have to be careful interpreting this result. A drop in the border effect does not necessarily imply that barriers posed by the border have weakened and countries have become more integrated. The change in the border effect can also be a result of changes in the extent of integration among regions of the same country. It is therefore of interest to know to what extent the change in the border effect is associated with a change in within-country correlations or a change in the cross-country correlations. Table 4 sheds light on this.

Table 4 shows that the weakened role of the U.S.-Canada border is primarily due to higher correlations between states and provinces. The average within country-correlation has not changed much. This suggests that the barriers posed by the border have weakened and the countries have become more integrated. These results are further illustrated in Figure 1. During the first half of the sample almost all correlations between 0.7 and 1 are among regions belonging to the same country. During the second half of the sample the band of squares (cross-country correlations) has shifted up and mixed

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[9] The standard error on the change in the border effect is calculated assuming the sub–sample estimates to be independent.

with the within-country correlations. For a given distance we can no longer say that within-country correlations are larger than cross-country correlations. Table 3 shows that the border effect has indeed become small and insignificant during the second half of the sample.

Although these results are suggestive, problems with the data do not allow us to draw strong conclusions. There is a break in the Canadian employment data in 1983, at which time coverage increased substantially. Firms with 20 or more employees were excluded before 1983. Moreover, the data did not cover employment in education, health and welfare, and public administration. Overall coverage slightly more than doubled in 1983. Although we do not find a significant change in the standard deviation of employment growth before and after 1983, it is nonetheless quite possible that the change in the common border coefficient is due to a change in data coverage.

Completely separate from whether there is a change in the role of the border, it is important to emphasize that the border effect is essentially zero in the second half of the sample. We have further confirmed this by re-estimating the regression for the 1983-1997 period, using only the comprehensive Canadian employment data. We again find a coefficient on the border dummy close to zero. After controlling for distance and size the coefficient on the common border dummy is respectively -0.04 and 0.04 for annual and quarterly employment growth data, with standard errors of 0.11 and 0.08.[10] This implies that during the eighties and nineties the border between Canada and the United States has not had any significant effect on the synchronization of business cycles between states and provinces.[11]

Next we turn to a discussion of results for Europe. Although Table 3 shows a drop in the coefficient of the common border dummy for both the France-Germany and the U.S.-EU data sets, the evidence does not indicate that this is the result of increased integration across European countries. First consider the France-Germany results. Table 4 shows that the average business cycle correlation between French and German regions has not changed much. The correlation between regions of the same country has not changed much either. The only reason the border effect dropped in Table 3 is because of a change

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[10] Similarly, the coefficients are -0.05 and 0.01 for annual and quarterly Hodrick Prescott filtered data, with standard errors of 0.11 and 0.08.

[11] It is worth reiterating that this does not mean that there were no border-related barriers. For example, as is well documented, and further discussed in the next section, trade between provinces is more than 10 times larger than between states and provinces, even after controlling for distance and size. One may either argue that such barriers were not large enough to have had a significant effect on business cycle correlations, or that different barriers have had offsetting effects on these correlations.

in the coefficient on the distance variable from positive to negative. The problem is that for this data set the subsamples are too short (11 years) to identify the role of distance, size and border. The change in the border effect is indeed insignificant. More informally, Figure 2 also confirms that there is no evidence of a change in the border effect. For a given distance, the correlations remain substantially lower between French and German regions (squares) than between regions of the same country (diamonds).

For the U.S.-EU data set almost all of the drop in the border effect is due to a lower correlation across U.S. regions.[12] Table 4 shows that the average correlation across European countries remains practically unchanged from the first to the second half of the sample, while for the U.S. regions both the employment and output growth correlations dropped by 0.2. If the drop in the common border coefficient were the result of increased integration across European countries we would have expected the exact opposite: a rise in the average correlation across European countries towards a level seen across U.S. regions. The drop in the correlation across the U.S. regions is statistically significant, so we cannot simply attribute it to a sample-specific change in the importance of common shocks. Figure 3 shows that seven of the correlations between U.S. regions drop to a level near zero. These all involve the Census region that contains Texas and are therefore likely to be related to the drop in oil prices in the 1980s. However, this only explains a small part of the drop in correlations. The figure shows that there was a general shift downwards from correlations concentrated between 0.8 and 1 to correlations mostly below 0.8.

3.4 Literature Comparison

Because there is not much evidence in the literature on the U.S.-Canada border effect, in this section we limit ourselves to a discussion of other papers that shed light on the European border effect.[13]

Our results are generally in line with the existing evidence on business cycle correlations. Bayoumi and Eichengreen (1993) find that growth rates are substantially more correlated among the 8 U.S. regions defined by the BEA than among 11 EU countries.

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[12] Consistent with this, Clark (1998) finds that shocks specific to U.S. Census regions have increased in relative importance in recent years. According to Clark's variance decomposition, the increased relative importance of region–specific shocks is due primarily to the secular decline in manufacturing's share of total employment.

[13] Many papers focus on a broader range of countries when comparing intranational to international data. We will not discuss those here. See Clark and Shin (1999) for an overview.

They find that both demand and supply shocks are more correlated in the U.S. and that the U.S. regions adjust more quickly to these shocks than EU countries. Wynne and Koo (1997) also find that business cycle correlations are substantially higher among U.S. regions than among European countries. They use data for the 11 Euro zone countries and for the 12 Federal Reserve Districts, although the latter requires some approximations as the Districts do not always follow state borders. Applying the Baxter and King (1995) filter, they obtain differences between correlations in the U.S. and Europe of a similar magnitude to what we find.

Our results are also generally consistent with the related literature that decomposes the sources of within–country and cross–country fluctuations into common, national, region–specific, and industry–specific components. While few studies make explicit comparisons between within–country and cross–country results, Clark and Shin (1999) find that the bulk of the evidence indicates that national shocks play a much larger role in fluctuations across countries than regional shocks in fluctuations within countries. Although much of the cross–country evidence from this literature is based on non–EU nations, such as the G7, estimates in Clark and Shin indicate that the basic pattern in the literature applies to comparisons of U.S. regions to EU nations.

The variance decomposition literature, however, does include some studies that yield contrary results — most notably, Forni and Reichlin (1998).[14] Forni and Reichlin decompose fluctuations in regions of European countries into local, national, and European components. Similarly, fluctuations in U.S. counties are decomposed into local, state, and U.S. national components. According to their estimates, the percent of the variation attributable to state shocks in the U.S. is similar to the variance share attributable to national shocks in Europe. Apart from the different methodology, size differences make it hard to compare our results to Forni and Reichlin's. In particular, U.S. counties and states are generally much smaller than European regions and countries. Moreover, Forni and Reichlin's conclusion that pre-monetary union Europe is already highly integrated

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[14] Two other studies also conclude that EU regions are as integrated as U.S. states, but the results of these studies can be viewed as consistent with the usual finding that EU regions are less integrated. While Bayoumi and Prasad (1997) conclude that common forces are equally important to the BEA regions in the U.S. and EU nations, their estimates show that common shocks are somewhat more important within the U.S. than within EU nations. Viñals and Jimeno (1996) also conclude that variance decompositions are similar for U.S. states and EU nations. But according to their estimates, which are based on unemployment rates, the share of variance in U.S. states due to a national shock is greater than the share of variance in EU nations due to a common EU shock in the year of the shock, as well as in the following three years. Only in the fourth year are the US and EU shares about equal.

is based on a small set of core countries. For a larger set of nine EU countries they find that, on average, the variance of nation-specific shocks is about the same as the variance of European shocks, while in the U.S. the variance of state shocks is less than half the variance of national shocks.

Some authors have looked at changes over time in the correlation patterns. Angeloni and Dedola (1998) find that GDP correlations between Germany and other EU countries were much higher during the period 1993-1997 than during 1986-1992, which they describe as a tendency towards the fulfillment of optimal currency area conditions. One has to be careful drawing conclusion from this though as these correlations are based on very short 5-year intervals. While the authors do not report standard errors, our own findings indicate that standard errors can become very large over such short periods. A large drop in the correlation with the German business cycle reported by Angeloni and Dedola from 1979-1985 to 1986-1992 appears consistent with the view that sampling variation, rather than increased integration, is driving these changes over short intervals.

Another paper that has studied changes in European correlation patterns over time is Fatás (1997), who uses a data set of annual employment growth rates of regions within Germany, Italy, France, and the UK. Fatás finds that from 1966-1979 to 1979-1992 the average correlation with the aggregate EU-12 annual employment growth has increased by 0.05, while the average correlation with the regions's own country growth rate has dropped 0.15.[15] During the most recent half of the sample the average correlation with the EU-12 aggregate (0.48) is not much lower than the average correlation with a region's own country (0.57).

These findings are not necessarily inconsistent with ours. First, in the absence of border effects one may expect a region's correlation with the EU-12 aggregate to be substantially larger than with the region's own country as a result of the larger size of the EU-12. Without controlling for size it is hard to draw conclusions. Second, Fatás' results are consistent with our finding that cross-country correlations have not changed much. Fatás finds that over the same two sub-periods the correlation between national employment growth rates of the EU-12 countries with the EU-12 aggregate increased only slightly from 0.49 to 0.57. This change is likely to be statistically insignificant (standard errors are not reported). Our own calculations show that for the same set of countries (except Luxembourg) the average cross-country correlation increased from 0.22 to 0.25. The standard error on the small 0.03 increase is 0.08.

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[15] This drop in within-country correlations is concentrated in the UK and Italy. In Germany and France within-country correlations have not changed much, as we report in Table 4.

4 What Accounts for the Border Effect?

In this section we consider some potential explanations for the border effect. Although in principle there are many factors that can play a role, we focus on three aspects that have received considerable attention in the debate about European Monetary Union: sectoral specialization, trade, and exchange rate volatility.

4.1 Production Structure

Trade barriers and industrial policy are likely to have an affect on production structures, which in turn can affect business cycle synchronization. As noted by Clark (1998), Imbs (1998b), and Krugman (1993), among others, greater similarity in production structures is likely to increase business cycle correlations. Industry–specific shocks will create more comovement among regions with similar production structures than among regions with dissimilar structures. To the extent that regions within a country have more similar production structures than regions in different countries, some of the border effect may be attributable to sectoral specialization.

To measure similarity in industry specialization, we adopt the absolute value index suggested by Krugman (1991). Letting s_{nj} and s_{nk} denote the GDP shares for industry n in regions j and k, the similarity of region j's and region k's production structures is measured as

$$\sum_{n=1}^{N} |s_{nj} - s_{nk}|. \tag{5}$$

Because industry specialization may affect business cycle comovement through a variety of mechanisms, we measure specialization with several different sectoral breakdowns. As detailed in the appendix, we use one broad measure that covers essentially 10 one–digit industries, a narrower measure that covers 8 one–digit non–manufacturing industries and 8 two–digit manufacturing industries, and, in results not reported, a measure based on just 8 two–digit manufacturing industries. If, as suggested by Long and Plosser (1983), among others, business cycles are driven by shocks specific to broad industries, the degree of specialization across broad industries will be an important determinant of the degree of regional comovement. On the other hand, to the extent barrier–free trade allows specialization in the production of traded goods, specialization in manufacturing may be important.

Most of the existing evidence on specialization is based only on the manufacturing sector. Krugman (1991) presents evidence showing that manufacturing is more specialized across 4 large U.S. regions than across the 4 largest European countries. He expresses concern that business cycles may become less synchronized in Europe when the degree of specialization becomes similar to that in the United States. But as pointed out by Peri (1998), the comparison is not valid because the U.S. data are for 1977, while the EU data are for 1985. As shown in Kim (1995), the nine U.S. Census regions have become gradually less specialized during the post-war period. Peri (1998), based on the same U.S. regions and European countries as in Krugman (1991), finds that in 1986 the degree of specialization in the U.S. was about the same as that in Europe.

Our own findings indicate that U.S. Census regions are, by most measures, less specialized than EU nations. For example, as shown in Figure 4, our 10 sector–based specialization index across Census regions is about 0.24 since the mid-1980s, compared to an average of about 0.30 for EU nations. Our narrower 16-sector index produces roughly the same figures. When coverage is limited to 8 two-digit manufacturing industries, specialization is roughly the same in U.S. Census regions and EU nations, consistent with Peri (1998). Figure 4 also confirms the trend towards decreased regional specialization in the U.S. documented in Kim (1995). In Europe the extent of specialization has not changed much since the mid-1980s, a finding also reported by Peri (1998).

Ultimately, industry specialization helps explain cross–region correlations, but fails to account for much of the border effect. Table 5 reports estimates of the role of specialization for the two datasets for which GDP data by sector are available, the U.S.-Canada dataset and the U.S.-EU dataset. Since we do not have comprehensive data for the first half of the sample, we only report regression results based on the second half of the sample.[16] For provinces and states, the degree of similarity in production structure has considerable explanatory power for business cycle correlations, but virtually no effect on the estimated border coefficient. For example, using correlations based on annual percent changes in employment and the narrower specialization index based on 16 sectors, the specialization coefficient has a t-value of 4.5.[17] But the estimated border coefficient is -0.07, the same obtained when specialization is excluded (Table 3). The reason is that the estimate of production structure similarity is about the same for regions in dif-

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[16] For U.S.-Canada, we average sectoral output shares from 1984 to 1993 because many industries were not covered in Canada before 1984. For the U.S.-EU we use average sectoral output shares from 1980 to 1993. Data are not available after 1993 for several countries.

[17] This is consistent with the variance decomposition literature, which has documented that industry-specific shocks are an important component of the variance of regional U.S. and Canadian growth rates. See Clark and Shin (1999).

ferent countries as for regions in the same country. While not reported in the interest of brevity, regressions using specialization based on 8 manufacturing industries produced the same basic conclusion, with the modification that specialization's explanatory power is more limited.

For the U.S.-EU data set we limit ourselves to 11 EU countries because of incomplete data for Portugal, Spain and Ireland. We therefore also report the regression without the structure variables in order to better evaluate the impact of the structure variables on the border coefficient. As was the case for the U.S.-Canada data set, industry specialization has strong explanatory power when using annual employment growth data. But its effect is small and insignificant for GDP growth rates. We are not sure what causes this difference. As shown in Figure 5, specialization tends to have more explanatory power across Census regions than across EU nations.[18] Although including the structure variables does not change the border effect when using annual GDP growth rates, it lowers it somewhat based on employment growth rates: from 0.41 to 0.36 for the 10-sector index, to 0.32 for the 16-sector index, and to 0.39 for the index based on 8 manufacturing sectors. The fact that European countries are more specialized than U.S. regions therefore can account for at most a small part of their lower business correlations.

Changes in the extent of specialization are unlikely to account for the decline in the border effect documented in section 3. While the approximately constant degree of specialization in Europe is consistent with the unchanged business cycle correlations across European countries, the decrease in specialization in the U.S. clearly cannot explain the lower business cycle correlations across U.S. Census regions.

4.2 Trade

With regards to trade we would like to address two questions. First, can the European border effect be explained by a much lower level of trade than among U.S. Census regions? Second, how much would one expect business cycle correlations among European countries to have increased due to a higher level of intra-European trade during the second half of the sample?

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[18] But when specialization is measured using 8 two–digit manufacturing industries, this result is reversed: specialization has more explanatory power across EU countries than the Census regions. This last result is consistent with findings in the variance decomposition literature, based on 2-digit manufacturing sectors, that industry-specific shocks are a larger source of variation in European countries than in U.S. regions. See Clark and Shin (1999).

The answer to the first question is complicated by the absence of data on merchandise trade between the Census regions. We first evaluate the importance of bilateral European trade in regressions involving only European business cycle correlations. Bilateral merchandise trade between the EU-14 countries is available from the IMF Direction of Trade Statistics. In order to determine how much European business cycle correlations would rise if the level of trade were similar to that among the Census regions, we combine the regression results with an approximation of *average* trade between the Census regions.

We use two data sets to approximate U.S. trade. The first is the 1993 Commodity Flow Survey, compiled by the Bureau of the Census. It provides data on both within-state and cross-state shipments, covering mostly manufacturing and wholesale trade.[19] There are two important differences between these shipments data and the merchandise trade data. First, the Commodity Flow Survey data include all shipments, including products that are re-sold rather than produced. The merchandise trade data excludes re-exports. Second, the sectoral coverage is not exactly the same. Although the Commodity Flow Survey includes almost all of manufacturing, it excludes agriculture and part of mining, while it includes wholesale trade.

We aggregate the data of shipments between the states to shipments between the Census regions. These numbers overstate the extent of trade because all shipments are counted, rather than just shipments from source to final destination. We scale down the numbers by using a second data set that provides information on overall domestic merchandise trade. Following Helliwell (1997,1998) and Wei (1996), we approximate this as gross output in agriculture, mining and manufacturing, minus merchandise exports.[20] The total for 1993 is 3025 bln. dollars, compared to 5846 billion dollars in shipments from the Commodity Flow Survey. For each set of Census regions we therefore scale down shipments by 3025/5846. While this may give a poor estimate of merchandise trade for a particular set of Census regions (particularly ones with large harbors or unusually large or small wholesale trade), on average it should be quite close.

We consider five different measures of trade. The first two, taken from Frankel and

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[19] Details about this data set can be found on the web site www.bts.gov. Beyond manufacturing and wholesale trade, also included in the survey are part of mining (excluding oil and gas extraction), catalog and mail-order houses, and motion picture and videotape distribution.

[20] Gross output data are available in Table 4.1 of the United Nations National Accounts Statistics.

Rose (1998), capture the bilateral trade intensity between regions j and k:

$$TRADE^1_{jk} = \frac{1}{T}\sum_t \frac{X_{jkt} + M_{jkt}}{Y_{jt} + Y_{kt}} \tag{6}$$

$$TRADE^2_{jk} = \frac{1}{T}\sum_t \frac{X_{jkt} + M_{jkt}}{X_{j\cdot t} + X_{k\cdot t} + M_{j\cdot t} + M_{k\cdot t}}, \tag{7}$$

where X_{jkt} denotes total nominal merchandise exports from region j to k, M_{jkt} represents imports to j from k, Y_{jt} denotes nominal GDP in region j, $X_{j\cdot t}$ is global exports from j, and $M_{j\cdot t}$ represents global imports to j.

One might expect the level of trade between two regions to be proportional to the product of their GDPs, as opposed to the sum of their GDPs. As formalized in Deardorff (1998), bilateral trade between i and j, multiplied by world GDP and divided by the product of the GDPs of i and j, is equal to one if preferences are homothetic and there are no trade barriers.[21] More generally it is a function of transport costs and tariff barriers.[22] Based on this, we construct a third bilateral trade measure as follows:

$$TRADE^3_{jk} = 0.5\frac{1}{T}\sum_t \frac{(X_{jkt} + M_{jkt})Y^W_t}{Y_{jt} * Y_{kt}}, \tag{8}$$

where Y^W_t is world GDP.

The advantage of this trade measure is that it is comparable across pairs of regions that are of very different size. The first two trade measures are both size dependent. They are expected to be higher for larger regions. Because the third trade measure depends on trade barriers, but not on size, it provides a more accurate picture of the extent of integration among regions. Figure 5 shows a time series of the third trade measure for EU-14 trade. The level of trade among European countries has substantially increased over time. It is about 50% higher at the end of the sample than at the beginning of the sample, rising from 0.48 in 1960 to 0.73 in 1996.[23]

All trade measures described so far only capture bilateral trade. Business cycle correlations may also be affected by trade with other regions or countries. For example, the business cycles of Greece and Denmark may be correlated not because of bilateral trade

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[21] There is only final goods trade in Deardorff's model. Taking into account intermediate and capital goods trade, the number can be expected to be larger than one in the absence of trade barriers.

[22] See also Wei (1996).

[23] The temporary blip in the 1980s is a result of the large dollar appreciation and depreciation during that period, which affected the dollar value of European trade and GDP more than the dollar value of world GDP.

relationships, but because they are indirectly connected through their trade with other European countries. The final two trade variables are designed to capture similarity in trade patterns:

$$TRADE^4_{jk} = \frac{1}{T}\sum_t \left[\sum_{s\neq j,k} \left| \frac{X_{j,s,t}+M_{j,s,t}}{X_{j\cdot t}+M_{j\cdot t}} - \frac{X_{k,s,t}+M_{k,s,t}}{X_{k\cdot t}+M_{k\cdot t}} \right| \right] \tag{9}$$

$$TRADE^5_{jk} = \frac{1}{T}\sum_t \left[\sum_{s\neq j,k} \left| \frac{X_{j,s,t}+M_{j,s,t}}{\sum_{l\neq j,k}(X_{j,l,t}+M_{j,l,t})} - \frac{X_{k,s,t}+M_{k,s,t}}{\sum_{l\neq j,k}(X_{k,l,t}+M_{k,l,t})} \right| \right]. \tag{10}$$

Consider again Greece and Denmark. For each country we compute the fraction of their trade that is done with European countries other than each other. This leads to a vector of trade shares with other European countries. $TRADE^4_{jk}$ measures the absolute distance between these trade vectors, which is lower when trade patterns are more similar. The last trade measure does the same, except that in computing the trade vectors we normalize by total European trade (excluding j and k), so that the elements of the trade vectors sum to one.

Three issues arise when including trade variables in European business cycle regressions. First, when adding these trade variables to a regression of correlations on a constant, distance and size, the coefficient on distance becomes small and insignificant. This is exactly what one would expect when the effect of distance on business cycle correlations takes place mostly though its effect on trade. We therefore take distance out of the regressions. Second, Frankel and Rose (1998) argue that trade may be endogenous. In particular, countries whose business cycles are highly correlated are better candidates for an optimum currency area and may therefore adopt a monetary policy leading to more stable bilateral exchange rates. This, in turn, could increase the level of trade. In order to avoid such endogeneity problems we instrument the trade variable. The instruments we use are distance, a common border dummy, a dummy variable that is one if two countries' legal systems have the same origin,[24] and a measure of central bank independence (from Cukierman et.al. (1992)). Finally, we also would like to exploit the fact that trade has increased during the sample, which may have increased business cycle correlations. We therefore estimate regressions for the first and second half of the sample jointly, assuming that the sampling error v in (1) is uncorrelated across the subsamples. The sub-samples are 1961-1979 and 1980-1997.

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[24] One might argue that countries with more similar financial systems trade more. La Porta et.al.(1997) establish that the character of a country's financial system is related to the origin of its legal system. The legal families are English, Scandinavian, French and German.

The results are reported in Table 6. In order to save space we only report results for two business cycle measures, annual growth rates of employment and GDP. We use natural logarithms of the bilateral trade measures. The last column reports the increase in the average business cycle correlation that is the result of the increase in average trade from the first to the second half of the sample. This is computed by multiplying the coefficient on trade by the change in the average level of trade.

All trade measures have the expected sign, and almost all are highly significant. Although not reported in the table, adding the production structure variables has little effect on the coefficient, and significance, of the trade variables. The last column shows that the increase in the level of trade from the first to the second half of the sample can be expected to raise business cycle correlations by at most 0.05. Such a small change is consistent with the finding in Table 4 that European business cycle correlations have remained almost unchanged.

A simple comparison of U.S. and EU trade levels suggests that the European countries are already quite integrated in terms of trade relationships. Using the approximation for U.S. trade described above we find that the average level of $Trade^3_{ij}$ is 0.87 in 1993, while for the European countries the average is 0.67, a difference of only 30%. With regards to trade patterns we do not find any evidence at all of differences between Europe and the United States. For both we find that the average of $Trade^5_{ij}$ is 0.54 in 1993.

In order to determine to what extent the higher level of the third trade measure in the U.S. can contribute to higher business cycle correlations in the U.S. we need to compare the average of $ln(Trade^3_{ij})$ after controlling for distance. We regress $ln(Trade^3_{ij})$ for 1993 European trade on a constant and distance. After substituting the average distance between the Census regions, we find that the average $ln(Trade^3_{ij})$ would be -0.94 in Europe if the average distance were the same as between the Census regions. This needs to be compared with the average of -0.32 among the Census regions.

We therefore expect $ln(Trade^3_{ij})$ to rise on average by 0.62 in Europe if EU countries became equally integrated as the Census regions. Using the coefficient on the third trade measure, this implies an increase in European business cycle correlations of 0.08 for annual employment growth and 0.06 for GDP growth. 10% confidence intervals of the border effect accounted for by trade are respectively (0.05,0.11) and (0.04,0.09). These results suggest that only a small part of the observed border effect can be accounted for by trade.

Evidence from the U.S.-Canada data set further strengthens the view that the European border effect is not primarily the result of a low level of European trade. If trade were an important factor in accounting for the European border effect, we would also expect to see a large U.S.-Canada border effect. Mccallum(1995) and Helliwell (1998) find that trade between Canadian provinces is a factor 10 to 20 larger than trade between Canadian provinces and U.S. states, after controlling for distance and size. This is an even much larger difference than between EU countries and U.S. Census regions.[25] The fact that we do not observe a strong U.S.-Canada border effect in business cycle synchronization suggests that trade is unlikely to play a key role.[26]

We have attempted to directly measure the importance of trade for business cycle synchronization of states and provinces by adding the third trade measure to the U.S.-Canada regression. This does not provide much information though, for two reasons. First, we need to exclude the state-state correlations because we do not have comparable interstate trade data. Second, the regions are on average very small, so that bilateral trade becomes a poor proxy for overall trade relationships. When, for the second half of the sample, we add bilateral trade to a regression of correlations on a constant, border dummy, size and distance, the coefficient on trade is insignificant and often has the wrong sign. Distance, however, remains significant. Distance is probably a better proxy for overall trade connections than bilateral trade in this case.

4.3 Exchange Rate Regime

An important question in the context of European Monetary Union is the impact of the exchange rate system on business cycle synchronization. It is possible that the exchange rate system has indirect effects on business cycle comovements through its long run impact on trade and specialization. The question we would like to address here though is whether there is an immediate effect of the exchange rate regime itself on business cycle comovement, separate from its effects on trade and specialization.

Theoretically a fixed exchange rate system (or a single currency) may either lower or

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[25] The small size of Canada as a whole plays a role in explaining the high level of trade between the provinces. We find that the average of $Trade^3_{ij}$ in 1993 is 13.5 for the Canadian provinces, versus 0.87 for the Census regions. To the extent that there are trade barriers between Canada and the U.S., it raises trade between the existing provinces much more than would be the case if there were 12 times as many provinces (in which case Canadian GDP would be about the same as U.S. GDP).

[26] Maybe related to this, Schmitt-Grohe (1998) finds that a wide class of international real business cycle models is unable to explain through trade relationships the cyclical response of the Canadian economy to fluctuations in U.S. output.

raise correlations. One may argue that the absence of monetary policy flexibility does not allow countries to dampen idiosyncratic shocks through adjustments in interest rates and exchange rates. This should lead to lower correlations under a fixed exchange rate system and larger business cycle fluctuations. This has long been the main argument of sceptics of the single European currency.[27] On the other hand, one may also argue that a flexible exchange rate system leads to lower business cycle correlations. Money demand shocks, or bad monetary policy, can contribute to idiosyncratic fluctuations that would not be present under a fixed exchange rate. Exchange rate volatility unrelated to fundamentals can also reduce business cycle correlations. Finally, it has been argued that exchange rate flexibility insulates a country from external shocks, thus reducing correlations, although this argument no longer holds with substantial international capital mobility.

Ultimately the question is an empirical one. The existing evidence is mixed. Artis and Zhang (1997,1999) report evidence of a negative relationship between exchange rate volatility and business cycle correlations for a large set of OECD countries. They also point out that business cycle correlations of countries joining the ERM have increased. Frankel and Rose (1998) do not find any evidence that business cycle correlations are affected by the exchange rate system. Using data for 21 industrial countries, they estimate with instrumental variables a regression of business cycle correlations on trade and the period-average of a dummy that is one when the country has a mutually fixed exchange rate. The coefficients on the dummy variable are mostly negative (implying a negative effect of exchange rate stability on correlations), but they are almost always insignificant.

Table 7 reports results when adding exchange rate volatility to the regression of European business cycle correlations.[28] Because for many countries exchange rate volatility has changed from the first to the second half of the sample, we again estimate jointly the two halves of the sample. We measure exchange rate volatility as the standard deviation of changes in the natural logarithm of the quarterly exchange rate during each subsample. Instruments are the same as in the trade regressions.

For both employment growth and GDP growth we find that exchange rate volatility

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[27] Martin Feldstein, in a November 1997 Foreign Affairs article, went so far as to raise the prospect of war. For a detailed discussion of difficulties that EMU countries are likely to face in the adjustment to asymmetric shocks, see Obstfeld and Peri (1998).

[28] We have also experimented with adding exchange rate volatility to the joint EU-EU regression, but then the exchange rate volatility variable becomes highly correlated with the common border dummy as the exchange rate is constant among the U.S. regions.

has a negative effect on correlations when it is the only variable in the regression (together with sample-specific constants). The negative relationship still holds when adding size to the regression. However, in neither case is the coefficient statistically significant. Moreover, the negative relationship collapses when either distance or trade variables are included. While distance and trade have the correct sign and are statistically significant, the coefficient on exchange rate volatility becomes a large positive number. In most cases it remains insignificant. Adding production structure to the regression (not shown in the table) does not alter this conclusion.

These results are consistent with those in Frankel and Rose (1998). It casts doubt on the view that the higher business cycle correlations in the U.S. are a result of exchange rate stability and that adopting a single currency in Europe will itself be enough to achieve similar business cycle comovements as observed in the United States. We do not want to completely rule out though that exchange rate stability has a positive effect on correlations. The standard errors are quite large. One problem is that the instruments for exchange rate volatility are not as good as for trade. The instruments explain 37% of the cross-section variation of exchange rate volatility, versus 63% for the third trade variable. Another problem is that trade and exchange rate volatility are negatively correlated. The cross section correlation between the third trade measure and exchange rate volatility is -0.55 during the first half of the sample, and -0.30 during the second half of the sample.

The average exchange rate volatility during the first half of the sample (0.028) is almost the same as during the second half of the sample (0.029). Therefore, no matter one's view on the impact of exchange rate volatility, we would not expect to see a change in European business cycle correlations across the two subsamples. This is again consistent with the almost unchanged correlations across the two subsamples. None of the factors that we have considered would lead us to expect a substantial increase in European business cycle correlations.

5 Conclusion

We set out in this paper to answer three key questions. First, is there evidence of a border effect in the synchronization of business cycles? Second, has this border effect changed over time? Third, what accounts for the border effect? In answering these questions we have focused on the U.S.-Canada border and inter-European borders. The main conclusions can be summarized as follows. We find that the U.S.-Canada border has, at most, a weak effect on business cycle correlations between states and provinces. On the other hand, there is a large and statistically significant European border effect. The average business cycle correlation between a region in France and a region in Germany is considerably lower than that of regions within the same country. Moreover, business cycle correlations are substantially lower across European countries than across U.S. Census regions, even after controlling for distance and size. The European border effect has become somewhat smaller during the second half of the sample (80s and 90s), but this is the result of lower correlations across the Census regions rather than increased synchronization of European business cycles.

We have shown that both the lower level of trade, and the higher degree of sectoral specialization, contribute to the lower European business cycle correlations. But together they cannot fully explain the European border effect. Moreover, the evidence does not indicate that bilateral exchange rate flexibility in Europe has reduced business cycle correlations and contributed to the border effect.

Therefore the size of the European border effect remains a bit of a puzzle. One important topic for future research is to obtain a better understanding of the relationship between trade and business cycles. Bilateral trade is at most a proxy of the intricate trade relationships that exist between regions and countries. One might expect that the business cycle comovements between two regions depend not only on the total level of trade between them, but also on trade with others and the type of goods that are traded. We are likely to achieve a better understanding of the connection between trade and business cycle synchronization in the context of fully developed trade models.

Future research also needs to consider other factors, such as fiscal policy, capital mobility, labor mobility, and technology dissemination. More work also needs to be done to obtain a better understanding of the role of exchange rate volatility. Standard errors are too large to draw definitive conclusions about the importance of exchange rate volatility. If one can demonstrate that exchange rate stability contributes to positive business cycle correlations, it could also help in understanding the low U.S.-Canada border effect. For each half of the sample the standard deviation of bilateral exchange rate volatility for U.S.-Canada is about half the average bilateral volatility across the EU nations.

6 Data Appendix

6.1 U.S.-Canada

Employment data are monthly, seasonally unadjusted, non–farm payroll figures spanning 1961:1–1998:9. The state and province data were obtained from the U.S. Bureau of Labor Statistics (U.S. BLS) and Statistics Canada, respectively. The full Canadian time series were obtained by splicing 1961:1–1983:3 series based on an earlier version of Canada's payroll survey to 1983:1–1998:9 series based on the current version of the survey. The earlier version of the survey covered only firms with at least 20 employees and excluded employees in the education, health and welfare, and public administration. Our results are based on annual and quarterly period averages of monthly data seasonally adjusted using the X11 filter in RATS.

Distances between states and provinces are measured as the geographic distance between capital cities. Specifically, distances are calculated as a function of the latitudes and longitudes of capital cities, using Arcview GIS mapping software. Our measure of each region's size is based on population, also from Arcview GIS mapping software. U.S. state populations are for 1990, while Canadian province populations are for 1991.

Industry specialization is measured using 1984-93 data on nominal gross state product (GSP) and provincial GDP at factor cost, obtained from the U.S. Bureau of Economic Analysis (U.S. BEA) and Statistics Canada. The U.S. and Canadian data are reported according to 1987 and 1980 SIC codes, respectively. Comparable industry definitions are determined by mapping sectors to the ISIC, Revision 3, using U.S. Bureau of the Census publication "International concordance between the industrial classifications of the United Nations (ISIC Rev.3) and Canada (1980 SIC), the European Union (NACE Rev.1), and the United States (1987 SIC)". Our first index of specialization covers 10 broad sectors, listed below. Another, more narrow index covers 16 sectors — the eight non–manufacturing industries included in our broad index and the eight manufacturing sectors listed below. Our final measure of specialization is based on just the 8 manufacturing sectors.

Annual 1988-95 data on merchandise trade between provinces and between provinces and states were kindly provided by John Helliwell. The trade variables used in the analysis span just 1988-93 because our first measure of trade requires nominal GDP data, and, as described above, the provincial GDP series end in 1993. U.S. nominal GDP is converted to Canadian dollars using annual average exchange rates.

Broad Industries

Agriculture, forestry, and fishing	Transportation, storage, and communications
Mining	Electric, gas, and sanitary
Construction	Wholesale and retail trade, and restaurants and hotels
Manuf.–durable goods	Finance, insurance, real estate, and business and legal services
Manuf.–nondurable goods	Community, personal, and other services and government

Manufacturing Industries

Wood and wood products	Non-metallic mineral products
Basic metals	Fabricated metals and machinery and equipment
Food, beverages, and tobacco	Paper and paper products and printing and publishing
Textile, apparel, and leather	Chemicals and coal, rubber and plastic products

6.2 French and German Regional Data

Annual employment data for 1970-92 were kindly provided by Antonio Fatas. Real GDP data by region for 1982-96 were obtained by deflating nominal regional GDP with national GDP deflators. Nominal GDP data are from Eurostat's REGIO database. Deflators are implicit price indexes from the OECD's Quarterly National Accounts. The NUTS 1 regions we use are listed below.

Distances between the NUTS 1 regions are measured as population–weighted averages of geographic distances between the NUTS 3 regions within each NUTS 1 region. As in the U.S.–Canada comparison, distances between NUTS 3 regions are a function of latitude and longitude. The latitude and longitude of a NUTS 3 region are defined as the coordinates of the center of a box drawn around the region (with minimum excess

Regions in France and Germany

France	Germany
Ile de France	Schleswig-Holstein and Hamburg
Bassin Parisien	Niedersachsen and Bremen
Nord Pas-de-Calais	Nordrhein-Westfalen
Est	Hessen
Ouest	Rheinland-Pfaltz and Saarland
Sud-Ouest	Baden-Wuttenburg
Centre-Est	Bayern
Mediterranee	Berlin

area). The distance between NUTS 1 regions j and k is then

$$D_{jk} = \sum_{l \in j} \sum_{m \in k} \frac{P_l P_m}{P_j P_k} D_{lm}, \tag{11}$$

where D and P denote distance and population, respectively. The population data needed for the France–Germany distance and size variables are January 1, 1994 estimates from the Arcview GIS mapping software.

6.3 U.S.–Europe

The U.S. Census regions are simple aggregates of states, defined below. Unless otherwise noted, Census Region data are derived as simple sums of source state data. For simplicity, just the state sources are detailed below. The European countries we use are Austria, Belgium, Denmark, Finland, France, West Germany, Greece, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom.

New England: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont
Middle Atlantic: New York, New Jersey, Pennsylvania
South Atlantic: Delaware, District of Columbia, Florida, Georgia, Maryland, N. Carolina, S. Carolina, Virginia, West Virginia
East South Central: Alabama, Kentucky, Mississippi, Tennessee
West South Central: Arkansas, Louisiana, Oklahoma, Texas
East North Central: Illinois, Indiana, Michigan, Ohio, Wisconsin
West North Central: Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota
Mountain: Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming
Pacific: California, Oregon, Washington, Alaska, Hawaii

Annual employment data for 1961-97 were obtained from the U.S. BLS (as described above) and the OECD's Annual Labor Force Survey.[29] Annual, 1964-96 real GDP data for U.S. states and EU-14 countries are from the U.S. BEA and the OECD's National Accounts database, respectively.[30] Real GDP by state is measured using (i) 1964-76

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[29] For EU nations, 1997 figures are calculated using growth rates from national sources. West German values for 1991-97 are approximated using German growth rates.

[30] National sources were used to estimate 1995 and 1996 values for West Germany.

nominal GSP deflated by the U.S. GDP (chain–weight) deflator and (ii) 1977-96 chain–weighted real GSP.

The distance between any two Census regions is a population–weighted average of the distances between the component states (measured from capital to capital). The distance between two EU-14 countries is a population–weighted average of the distances between the NUTS 3 regions comprising each nation, calculated using the above France–Germany methodology. The population data needed to calculate these distance variables and to measure the size of the regions are January 1, 1994 estimates from the Arcview GIS mapping software.

Industry specialization is measured using annual, 1977-96 nominal GSP by state and 1976-1993 gross value added by country, obtained from the BEA and the OECD's National Accounts database. In our reported regression results for employment (GDP) growth, specialization is measured using average industry shares over 1979-93 (1980-93) using the same industry breakdown as in the U.S.–Canada analysis.

Annual bilateral merchandise trade data for EU-14 countries over 1960-97 are from the IMF's Direction of Trade Statistics database. West German trade levels for 1990-97 are adjusted using German growth rates. The annual nominal GDP data required in our first and third trade variable are taken from the IFS database, with EU-14 GDP converted to U.S. dollars using exchange rates from the IFS.

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Data Set	business cyle variable (N=employment) (Y=GDP)	Average Within-Country Correlation	Average Cross-Country Correlation	Border Dummy
Canada and United States	$\frac{\Delta N}{N}$-annual	0.54	0.40	0.14
1320 within-country correlations		(0.05)	(0.09)	(0.08)
(state-state,province-province)	$\frac{\Delta N}{N}$-quarterly	0.43	0.25	0.18
510 cross-country correlations		(0.04)	(0.06)	(0.05)
(state-province)	N-annual,HP(10) filtered	0.60	0.42	0.18
N-annual:1961-1997		(0.04)	(0.07)	(0.08)
N-quarterly:1961:01-1998:03	N-quarterly,HP(1600) filtered	0.60	0.38	0.22
		(0.04)	(0.07)	(0.07)
Nuts 1 regions within	$\frac{\Delta N}{N}$-annual	0.61	0.19	0.42
Germany (8) and France (8)		(0.08)	(0.08)	(0.09)
56 within country correlations	$\frac{\Delta Y}{Y}$-annual	0.74	0.43	0.31
64 cross-country correlations		(0.06)	(0.12)	(0.11)
N: 1970-1992	N-annual,HP(10) filtered	0.66	0.32	0.34
Y: 1982-1996		(0.05)	(0.10)	(0.07)
	Y-annual,HP(10) filtered	0.81	0.43	0.37
		(0.05)	(0.10)	(0.11)
United States (9 Census Regions)	$\frac{\Delta N}{N}$-annual	0.71	0.20	0.51
and European Union (14 countries).		(0.05)	(0.03)	(0.06)
36 within-country correlations	$\frac{\Delta Y}{Y}$-annual	0.84	0.47	0.37
(US regions); 91 cross-country		(0.04)	(0.05)	(0.07)
correlations (EU countries)	N-annual,HP(10) filtered	0.78	0.29	0.49
N: 1961-1997		(0.04)	(0.04)	(0.05)
Y: 1963-1996	Y-annual,HP(10) filtered	0.81	0.41	0.40
		(0.06)	(0.04)	(0.08)

Table 1: Cross-Region Business Cycle Correlations

Data Set	Business Cycle Variable	Sample Period	Common Border	ln(Distance)	Size
Canada-United States	$\frac{\Delta N}{N}$-annual	1962-1997	0.06	-0.14	0.057
			(0.08)	(0.02)	(0.011)
	$\frac{\Delta N}{N}$-quarterly	1961:2-1998:3	0.11	-0.10	0.063
			(0.05)	(0.01)	(0.008)
	N-annual,HP(10) filtered	1961-1997	0.11	-0.13	0.02
			(0.08)	(0.02)	(0.009)
	N-quarterly,HP(1600) filtered	1961:1-1998:3	0.14	-0.12	0.067
			(0.07)	(0.01)	(0.007)
France-Germany	$\frac{\Delta N}{N}$-annual	1971-1992	0.40	-0.04	0.015
			(0.09)	(0.05)	(0.032)
	$\frac{\Delta Y}{Y}$-annual	1983-1996	0.23	-0.14	0.159
			(0.12)	(0.03)	(0.052)
	N-annual,HP(10) filtered	1970-1992	0.33	-0.01	-0.023
			(0.09)	(0.04)	(0.042)
	Y-annual,HP(10) filtered	1982-1996	0.30	-0.13	0.149
			(0.11)	(0.02)	(0.040)
United States-European Union	$\frac{\Delta N}{N}$-annual	1962-1997	0.51	-0.11	0.037
			(0.08)	(0.03)	(0.020)
	$\frac{\Delta Y}{Y}$-annual	1964-1996	0.33	-0.07	0.061
			(0.06)	(0.02)	(0.013)
	N-annual,HP(10) filtered	1961-1997	0.49	-0.09	0.026
			(0.07)	(0.04)	(0.012)
	Y-annual,HP(10) filtered	1963-1996	0.40	-0.09	0.032
			(0.08)	(0.02)	(0.020)

Table 2: Role of the National Border After Controlling for Size and Distance

Data Set	Business Cycle Variable	Sample Period	Common Border	ln(Distance)	Size	change Border Coefficient
Canada-United States	$\frac{\Delta N}{N}$-annual	1962-1979	0.18	-0.13	0.087	
			(0.11)	(0.03)	(0.016)	
		1980-1997	-0.07	-0.17	0.044	-0.24
			(0.11)	(0.03)	(0.016	(0.16)
	$\frac{\Delta N}{N}$-quarterly	1961:2-1979:4	0.16	-0.09	0.074	
			(0.07)	(0.02)	(0.011)	
		1980:1-1998:3	0.03	-0.11	0.051	-0.13
			(0.07)	(0.02)	(0.011)	(0.10)
	N-annual,HP(10) filtered	1962-1979	0.27	-0.10	0.06	
			(0.12)	(0.02)	(0.012)	
		1980-1997	-0.04	-0.15	0.056	-0.31
			(0.12)	(0.024)	(0.012)	(0.17)
	N-quarterly,HP(1600) filtered	1961:2-1979:4	0.27	-0.10	0.075	
			(0.10)	(0.02)	(0.010)	
		1980:1-1998:3	0.01	-0.13	0.060	-0.26
			(0.10)	(0.02)	(0.010)	(0.14)
France-Germany	$\frac{\Delta N}{N}$-annual	1971-1981	0.48	0.12	0.096	
			(0.13)	(0.08)	(0.045)	
		1982-1992	0.27	-0.15	-0.036	-0.21
			(0.13)	(0.08)	(0.045)	(0.16)
	N-annual,HP(10) filtered	1971-1981	0.39	0.13	0.107	
			(0.12)	(0.06)	(0.061)	
		1982-1992	0.24	-0.09	-0.082	-0.15
			(0.12)	(0.06)	(0.061)	(0.17)
United States-European Union	$\frac{\Delta N}{N}$-annual	1962-1979	0.65	-0.16	-0.014	
			(0.11)	(0.04)	(0.028)	
		1980-1997	0.35	-0.11	0.065	-0.30
			(0.11)	(0.04)	(0.028)	(0.16)
	$\frac{\Delta Y}{Y}$-annual	1965-1980	0.39	-0.08	0.076	
			(0.09)	(0.03)	(0.019)	
		1981-1996	0.20	-0.10	0.070	-0.19
			(0.09)	(0.03)	(0.019)	(0.13)
	N-annual,HP(10) filtered	1962-1979	0.70	-0.17	-0.011	
			(0.10)	(0.05)	(0.017)	
		1980-1997	0.39	-0.06	0.050	-0.31
			(0.10)	(0.05)	(0.017)	(0.14)
	Y-annual,HP(10) filtered	1965-1980	0.44	-0.10	0.048	
			(0.11)	(0.04)	(0.028)	
		1981-1996	0.32	-0.04	0.035	-0.12
			(0.11)	(0.04)	(0.028)	(0.16)

Table 3: Change in the Role of National Borders

Data Set	Business Cycle Variable	Sample Period	Average Within-Country Correlation	Change	Average Cross-Country Correlation	Change
Canada-United States	$\frac{\Delta N}{N}$-annual	1962-1979	0.52 (0.07)		0.24 (0.13)	
	$\frac{\Delta N}{N}$-annual	1980-1997	0.47 (0.07)	-0.05 (0.10)	0.46 (0.13)	0.21 (0.19)
	$\frac{\Delta N}{N}$-quarterly	1961:2-1979:4	0.39 (0.06)		0.15 (0.09)	
	$\frac{\Delta N}{N}$-quarterly	1980:1-1998:3	0.44 (0.06)	0.04 (0.08)	0.33 (0.09)	0.18 (0.13)
	N-annual,HP(10)	1962-1979	0.65 (0.06)		0.31 (0.10)	
	N-annual,HP(10)	1980-1997	0.58 (0.06)	-0.07 (0.09)	0.54 (0.10)	0.23 (0.14)
	N-quarterly,HP(1600)	1961:2-1979:4	0.62 (0.10)		0.27 (0.09)	
	N-quarterly,HP(1600)	1980:1-1998:3	0.60 (0.06)	-0.02 (0.08)	0.51 (0.09)	0.24 (0.13)
France-Germany	$\frac{\Delta N}{N}$-annual	1971-1981	0.67 (0.12)		0.26 (0.11)	
	$\frac{\Delta N}{N}$-annual	1982-1992	0.62 (0.12)	-0.05 (0.17)	0.26 (0.11)	0.00 (0.16)
	N-annual,HP(10)	1971-1981	0.70 (0.08)		0.39 (0.14)	
	N-annual,HP(10)	1982-1992	0.63 (0.08)	-0.07 (0.11)	0.34 (0.14)	-0.05 (0.20)
United States-European Union	$\frac{\Delta N}{N}$-annual	1962-1979	0.79 (0.07)		0.19 (0.05)	
	$\frac{\Delta N}{N}$-annual	1980-1997	0.59 (0.07)	-0.20 (0.10)	0.21 (0.05)	0.02 (0.07)
	$\frac{\Delta Y}{Y}$-annual	1965-1980	0.84 (0.05)		0.41 (0.07)	
	$\frac{\Delta Y}{Y}$-annual	1981-1996	0.64 (0.05)	-0.20 (0.07)	0.40 (0.07)	-0.01 (0.10)
	N-annual,HP(10)	1962-1979	0.85 (0.06)		0.21 (0.05)	
	N-annual,HP(10)	1980-1997	0.72 (0.06)	-0.13 (0.08)	0.30 (0.05)	0.09 (0.07)
	Y-annual,HP(10)	1965-1980	0.85 (0.08)		0.40 (0.06)	
	Y-annual,HP(10)	1981-1996	0.76 (0.08)	-0.09 (0.11)	0.42 (0.06)	0.02 (0.08)

Table 4: Change in Correlations

Data Set	Business Cycle Variable	Sample Period	Common Border	Log Dist.	Size	Structure (Broad)	Structure (Narrow)
Canada-United States	$\frac{\Delta N}{N}$-annual	1980-1997	-0.06	-0.14	0.005	-0.85	
			(0.11)	(0.03)	(0.019)	(0.19)	
			-0.07	-0.14	0.005		-0.86
			(0.11)	(0.03)	(0.019)		(0.19)
	$\frac{\Delta N}{N}$-quarterly	1980:1-1998:3	0.03	-0.09	0.023	-0.63	
			(0.07)	(0.02)	(0.013)	(0.13)	
			0.03	-0.09	0.023		-0.65
			(0.07)	(0.02)	(0.014)		(0.14)
	N-annual,HP(10) filtered	1980-1997	-0.04	-0.13	0.025	-0.67	
			(0.12)	(0.03)	(0.013)	(0.10)	
			-0.05	-0.13	0.026		-0.66
			(0.12)	(0.03)	(0.014)		(0.10)
	N-quarterly,HP(1600) filtered	1980:1-1998:3	0.01	-0.11	0.032	-0.61	
			(0.10)	(0.02)	(0.011)	(0.10)	
			0.01	-0.11	0.033		-0.61
			(0.10)	(0.02)	(0.012)		(0.10)
United States-EU(11)	$\frac{\Delta N}{N}$-annual	1980-1997	0.41	-0.16	0.056		
			(0.10)	(0.04)	(0.022)		
			0.36	-0.15	0.058	-0.69	
			(0.11)	(0.04)	(0.022)	(0.27)	
			0.32	-0.13	0.059		-0.87
			(0.11)	(0.04)	(0.022)		(0.28)
	$\frac{\Delta Y}{Y}$-annual	1981-1996	0.22	-0.11	0.043		
			(0.10)	(0.04)	(0.026)		
			0.22	-0.11	0.043	-0.05	
			(0.10)	(0.04)	(0.026)	(0.24)	
			0.22	-0.11	0.043		-0.04
			(0.10)	(0.04)	(0.026)		(0.23)

Table 5: The Border Effect and the Role of Industry Specialization

Business Cycle	Size	ln(Trade1)	ln(Trade2)	ln(Trade3)	Trade4	Trade5	Implied Δ Correlation ’62-’79 to ’80-’97
$\frac{\Delta N}{N}$-annual	-0.003	0.117					0.050
	(0.026)	(0.030)					(0.013)
	-0.028		0.136				0.027
	(0.028)		(0.032)				(0.006)
	0.054			0.127			0.052
	(0.020)			(0.036)			(0.015)
	0.017				-0.31		0.016
	(0.021)				(0.21)		(0.011)
	0.023					-0.21	0.021
	(0.019)					(0.12)	(0.012)
$\frac{\Delta Y}{Y}$-annual	0.045	0.077					0.033
	(0.013)	(0.019)					(0.008)
	0.029		0.090				0.018
	(0.013)		(0.021)				(0.004)
	0.085			0.104			0.043
	(0.017)			(0.026)			(0.011)
	0.014				-0.88		0.044
	(0.020)				(0.19)		(0.010)
	0.035					-0.52	0.052
	(0.018)					(0.11)	(0.011)

Table 6: EU-14 Trade Regressions

Business Cycle	Exchange Rate Volatility	Size	Distance	ln(Trade1)	ln(Trade2)	ln(Trade3)
$\frac{\Delta N}{N}$-annual	-7.31 (6.29)					
	-8.72 (6.02)	0.042 (0.019)				
	40.39 (21.66)	-0.036 (0.027)	-0.53 (0.19)			
	22.08 (15.69)	-0.064 (0.034)		0.256 (0.094)		
	15.80 (13.45)	-0.088 (0.042)			0.245 (0.088)	
	17.47 (15.63)	0.063 (0.025)				0.269 (0.110)
$\frac{\Delta Y}{Y}$-annual	-3.82 (3.53)					
	-6.33 (3.85)	0.075 (0.016)				
	19.46 (11.65)	0.034 (0.025)	-0.28 (0.10)			
	12.45 (8.77)	0.010 (0.030)		0.156 (0.048)		
	8.61 (7.70)	-0.004 (0.034)			0.149 (0.047)	
	18.45 (9.20)	0.095 (0.015)				0.255 (0.066)

Table 7: EU-14 Regressions: The Role of Exchange Rate Volatility

Figure 1 Employment Growth Correlations: US-Canada

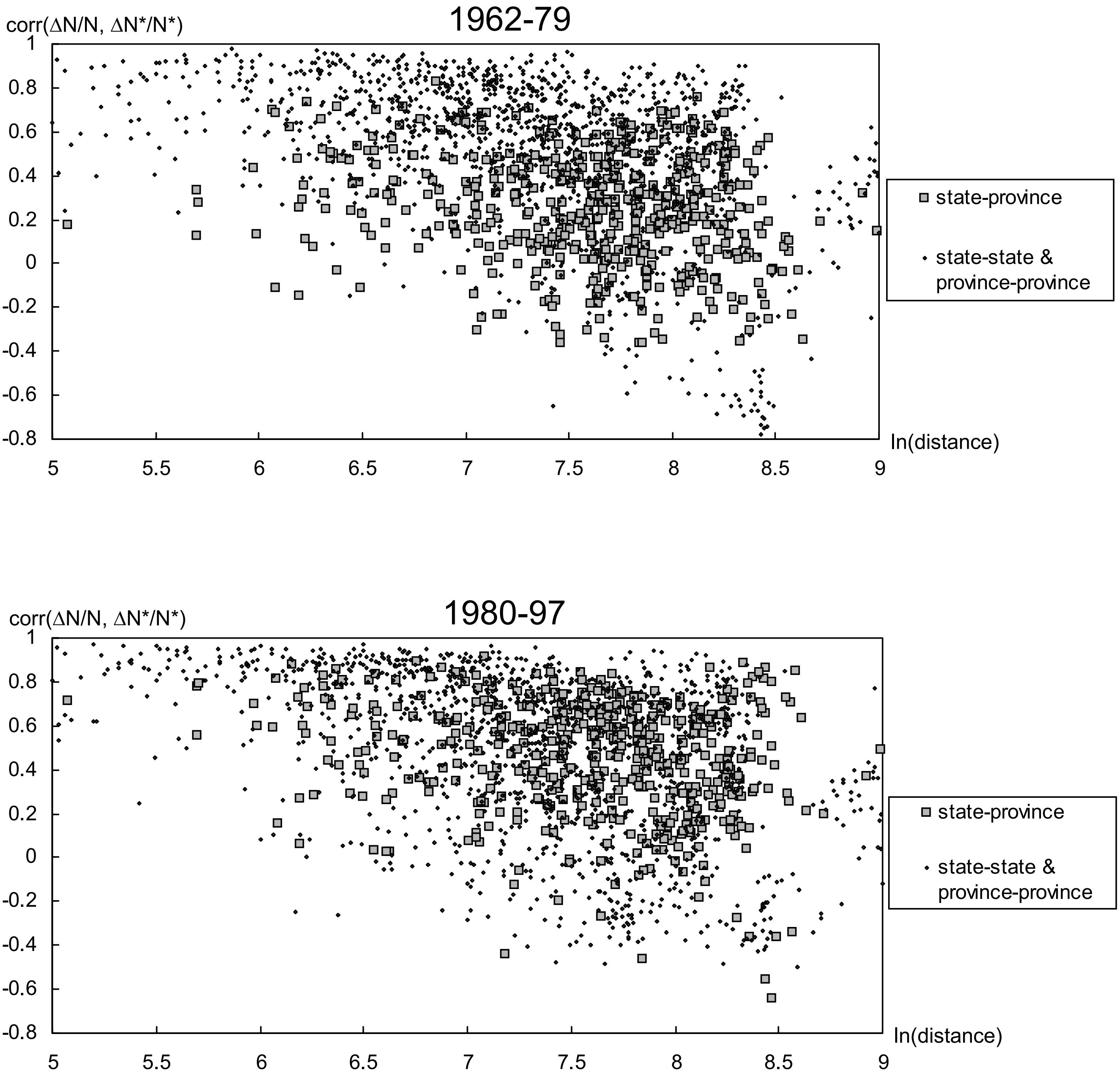
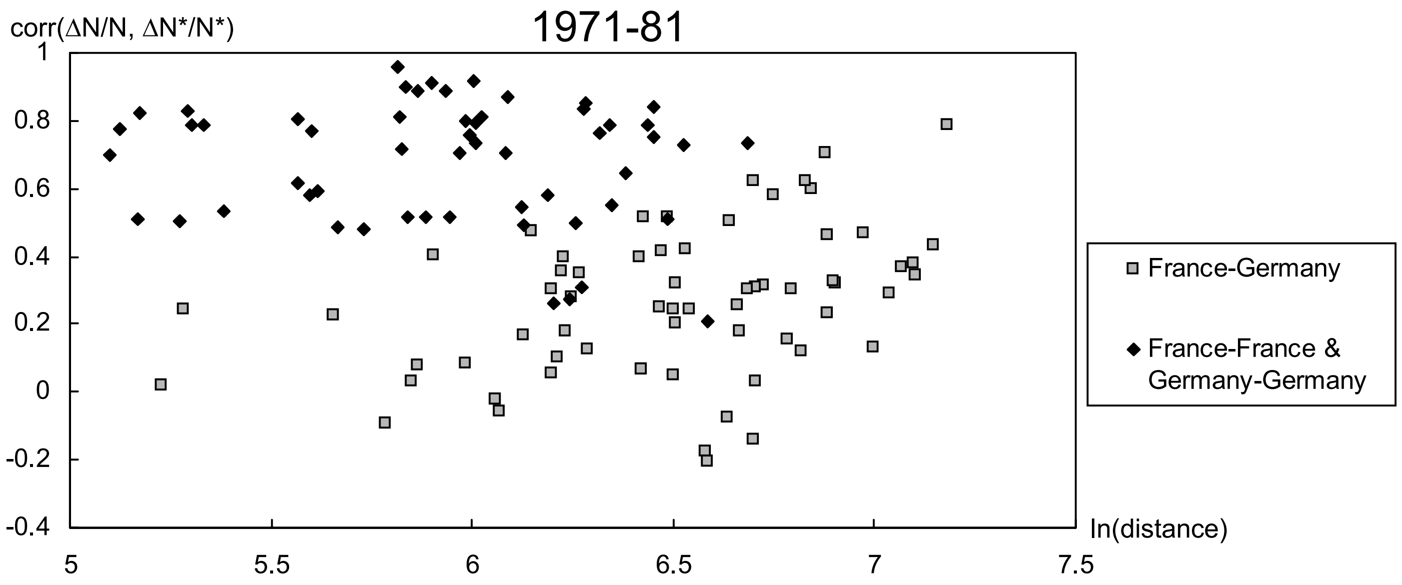


Figure 2 Regional Employment Growth Correlations: France & Germany



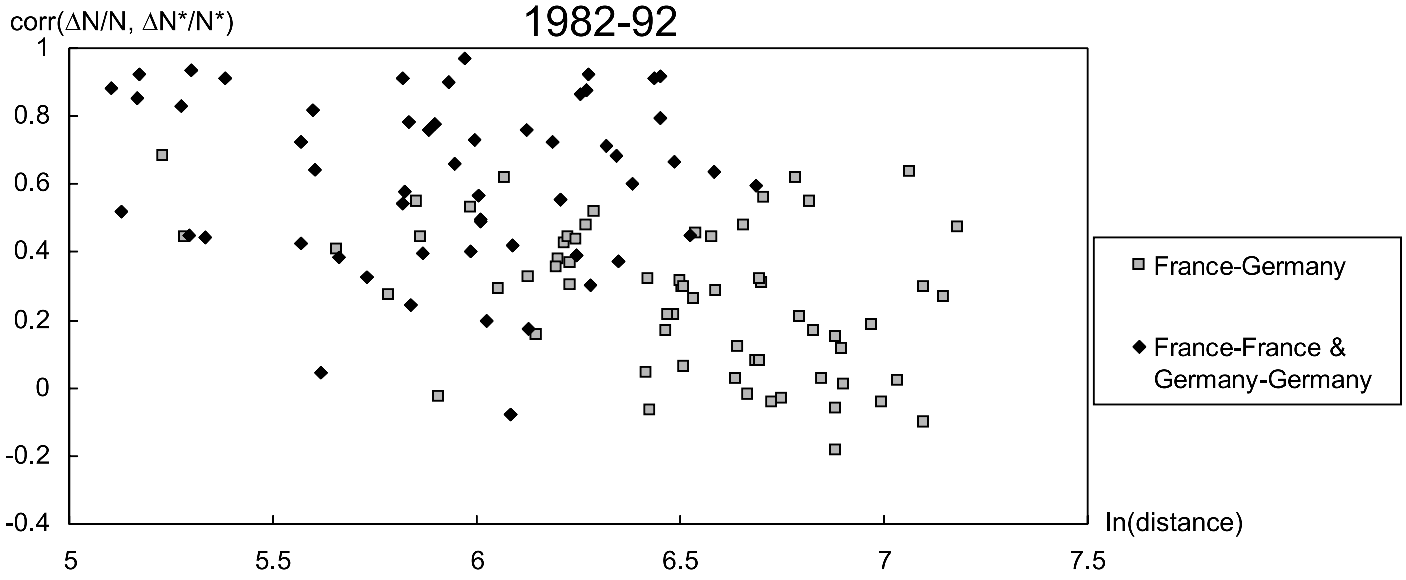
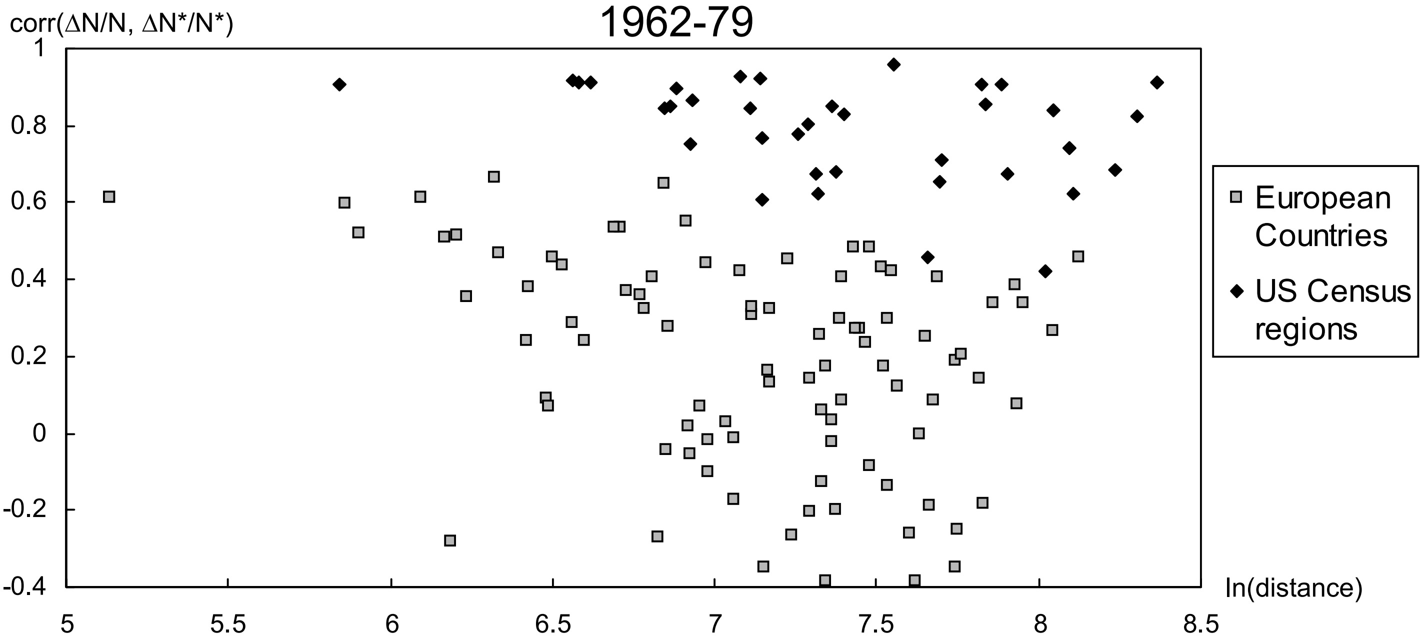


Figure 3 Employment Growth Correlations: US-Europe



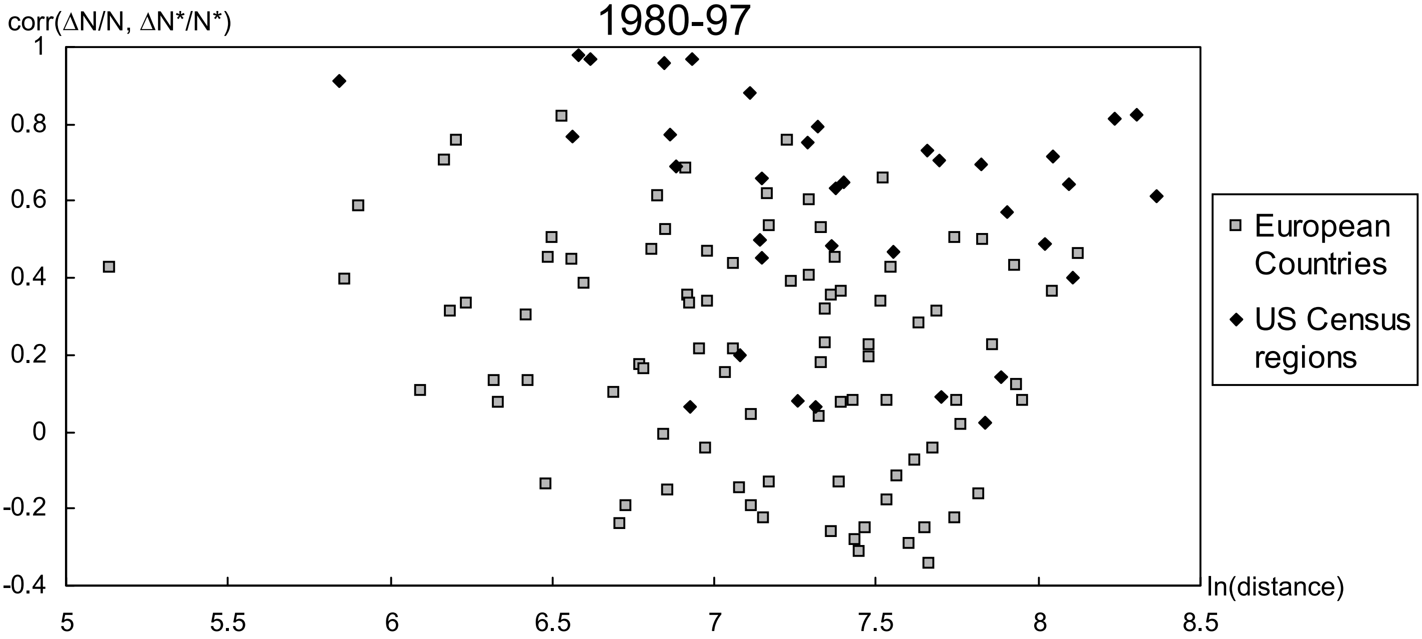
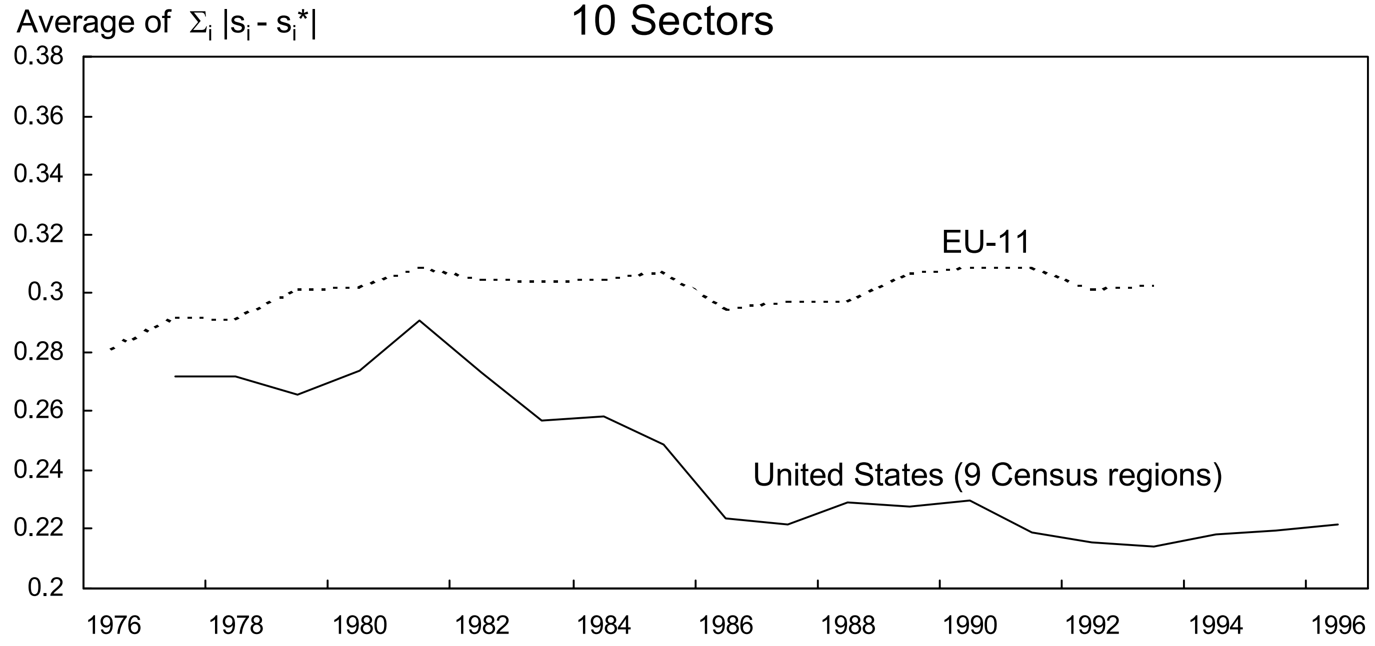
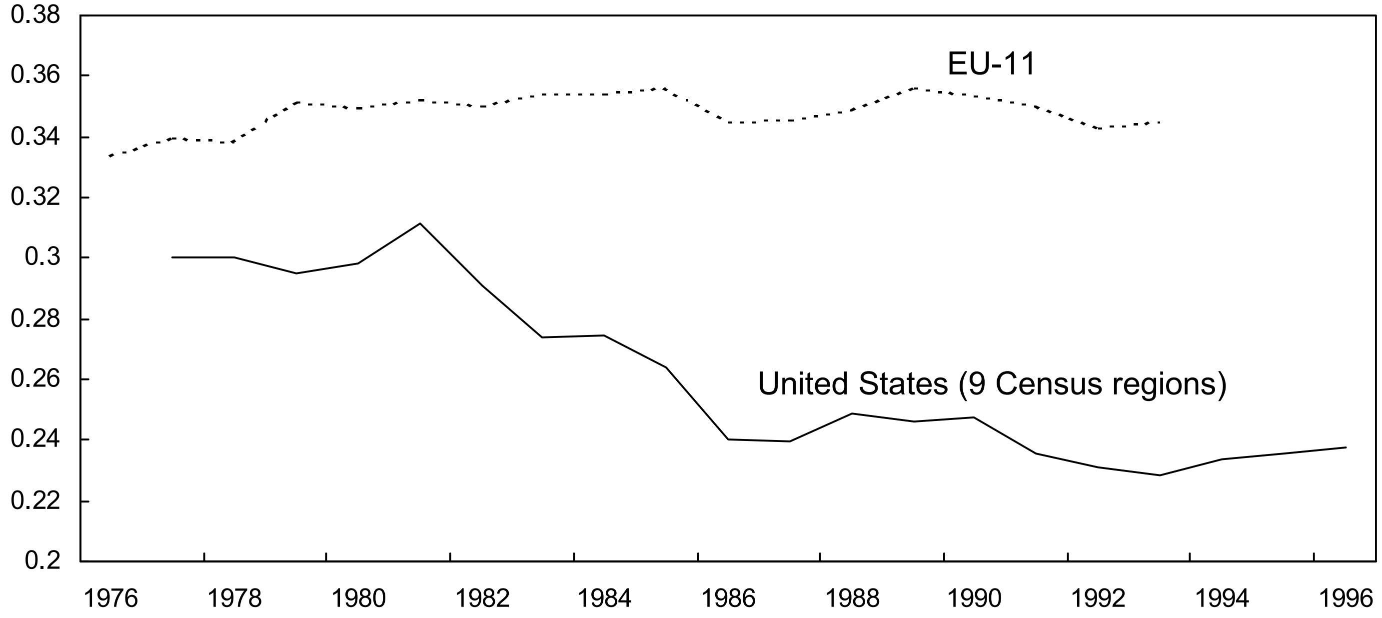


Figure 4   Specialization Indices

10 Sectors

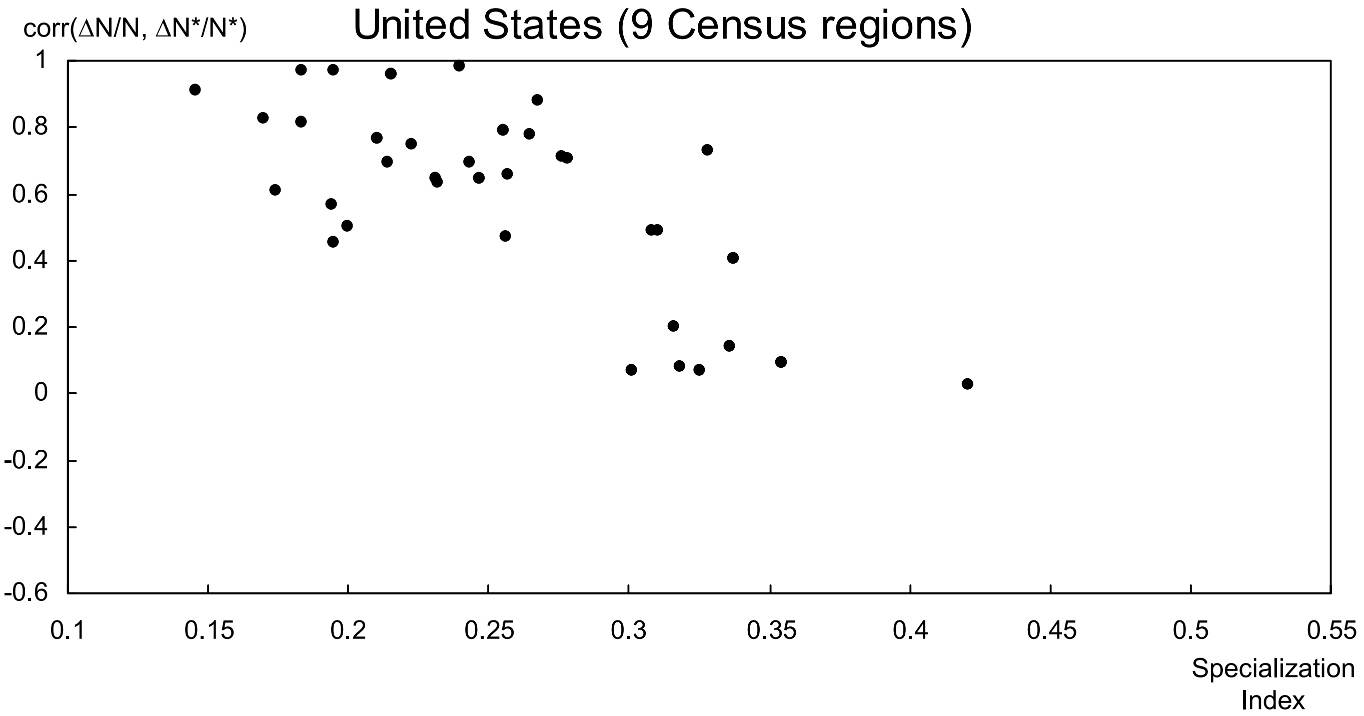


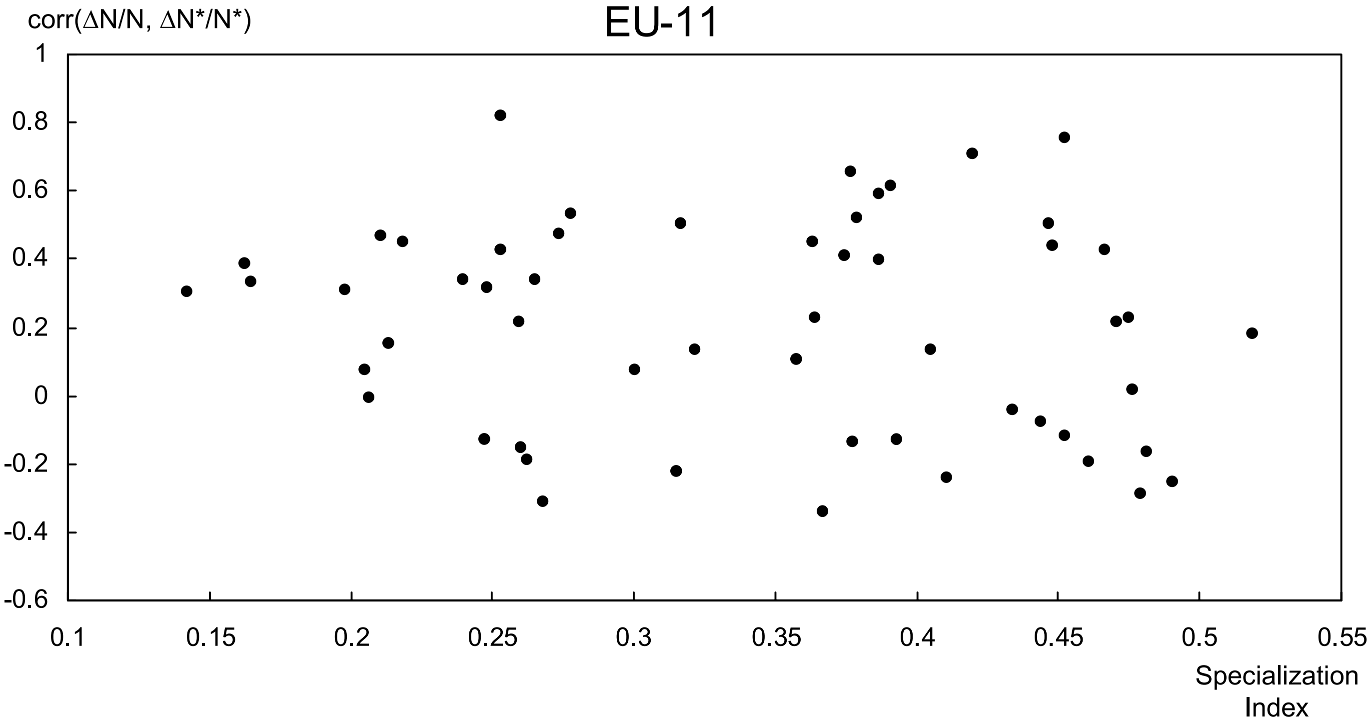
16 Sectors



Notes: These graphs show an average index of specialization for both the 9 US Census regions and 11 EU countries (all except Ireland, Luxembourg, Portugal and Spain). The index is an average, across all pairs of regions or countries, of the absolute distance between the vectors of sectoral output shares (s_i = GDP share of industry i). The results are shown for a set of 10 broad sectors and a set of 16 sectors. The latter breaks down the "durables" and "non-durables" manufacturing sectors into eight two-digit industries (see data appendix).

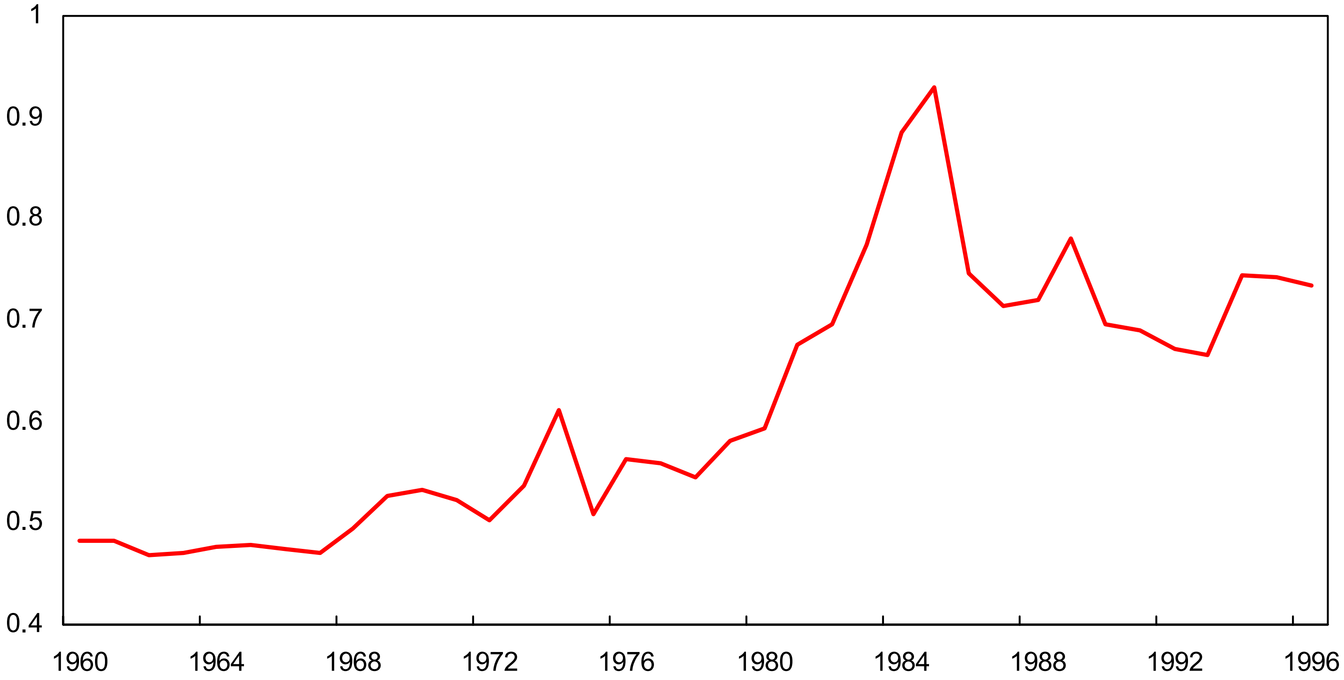
Figure 5 Correlation vs. Specialization


United States (9 Census regions)


EU-11

Note: These graphs show for both the 9 US Census regions and 11 EU countries (all except Ireland, Luxembourg, Portugal and Spain) the relationship between specialization and the business cycle correlation. The business cycle correlation is based on annual employment growth from 1980 to 1997. The specialization index for a set of regions or countries is based on the absolute difference between the vector of sectoral output shares, using data for 16 sectors (see data appendix) and averaged over the period 1977-1993.

Figure 6 Average Bilateral Trade Intensity EU-14 Countries



Note: This figure shows the average bilateral trade intensity for trade between EU-14 countries. The bilateral trade intensity between two countries i and j is defined as $0.5(X_{ij} + M_{ij})*Y^W/(Y_i * Y_j)$, where X and M are exports and imports, Y^W is world GDP and Y_i and Y_j are GDP of countries i and j.