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ABSTRACT

Co-Fluctuations*

This Paper provides novel evidence on the determinants of the synchronization in business cycles. I find trade has surprisingly small quantitative effects. On the other hand, pairs of countries with higher aggregate income level experience significantly more synchronized business cycles and this happens largely because they have similar sectoral production patterns. Geographic considerations do not matter systematically. The results hold for a large sample of countries with very different income levels, as well as within the OECD. They are robust to different filtering devices, across yearly and quarterly frequencies and for a variety of data sources. These findings are interpreted in a model where international income disparities correspond to differences in production patterns and thus to different degrees of exposure to common sectoral stochastic developments.

JEL Classification: E32, F12, F41
Keywords: international business cycles, trade, sectoral shocks

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NON-TECHNICAL SUMMARY

Upon reading the current press, there seems to be little doubt that it has become impossible for countries to insulate themselves from foreign developments. Openness to trade is by far the most frequently cited culprit for this apparent globalization of cycles: Japan enters a recession for purely domestic reasons and insofar as a significant proportion of its exports target the Japanese market, the rest of Asia can only suffer from it. Within the academic profession, however, few economists would agree that this is the sole, or even most important, mechanism. There are two reasons for this restraint. First, openness as measured for instance by the share of exports to GDP rarely reaches levels compatible with promoting trade as the sole reason for co-fluctuations, particularly in large economies. Second, economic theory offers no definite answer to the question of what drives the international business cycles.

Backus, Kehoe and Kydland (1994) argue that, through their effect on the interest rate, productivity shocks are decisive in explaining the time pattern of net exports, for they are the source of both a real depreciation and a current account deficit (a capital account surplus caused by an investment boom) on impact. As time passes, the investment boom dissipates and the current account enters surplus. Although it reproduces a well documented empirical regularity coined the ‘J-curve’, this mechanism implies a negative contemporaneous correlation between aggregate outputs, an observation hardly supported by the data. Therefore, subsequent research has shifted emphasis onto alternative models of international fluctuations, most of which, I shall argue, imply that higher output correlation is associated with more intense bilateral trade. An exception is the class of models relying on the existence of a significant common component to the international business cycle.

This Paper makes a first attempt at discriminating between these competing models and in so doing provides an original view on the generation of international cycles. I provide evidence on the determinants of co-fluctuations, measured by GDP bilateral correlations for several sub-samples of the Penn World Tables (PWT) and International Financial Statistics (IFS) datasets. Preliminary evidence points to three sub-groups where cycles are more synchronized: within-Europe, between Europe and the Americas and within the Americas. This somewhat reduces the set of variables that ought to be included as determinants of GDP synchronization, to bilateral trade, the level of aggregate income of a given country pair and geographic considerations, perhaps having to do with proximity or the presence of a common border. But of course this stays mute about the relative importance of different

determinants, which only careful multivariate regression analysis can deliver. The trade-off is therefore to use cross-sectional information on the extent of co-fluctuations to discriminate between alternative models of the international business cycle, at the risk of estimating equations that might suffer from serious multi-colinearity problems. This Paper will argue that econometrically sound estimations can be run to conclude that the extent of cycle synchronization has surprisingly little to do with the intensity of bilateral trade. Rather, two rich countries, as measured by GDP per capita levels, appear to co-fluctuate significantly more than two poor countries, or than one rich and one poor, for that matter. Using three-digit sectoral data from UNIDO, the Paper goes on to compute an index of similarity in economic structure, which is shown to explain very significantly the extent of co-fluctuations at the expense of the income variable. Note that none of these results are driven by considerations of data quality, nor by long-run growth phenomena, for they hold, sometimes even more strongly, in a sample of 21 OECD countries, at the quarterly frequency and across a variety of data sources.

These results are interesting in at least three ways. First, the quantitatively small role of bilateral trade in explaining the extent of co-fluctuations casts doubt on models that place trade in goods at the sole source of international business cycles. Second, the fact that countries sharing similar structures of production tend to co-fluctuate more, irrespective of other pair-specific considerations, brings into light the potential importance of sector-specific world cycles. Third, economic structure matters at the expense of the importance of income levels. Thus, to a large extent, business cycles in rich countries are more synchronized because rich countries tend to share similar sectors and seem therefore perturbed by similar stochastic developments. The data are therefore consistent with a model where the structures of production in different countries converge to a similar degree of diversification as countries grow richer. The Paper finally describes a model in the economic geography tradition where this happens because agglomeration forces are counter-balanced by local congestion costs. There, full international specialization can only occur in specific and unstable, conditions, having to do with the extent of transport costs relative to congestion costs and the world converges sooner or later to a state of affairs where industrial goods are produced in both countries in equal proportions.

1 Introduction

Upon reading the current press, there seems to be little doubt that it has become impossible for countries to insulate themselves from foreign developments. Openness to trade is by far the most frequently cited culprit for this apparent globalization of cycles: Japan enters a recession for purely domestic reasons, and insofar as a significant proportion of its exports target the Japanese market, the rest of Asia cannot but suffer from it. Within the academic profession, however, few economists would agree that this is the sole -or even most important- mechanism. There are two reasons to this restraint. First, openness as measured for instance by the share of exports to GDP rarely reaches levels compatible with promoting trade as the sole responsible for co-fluctuations, in particular for large economies[1]. Further, as argued for instance by Krugman (1996), openness was by some measures actually highest at the end of the nineteenth century, a period of history hardly characterized by questions about globalization[2]. Second, economic theory offers no definite answer to the question of what drives the international business cycles. Backus, Kehoe and Kydland (1994) argue that supply shocks are decisive in explaining the time pattern of net exports, for they are the source of both a real depreciation and a current account deficit (a capital account surplus caused by an investment boom) on impact. As time passes, the investment boom dissipates and the current account enters surplus. Although it reproduces a well-documented empirical regularity coined the "J-curve", this mechanism implies a negative contemporaneous correlation between aggregate outputs, an observation hardly supported by the data. Therefore, subsequent research has shifted emphasis onto alternative models of international fluctuations, most of which, I shall argue, having the implication that higher output correlation is associated with more intense bilateral trade. An exception is the class of models relying on the existence of a significant common component to the international business cycle.

This paper makes a first attempt at discriminating between these competing models, and in so doing provides an original view on the generation of international cycles. I provide evidence on the determinants of co-fluctuations, measured by GDP bilateral correlations for several sub-samples of the Penn World Tables (PWT) and International Financial Statistics (IFS) datasets. Figure 1 reports positive bilateral GDP correlations between 136 countries in PWT[3], sorted geographically for lack of a better univariate

[1] As is well-known, the figure for the U.S. is around 12%. In Japan, it was 9.6% in 1995.

[2] Globalization is actually one of the prominent theses in Marx (1848), but with concern for long-run predictions, rather than international synchronization of economic fluctuations.

[3] Correlations are computed using first-differences of GDP. The correlations reported are limited to the positive subset for clarity of exposition. Conclusions of the subsequent multivariate analysis remain however unchanged when including negative correlations, and that is because highly correlated subgroups of countries are positively correlated. Appendix A lists the countries contained in the different sub-samples utilized in the paper.

criterion a priori. Casual eyeballing points to three sub-groups where cycles are more synchronized: within-Europe, between Europe and the Americas, and within the Americas. This reduces somewhat the set of variables that ought to be included as determinants of GDP synchronization, say to bilateral trade, the level of aggregate income of a given country pair, and geographic considerations, perhaps having to do with proximity or the presence of a common border[4]. But of course the matrix stays mute about the relative importance of different determinants, which only careful multivariate regression analysis can deliver. The tradeoff is therefore to use cross-sectional information on the extent of co-fluctuations to discriminate between alternative models of the international business cycle, at the risk of estimating equations that might suffer from serious multicollinearity problems[5]. This paper will argue that econometrically sound estimations can be run to conclude that the extent of cycle synchronization has surprisingly little to do with the intensity of bilateral trade. Rather, two rich countries -as measured by GDP per capita levels- appear to co-fluctuate significantly more than two poor countries, or than one rich and one poor, for that matter. Using three-digit sectoral data from UNIDO, the paper goes on to compute an index of similarity in economic structure, which is shown to explain very significantly the extent of co-fluctuations at the expense of the income variable. Note that none of these results are driven by considerations of data quality, nor by long-run growth phenomena, for they hold as well in a sample of 21 OECD countries, sometimes even more strongly.

These results are interesting in at least three ways. First, the quantitatively small role of bilateral trade in explaining the extent of co-fluctuations casts doubt on models that place trade in goods at the sole source of international business cycles. Second, the fact that countries sharing similar structures of production tend to co-fluctuate more, irrespective of other pair-specific considerations, brings into light the potential importance of sector specific world cycles. Third, economic structure matters at the expense of the importance of income levels. Thus, to a large extent, business cycles in rich countries are more synchronized because rich countries tend to share similar sectors, and are therefore perturbed by similar stochastic developments[6]. The data are therefore consistent with a model where the structures of production in different countries converge to a similar degree of diversification as countries grow richer. There is wide empirical support for the fact that production structures are evolving to a common pattern, documented for

[4]Although theoretical support for this is unclear, a potentially important omission is capital flows. I shall come back to this issue when discussing results.

[5]Trade is indeed notoriously determined by geographic considerations, and income levels of the trading partners. See for instance Frankel and Romer (1996).

[6]The issue whether unexpected developments occur mostly at the sectoral or at the country level is open. Papers by Stockman (1988) and Costello (1993) provide evidence in favor of country effects. In a recent paper, Ghosh and Wolf (1996) argue however that the result is an artefact of aggregation, which averages away sectoral shocks to a larger extent than national ones. Further, Fatas (1997) or Kollmann (1995) discuss results in support of the present assumption.

instance in the literature on intra-industry trade[7]: the novelty in this paper is to relate that evidence to international fluctuations.

The rest of the paper is structured as follows. Section 2 presents casual evidence based on a sample of 136 countries taken from the Penn-World Tables, and relates it to the literature on international business cycles. Section 3 narrows the focus to 49 countries where both bilateral trade and sectoral data are available, and thus multivariate analysis is possible. Section 4 addresses concerns of robustness, pertaining among others to data quality, frequency and filtering issues, by repeating the analysis for 21 OECD countries. Section 5 briefly presents a model of endogenous structural change in the economic geography tradition, consistent with the evidence. Section 6 concludes.

2 Literature and Preliminary Evidence

This section presents preliminary cross-sectional evidence on the extent of co-fluctuations, as implied by bilateral per capita GDP correlations for a large sample of 136 countries, and relates it to the literature. From a theoretical standpoint, recent research has mostly focused on the generation of positive international GDP correlations - addressing the celebrated *quantity puzzle* coined by Backus, Kehoe and Kydland (1994)- for in the standard international real business cycle model, resources go wherever the return to capital is highest and thus the model generates negatively correlated international fluctuations to the extent that aggregate shocks are imperfectly correlated internationally. On the other hand, world aggregate supply shocks would shut off the capital flow-based mechanism able to reproduce the response over time of the current account after a real depreciation. Resolving this dilemma has been the purpose of a subsequently rich literature, which is next described.

A first branch of the literature promotes trade as the channel whereby countries co-fluctuate. Thus, Kollmann (1998) develops a two-country world where variations in aggregate demand, in the form of money supply shocks, matter for GDP because prices and wages are rigid. There, in response to a positive domestic aggregate demand shock, the standard Keynesian depreciation effect, inducing agents to substitute domestic to foreign goods and thus inducing a fall in foreign aggregate demand, is dominated by a "quantity" and a "price" effects. The former tends to increase foreign aggregate demand since part of the increase in domestic demand falls on foreign goods; and the latter has the same effect, but through a decrease in the foreign price index, that embeds the price of domestic goods, now relatively cheaper. Aggregate demands therefore co-fluctuate[8].

[7] See among many others Krugman and Obstfeld (1997), Chapter 6, or Balassa (1966 and 1979).

[8] Betts and Devereux (1997) show further that the first mechanism will not obtain in an economy with pricing to market, thus improving the ability of the model to generate positive output correlations.

Hornstein and Praschnick (1997) present a two-sector world, where production of capital requires intermediate goods: technology shocks to either sector will result in higher capital production, and thus higher demand for intermediate goods, so that employment and output co-move across sectors. Of course, transferring the mechanism to a two-country setting would highlight the importance of intermediate goods trade in explaining international co-movements[9], as for instance illustrated in Ambler, Cardia and Zimmermann (1998). Notice that these models imply a close positive association between the intensity of bilateral trade, be it in final or intermediate goods, and the extent of co-fluctuations.

A second strand of the literature remains agnostic as to the role for trade. The best example is probably the work of Backus, Kehoe and Kydland (1995): there, it is not clear how the degree of output synchronization will change as bilateral trade rises with the share of foreign goods in domestic production[10]. Such experiments can probably be thought of as the theoretical counterpart to the present empirical approach, and potentially as a way to discriminate further between different mechanisms. Similarly, in Boileau (1996) international reallocation of factors in response to a technology shock has growth effects through the presence of increasing returns to scale, and diffuses back into the origin country in the form of knowledge; further, intersectoral reallocation from non-market to market activities ensures that international output fluctuations be contemporaneously synchronized.

From an empirical standpoint, many authors indeed question that trade in goods be conducive of synchronized business cycles. For instance, Canova and Dellas (1993) find weak evidence supporting the importance of trade interdependence for outputs cross-correlations, and Schmitt-Grohe (1998) shows that it is blatantly insufficient to explain correlation between the U.S and Canadian business cycles. Furthermore, there seems to be wide support for the existence of a significant world component to international cycles. Canova (1993) for instance argues that such a common component is a required ingredient if calibrated models are to replicate the data. Lumsdaine and Prasad (1997) and Forni and Reichlin (1997) take a purely empirical approach and find further evidence in support of a world business cycle. The cross-sectional variation in the extent of co-fluctuation must then be explained through varying exposure to world cycle[11]. For instance, Rodrik (1996) argues that exposure may increase with the degree of openness, and Keller (1997) or

[9] Such a transfer would not be straightforward since it would presumably require extreme assumptions on the specialization pattern of the two countries.

[10] Table 11.8 B on page 351 presents such an exercise in comparative statics, and, although it is only partial, it seems to point to quantitatively very small effects. I thank Dave Backus for pointing this out to me.

[11] An exception is Kraay and Ventura (1997). There, world supply shocks are capital-augmenting, so that foreign booms result in relative scarcity of labor-intensive goods, and in as much as they are traded freely, in domestic wage and employment increases. Co-fluctuations are driven by a combination of factor-price equalization, free trade and common shocks.

Imbs (1998a) show that diffusion of technology occurs with more intensity between close neighbors. The contention here is that exposure to common -sectoral- shocks vary with the pattern of production, as reflected by the degree of industrialization.

In summary, the literature does not appear to provide a definite answer as to why countries co-fluctuate, and one must remain agnostic when addressing the issue empirically. This is illustrated in Figure 1, which reports the positive bilateral correlations between GDP growth for 136 countries in the Penn-World Tables, presented in the original geographic ordering[12]. Figure 2 reports those of the correlations that are negative, and confirms that there is a large majority of positive correlations amongst the 9180 pairs, indeed a quantity puzzle. Further, highly correlated sub-groups tend to be positively correlated, thus including negative correlations as is done subsequently will not modify substantially our results. Three clusters of countries stand out: correlations within Europe, between Europe and the Americas, and within the Americas appear higher than in the rest of the world[13]. Figure 3 gives average correlations by continental sub-groups, inclusive of negative correlations, and although standard errors are too large to support a statistical claim, the three mentioned geographic clusters do indeed stand out, at least as far as point estimates, respectively equal to 0.192, 0.130 and 0.164, vs. 0.073 using the whole sample. Notice that variation is substantial in each sub-groups, thus justifying further the present work. This bears several explanations.

First, geography, proximity or common -continental- institutional agreements, such as the European Community, could matter independently, as suggested for instance in Artis and Zhang (1996) where evidence is presented that a fixed exchange rate regime imposes policy discipline that leads to conformity in business cycles. The importance of the border in particular is studied in Clark and van Wincoop (1999). Membership to international agreements could also confer some credibility liable to foster trade or investment flows. Or in a context of multiple equilibria, proximity could lead to coordination on the same equilibrium, for instance if the same language or media are shared. The clear cluster of high bilateral correlations in Europe argues in favor of such mechanisms, provided it prevails once other factors are accounted for.

Second, Figure 1 is *a priori* consistent with an important role for trade in explaining the cross-section of co-fluctuations. This could happen because of intense bilateral trade links, as is the case for instance within Europe, or across the Atlantic, or because more

[12] Admittedly, this is only illustrative, since each series extends at most from 1950 to 1992, and thus at most 43 x 43 bilateral correlations are independent. Thus, subsequent multivariate regressions are run using samples of fewer countries, though without changing the results.

[13] Most countries have data from 1958 on. Correlation coefficients are of course estimated with error. Our arbitrary discretization into different ranges is meant to -imperfectly- reflect significance levels. Back of the envelope computations show that, given an average number of 35 observations, a correlation above 0.3 is indeed significant at the 5% level.

openness actually results in more exposure to world cycles. However, the importance of trade in goods is somewhat brought into question by the weak synchronization in Asia, since for instance in 1980, average trade within Asia was almost three times higher than intra-American trade[14]. Furthermore, the importance of openness as such becomes dubious upon inspection of Figure 4, that orders countries by degree of openness[15]. As is plain to see, no definite pattern appears. Since measures of openness give of course a very imperfect account of bilateral trade intensity, I use instead data on bilateral exports between 61 countries[16], and present a plot of the relation with GDP correlations in Figure 5. If statistically significant, the correlation is surprisingly small, at 0.226 using 1970 trade data[17]. Thus, explanations based on diffusion through trade in goods seem to find some support in the data, though to an extent that remains unexplored, a fact that motivates inclusion of a bilateral trade variable in the multivariate analysis.

Third, it is a well-known fact, documented for instance in Kraay and Ventura (1998) that richer countries tend to display cycles that are more synchronized. The fact is quite strikingly confirmed in Figure 6, where countries are ordered according to GDP per capita in 1960: each cell representing one bilateral GDP correlation indeed fade almost perfectly to clearer shades of gray as one moves down the distribution of income. The paper interprets cycle synchronization as independently reflecting similarities in the productive structures. If, as argued by numerous authors, stochastic developments at the source of aggregate fluctuations occur at the sectoral level, then economies with a large number of common sectors will display correlated cycles[18]. Next section presents multivariate regressions involving an index of similarity in production patterns, that confirm this is a robust result.

The issue of trade in capital goods, in the form of capital flows or foreign direct investment (FDI), is more problematic, be it only for lack of data at the level of generality endeavoured here[19]. The concern is addressed in three ways. First theoretically, it is far from clear that capital flows should be intense between countries whose cycles are *contemporaneously* synchronized: if anything, diversification motives would encourage flows

[14]When including the U.S and Canada, intra-American trade becomes four times higher than in Asia. These two countries cannot however solely account for the wide discrepancy between degrees of synchronization in Asia and in the Americas. The data is taken from Frankel and Wei (1995).

[15]As measured by the ratio of the sum of exports and imports to GDP.

[16]The data comes from Frankel and Wei (1995). Bilateral trade is equal to the sum of exports in both directions. The countries are listed in Appendix A.

[17]The numbers using 1980 and 1990 trade data are 0.238 and 0.224, respectively.

[18]Kraay and Ventura (1998) is parallel to the present paper, although their focus is theoretical whereas mine is empirical. They identify rich and poor countries with high-tech and low-tech production, respectively. Rather than resorting to sectoral shocks, they argue different market structures cause sectors -and countries- to respond differently to a given aggregate shock.

[19]Both the IMF and the OECD gather data on Foreign Direct Investment. However, the IMF publications do not provide information about the country of origin, and the OECD only reports FDI flows originating from OECD countries.

of capital into countries at different stages of their cycle[20]. Second, data on FDI, though incomplete, hardly shows any tendency for FDI to occur mostly between rich countries, at least when levels are normalized by a measure of the receiving economy's scale. Wei (1995) presents a dataset reporting foreign direct investment originating from the five largest source countries[21]: as shown in Table 1, when normalized by the level of GDP at the receiving end[22], FDI flows between countries whose income per capita levels vary widely, including many developing economies[23]. Thus the claim that most FDI occurs amongst developed countries ought to be qualified somewhat, and it is doubtful that preliminary results in Figure 6 should change dramatically if it were possible to account for bilateral capital flows. Finally, whether financial integration, in the sense of intense international cross-ownership of capital, does indeed matter for co-fluctuations in GDP or not, it probably explains mostly why synchronization is highest amongst rich economies, in contrast with co-fluctuations in Africa or Asia. The same conclusions about the significant impact of income level and productive structure on the extent of co-fluctuations does however hold *within* the OECD, sometimes even more strongly. There, cross-sectional variation in financial integration is in all likelihood too mild to qualify as an omitted variable that is cause for worry[24].

3 Co-Fluctuations and Economic Structure

This part implements the multivariate estimations suggested in the previous section. The purpose is to explain the extent of cycle synchronization by bilateral trade intensity, geographic considerations, such as proximity, the presence of a common border, and potentially the importance of continents, the level of income per capita, and similitudes in the sectoral structure of the economy. This restricts the analysis to 49 countries, listed in Appendix A, where both bilateral trade and sectoral data are available[25], and thus to a sample of 1176 bilateral observations. The mentioned variables explain close to 20% of co-fluctuations, and interestingly, mainly because of income level and similitude in sectoral

[20] This is not to suggest that capital flows do not contribute to the *diffusion* of crises say, over time and across borders.

[21] France, Germany, the U.K, Japan and the U.S.

[22] There is of course no claim this is the relevant measure for a theory of FDI, but it is however used in Borensztein, De Gregorio and Lee (1995), who attempt to estimate growth effects of FDI.

[23] Not to mention the strong sample selection bias that probably results from the fact that missing observations are particularly numerous for developing countries.

[24] In recent work, Portes and Rey (1999) show that gravity variables, and in particular income per capita, predict quite strongly bilateral equity flows between 14 OECD countries. These results are interpreted in Section 4 when discussing results pertaining to the OECD sample.

[25] Data on bilateral trade is from Frankel and Wei (1995), and it covers 61 countries in 1970, 1980, 1990 and 1992. Three-digit sectoral data is from UNIDO, and was used to construct an index of similarities in sectoral production for 49 countries.

production. In particular, bilateral trade matters only weakly, both in an economic and a statistic sense, and in some cases not at all. Geography, in turn, enters independently but with a magnitude that varies substantially while remaining small.

Table 2 presents results corresponding to different specifications. Regression (i) confirms the positive and significant univariate role for bilateral trade[26], but with very little contribution to the cross-sectional variability (R^2 is 0.05). The weak explanatory power of bilateral trade, even when it is the only explanatory variable, turns out to be very robust, and holds across various country samples, and measures of trade (in levels, relative to per capita GDP and relative to total trade) as shown in the Appendix. Specification (ii) adds geographic considerations in the form of the distance between main cities and a dummy variable for the existence of a common border. Signs are as expected, and distant countries tend to be less correlated, whereas neighbors are significantly more synchronized. Notice that the coefficient on trade falls, but by a small amount, and the R^2 augments, but by merely 3%. This is reassuring, for it argues against the presence of problematic multicollinearity.

Multicollinearity is indeed potentially a recurrent issue in the present work, for it is well-known that the pattern of bilateral trade is predicted by considerations of distance, size or proximity between trade partners[27]. However, if perfect multicollinearity results in estimations with infinite uncertainty, the issue is more or less pervasive in most multivariate estimations, and the question is how far one is from perfectly correlated independent variables. Although Section 2 already presented some evidence that the suggested dependent variables provide independent sources of variation, it is useful to recall the three symptoms of multicollinearity discussed in Greene (1993): a) small changes in the data produce wide swings in the estimates, b) coefficients have low significance in spite of quite high R^2, and c) coefficients are implausible. Throughout the paper, coefficients are plausible and estimated quite precisely, and R^2 is never in excess of 30%. To supplement the argument, Table 2 provides a condition number, the ratio of the largest to the smallest characteristic roots of the moment matrix, for each regression. Common practice suggests that multicollinearity becomes a potentially serious problem when the moment condition is in excess of 20. This is not the case in (ii). Finally, Table 2 reports the R^2 corresponding to the regression of trade on the other independent variables, which one would expect to be smaller than that of the whole estimation, as is always the case.

Estimation (iii) includes the sum of GDP per capita in the two countries and their difference in absolute value. Ideally, one would want to discriminate between pairs of

[26]Trade is measured in level. In the Appendix, I show that all results prevail when including trade as a share of GDP, and as a share of total trade.

[27]For instance, Frankel and Romer (1996) use GDP per capita, population, area, distance, adjacency, a landlock dummy variable to instrument for trade in growth regressions. With all the variables and their interactions, they manage to explain 36% of the variation in bilateral trade between 63 countries.

countries where both countries are rich, both are poor, and instances where they have very different income levels. This justifies including both the sum and the difference. For all country pairs (i, j), both Y_i+Y_j and $|Y_i-Y_j|$ enter significantly, though with opposite signs. The coefficient on trade falls substantially, but the impact of geographic variables remains quite unchanged and R^2 jumps to 17%. Estimation (iii) probably suffers from multicollinearity, and that is because Y_i+Y_j and $|Y_i-Y_j|$ carry very similar information. Indeed, coefficients are almost equal and of opposite signs. Thus, Y_j, income level in the poorer country, probably impacts positively GDP correlations, while the sign of Y_i is ambiguous. Regression (iv), where $\mathrm{Min}(Y_i,Y_j)$ and $\mathrm{Max}(Y_i,Y_j)$ are used in place of the previous income variables shows that GDP correlations robustly increase with the income in country j, the poorer of the pair, but that income in i does not matter. Insofar as all other coefficients remain strikingly similar between regressions (iii) and (iv), and the performance of the estimation is essentially identical, it also suggests that including both Y_i+Y_j and Y_i-Y_j carried unnecessary information. Regression (v) drops $\mathrm{Max}(Y_i,Y_j)$ without any substantial effect, except for the moment condition which returns in the range of tolerable values[28]. Thus, results in estimation (v) are probably econometrically sound, and point to the level of income per capita in the poorer country of the pair as a strong determinant of the extent of co-fluctuations, with 9% of the total variation. Trade on the other hand, merely explains 5%, and the geographic variables taken together 2.8% of the total variability. Section 4 will show that this surprising result is not an artefact of data quality, nor is it sensitive to alternative measures of co-fluctuations or bilateral trade. It must therefore be interpreted.

In this paper, this is done by assuming that rich countries tend to produce similar goods, and as a result experience sectoral shocks of equal importance. The convergence of economies to similar production patterns finds support in the literature on intra-industry trade, which documents the large propension of developed economies to trade mostly within the same industry, whereas countries at different levels of development do if anything trade goods from different industries[29]. The relevance of this empirical fact is bolstered by introducing an index of similitude in the sectoral composition of aggregate output using three-digit data from UNIDO to compute a correlation coefficient between sectoral shares in aggregate employment for all country pairs. In particular, define the

[28]The value is still larger than in (ii). This is not surprising: Frankel and Romer (1996) already argued that GDP per capita in the trading partners is a powerful determinant of trade flows, probably more so than geography.

[29]Ambler, Cardia and Zimmermann (1998) estimate the share of trade in intermediate goods at 60% of the total trade volume. See also Hummels, Rapoport and Yi (1998).

correlation between countries i and k:

$$Sector_{ik} = \frac{\sum_{j=1}^{M} s_{ji} \cdot s_{jk}}{\left(\sum_{j=1}^{M} s_{ji}{}^{2}\right)^{1/2} \left(\sum_{j=1}^{M} s_{jk}{}^{2}\right)^{1/2}}$$

where s_{ji} denotes the share of sector j in country i 's employment and M is the number of sectors. Figure 7 plots the *Sector* variable against GDP correlation, with a clear positive pattern. Furthermore, the several examples singled out on Figure 7 are in agreement with the hypothesis that only pairs of rich countries have similar productive structures. Table 3 confirms these speculations: *Sector* is indeed positively correlated with the extent of co-fluctuations, even after distance, adjacency and trade intensity are controlled for. In particular, sharing the same sectors results in higher cycle synchronization irrespective of the extent to which it leads to intra-industry trade. Comparing (iv) and (v) yields further insight on the importance of economic structure: adding *Sector* has nearly no impact on any coefficient estimates, with the interesting exception of the coefficient on the income variable, whose point estimate falls by a quarter. Its degree of significance also falls substantially, and its contribution to the variation in co-fluctuations falls from 9% in (v) to 4.5% in (iv)[30]. Thus, chances are that $\mathrm{Min}(\mathrm{Y_i},\mathrm{Y_j})$ matters in (v) largely because it is a good proxy for the extent to which two countries share the same production pattern. Given estimates in (iv), one standard error increase in bilateral trade intensity results in a correlation higher by 0.019, and one standard error increase in distance results in a coefficient lower by 0.016. The numbers for $\mathrm{Min}(\mathrm{Y_i},\mathrm{Y_j})$ and *Sector* are 0.042 and 0.033, respectively. The data is consistent with a world in which aggregate income per capita grows as economies converges to a given production pattern, with rich countries thus sharing the same sectors. Poor ones on the other hand are characterized by little diversification, or a low value for *Sector* (either with rich countries, or with other poor ones), associated with little co-fluctuations because they share few sectors with the rest of the world[31].

The rest of this section is dedicated to ensuring the robustness of the results. Table 4 checks for the presence of non-linearities, first through quadratic terms. As it appears, the income variable enters concavely, so that an increase in the income of the poorer country of a country pair has a decreasing effect on cycle synchronization. This does not appear to be driven by the fact that the dependent variable is bounded in [-1,1], since (ii) shows the concavity result obtains as well when the logistic transform of the correlation

[30] This is an extremely robust feature of the data, as shown in Section 4 and the Appendix.

[31] In similar work, Clark and van Wincoop (1999) have shown that similarities in the production pattern contribute to explaining both cross-regional and cross-country correlations, but do not account for discrepancies between the two. Their result translates here in the fact that the inclusion of *Sector* has no impact on the estimated effect of Adjacency.

coefficient is on the left-hand side. The last three regressions in Table 4 run the estimation in logarithms. This in effect selects the sample of positive correlations. Here, strikingly, bilateral trade cease to matter when income considerations are introduced, which in turn become irrelevant when *Sector* is an independent variable. Only the elasticity associated with economic structure similarity is significant at the 1% confidence level, and two-third of an increase in *Sector* is reflected in the extent of co-fluctuations.

Finally, Table 5 introduces continental dummy variables, none of which is significant, then uses trade data for 1980, and the Hodrick-Prescott filter to isolate fluctuations from trend in GDP per capita series. No results change. If anything, the role of bilateral trade is weakened, while that of income per capita and especially sectoral similarities come out strengthened. Notice that geographic variables do not enter systematically, a reassuring fact given the difficulty in finding a convincing explanation for their independent role[32]

4 Determinants of the OECD Cycle

This section repeats the analysis for a subsample of 21 OECD countries, listed in Appendix A. Such repetition is interesting for a variety of reasons: more data is available, both from the Penn-World Tables and other sources, and it is of homogenous quality. Frequency is not restricted to yearly series, and estimations may be run using quarterly series on GDP per capita from the International Financial Statistics base, spanning from 1959:1 to 1993:4. Further, in the Penn-World Tables real GDP per capita is expressed in international prices, while it is in units of domestic currency in the IFS base, thus accounting for the potential effects of assumptions about purchasing power parity. Perhaps most importantly, the fact that similar results obtain makes it impossible to ascribe the importance of economic structure through the variable *Sector* to long-run sectoral change. I show that although bilateral trade does matter within the OECD, so does the extent to which two economies share the same sectors. Quantitatively, the latter has the most substantial effect. Overall, the results are very robust to alternative frequency, filtering and the use of GDP series and bilateral trade data from the IMF.

Table 6 summarizes the results when the previous section's data is used. As before, GDP per capita matters through income level in the poorer country, at the expense of bilateral trade intensity, whose effect is however positive[33]. Contrary to the previous section, the coefficient on trade has a similar magnitude as that on $\mathrm{Min}(Y_i, Y_j)$. Notice that

[32]As Frankel and Rose (1996) put it, "it is difficult to think of reasons that, for instance, geographic isolation can affect a country's income other than by reducing its interactions with other countries".

[33]Frankel and Rose (1998) interpret the same result in the context of a monetary union and the effects it might have on trade, and thus on cycle correlations.

geographic considerations do not appear to have any impact between OECD countries. As expected because of substantially smaller cross-sectional variation, multicollinearity becomes more of a problem within this reduced sample, although within a tolerable range. Interestingly, the strong impact of the *Sector* variable still prevails, and it accounts for 9.2% of the variation in co-fluctuations (19% in the univariate estimation), against 1.3%, 1.7% and 1.8% for trade, Min(Y_i,Y_j) and the geographic variables, respectively. Given estimates in (v), one standard error increase in *Sector* results in a correlation higher by 0.067, against 0.032, 0.029 and 0.022 for Trade, Min(Y_i,Y_j) and Distance, respectively. Figure 8 confirms the univariate relationship between *Sector* and GDP correlations, and emphasizes that *Sector* does indeed capture some of the characteristics identified as likely to result in more cycle synchronization in Section 2. Table 7 checks for the presence of non-linearities, and shows that introducing quadratic expressions reinforces further the role of economic structure at the expense of GDP per capita, particularly when the logistic transform of bilateral correlations is the dependent variable. Finally, (based on the sample of 184 positive GDP correlations) the only elasticity estimated significantly at the 1% confidence level is that with respect to the *Sector* variable.

Table 8 includes a dummy variable for member countries in the European Union, with no significant effect, and proceeds to replace the trade variable with data from the IMF Direction of Trade base. As in Frankel and Rose (1998) who use this data, bilateral trade matters positively and significantly[34], with larger point estimates than the income variable. Given estimates in (iii), one standard error increase in *Sector* results in a correlation higher by 0.047, whereas the number is slightly smaller for bilateral trade, with 0.042. Thus, although the statistical importance of bilateral trade cannot be ruled out, the extent to which two OECD countries display similar economic structures has substantial economic consquences. The last two estimations revert to the trade data described in Frankel and Wei (1995), and uses the Hodrick-Prescott filter to compute GDP correlations, with no significant effect. Finally, the main results still obtain when quarterly GDP data is used instead in Table 9: *Sector* matters substantially more than trade or income per capita, at the expense of the latter, with coefficients of the same order of magnitude as previously, and geographic variables are not significant, although they have the right signs.

There is a distinct theoretical possibility that the causality between trade and co-fluctuations go both ways, thus making it difficult to interpret significant coefficients on trade in the previous estimations. Indeed, in Kollmann (1998), countries subjected to aggregate demand shocks of similar amplitudes will indeed presumably trade more, for

[34] I have argued in Imbs (1998b) that the importance of trade is sensitive to the inclusion of fixed effects, causing jointly intense bilateral trade and correlated cycles. The importance of such effects is reflected in the present work by the direct economic significance of *Sector*, and to a lesser extent, of geographic considerations. The degree of similarity in sectoral employment is indeed extremely persistent over time, with a correlation between measures in 1970 and 1990 equal to 0.95.

only the "quantity" effect is at play[35]. Although this has little to do with the importance of the variable *Sector* per se, correcting for the potential bias is relevant when interpreting the relative magnitudes of estimated coefficients. This is however not an easy task, for the use of gravity variables as instruments for trade is forbidden since they do belong to the set of variables explaining co-fluctuations. Rather, Table 10 presents results if correlations are computed using the second half of the sample, i.e. from 1976:1 to 1993:4, and regressed on the previous set of variables, thus in essence taking lags of the independent variables. Estimation (i) confirms the importance of both the trade and the *Sector* variables in such a lagged setting, with R^2falling by 6% when either one is omitted from the estimation. Finally, estimations (ii) and (iii) ensure that the main results of the paper hold in the sub-period 1976:1 - 1993:4 as well.

Overall, the estimates in this section leave little significant role to geographic considerations in explaining GDP correlations, and the coefficient on $\text{Min}(Y_i,Y_j)$ is in the order of 2 x 10^{-5}, but not always significant. Portes and Rey (1999) show that bilateral equity flows between 14 OECD countries are predicted quite strongly by this type of "gravity" variables, with an emphasis on GDP per capita[36]. Thus, combining those two sets of results confirms the prior that capital flows, in the form of equity flows, contribute little to explaining positive *contemporaneous* GDP correlations. At most, equity flows, as proxied by both income and geographic variables, accounts for 3% of the variation in co-fluctuations using the estimates from Table 6, and do not matter at all using data from the IMF.

Co-fluctuations in the OECD seem therefore to come from the same sources as in the rest of the world: bilateral trade matters, but to a surprisingly weak and varying extent quantitatively, whereas sharing a similar production pattern at the sectoral level, something occurring mostly in the richer countries of the sample, does result in more synchronized cycles. These claims prevail when fluctuations occur at the quarterly or yearly frequency, whether the data is filtered using first-differences or the HP filter, over sub-periods of the sample, and across various measures of GDP per capita and bilateral trade flows[37]. Next section summarizes a slightly modified version of a model of economic geography presented in Baldwin, Martin and Ottaviano (1998), that is consistent with this evidence.

[35] The effect of perfectly correlated supply shocks in Backus, Kehoe and Kydland (1995) is not unambiguous, and ought to be subjected to careful calibration exercises.

[36] Depending on the specification, roughly 36% of equity flows can be explained by gravity variables.

[37] In the Appendix, I show that they are also robust to measuring trade in proportion of GDP and total trade in the trading economies. For the 21 countries sample, the correlation coefficient between bilateral trade and total trade is 0.91; for the 49 countries sample, the correlation coefficient between bilateral trade and trade normalized by GDP level is 0.67.

5 A Model of Endogenous Structural Change

This section presents a model to illustrate the main empirical findings. In the model, similar countries choose to produce similar goods and as a result experience sectoral shocks that are of roughly equal importance. If instead one country is rich and the other is poor, the rich country will be hit by shocks to manufacturing and services, while the poor will be hit by shocks to a traditional sector. Since there is no particular reason why those two sets of shocks should be correlated with one another, we should expect less cyclical co-movement between a rich and a poor country[38]. The empirical relevance of the *Sector* variable for co-fluctuations, and its positive correlation with $\text{Min}(Y_i,Y_j)$ call for a model of endogenous structural change, with new sectors emerging as economies grow in such a way as to make their production patterns increasingly similar. The so-called new economic geography, based on the presence of transport costs and local external effects, provides a framework in which industrial agglomeration occurs endogenously[39], and is thus of relevance to the present purpose. In recent work, Baldwin, Martin and Ottaviano (1998) -BMO henceforth- present a model of economic geography unique in providing reduced form expressions and thus unequalled transparence in the mechanisms at play. The model in this section is theirs, with one added -crucial- component, namely the presence of convex congestion costs.

In BMO as well as others, firms in a monopolistically competitive sector decide to cluster, because their profits depend on the local[40] level of expenditures, which in turn increases with the number of goods produced locally[41] - the now standard *demand linkage.* Thus, imperfect substitutes of the heterogenous good -usually modeled as industries- are eventually all produced in a given country or region. Here, I want to model precisely the opposite mechanism: as they grow, countries are increasingly likely to produce the same type of goods. The agglomeration result is reversed by introducing some congestion costs of entry that increase convexly with the number of goods produced locally. The intuition is straightforward: when deciding where to start business, firms weigh the added profits granted by demand linkages against the cost of entering the market. Insofar as the latter increases convexly with market size, full international specialization can only occur in specific -and unstable- conditions, having to do with the extent of transport costs relative

[38]The model's prediction is therefore that poor countries ought to be more synchonized as well, insofar as they produce the same -traditional- goods. However, traditional goods are usually associated with agriculture or exploitation of raw materials, and thus subjected to idiosyncratic developments corresponding to world market prices. Crucially, we assume there is international specialization in the production of traditional goods resulting from pre-exisiting resources, that is imperfectly reflected in our assumption of a homogenous traditional sector, but is consistent with joint low values for $\text{Min}(Y_i,Y_j)$ and *Sector*.

[39]See for instance Krugman (1991) or Krugman and Venables (1995, 1996)

[40]The very concept of locality requires the presence of transport costs.

[41]Through a variety of local external effects. In BMO, it is because firms are associated with capital, whose earnings are spent locally.

to congestion costs. The world thus converges sooner or later to a stable symmetric situation, where industrial goods are produced in both countries in equal proportions. This state of affairs is stable since the increase in profits resulting from deviation always falls short of the increase in costs. The model also predicts that countries with similar income levels trade mostly within industries, a fact well-documented in the literature on intra-industry trade.

The specifics of the model follow BMO closely. Consumers in the North and the South derive utility from a traditional good T and imperfectly substitutable manufactures M_i ($i = 1 \ldots K + K^*$), where K denotes the number of varieties exploited -and invented- in the North, and a star indicates a Southern variable. BMO identify the number of varieties in the manufacturing sector with capital stock, thus making it possible to model the innovation sector as producing capital. Insofar as agents own the capital stock, an important implication is that wealth increases with the number of varieties available. As will become clear, the ratio of Northern to world capital thus defined, $S_K \equiv \frac{K}{K+K^*}$ summarizes most of the model's properties, and characterizes fully the steady states of the economy. With exception of the entry costs, assumed to increase with S_K, the model is identical to BMO.

5.1 Equilibrium

Consumers derive utility from both the heterogenous manufacture and the homogenous traditional good. Northern demand C_i for a given variety i of the manufacture is standard, and equal to:

$$C_i = p_i^{-\frac{1}{1-\sigma}} \frac{\alpha\ E}{\sum_{i=1}^{K} p_i^{\frac{\sigma}{\sigma-1}} + \sum_{i=K+1}^{K^*} (\tau\, p_i^*)^{\frac{\sigma}{\sigma-1}}} \tag{1}$$

where $\frac{1}{1-\sigma}$ is the elasticity of substitution between varieties of the manufactured good, α is the share of expenditures consumed in the manufacturing good[42], p_i (p_i^*) is the price of manufacture i in the North (South), and transport costs decrease in $0 < \tau < 1$. The monopolistically competitive firm chooses its price taking into account demand arising from both the North and the South.

Labor is immobile. One unit of the traditional good is produced with constant returns using one unit of labor. Thus profit maximization in the T sector requires that $p_T = w \equiv 1$, where the nominal wage has been normalized to one. Assuming σ units of labor are required to produce one unit of M_i, the firm producing variety i chooses p_i and p_i^* to maximize profits subject to (1), where profits Π_M are given by:

$$\Pi_M = (p_i\ C_i - w\ \sigma\ C_i) + (p_i^*\ C_i^* - w\ \sigma\ \tau\ C_i^*) \tag{2}$$

[42]This arises easily from Cobb-Douglas preferences in manufacturing and traditional goods.

The definition for C_i^* follows directly from (1). Profits are maximized for $p_i = p = 1$ and $p_i^* = p^* = \tau$, so that maximized profits are:

$$\Pi_M = (1-\sigma)\frac{\alpha E}{K + \tau^{\frac{\sigma}{\sigma-1}} K^*} + (1-\sigma)\frac{\tau^{\frac{\sigma}{\sigma-1}}\alpha E^*}{\tau^{\frac{\sigma}{\sigma-1}} K + K^*}$$

Introducing $S_K = \frac{K}{K+K^*}$, $S_E = \frac{E}{E+E^*}$ and $\theta = \tau^{\frac{\sigma}{\sigma-1}}$ maximized Northern profits can be rewritten

$$\Pi_M = \frac{\alpha(1-\sigma)(E+E^*)}{K+K^*}\left\{\frac{S_E}{S_K + \theta(1-S_K)} + \frac{\theta(1-S_E)}{\theta S_K + (1-S_K)}\right\} \tag{3}$$

It is easy to compute the equivalent expression for Southern profits, and obtain

$$\Pi_M^* = \frac{\alpha(1-\sigma)(E+E^*)}{K+K^*}\left\{\frac{\theta S_E}{S_K + \theta(1-S_K)} + \frac{1-S_E}{\theta S_K + (1-S_K)}\right\} \tag{3'}$$

In the absence of a fixed cost of entry in the manufacturing sector, an infinite number of firms would start exploiting new varieties, and the competitive result would obtain in the limit. Imperfect competition requires therefore the presence of a cost of entry η. We choose to model η as a quadratic function of S_K. This is to reflect the idea that exploitation of a new variety requires the utilization of a resource that is in limited supply locally, such as human capital, infrastructures or institutional administrative services. Thus the production of new capital becomes increasingly costly as K rises. On the other hand, world knowledge $K + K^*$ is assumed to render innovation easier through international spillovers, as is now standard in models of perpetual endogenous growth. Better world knowledge makes it possible to exploit more efficiently scarce resources towards further innovation[43]. Finally, η has a constant component, incurred irrespective of the level of local or world knowledge. Examples include installment of machines, buildings, purchase of licenses or bribes. The capital producing sector hires η units of labor to produce one unit of capital, so that capital grows according to

$$\dot{K} = \frac{L_I}{a + (S_K)^2} \tag{4}$$

where $a > 0$ and L_I is labor used in the capital sector.

[43] Barro and Sala-I-Martin (1995) say page 216: "the tendency to run out of new ideas suggests that the cost [to create new types] would rise with [world knowledge]. But if the concepts already discovered make it easier to come up with new ideas, then the cost could fall with [world knowledge]. We assume that the two effects roughly cancel." The difference here is that the former effect is assumed local.

Assuming that payment of η confers a perpetual monopoly on the variety exploited, and thus secures the present value of all future profits[44] generated by exploitation of i, V, the following must hold in equilibrium :

$$V = \int_0^\infty \Pi_{M,t}\; e^{-r\;t}\; dt = \eta = a + (S_K)^2$$

By definition at the steady state, $\frac{\partial E}{\partial t} = \frac{\partial E^*}{\partial t} = \frac{\partial S_K}{\partial t} = 0$. The expression for Northern profits (3) shows that Π_M falls at the rate at which $K + K^*$ grows[45], g. Furthermore, intertemporal utility maximization yields the standard Euler equation $\frac{1}{E}\frac{\partial E}{\partial t} = r - \rho$, where ρ is the subjective discount rate and intertemporal elasticity of substitution is assumed to be one. Thus at the steady state, $r = \rho$, and the zero profit condition simplifies to:

$$\Pi \equiv \Pi_{M,0} = \eta\;\;(\rho + g) = (\rho + g)\;\;\left[a + (S_K)^2\right] \tag{5}$$

Firms do not have any incentive to start business in the North whenever $\Pi < \eta\;\;(\rho + g)$. An equivalent expression holds in the South.

By definition, expenditures equal income net of investment. Northern agents own all local labor and capital[46], and derive income from rental of factors or production. Investment corresponds in the model to labor hired in the capital sector, L_I. Thus,

$$E = L + \Pi\;K - L_I$$

I show later that the number of steady states is three: one symmetric where both countries generate capital and $S_K = \frac{1}{2}$, and two asymmetric where all innovation occurs in one country. To avoid repetition, the focus is on the asymmetric case where all innovation is Northern: then, in all steady states, new varieties of the heterogenous good are invented in the North, so that it had better be the case that

$$\Pi = \eta\;\;(\rho + g) = \eta\;\;\left(\rho + \frac{L_I}{\eta\;K}\right)$$

where I made use of (4) and the fact that at all steady states, the economy grows at the rate of innovation in the North. Then,

$$E = L + \rho\;\eta\;K$$

[44]Note that given the characteristics of the steady state, the zero-profit condition will yield analogue results, up to a constant, when it is assumed instead that firms pay η every period.

[45]World growth is of course endogenous. It will however equal Northern growth g in all the steady states considered.

[46]Factors of production are assumed immobile. Labor endowments are identical in the two countries, which simplifies somewhat the algebrae with innocuous consequences on the results.

As in BMO, steady state expenditures are equal to transitory -labor- income plus a fixed share of the wealth conferred by holdings of capital, equal to the subjective discount rate ρ. Rearranging,

$$S_E = \frac{E}{E+E^*} = \frac{L+\rho\,\eta\,K}{2L+\rho\,\eta\,K+\rho\,\eta^*\,K^*}$$

Using the definition of η, further manipulation yields

$$S_E = \frac{\frac{L}{K+K^*} + \rho\ \left(a+S_K^2\right) S_K}{\frac{2L}{K+K^*} + \rho\ \left(a+S_K^2\right) S_K + \rho\ \left(a+\left(1-S_K\right)^2\right)\left(1-S_K\right)} \tag{6}$$

Equations (5) and (6) form together a system in (S_K, S_E) whose solutions determine the characteristics of the steady states of this economy.

5.2 Steady State Analysis and Stability

5.2.1 Steady States

We seek to characterize situations where the local share of world capital remains constant, i.e. $\frac{\partial S_K}{\partial t} = 0$. It is easy to see that at a steady state thus defined

$$S_K\left(1-S_k\right)\left(g-g^*\right) = 0$$

where $g = \frac{\dot{K}}{K}$ and $g^* = \frac{\dot{K}^*}{K^*}$. In other words, either industrialization -as measured by the number of varieties of the heterogenous good- occurs at equal rates $g = g^*$ in the North and the South, or world growth in varieties of manufactures originates in one country only.

In the symmetric steady state, the zero profit condition holds with equality everywhere, for innovation occurs in both countries. In particular since $g = g^*$,

$$\frac{\Pi}{\Pi^*} = \frac{a+S_K^2}{a+\left(1-S_K\right)^2}$$

However, profits are given by (3) and (3'), so that we must have

$$\frac{\left(\theta\ S_K+1-S_K\right)+\theta\ \left(\frac{1}{S_E}-1\right)\left(S_K+\theta\ \left(1-S_K\right)\right)}{\left(\frac{1}{S_E}-1\right)\left(S_K+\theta\ \left(1-S_K\right)\right)+\theta\ \left(\theta\ S_K+1-S_K\right)} = \frac{a+S_K^2}{a+\left(1-S_K\right)^2} \tag{7}$$

Simple manipulation of (6) shows that $\frac{1}{S_E}-1$ depends on S_K in symmetric fashion, with

$$\frac{1}{S_E} - 1 = \frac{\frac{L}{K+K^*} + \rho\ a\ \left(1 - S_K\right) + \rho\ \left(1 - S_K\right)^3}{\frac{L}{K+K^*} + \rho\ a\ S_K + \rho\ S_K^3} \tag{8}$$

It is easy to see that $S_K = \frac{1}{2}$ verifies the system formed by (7) and (8), and characterizes therefore an equilibrium steady state. Under mild conditions described in appendix B, it is also the only one where innovation occurs in both countries. Thus, at the symmetric steady state, Northern and Southern growth rates are identical, and the share of manufactures is equal in both countries.

In the asymmetric steady state, all new varieties are supposed to be invented in the North, i.e. $S_K = 1$. It has to be the case that innovation is not profitable in the South, so that $\Pi^* < \eta^* \left(\rho + g\right)$. However, entry is profitable in the North, implying that $g = \frac{\Pi}{\eta} - \rho$. Combining all restrictions with the expressions for profits (3) and (3'), at the asymmetric steady state

$$\frac{a+1}{a}\left[\theta\ \frac{\frac{L}{K+K^*} + \rho\left(a+1\right)}{\frac{2L}{K+K^*} + \rho\left(a+1\right)} + \frac{1}{\theta}\ \frac{\frac{L}{K+K^*}}{\frac{2L}{K+K^*} + \rho\left(a+1\right)}\right] < 1 \tag{9}$$

Appendix C shows that this will be true under some weak restrictions on $\frac{2L}{K+K^*}$ and for $\theta_1 < \theta < \theta_2$, where θ_1 and θ_2 are defined in the appendix. Recall that transport costs decrease in τ and thus increase in θ: the asymmetric equilibrium can only prevail for sufficiently low levels of transport costs, below θ_2. In summary, as long as transport costs are such that $Max\left(\frac{1}{4a}, \theta_1\right) < \theta < \theta_2$, there are two steady states. The characteristics of the third -asymmetric- one are easy to infer from what precedes.

5.2.2 Stability

Consider an exogenous shift of one innovating firm from the North to the South - a fall in S_K. Stability requires that the increase in relative Southern profitability, due to higher expenditures and thus higher profits in the South, be smaller than the increase in relative Southern costs, due to higher congestion. In that case, the displaced firm has no incentive to stay in the South, and market forces will re-establish the initial production and trade pattern. If on the other hand Southern relative profitability rises by more than relative costs, the steady state is unstable. I now show that the former applies in the symmetric and the latter in the asymmetric case. The Appendix provides an expression for $\Omega\left(S_K\right) = \frac{\Pi}{\Pi^*} - \frac{\eta}{\eta^*}$ derived from (7) and (8), that measures relative Northern profits net of relative costs. If $\Omega > 0$, is it more profitable to invent and produce new manufactures in the North. On the other hand,

$$\Omega\left(1\right) = A\left(1\right) + B\left(1\right) + C + D\left(1\right) + E < 0$$

The polynomials $A(S_K)$, $B(S_K)$, C, $D(S_K)$ and E are defined and shown to be unambiguously negative in the Appendix. Thus, when all manufacturing production is agglomerated in the North, it is relatively more profitable to start industrializing the South, where congestion costs are lower. In other words, the asymmetric steady state is unstable, and there will be incentive for firms to relocate for as long as $\Omega(S_K) < 0$, that is until the world reaches the symmetric equilibrium where $\Omega(S_K) = 0$ by definition.

To examine stability of the symmetric steady state, we need to determine how $\Omega(S_K)$ responds to infinitesimal changes in S_K, and evaluate that differential response for $S_K = \frac{1}{2}$ There is no particular difficulty in computing

$$\Omega'(S_K)_{\,|\,S_K=\frac{1}{2}} = 2A\left(\frac{1}{2}\right) + 2B\left(\frac{1}{2}\right) + \frac{3}{2}C + D\left(\frac{1}{2}\right) + \frac{3}{8}E < 0$$

Thus, a fall in S_K results in a rise in Northern net relative profitability. The rise in Southern profits, brought about through higher relative southern expenditures in (7), falls short of the rise in relative Southern costs. Thus, the very firm that was exogenously displaced to the South has a net incentive to move back home.

5.2.3 Income Levels

I finally provide verification that income level disparity is maximized in the asymmetric equilibrium, and shrinks as manufacturing relocates to the South, on the transition path to the stable symmetric steady state. To see this, recall that Northern real income Y will be given in $PY = wL + \Pi K$, where

$$P = p_T^{1-\alpha}\ p_M^{\alpha} = (K + K^*)^{\alpha\frac{\sigma-1}{\sigma}}\left[S_K + \theta(1 - S_K)\right]^{\alpha\frac{\sigma-1}{\sigma}}$$

Thus using the equivalent Southern definitions,

$$\frac{Y}{Y^*} = \frac{\left[S_K + \theta(1 - S_K)\right]^{\alpha\frac{\sigma-1}{\sigma}}}{\left[\theta S_K + (1 - S_K)\right]^{\alpha\frac{\sigma-1}{\sigma}}}\ \frac{\frac{L}{K+K^*} + \Pi S_K}{\frac{L}{K+K^*} + \Pi^*(1 - S_K)}$$

At the symmetric equilibrium profits are equal, so that $Y = Y^*$. However, when $S_K = 1$,

$$\frac{Y}{Y^*} = \theta^{\alpha\frac{1-\sigma}{\sigma}}\left[1 + \frac{\Pi}{\frac{L}{K+K^*}}\right] > 1$$

The intuition is the same as in BMO: a high level of S_K translates into higher steady state wealth and a lower Northern price index. Insofar as synchronized co-fluctuations arise in this paper from similar sectoral structure, maximum international specialization -the smallest possible correlation- is assumed at the outset. The previous section showed this is an equilibrium where Northern income level is relatively higher. There, stochastic developments in the traditional sector matter for the South, whereas shocks in manufacturing only impact the North. Since there is no a priori reasons why these two sets of shocks should be correlated with one another, co-movements between the two countries are less cyclical. However, since that state of affairs is unstable, the world eventually reaches a situation where both countries produce manufactures, in equal proportions, and have the same income level. A significant share of each economy thus responds to similar developments, and aggregate cycles are more correlated.

Because entering firms find it optimal to exploit and produce unused varieties rather than share the profits on already produced manufactures, each variety is produced by one firm. It is in that sense that the manufacturing sector expands in the South along the transition. Further, goods produced in the South at the symmetric steady state are all different from goods in the North. Thus, given preferences for diversity, they are all traded. The model predicts a majority of intra-industry trade between countries with similar income levels, as observed in the data.

6 Conclusion

This paper provides novel evidence on the determinants of the synchronization in business cycles in a multivariate context. I find trade has surprisingly small quantitative effects. On the other hand, pairs of countries with higher aggregate income level experience significantly more synchronized business cycles, and this happens largely because they have similar sectoral production patterns. These very robust findings are interpreted in a model where international income disparities correspond to differences in production patterns, and thus to different degrees of exposure to common sectoral stochastic developments. On the modeling front, one can think of the present findings as a set of additional "stylized facts" that calibrated dynamic stochastic general equilibrium models of the international business cycle ought to reproduce. Thus, the joint impact of bilateral trade and sectoral developments calls for a careful look into trade flows when shocks are sectoral and production patterns endogenous, with an aim to reproducing both the "J curve" and positive co-fluctuations. On the empirical front, insofar as they rely on extreme assumptions about structural change, these results call for a closer analysis of the dynamics of international specialization.

7 Appendix

A. Samples

- Penn-World Tables: 136 Countries

AFRICA: Algeria, Angola, Benin, Botswana, Burkina, Burundi, Cameroon, Cape Verde, Central Africa, Chad, Comoros, Congo, Djibouti, Egypt, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Reunion, Rwanda, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, Sudan, Swaziland, Tanzania, Togo, Tunisia, Uganda, Zaire, Zambia, Zimbabwe.

AMERICA: Barbados, Belize, Canada, Costa Rica, Dominican Republic, Salvador, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Puerto Rico, Trinidad & Tobago, USA, Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay, Venezuela.

ASIA: Bangladesh, China, Hong Kong, India, Indonesia, Iran, Iraq, Israel, Japan, Jordan, South Korea, Malaysia, Myanmar, Nepal, Oman, Pakistan, Philippines, Saudi Arabia, Singaopre, Sri Lanka, Syria, Taiwan, Thailand, Yemen.

EUROPE: Austria, Belgium, Bulgaria, Cyprus, Czechoslovakia, Denmark, Finland, France, East Germany, West Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland.Turkey, UK, USSR, Yugoslavia.

AUSTRALASIA: Australia, Fiji, New Zealand, Papua New Guinea, Western Samoa

- Penn-World Tables: 61 Countries

AFRICA: South Africa, Algeria, Nigeria, Egypt, Morocco, Tunisia, Sudan, Ghana, Kenya, Ethiopia.

AMERICA: Canada, USA, Argentina, Brazil, Chile, Colombia, Ecuador, Mexico, Peru, Venezuela, Bolivia, Paraguay, Uruguay.

ASIA: Japan, Australia, New Zealand, Israel, Iran, Saudi Arabia, Indonesia, Taiwan, Hong Kong, India, South Korea, Malaysia, Pakistan, Philippines, Singapore, Thailand, China.

EUROPE: France, West Germany, Italy, UK, Austria, Belgium, Denmark, Finland, the Netherlands, Norway, Sweden, Switzerland, Greece, Iceland, Ireland, Portugal, Spain, Turkey, Yugoslavia, Hungary, Poland.

- Penn-World Tables: 49 Countries

AFRICA: Egypt Ethiopia Ghana Kenya Nigeria South Africa Tunisia

AMERICA: Argentina Bolivia Brazil Canada Chile Colombia Ecuador Paraguay U.S.A Uruguay Venezuela

ASIA: Australia Hong Kong India Indonesia Iran Israel Japan Korea Malaysia New Zealand Pakistan Philippines Singapore Thailand

EUROPE: Austria Denmark Finland France West Germany Greece Hungary Iceland Ireland Italy Norway Poland Spain Sweden Turkey United Kingdom Yugoslavia

- Penn-World Tables and IFS: 21 Countries

Australia, Austria, Canada, Denmark, Finland, France, West Germany, Greece, Iceland, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Turkey, UK, USA.

B. Unicity of the Symmetric Steady State

We seek to establish under what conditions $S_K = \frac{1}{2}$ is the only solution to (7) and (8). After tedious though simple manipulation, substituting (8) in (7) yields

$$A(S_K)\left[S_K - (1-S_K)\right] + B(S_K)\left[S_K^2 - (1-S_K)^2\right] + C\left[S_K^3 - (1-S_K)^3\right]$$

$$+D(S_K)\left[S_K^4 - (1-S_K)^4\right] + E\left[S_K^6 - (1-S_K)^6\right] = 0$$

where:

$A(S_K) = -a(1-\theta)^2 \frac{L}{K+K^*} - 2\theta \frac{L}{K+K^3}\ S_K\ (1-S_K)$,

$B(S_K) = -\rho a^2 \theta(\theta-1) - 2\theta\rho a\ S_K\ (1-S_K) + \rho\theta\ S_K^2\ (1-S_K)^2$,

$C = -(1+\theta^2)\frac{L}{K+K^*}$,

$D(S_K) = -\rho a\theta(2\theta-1) - \rho\theta\ S_K\ (1-S_K)$,

$E = -\rho\theta^2$.

Recall that $\theta = \tau^{-\frac{\sigma}{1-\sigma}} > 1$ to see that C, $D(S_K)$ and E are all strictly negative. Furthermore, $A(S_K)$ is strictly negative for $\theta > 1$, i.e. positive transport costs. To sign $B(S_K)$, compute the discriminant $\Delta_1 = 4a(a+\theta-1) > 0$. $B(S_K)$ is negative for

$$2a - \sqrt{\Delta_1} < S_K\ (1-S_K) < 2a + \sqrt{\Delta_1}$$

However, it is easy to check that $2a - \sqrt{\Delta_1} < 0$ and $2a + \sqrt{\Delta_1} > 1$ whenever $\theta > \frac{1}{4a}$. Thus, if transport costs are sufficiently higher than the fixed cost of entry a, the only solution to the system formed by (7) and (8) is $S_K = \frac{1}{2}$. Indeed, all the expressions between brackets are either strictly positive when $S_K > \frac{1}{2}$ or strictly negative when $S_K < \frac{1}{2}$.

C. Existence of the Asymmetric Steady State

Rearranging (9) yields a quadratic equation in θ, that ought to be negative if the asymmetric steady state is to be an equilibrium:

$$(a+1)\left(\frac{L}{K+K^*}+\rho(a+1)\right)\theta^2 - a\left(\frac{2L}{K+K^*}+\rho(a+1)\right)\theta$$
$$+(a+1)\frac{L}{K+K^*}<0 \tag{9'}$$

The discriminant

$$\Delta_2 = a^2\rho^2(a+1)^2 - (2a+1)\left(\frac{2L}{K+K^*}\right)^2 - 2\rho(2a+1)(a+1)\left(\frac{2L}{K+K^*}\right)$$

corresponding to (9) is positive whenever the ratio of world labor to capital is not too high to start with. To see this, consider Δ_2 a quadratic expression in $\frac{2L}{K+K^*}$, compute the corresponding discriminant $\delta = 4\rho^2(2a+1)(a+1)^4$ and notice that one of the two real roots is negative, and the other is given by $\gamma \equiv \rho(a+1) + \frac{\rho(a+1)^2}{\sqrt{2a+1}}$.

Thus, $\Delta_2 > 0$ whenever $\frac{2L}{K+K^*} < \gamma$, which if ensured at the outset will always be true as world capital expands. Then (9) admits two real roots, given by

$$\theta_{1,2} = \frac{a\left[\frac{2L}{K+K^*}+\rho(a+1)\right] \pm \sqrt{\Delta_2}}{2(a+1)\left[\frac{L}{K+K^*}+\rho(a+1)\right]}$$

Thus, (9') will be negative for $\theta_1 < \theta < \theta_2$. The asymmetric steady state will exist for sufficiently low transport costs, whenever $\theta < \theta_2$.

Appendix D: Sensitivity to Alternative Measures of Trade

Table D.1 : Trade / GDP - Sample of 49 Countries

	(i)	(ii)	(iii) - Logs	(iv) - HP
Constant	0.066 [4.57]**	-0.109 [2.70]**	-1.230 [1.71]	-0.122 [2.17]*
Trade	1.837 [1.85]	2.161 [2.18]*	0.048 [2.31]*	2.764 [1.93]
Sector		0.246 [4.71]**	0.702 [2.92]**	0.265 [3.65]**
Min (Y_i, Y_j)	3.64×10^{-5} [9.44]**	2.78×10^{-5} [6.77]**	0.077 [1.21]	2.49×10^{-5} [4.51]**
Distance	-3.38×10^{-6} [2.53]*	-3.34×10^{-6} [2.53]*	-0.079 [1.72]	-5.00×10^{-6} [2.78]**
Adjacency	0.119 [3.65]**	0.103 [3.04]**	0.286 [1.93]	0.052 [1.37]
R-Square	0.165	0.190	0.077	0.109

All estimations use yearly data from PWT and the trade measure is $(X_{ij} + X_{ji}) / (Y_i + Y_j)$. (i) and (ii) use a GDP growth rates, (iii) runs the estimation in logarithms (except for the dummy variable Adjacency), and (iv) uses HP filtered GDP series with = 1600.

Table D.2 : Bilateral Trade / Total Trade - Sample of 21 Countries

	(i) - Yrly	(ii) - Yrly	(iii) - Qrtly	(iv) - Qrtly
Constant	0.232 [6.79]**	-0.110 [0.77]	0.027 [0.21]	-0.167 [1.24]
Trade	0.912 [3.35]**	0.747 [2.63]**	0.870 [3.31]**	0.837 [1.93]
Sector		0.440 [2.61]**	0.303 [1.98]*	0.464 [2.57]**
Min (Y_i, Y_j)	8.60×10^{-6} [1.14]	1.39×10^{-6} [0.17]	1.98×10^{-7} [0.03]	2.90×10^{-6} [0.45]
Distance	-3.65×10^{-6} [1.60]	-3.99×10^{-6} [1.73]	-3.66×10^{-6} [1.93]	-9.98×10^{-6} [3.45]**
Adjacency	0.034 [0.50]	0.043 [0.63]	0.046 [0.70]	-0.065 [0.75]
R-Square	0.144	0.175	0.197	0.251

Yearly data comes from PWT, quarterly data from IFS. The trade variable is $(X_{ij} + X_{ji}) / (X_i + X_j)$ computed from the Direction of Trade base. GDP correlations are based on growth rates. (iv) is estimated over the later sub-period.

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Figure 1

Complete Penn-World Tables - Positive Correlations

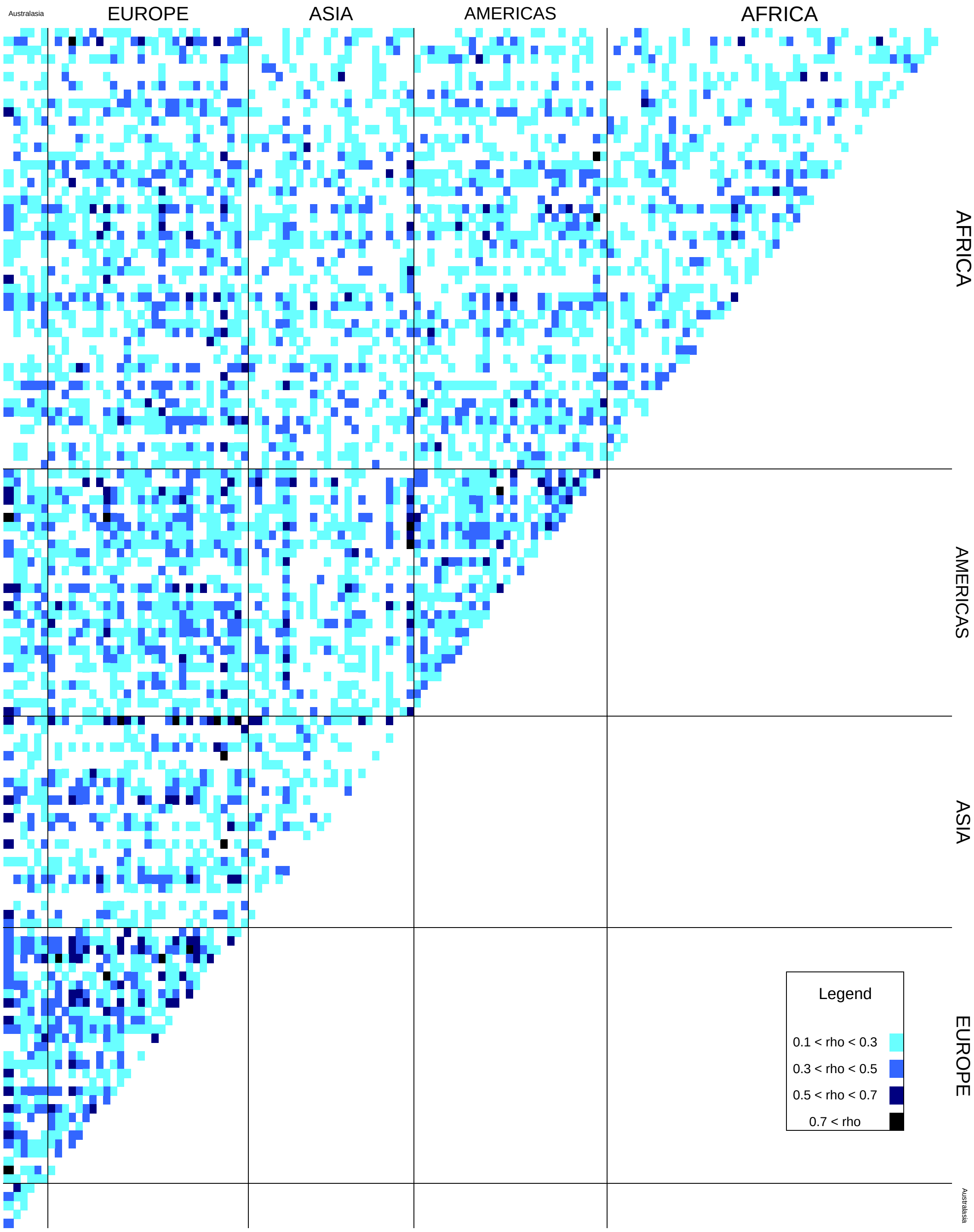

Figure 2

Complete Penn-World Tables - Negative Correlations
Australasia
EUROPE
ASIA
AMERICAS
AFRICA
Legend
0.1 < rho < 0.3
0.3 < rho < 0.5
0.5 < rho < 0.7

Figure 3

All Correlations

	Australasia	EUROPE	ASIA	AMERICAS	AFRICA
AFRICA	0.037 [0.222]	0.077 [0.209]	0.027 [0.203]	0.067 [0.189]	0.030 [0.193]
AMERICAS	0.121 [0.244]	0.130 [0.197]	0.054 [0.209]	0.164 [0.182]	
ASIA	0.126 [0.239]	0.064 [0.229]	0.027 [0.209]		
EUROPE	0.159 [0.245]	0.192 [0.226]			
Australasia					

Figure 4

Complete Penn-World Tables Countries - Positive Correlations ordered by Openness in 1960

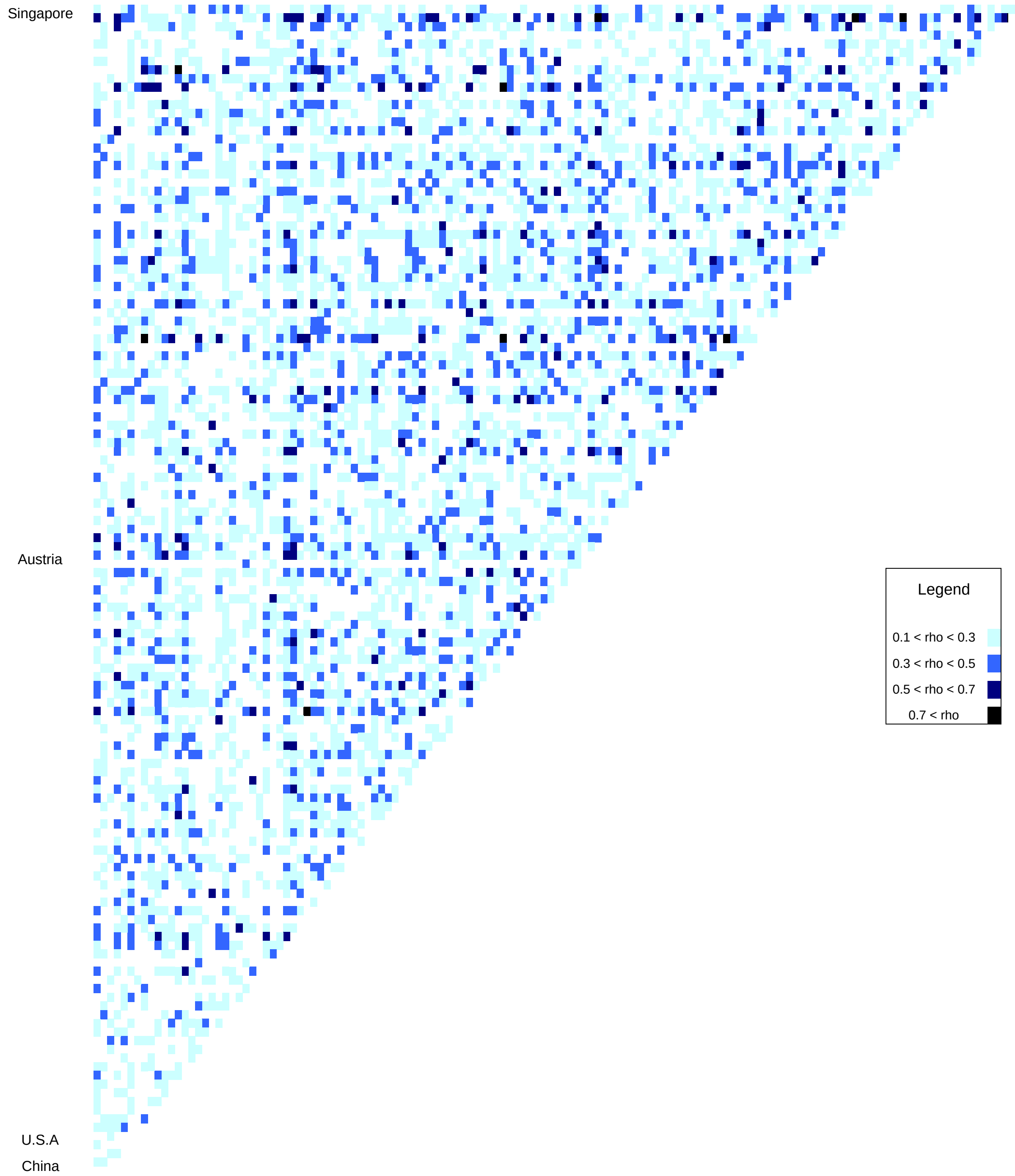

Figure 5: GDP Correlations and Bilateral Trade in 1970 (61 countries)

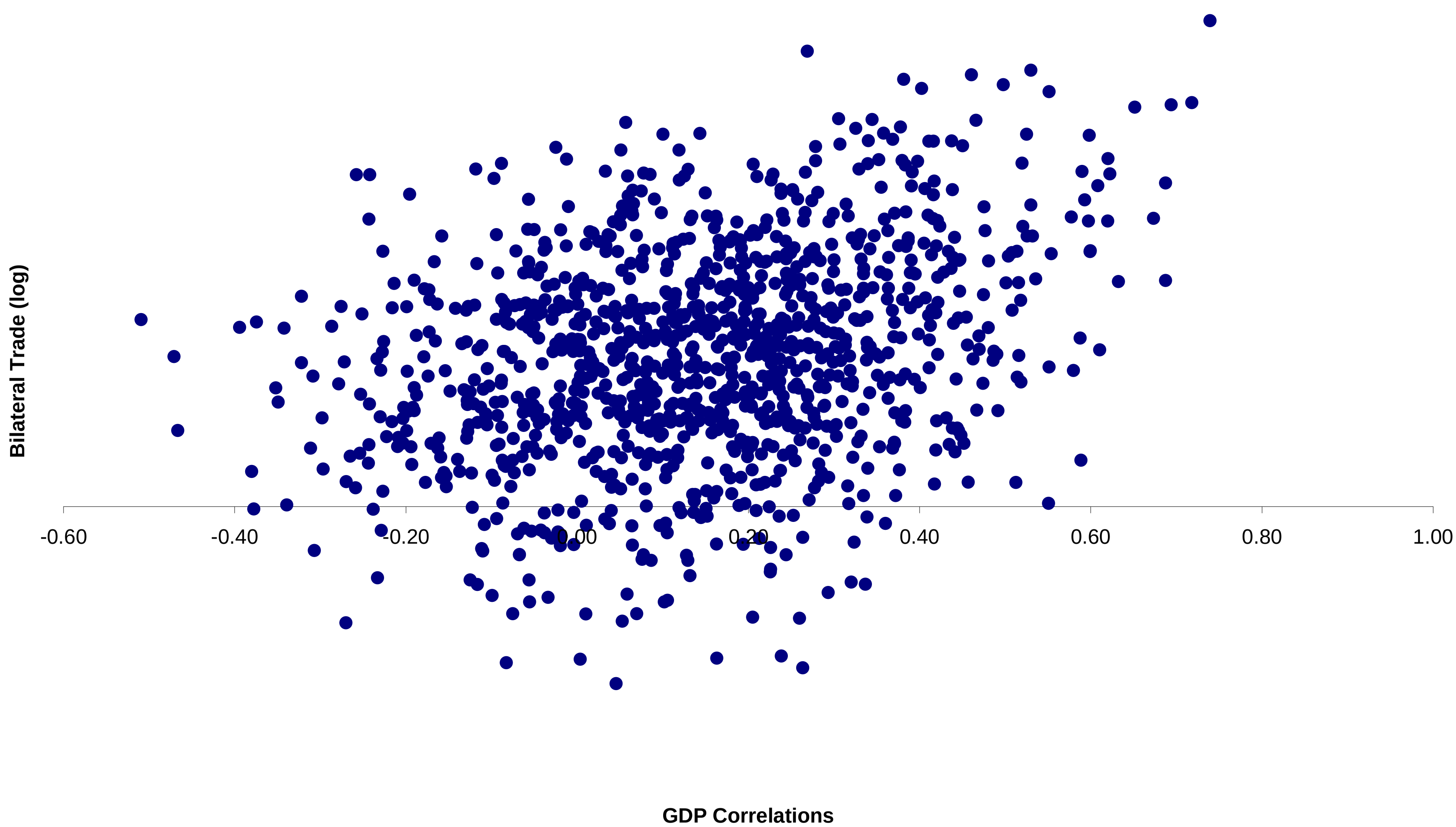

Figure 6

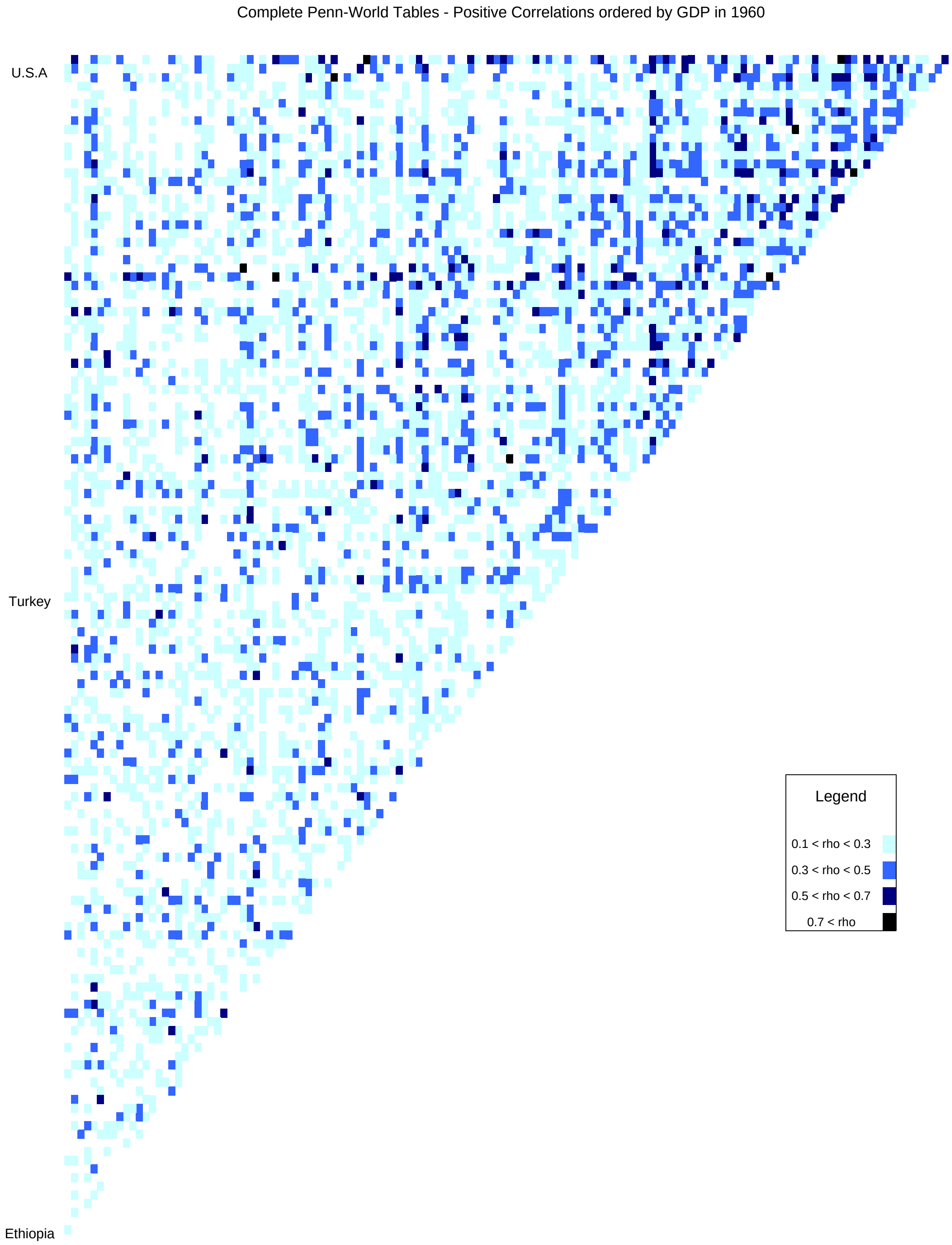
Complete Penn-World Tables - Positive Correlations ordered by GDP in 1960
U.S.A
Turkey
Ethiopia
Legend
0.1 < rho < 0.3
0.3 < rho < 0.5
0.5 < rho < 0.7
0.7 < rho

Figure 7: GDP Correlations and Sectoral Similarities (49 countries)

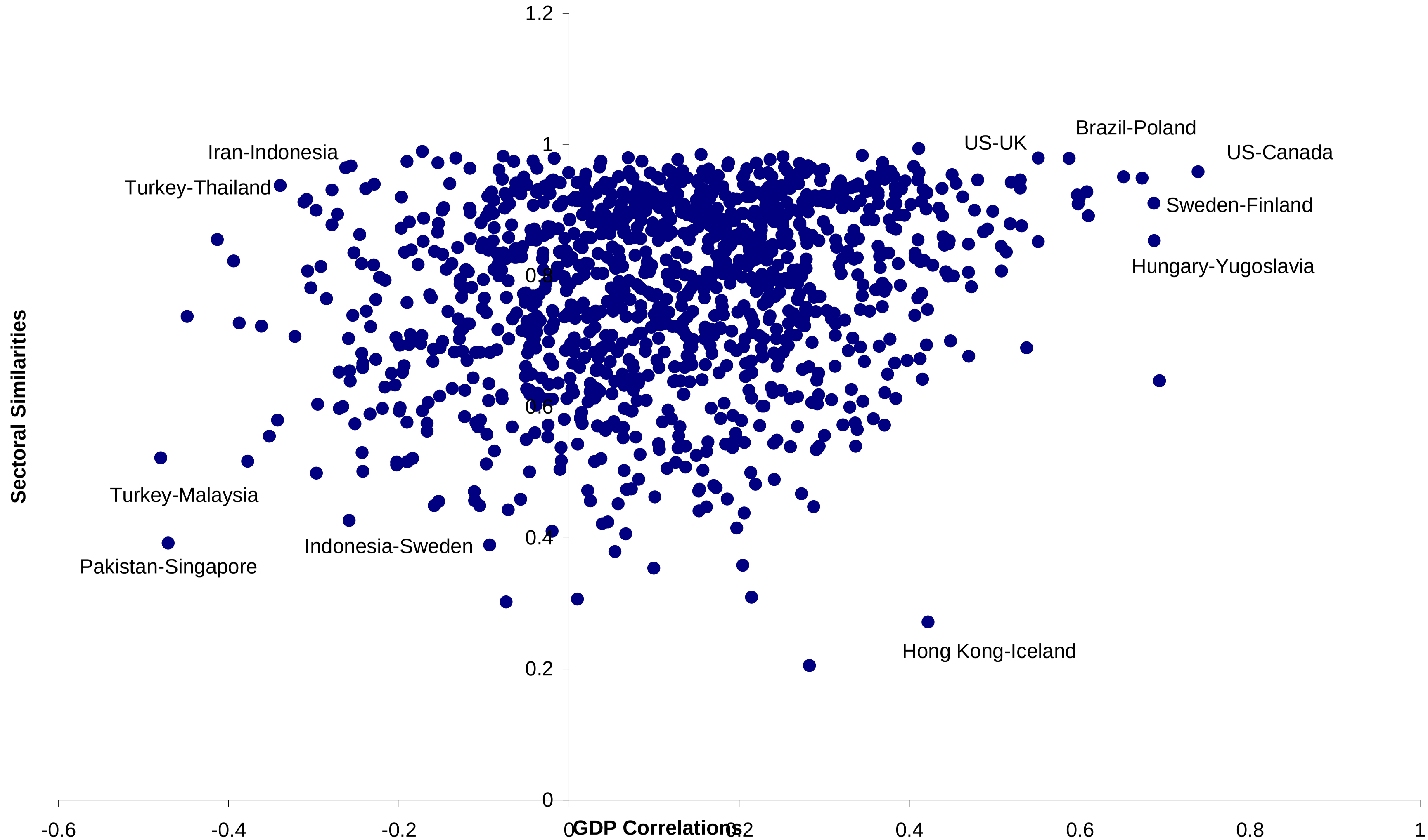

Figure 8: GDP Correlations and Similarities in Economic Structure

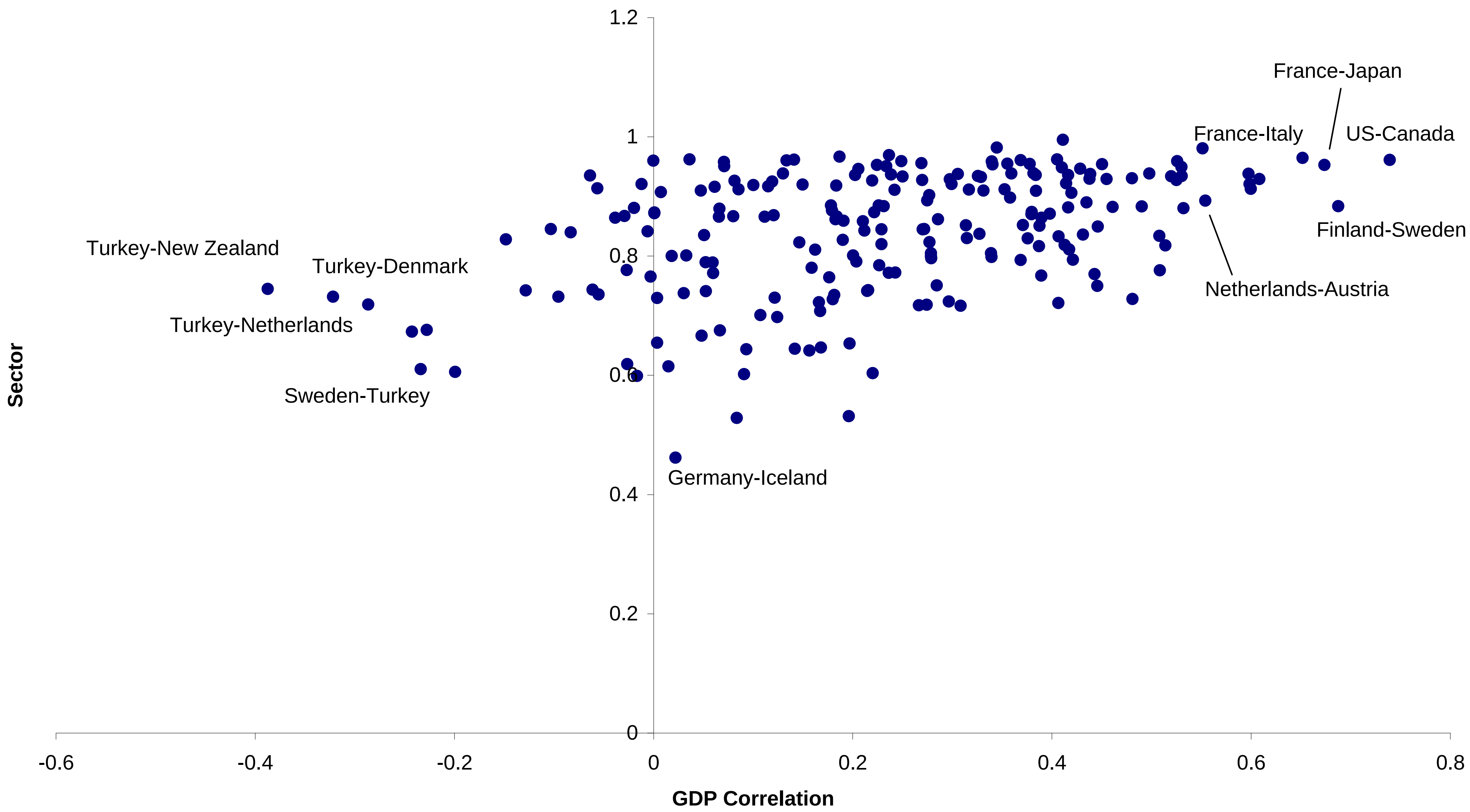

Table 1 : FDI Stocks in 1989 – 1990

Top ten destinations for the five largest source countries – in level and in share of destination GDP

France		Germany		U.K.		Japan		U.S.	
Level	Share	Level	Share	Level	Share	Level	Share	Level	Share
U.S.	Belux	U.S.	Ireland	U.S.	Singapore	U.S.	Panama	Canada	Panama
U.K.	Switzerland	Belux	Belux	Australia	Ireland	U.K.	Vanuatu	U.K.	Switzerland
Belux	Netherlands	France	Switzerland	Netherlands	Netherlands	Panama	Singapore	Germany	Ireland
Netherlands	Ireland	U.K.	Austria	Canada	Barbados	Australia	Hong Kong	Switzerland	Canada
Spain	Spain	Netherlands	Netherlands	France	Australia	Netherlands	Netherlands	Netherlands	Singapore
Italy	U.K.	Spain	Spain	Germany	Zimbabwe	Indonesia	Australia	Japan	Netherlands
Germany	Iran	Italy	France	Spain	NewZealand	Hong Kong	Belux	Bermuda	Gabon
Switzerland	Argentina	Switzerland	Gabon	Bermuda	Panama	Cayman Is.	Papua N.G.	France	U.K
Iran	Portugal	Austria	U.K.	S. Africa	Hong Kong	Belux	Fiji	Brazil	NewZealand
Canada	Denmark	Canada	Denmark	Switzerland	Jamaica	Brazil	Malaysia	Australia	Hong Kong

Data is taken from Wei (1995). It is for 1989 in France and the U.K, and for 1990 in Germany, Japan and the U.S. Observations exist mainly for developed receiving countries, though there are a few exceptions.

Table 2 : Specification Search – Sample of 49 Countries

	(i)	(ii)	(iii)	(iv)	(v)
Constant	0.121 [17.48]**	0.139 [10.28]**	0.082 [4.32]**	0.082 [4.32]**	0.068 [4.69]**
Tr70	4.06×10^{-5} [4.62]**	3.40×10^{-5} [4.14]**	1.93×10^{-5} [4.41]**	1.93×10^{-5} [4.41]**	1.81×10^{-5} [4.44]**
Income variables (1960)					
Y_i+Y_j			1.66×10^{-5} [8.11]**		
$\lvert Y_i-Y_j \rvert$			-2.06×10^{-5} [6.96]**		
Min (Y_i, Y_j)				3.72×10^{-5} [9.23]**	3.50×10^{-5} [9.29]**
Max (Y_i, Y_j)				-3.92×10^{-6} [1.27]	
Geographic variables					
Distance		-2.98×10^{-6} [2.02]*	-2.93×10^{-6} [2.16]*	-2.93×10^{-6} [2.16]*	-3.29×10^{-6} [2.46]*
Adjacency		0.127 [4.03]**	0.114 [3.63]**	0.114 [3.63]**	0.118 [3.79]**
R-Square	0.052	0.081	0.173	0.173	0.171
Condition Number	1.631	15.353	46.869	46.383	22.248
Trade R-Square		0.048	0.142	0.142	0.123

Dependent variable is GDP growth bilateral correlation between countries i and j, over 1950-1992 (pdy). Estimation with Huber-White standard errors, with t-statistics reported in brackets. * indicates significance level at the 5% level, ** at the 1% level. The condition number reports the ratio of the largest to the smallest eigenvalues of the moment matrix. The Trade R-Square corresponds to the regression of trade on the other dependent variables.

Table 3 : Similarities in Economic Structure– Sample of 49 Countries

	(i)	(ii)	(iii)	(iv)	(v)
Constant	-0.110 [3.49]**	-0.186 [4.72]**	-0.154 [3.83]**	-0.102 [2.54]**	0.068 [4.69]**
Tr70		3.31×10^{-5} [4.91]**	2.78×10^{-5} [4.46]**	1.77×10^{-5} [4.57]**	1.81×10^{-5} [4.44]**
Economic Structure (1970)					
Sector	0.288 [7.17]**	0.391 [7.91]**	0.374 [7.65]**	0.238 [4.59]**	
Income variables (1960)					
Min (Y_i, Y_j)				2.70×10^{-5} [6.76]**	3.50×10^{-5} [9.29]**
Geographic variables					
Distance			-3.05×10^{-6} [2.16]*	-3.26×10^{-6} [2.47]*	-3.29×10^{-6} [2.46]*
Adjacency			0.103 [3.15]**	0.105 [3.27]**	0.118 [3.79]**
R-Square	0.046	0.128	0.150	0.195	0.171

Dependent variable is pdy. Estimation with Huber-White standard errors, with t-statistics reported in brackets. * indicates significance level at the 5% level, ** at the 1% level. The variable "Sector" reports the correlation coefficient between sectoral shares in total manufacturing employment in countries i and j, measured in 1970. The 18 sectors utilized are : Food Products, Beverages, Textiles, Wearing Apparel, Leather Products, Footwear, Wood Products, Furniture, Paper and Products, Printing and Publishing, Industrial Chemicals, Other Chemicals, Rubber Products, Other Mineral Products, Fabricated Metal Products, Machinery Electric, Transport Equipment and Other Manufactured Products.

Table 4 : Non Linearities – Sample of 49 Countries

	(i) – pdy	(ii) – logis(pdy)	(iii) - ln(pdy)	(iv) - ln(pdy)	(v) - ln(pdy)
Constant	0.146 [0.87]	-0.249 [2.93]**	-2.088 [29.04]**	-2.393 [3.74]**	-1.624 [2.32]*
Tr70	3.55×10^{-5} [2.95]**	5.56×10^{-5} [5.22]**			
$(Tr70)^2$	-8.64×10^{-10} [1.67]				
ln(Tr70)			0.067 [3.97]**	0.026 [1.36]	0.027 [1.40]
Economic Structure (1970)					
Sector	-0.567 [1.22]	0.377 [3.39]**			
$(Sector)^2$	0.506 [1.63]				
ln(Sector)					0.672 [2.79]**
Income variables (1960)					
Min (Y_i, Y_j)	8.28×10^{-5} [6.08]**	1.75×10^{-4} [5.38]**			
Min $(Y_i, Y_j)^2$	-8.55×10^{-9} [4.48]**	-1.75×10^{-8} [6.09]**			
ln[Min (Y_i, Y_j)]				0.166 [2.78]**	0.084 [1.23]
Geographic variables					
Distance	-2.80×10^{-6} [2.11]*	-6.31×10^{-6} [2.26]*			
ln(Distance)				-0.097 [2.16]*	-0.096 [2.16]*
Adjacency	0.103 [3.17]**	0.241 [3.21]**		0.331 [2.27]*	0.293 [1.97]*
R-Square	0.217	0.224	0.025	0.060	0.072

Dependent variable in (i) is pdy, in (ii) it is replaced by its logistic transform, and in (iii)-(iv)-(v) by its logarithm. Estimation with Huber-White standard errors, with t-statistics are reported in brackets. * indicates significance level at the 5% level, ** at the 1% level.

Table 5 : Robustness Check – Sample of 49 Countries

	(i)	(ii) - Tr80	(iii) – HP	(iv) - HP	(v) - HP
Constant	-0.107 [2.61]**	-0.142 [3.89]**	0.068 [3.50]**	-0.114 [2.03]*	-0.119 [2.13]*
Trade	2.23×10^{-5} [4.86]**	5.13×10^{-6} [4.50]**	2.12×10^{-5} [4.95]**	2.08×10^{-5} [4.97]**	2.27×10^{-5} [4.91]**
Sector	0.181 [3.36]**	0.179 [3.87]**		0.256 [3.54]**	0.230 [3.09]**
Min (Y_i, Y_j)	8.09×10^{-5} [5.19]**	9.35×10^{-5} [7.45]**	3.29×10^{-5} [6.55]**	2.43×10^{-5} [4.57]**	4.78×10^{-5} [2.62]**
Min $(Y_i, Y_j)^2$	-8.09×10^{-9} [3.87]**	-9.68×10^{-9} [5.42]**			-3.48×10^{-9} [1.34]
Distance	-3.41×10^{-6} [1.94]	-1.74×10^{-6} [1.47]	-4.94×10^{-6} [2.74]**	-4.91×10^{-6} [2.73]**	-4.79×10^{-6} [2.66]**
Adjacency	0.111 [3.17]**	0.097 [3.11]**	0.070 [2.03]*	0.056 [1.55]	0.056 [1.55]
Continents					
Europe	-4.37×10^{-3} [0.18]				
Asia	-0.033 [1.44]				
America	-0.016 [0.59]				
Africa	3.97×10^{-4} [0.01]				
R-Square	0.215	0.221	0.096	0.112	0.114

Estimation (ii) uses bilateral trade data in 1980; estimations (iii)-(iv)-(v) compute bilateral GDP correlations using the HP-filtered series with lambda = 100.

Table 6 : Specification Search – Sample of 21 Countries

	(i)	(ii)	(iii)	(iv)	(v)
Constant	0.196 [3.56]**	0.196 [3.56]**	0.114 [3.28]**	-0.480 [4.91]**	-0.367 [4.12]**
Tr70	2.53×10^{-5} [4.06]**	2.53×10^{-5} [4.06]**	2.13×10^{-5} [2.87]**		1.57×10^{-5} [3.23]**
Economic Structure					
Sector				0.847 [7.33]**	0.644 [5.69]**
Income variables (1960)					
Y_i+Y_j	8.01×10^{-6} [1.73]				
$\|Y_i-Y_j\|$	-2.60×10^{-5} [3.67]**				
Min (Y_i, Y_j)		3.40×10^{-5} [4.41]**	2.77×10^{-5} [3.87]**		1.62×10^{-5} [2.25]*
Max (Y_i, Y_j)		-1.80×10^{-5} [1.96]*			
Geographic variables					
Distance	-6.44×10^{-7} [0.27]	-6.44×10^{-7} [0.27]	-2.33×10^{-6} [1.06]		-3.73×10^{-6} [1.71]
Adjacency	0.061 [0.96]	0.061 [0.96]	0.078 [1.53]		0.057 [0.92]
R-Square	0.193	0.193	0.178	0.190	0.270
Condition Number	124.72	151.74	37.13		
Trade R-Square	0.259	0.259	0.190		

Dependent variable is GDP growth bilateral correlation between countries i and j (pdy), over 1950-1992. The -yearly- data are taken from the Penn-World Tables (Version 5.6). Estimation with Huber-White standard errors, with t-statistics reported in brackets. * indicates significance level at the 5% level, ** at the 1% level. The condition number reports the ratio of the largest to the smallest eigenvalues of the moment matrix. The Trade R-Square corresponds to the regression of trade on the other dependent variables. The variable "Sector" reports the correlation coefficient between sectoral shares in total manufacturing employment in countries i and j, measured in 1971. The 20 sectors utilized are : Food Products, Beverages, Textiles, Wearing Apparel, Footwear, Wood Products, Furniture, Paper and Products, Printing and Publishing, Industrial Chemicals, Other Chemicals, Rubber Products, Plastic Products, Glass and Products, Iron and Steel, Fabricated Metal Products, Machinery Electric, Transport Equipment, Professional and Scientific Equipment and Other Manufactured Products.

Table 7 : Non Linearities – Sample of 21 Countries

	(i) – pdy	(ii) – logis(pdy)	(iii) - ln(pdy)	(iv) - ln(pdy)	(v) - ln(pdy)
Constant	-0.484 [4.08]**	-1.091 [4.39]**	-2.460 [10.49]**	-2.01 [1.20]	-0.518 [0.33]
Tr70	2.66×10^{-5} [2.07]*	4.57×10^{-5} [3.44]**			
$(Tr70)^2$	-5.39×10^{-10} [1.04]				
ln(Tr70)			0.175 [4.50]**	0.154 [3.36]**	0.101 [2.06]*
Economic Structure (1970)					
Sector	0.598 [5.38]**	1.332 [5.62]**			
ln(Sector)					1.956 [3.46]**
Income variables (1960)					
Min (Y_i, Y_j)	1.00×10^{-4} [2.83]**	2.22×10^{-4} [2.95]**			
Min $(Y_i, Y_j)^2$	-9.95×10^{-9} [2.48]*	-2.24×10^{-8} [2.58]*			
ln[Min (Y_i, Y_j)]				0.060 [0.32]	-0.015 [0.09]
Geographic variables					
Distance	-2.59×10^{-6} [1.14]	-5.86×10^{-6} [1.20]			
ln(Distance)				-0.104 [1.66]	-0.137 [2.24]*
Adjacency	0.055 [0.92]	0.159 [1.11]			
R-Square	0.292	0.303	0.111	0.122	0.166

Dependent variable in (i) is pdy, in (ii) it is replaced by its logistic transform, and in (iii)-(iv)-(v) by its logarithm. Estimation with Huber-White standard errors, with t-statistics are reported in brackets. * indicates significance level at the 5% level, ** at the 1% level.

Table 8 : Robustness Check – Sample of 21 Countries

	(i)	(ii) - DOT	(iii) - DOT	(iv) - HP	(v) - HP
Constant	-0.382 [4.19]**	0.243 [7.06]**	-0.109 [0.77]	0.099 [2.39]*	-0.268 [2.40]*
Trade	1.79×10^{-5} [4.53]**	2.43×10^{-5} [5.00]**	2.09×10^{-5} [4.38]**	2.51×10^{-5} [5.29]**	2.02×10^{-5} [4.76]**
Sector	0.659 [5.78]**		0.449 [2.52]**		0.491 [3.67]**
Min (Y_i, Y_j)	1.67×10^{-5} [2.31]*	1.08×10^{-5} [1.47]	3.09×10^{-6} [0.38]	2.88×10^{-5} [3.39]**	1.98×10^{-5} [2.35]*
Distance	-4.07×10^{-6} [1.89]	-4.87×10^{-6} [2.19]*	-5.12×10^{-6} [2.26]*	-3.30×10^{-6} [1.42]	-4.22×10^{-6} [1.80]
EU	0.015 [0.59]				
R-Square	0.267	0.136	0.168	0.141	0.184

Estimations (ii)-(iii) uses bilateral trade from the IMF Direction of Trade base; estimations (iv)-(v) compute bilateral GDP correlations using the HP-filtered series.

Table 9 : Robustness Check – Sample of 21 Countries

	(i) - Qtr	(ii) - Qtr	(iii) - HP Qtr	(iv) - HP Qtr
Constant	0.179 [6.02]**	-0.105 [1.23]	0.054 [1.34]	-0.113 [0.96]
Trade	2.28×10^{-5} [4.02]**	1.94×10^{-5} [3.77]**	2.94×10^{-5} [4.35]**	2.74×10^{-5} [4.03]**
Sector		0.381 [3.50]**		0.225 [1.67]
Min (Y_i, Y_j)	2.00×10^{-5} [3.30]**	1.32×10^{-5} [2.09]*	1.31×10^{-5} [1.67]	9.06×10^{-6} [1.13]
Distance	-2.70×10^{-6} [1.49]	-3.53×10^{-6} [2.03]*	-2.09×10^{-6} [1.01]	-2.58×10^{-6} [1.28]
Adjacency	0.075 [1.39]	0.062 [1.13]	0.001 [0.01]	-0.001 [0.96]
R-Square	0.196	0.240	0.120	0.131

All estimation use quarterly data taken from the International Financial Statistics base published by the IMF. (i) and (ii) use a first-difference filter, while (iii) and (iv) use the HP filter with lambda = 1600.

Table 10 : Lagged Trade – 21 Countries

	(i) - Lag	(ii) - Cont	(iii) - Cont
Constant	-0.357 [2.23]*	-0.164 [1.23]	0.146 [2.25]*
Trade	2.20×10^{-5} [2.44]*	2.17×10^{-6} [2.02]*	2.46×10^{-6} [2.23]*
Sector	0.770 [3.93]**	0.477 [2.64]**	
Min (Y_i, Y_j)	-8.59×10^{-6} [0.89]	2.51×10^{-6} [0.39]	1.07×10^{-5} [1.86]
Distance	-1.11×10^{-5} [3.97]**	-1.05×10^{-5} [3.72]**	-1.07×10^{-5} [3.71]**
Adjacency	0.086 [1.16]	0.084 [1.09]	0.071 [0.99]
R-Square	0.271	0.257	0.229

Bilateral GDP correlations are computed over the sub-period 1976:1 – 1993:4, using GDP growth rates. The trade data in 1970 comes from the Direction of Trade base. (ii) uses “contemporaneous” variables: bilateral trade, minimum GDP per capita and Sector in 1990.