Co-Fluctuations*

Jean Imbs

London Business School and CEPR

June 2003

Abstract

This paper documents an often neglected yet intuitive determinant of business cycles synchronization. I find countries with similar sectoral production patterns to be more synchronized, holding other transmission channels constant, in particular trade intensity. The results hold for a large sample of countries with different income levels, as well as within the OECD. They are robust to different filtering devices, across yearly and quarterly frequency, and for a variety of data sources, subsamples and measurement strategies. The findings are interpreted in a model where countries diversify as they grow, develop an increasingly similar economic structure, and thus react in an increasingly similar fashion to (aggregate or sector-specific) shocks.

Keywords: International Business Cycles, Trade, Economic Structure.

JEL Classifications: F41, E32, F12.

*This paper is a substantially revised version of Chapter III from my dissertation. I have benefited from numerous insightful conversations with colleagues, among many others Manuel Arellano, Jean-Pierre Danthine, Robert Kollmann, Franck Portier, Jaume Ventura, Romain Wacziarg, Kei-Mu Yi and Fabrizio Zilibotti. Most of this paper was written while I was holding a temporary position at the University of Lausanne, whose hospitality I gratefully acknowledge. All errors are mine. This research was partly supported by a grant from the Fonds National de la Recherche Scientifique (Grant No 12-53584.98). Correspondence to: London Business School - Economics, Regent's Park, London NW1 4SA. Jimbs@london.edu

1 Introduction

This paper contributes to the empirical literature on international business cycles. I provide evidence on the cross-sectional 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. A robust determinant of cycles synchronization appears to be the similarity in their sectoral production patterns. Thus, fluctuations in Canada and the U.S. are highly correlated (in part) because the countries share similar industries.

The question of cycles synchronization has been the object of a substantial literature. Empirically, trade openness often tops the list of variables found to explain cycles synchronization.[1] Thus, Japan enters a recession for purely domestic reasons, and insofar as a significant proportion of Asian exports target the Japanese market, the rest of Asia cannot but suffer from it. This paper offers confirmation of this fact, but proposes to include sectoral specialization patterns in the list of relevant explanations. This result is subjected to an exhaustive sensitivity analysis, and holds for a variety of data sets, coverage, frequency, or filtering devices.

The relevance of sectoral production patterns is interesting in three ways. First, it obtains when trade is held constant. This casts doubt on models that place trade as the *sole* source of international business cycles, since co-fluctuations increase with specialization holding trade constant. These include theories of intra-industry trade, as standard aggregate measures capture both types of trade. If sectoral production mattered only inasmuch as they reflect the extent of intra-industry trade, their effect on cycles synchronization would only work through bilateral trade intensity, and the residual direct effect would be insignificant. Second, the results bring support to the possibility of sector-specific shocks, or, alternatively, to heterogeneous sector-specific responses to aggregate shocks, a hypothesis that has recently attracted

[1] See most prominently Frankel and Rose (1998).

renewed interest.[2] Third, they suggest the dynamics of specialization carry through to a non-negligible extent into the dynamics of co-fluctuations. For instance, Imbs and Wacziarg (2003) document a non-monotonicity in specialization patterns, with countries diversifying over most of their development, but actually (re-)specializing once they reach a high enough level of income per capita. Since this reversal is estimated to occur only amongst a few of the richest economies, the results in this paper suggest a long-run upward trend in the extent of business cycle synchronization, as economies grow to become increasingly diversified. They also suggest there are stuctural reasons to expect this trend to reverse.

The rest of the paper is structured as follows. Section 2 reviews the literature on international business cycles. Section 3 presents a multivariate analysis of the determinants of co-fluctuations, following theory in choosing a set of conditioning variables. Section 4 addresses concerns of robustness. Section 5 presents a model of endogenous structural change in the Ricardian tradition consistent with the evidence, where countries are exposed to sector-specific shocks and become more synchronized as they grow and diversify. Section 6 concludes.

2 Literature and Preliminary Evidence

From a theoretical standpoint, research has mostly focused on generating positive international cycles correlations, in order to address the celebrated *quantity puzzle* coined by Backus, Kehoe and Kydland (1994). In the standard international real business cycle model, resources go wherever the return to capital is highest and thus

[2] See for instance Kraay and Ventura (2001). The question whether unexpected developments occur mostly at the sectoral or at the country level is still open for debate. Papers by Stockman (1988) and Costello (1993) provide evidence in favor of country effects. Ghosh and Wolf (1997) argue however that the result is an artefact of aggregation, which averages away sectoral shocks to a larger extent than national ones. Fatas (1997) and Kollmann (1995) provide further evidence in favour of disaggregated shocks.

the model generates negatively correlated international fluctuations to the extent that aggregate shocks are imperfectly correlated internationally. On the other hand, perfectly correlated 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 (2001) develops a two-country world where variations in aggregate demand, in the form of money supply shocks, matter because of nominal rigidities. There, in response to a positive domestic aggregate demand shock, the standard Keynesian depreciation effect, that induces agents to substitute domestic to foreign goods and thus triggers 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, to an extent increasing with trade linkages, that determine the magnitude of both "quantity" and "price" effects. At the disaggregated level, Horvath (2000) shows that the input-output structure must be chosen parsimoniously for shocks in intermediate and final goods sectors to result in aggregate fluctuations, a result confirmed by Ambler, Cardia and Zimmermann (2002) in an international setting. Both aggregate and disaggregate 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 most prominent contribution is probably Backus, Kehoe and Kydland (1995). In that class of models, trade occurs because domestic absorption falls on both domestic and foreign goods, to an extent that is governed by their degree of substitutability and by the parametrized share of imports in output. Figure 1 reports how co-fluctuations respond to an increasing import share in this model, for different levels of the elasticity of substitution between domestic and foreign goods.[3] The relationship is clearly non-linear, with a peak just above an import share of 0.5, where a domestic technology shock actually translates into a foreign investment boom and a domestic slump, rather than the opposite in the original model with an import share of 0.15. As is well-known and plotted in Figure 2, more than three-quarters of all observations in the Penn-World Tables display a degree of openness smaller than 0.4.[4] Thus, most of the world economy is best represented by the section of Figure 1 where the extent of co-fluctuations hardly responds to trade intensity, at least for elasticities of substitution around 1.5. Of course, as foreign and domestic goods become increasingly complementary in producing final goods, the slope of the curve increases. Studies in the trade literature point however to estimates for the elasticity of substitution between home and foreign goods between 1 and 2.[5] Within this range of elasticities, the model in Backus, Kehoe and Kydland implies a flat relationship between trade and cycle synchronization.

The sectoral structure of an economy has recently been argued to affect independently the business cycle. For instance, Kraay and Ventura (2001) develop a model where rich (poor) countries are specialized in high-tech (low-tech) sectors, respectively. Different market structures cause sectors -and countries specialized in these- to respond differently to a given aggregate shock. Similarly, Lubik (2003) investigates the heterogeneous response to monetary policy shocks across traded and non-traded sectors. This paper can be interpreted to provide independent empirical confirmation to these conjectures, with focus on the international evidence.

The relationship between trade and business cycles synchronization is a well-explored area of empirical research. Most prominently, Frankel and Rose (1998) show

[3]ELA in Figure 1.

[4]Openness in the Penn-World Tables is the ratio of exports and imports over output. Backus, Kehoe and Kydland (1994) assume balanced trade, so that the import share is nothing but half the degree of openness from PWT, as reported in Figure 2.

[5]See for instance Stern, Francis and Schumacher (1976).

the cross-section of business cycles synchronization in the OECD to be significantly explained by trade intensity. Canova and Dellas (1993), on the other hand, question the robustness of this evidence to alternative choices of a filter, and Schmitt-Grohé (1998) shows that trade is insufficient to explain the observed correlation between the U.S. and Canadian business cycles. Clark and VanWincoop (2001) take a more agnostic approach, and allow geographic considerations, such as the presence of a common border, to affect co-fluctuations directly, as opposed to indirectly via trade intensity for example. They find evidence supportive of a significant border effect, with regional fluctuations more in phase within a country than across a border.[6] Finally, Artis and Zhang (1997) provide evidence that a fixed exchange rate regime imposes policy discipline, which leads to conformity in business cycles.

The link between cycles synchronization and financial integration is probably the least researched area in this literature, presumably because data limitations make an empirical verdict hard to reach. However, financial integration will only affect this paper's results if it associated with *both* specialization in production *and* lower business cycles correlations. In this case, finance would be an omitted variable likely to bias upwards the link between co-fluctuations and similarity in production patterns, as financially integrated economies would tend to be both specialized and out of phase. There is substantial evidence that financial openness affects patterns of specialization, as predicted by theory, and documented for instance in Kalemli-Ozcan et al (2001,

[6] This "border effect" is different from the one discussed in Anderson and VanWincoop (2003), who focus instead on the puzzlingly high impact of a border in explaining trade intensity. Anderson and VanWincoop show that this is an artefact of using bilateral data without accounting for a "multilateral resistance" effect capturing openness to third parties. This bias is largely innocuous for the present purpose, as it pertains to the impact of the border on trade, and possibly to that of trade on co-fluctuations. In what follows, the border effect is controlled for, both directly and indirectly (i.e. through trade), so that presumably the bias does not affect the estimation of the link of interest here, that between sectors and co-fluctuations.

2003).[7,8] On the other hand, the link between cycles and financial integration is weak, both theoretically and empirically. If shocks are to technology, capital will in theory flow between countries at different stages of their cycles, as it responds to differentials in returns. However, rational herding, asymmetric information or liquidity constraints, manifested for instance in margin calls, all open the possibility for flows of capital that are related positively, or not at all, with cycle synchronization.

The omission of a control for financial integration will only be problematic for the present purpose if the former diversification motive dominates. Empirical evidence supporting this possibility is tenuous at best. Capital flows appear to be governed by the availability of information on the recipient market, or by the economy's general level of openness, rather than by returns differentials: Portes and Rey (2001) and Lane and Milesi-Ferretti (2003) both find hardly any role for portfolio motives in accounting for bilateral financial flows.[9] In other words, the unambiguous link between finance and specialization is unlikely to induce a systematic bias causing the main result in this paper, namely that cycles synchronization and sectoral production patterns are

[7]Finance-induced specialization does not necessarily result in international differences in sectoral patterns, however. For countries to produce in different sectors, international specialization must in addition respond to other -trade related- incentives, such as factors endowments.

[8]Kalemli-Ozcan et al (2001) is probably the paper closest in spirit to the present exercise. They show that in a panel of U.S States and 11 OECD countries, specialized regions are less synchronized with the aggregate. Their analysis does however differ from the present one. First, they do not control for trade intensity. Second, their sample mixes intra-national and international information. Third, they measure synchronization and specialization with respect to an average, as opposed to a bilateral approach. Finally, and perhaps most importantly, as they are interested in the effects of finance on synchronization, they measure the asymmetry of fluctuations by an index of risk-sharing, rather than the correlations in GDP used here, more traditional in the international business cycles literature.

[9]Lane and Milesi-Ferretti (2003) find for instance a prominent role for financial hubs, irrespective of the characteristics of their business cycles.

significantly and independently related.[10,11]

In summary, neither theory nor the existing empirical literature provide a definite answer as to why countries co-fluctuate, so that the empirical issue must be addressed agnostically. Figure 3 reports the (positive) bilateral correlations between GDP growth rates for 136 countries in the Penn-World Tables, presented in the original geographic ordering.[12] Figure 4 reports only the negative correlations, and confirms that a majority of the 9180 correlations are positive, i.e. that there is a quantity puzzle. It is difficult to rule out any of the previous explanations *a priori*. Correlations seem higher on average between European countries, across the Americas and across the Atlantic Ocean, which points to the putative importance of trade intensity, geographic proximity or common institutions. But on the other hand, in spite of relatively high trade linkages between Asian countries, there is very little indication of an "Asian" business cycle.[13] Figure 5 reports bilateral GDP growth rates

[10] Actually, identifying the impact of financial integration on cycles is an important question in its own right, not least because theory does not provide a definite answer. But careful identification requires care be taken to account for both putative direct effects and indirect ones, via increased specialization. In other words, it requires a simultaneous estimation frameword, a machinery exceeding the scope of the present paper, but implemented in Imbs (2003). Consistent with what was just said, Imbs (2003) finds sectoral patterns to matter for co-fluctuations even holding financial integration constant. The estimates are quite similar to those in the present exercise.

[11] Estimates from a cross-section including both developing and rich economies are also very similar to an alternative sample focusing on rich countries only, even though the cross-section of financial integration is drastically different in both samples.

[12] Correlations are computed using first-differences of GDP. 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. Subsequent regressions are run using samples of fewer countries. Correlation coefficients are estimated with error. The 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. Appendix A lists the countries contained in the different sub-samples utilized in the paper.

[13] Trade data from Frankel and Wei (1998) show that in 1980, average trade within Asia was almost three times higher than across the Americas, when excluding the U.S and Canada.

correlations with countries ordered according to GDP per capita in 1960: it is quite clear that rich countries are more synchronized, which would happen if countries diversified in a widening range of goods and were thus subjected to an increasing range of common (sectoral) stochastic developments, or responded similarly to a given aggregate shock.[14]. Of course, none of the indications drawn from Figures 3, 4 and 5 are conclusive for they rely on mere bivariate claims and potentially suffer from omitted variable biases. We next address this concern.

3 Co-Fluctuations and Economic Structure

This section implements multivariate regression analysis. As suggested in the literature reviewed, the extent of cycle synchronization is regressed on bilateral trade intensity, geographic variables such as distance or the presence of a common border, the initial level of income per capita, and similitudes in the sectoral structure of the economy.[15] This restricts the analysis to a maximum of 49 countries, listed in appendix A, where both bilateral trade and sectoral data are available, and thus to a sample of 1176 bilateral observations. Data on trade is taken from Frankel and Wei (1998), and the value of bilateral exports flows is available for 61 countries in 1970, 1980, 1990 and 1992. Frankel and Rose (1998) and measure trade in intensive terms by normalizing exports values in both directions by the sum of nominal GDPs in both countries, i.e. by

$$T^1_{i,j} = \frac{X_{i,j} + X_{j,i}}{Y_i + Y_j}$$

where $X_{i,j}$ denotes total merchandise exports from country i to j and Y_i denotes nominal GDP in country i. All variables are measured in 1970, to assuage endogeneity

[14]This would also happen if data for rich countries were of better quality, a possibility ruled out later in the paper where the same conclusion is shown to prevail amongst OECD countries.

[15]This is a more exhaustive list than in the existing literature, typically content with estimating either the role of trade, or that of the border, for instance.

concerns.[16]

Measures of cycle synchronization are obtained by computing bilateral correlations between GDP annual growth rates as implied by the Penn-World Tables.[17] Three-digit sectoral data are from UNIDO, and were used to construct an index of similarities in manufacturing sectoral structure for 49 countries in 1970, 1980 and 1989. Following Shea (1996), an index S is computed, capturing the correlation between sectoral shares in aggregate employment for all country pairs (i, k) in the sample, defined as:

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

where s_{ji} denotes the share of sector j in country i 's employment and M is the number of sectors. S is measured in 1970.[18] Section 4 presents results using alternative measures of S. In particular, the index is computed on the basis of (i) value added data as opposed to employment, (ii) two-digit sectoral data covering all economic activities as opposed to manufacturing only. All results stand.

In what follows, results pertaining to a reduced data sample of 21 OECD countries

[16] Furthermore, the sensitivity analysis in the next section shows the results are not altered when trade is measured in level, at different dates, using an alternative normalization, introduced in Clark and VanWincoop (2001), or when trade is instrumented by the standard gravity variables.

[17] Section 4 shows the results are robut to using alternative filters to isolate the cyclical component of GDP.

[18] An alternative measure akin to a Herfindhal index was proposed by Krugman (1996) and implemented in Imbs (2003). In results available upon request, S is measured as an average over time rather than an initial value, without any differences to the results. Using initial values of S can help assuage endogeneity concerns. It is however far from obvious how low-frequency specialization patterns could respond to high-frequency business cycles characteristics. In theory, specialization patterns are determined by factor endowments, or openness to trade, both very persistent variables that are hardly responsive to the business cycle. Nevertheless, Imbs (2003) implements an instrumentation of S, using the result in Imbs and Wacziarg (2003) that the dynamics of specialization are largely explained by GDP per capita. Instrumenting S does not change any of the results there, suggesting the endogeneity of S is not a crucial empirical issue.

are also presented, using both yearly data from the Penn-World Tables and quarterly data from International Financial Statistics. Such repetition is interesting for a variety of reasons. The alternative data are of homogenous quality, frequency is not restricted to yearly series, and real GDP per capita is expressed in international prices in one case, while it is in units of domestic currency in the other. Table 1 provides some summary statistics for the variables used in all estimations.

Table 2 presents the results corresponding to the extended sample of 49 countries. Regression (i) confirms a positive and significant role for bilateral trade intensity, akin to the one documented in Frankel and Rose (1998). Specification (ii) adds some of the so-called "gravity variables", i.e. a measure of the distance between main cities and a binary variable taking value one when the two countries share a common border. Additional controls are also included, that reflect the initial cross-sectional distribution of income per capita, as suggested by Figure 5.[19] The signs of the geographic variables are as expected: distant countries tend to be less correlated, whereas neighbors are significantly more synchronized, a border effect already documented by Clark and VanWincoop (2001). Comparing estimations (ii) and (iii), it is clear that only the minimum of the two countries' initial GDP per capita affects cycles.[20] The coefficient on trade intensity becomes insignificant when gravity variables are included, but this result should not be taken as an indication that trade does not matter for cycles synchronization, given the well-known correlation between gravity variables and trade intensity. In other words, the significance of gravity variables could simply reflect the importance of trade, as trade tends to happen between geographically close economies. But this debate is irrelevant to this paper's point, as long as the (direct or indirect) impact of trade on co-fluctuations is accounted for, and thus does not

[19] A variable indicating usage of the same language was also included, with no significant effect.

[20] Ideally, one would want to discriminate between pairs of countries where both countries are rich, both are poor, and instances where they have different income levels. This justifies including both a minimum and a maximum in the estimation. Both variables turn out to enter significantly, though with opposite signs, which points to the significance of $\mathrm{Min}(\mathrm{Y}_i;\mathrm{Y}_j)$. The coefficients on the other variables remain virtually unchanged across specifications (ii) and (iii).

bias the estimate of interest. Controlling for trade intensity is important here because any remaining significant effect of sectoral patterns cannot be ascribed to any kind of trade, intra- or inter-industry. But establishing whether trade matters directly, or because it reflects geographic considerations is not of direct interest here.[21]

Specification (iv) underlines the univariate importance of economic structure, albeit in a bivariate setup that makes the coefficient hard to interpret: it could merely reflect the extent of (intra-industry) trade. Estimation (v) confirms its importance, holding trade, geography and income per capita constant. Interestingly, comparison between (iii) and (v) suggest that inclusion of S results in a point estimate of the coefficient on income 30% lower in magnitude and less significant. The paper interprets the combination of those two empirical results as an indication that countries tend to converge to a similar production structure as they grow rich, and as a result experience sectoral shocks of equal importance.[22] This result is significant in both a statistical and economic sense, and its importance in explaining business cycles synchronization at least equal in magnitude to that of trade linkages. Furthermore, economic structure matters holding trade constant, which points to an important independent transmission channel.[23]

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[21]This debate is reminiscent of the one surrounding the effect of openness to trade on economic growth. Frankel and Romer (1999) or Frankel and Rose (2002) have established a significant causal relationship, instrumenting trade intensity using gravity variables, but Rodrik et al (2002) have argued that this instrumentation is fallacious, as the very instruments are liable to affect economic growth directly.

[22]Imbs and Wacziarg (2003) provide detailed evidence of the former empirical fact.

[23]All coefficients are estimated with reasonable precision, point estimates do not vary widely and R^2 remain within quite a narrow range. This is reassuring, for it argues against the presence of problematic multicollinearity. To supplement the argument, Table 3 provides a condition number, defined as the ratio of the largest to the smallest characteristic roots of the moment matrix, for those regressions liable to suffer from multicollinearity. Common practice suggests that multicollinearity becomes a potentially serious problem when the moment condition is in excess of 20. The case only arises when both $\text{Min}(Y_i,Y_j)$ and $\text{Max}(Y_i,Y_j)$ are included in the estimation, a clear sign that they jointly carry unnecessary information.

The data are consistent with a world in which aggregate income per capita grows as economies converge to a similar 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 S (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.[24]

Table 3 reproduces Table 2 on the basis a reduced sample of 21 OECD countries, using both yearly and quarterly data. Three main results stand out: (i) the (direct) effects of trade intensity are larger in the OECD, as Frankel and Rose (1998) already documented. (ii) Geographic considerations are not significantly affecting the manner in which OECD countries co-fluctuate. In particular, there is no significant border effect. (iii) The richer OECD countries tend to be more synchronized, as evidenced in the second and fifth columns. But this appears to happen mostly because they have similar economic structures: income per capita ceases to matter significantly as soon as S is included in the specification, as can be seen from columns three and six. Thus, pairs of rich OECD countries are more synchronized *because* their production patterns are more similar. The coefficient on S is estimated to be significant whether cycles are measured on the basis of yearly or quarterly data. The next section discusses the robustness of these results.

4 Sensitivity Analysis

Sensitivity is conducted along four dimensions: a different filter to identify the cyclical component of GDP, different measures of trade and of the sectoral variable, both taken

[24] Clark and VanWincoop (2001) 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, i.e. for the border effect. Their result translates here in the fact that the inclusion of S has little impact on the border effect.

at alternative dates, and the omission of sub-periods potentially liable to drive the results, such as an oil shock for instance.[25]

4.1 Filter

Tables 4 and 5 mirror Tables 2 and 3, using a band-pass filter to isolate the cyclical component of (both yearly and quarterly) GDP when computing bilateral correlations.[26] All results carry through. In particular, both the role of trade and that of sectoral production patterns are confirmed in both samples.

4.2 Measures of Trade

Table 6 presents regressions results where trade is measured in level rather than intensive terms. Given the well-known persistence in trade patterns, it is no surprise that it makes very little difference to use trade data in 1970 or 1980. The main modification of the results is the systematically large and significant effect of the trade variable, but with hardly any change in the other coefficient estimates relative to Tables 2 and 3. In particular, both the point estimate and the significance of S remain almost identical.

The last column in Table 6 introduces an alternative measure of trade intensity, proposed by Clark and VanWincoop (2001), defined as

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[25] Measurement error specific to country i could carry through to all bilateral correlations involving i, thus creating a type of heteroskedasticity that Huber-White corrections cannot correct for. In results available upon request, a GMM estimator is implemented, that is able to correct for this heteroskedasticity, along the lines described in Clark and VanWincoop (2001). All results are robust to this alternative.

[26] The filter is described in Baxter and King (1999). The parameters are set according to that paper's recommendations. In particular, the filter is set to preserve the component of the data with period between 6 and 32 quarters for quarterly data, and between 2 and 8 years for yearly data.

$$T^2_{i,j} = \frac{(X_{i,j} + M_{i,j})\ Y^W}{Y_i * Y_j}$$

where Y^W denotes world GDP. T^2 differs from previous measures in that it depends only on trade barriers, and not on country size. In particular, Deardorff (1998) shows that T^2 equals 1 if preferences are homothetic and there are no trade barriers. Thus, T^2 is more likely to correlate with the gravity variables used here (distance and the border) than previous measures were, which is why geographic variables are omitted from specification (vii).[27] Once again, the similarity in sectoral structure matters significantly for business cycles correlations.

4.3 Economic Structure

The summary statistics presented in Table 1 make it quite clear that S is serially correlated, particularly among high income countries. Table 7 shows that measuring the degree of similarities in economic structure at different dates makes little difference. There may be a slight tendency for the coefficient on trade to increase and that on S to fall when data from 1989 is used.

Previous results were based on a measure of sectoral activity focused on employment in manufacturing activities. The conclusions might not generalize to the whole range of economic activities, nor to indices measured on the basis of value added as opposed to merely employment. The last two specifications in Table 7 make use of an alternative dataset, taken from the United Nations Statistical Yearbook, which contains information on two-digit sectoral Value Added in all sectors. The index S is computed using this alternative data, and specifications (v) and (vi) in Table 7 present the results, using two alternative measures of trade intensity. All results stand: trade continues being significant, and, more importantly, so does economic structure.

[27] The coefficient on S is unchanged if Distance and Border are included. But that on trade becomes insignificant.

4.4 Sub-Periods and Endogeneity

The importance of sectoral considerations in explaining aggregate cycle synchronization could stem from the prevalence of global shocks over the period under consideration, to which different sectors respond in a different manner. The huge swings in oil prices that pervaded the period 1973-1987 come immediately to mind. Estimations (i) and (ii) in Table 8 present results omitting the period 1973:1-1986:4 when computing GDP correlations.[28] If anything the period's omission reinforces the importance of sectoral considerations, thus suggesting that S matters for co-fluctuations because of sector-specific developments rather than heterogeneity in sector-level responses to the oil shocks of the 70s.

There is a 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 (2001), countries subjected to perfectly correlated aggregate demand shocks will trade more, for only the "quantity" effect is at play then. Although this has little to do with the importance of the variable S per se, correcting for the potential bias is relevant when interpreting the relative magnitudes of estimated coefficients. The last two estimations in Table 8 present results when trade is instrumented using gravity variables that notoriously predict trade flows.[29] Endogeneity does not appear a serious problem, as the coefficient on trade falls in the band-pass filter case, but increases when using GDP growth rates. The coefficient on S, on the other hand, hardly changes at all, and remains significant at the 5 percent level in all cases.

In summary, co-fluctuations seem to increase with bilateral trade intensity, *and* to the similarity of production patterns at the sectoral level. These claims prevail when fluctuations are measured at the quarterly or yearly frequency, using a range of

[28] This is done only with quarterly data, as there is not enough yearly observations for the truncation.

[29] And that are excludable from the set of independent variables in Tables 3 and 5.

different filters, across a variety of measures of economic structure and bilateral trade, and over sub-periods of the sample. The next section presents a model of a small open economy consistent with this evidence, where the number of sectors produced domestically is endogenously determined through a Ricardian comparative advantage argument.

5 A Model of Endogenous Structural Change

This section presents a small open economy model illustrating the paper's main empirical finding. In the model, it is optimal to start production in an expanding range of sectors as labor becomes more productive, so that the economy diversifies endogenously as it grows. Insofar as it reflects exposure to a wider range of sector-specific stochastic developments, the country's business cycle becomes more similar to the world's, which produces the whole continuum of goods. Put differently, as they grow richer and converge to a more diversified economic structure, countries become increasingly similar and business cycles synchronize.[30] This is consistent with the evidence documented in the previous section that economic structure matters holding trade constant, whether it be inter- or intra-industry. The artificial economy is also consistent with the evidence that including S renders the coefficient on income per capita insignificant in most instances. Rich countries have business cycles that are synchronized because they are diversified and share similar sectors, irrespective of how much they trade. Finally, with the added assumption that poor countries tend to be specialized in different sectors (determined for instance by their initial endowment), the model is also consistent with the evidence that business cycles in low income countries tend to be more idiosyncratic, as this reflects how different they are from the world average.[31]

[30] In Imbs and Wacziarg (2003) we provide robust evidence that countries do indeed diversify over most of the growth path.

[31] Empirically, this corresponds to a low value for S both amongst poor economies and between poor and rich countries, a fact supported by the data.

In the theoretical economy, the number of sectors is endogenously determined through a comparative advantage argument: at every point in time, the benefits of specializing are weighted against the cost of importing the goods that are not produced, but consumed domestically. This trade-off evolves over time, as aggregate productivity rises and it becomes efficient to produce an increasing range of goods domestically.[32] The next sections proceed with a description of the theoretical economy and the derivation of a model-implied measure of aggregate co-fluctuations.

5.1 Supply

Goods varieties are indexed by z over $[0, N]$, and ordered without loss of generality so that sectoral productivity $a(z)$ decreases in z. $a(z)$ is stochastic and follows an i.i.d. Bernouilli distribution, with probability λ of taking a non-zero value, unit mean and zero correlation across varieties, but perfect correlation in one given sector across countries. Domestic aggregate productivity A grows exogenously and affects indiscrimately all domestic sectors.[33] Firms hire factors of production prior to the realization of the sector-specific shock, and sectoral output is produced by combining capital $K(z)$ and labor $L(z)$ using a constant returns to scale technology, so that producers of variety z choose capital and labor to maximize their expected profits

$$E\{\Pi(z)\} = p_1^1(z)\ E\{\frac{A}{a(z)}\}\ K(z)^{\alpha}\ L(z)^{1-\alpha} - wL(z) - rK(z) \tag{1}$$

where E is the expectation operator, $\alpha < 1$, w is the wage rate, equal across sectors, and r is the (world) rate of interest.[34] Prices sub-indices denote the location of

[32] The model's setup is inspired from Dornbusch, Fischer and Samuelson (1977). This intuition requires that transport costs do not fall in line with technological progress. Hummels (1999) documents carefully how trading costs -and in particular shipping costs- have hardly fallen over the last three decades, and actually risen until recently.

[33] A can be interpreted as the "world technology frontier", that shifts out with advances in global purpose technologies, applicable indifferently across the spectrum of sectors.

[34] For convenience, $a(z)$ is constructed as a negative shock. This will turn out to simplify considerably the computation of aggregate outputs correlation coefficients.

production, and super-indices denote the location of consumption, so that $p_1^1(z)$ is the price of good z both produced and consumed in the domestic economy, indexed by 1. For all z

$$\frac{L(z)}{K(z)} = \frac{r}{w} \frac{1-\alpha}{\alpha} \tag{2}$$

With an appropriate choice of units, the optimal choice of labor can be rearranged to yield $p_1^1(z) = \frac{1}{A\ E\{\frac{1}{a(z)}\}}$.[35] There are costs associated with importing goods from abroad, denoted by $\psi > 1$, so that $p_2^1(z) = \psi\ p_2^2(z)$. Furthermore, since the domestic economy is small, foreign prices $\theta > 0$ are exogenous and constant across sectors, so that $p_2^1(z) = \psi\ \theta$. The economy will diversify as A rises: at every point in time, the range $[z_1, N]$ is produced domestically, where z_1 is defined by $p_1^1(z_1) = p_2^1(z_1)$, as the threshold variety for which it is equally costly to produce at home and to import. z_1 verifies $E\{\frac{1}{a(z_1)}\} = \frac{1}{A\ \psi\ \theta}$, which implies the range produced domestically expands with technological progress (i.e. z_1 falls), since $a'(.) < 0$.

5.2 Demand

For simplicity, the effects of demand-driven phenomena are minimized through Leontief preferences over all varieties. Preferences with constant positive elasticity of substitution would induce consumers to shift away from goods with high prices, thus mitigating the supply effect of increasing productivity. Choosing more general preferences would only obscure the point, without modifying the basic economic intuition. Each period, agents choose $X_1(z)$, the demand for each variety, to maximize

$$Min(X_1(0), ..., X_1(N))$$
$$\text{subject.to} \int_0^{z_1} p_2^1(z)\ X_1(z)\ dz + \int_{z_1}^{N} p_1^1(z)\ X_1(z)\ dz = E \tag{3}$$

where E is total domestic expenditure. For all z, z', $X_1(z) = X_1(z') \equiv X_1$, so that the budget constraint becomes

[35] In particular, units are chosen so that $\left(\frac{r}{\alpha}\right)^{\alpha} \left(\frac{w}{1-\alpha}\right)^{1-\alpha} \equiv 1$.

$$P \ X_1 = E \tag{4}$$

where $P = \int_0^{z_1} p_2^1(z)dz + \int_{z_1}^{N1} p_1^1(z)dz$ is the domestic consumer price index.

5.3 Equilibrium

Domestic production in each sector verifies the following resource constraint

$$Y(z) = \frac{A}{a(z)} \ K(z)^{\alpha} \ L(z)^{1-\alpha} = X_1(z) + X_2(z) = X_1 + X_2 \tag{5}$$

where X_2 is demand arising from the rest of the world and the last equality comes from Leontief preferences. Then, given (2)

$$L(z) = \frac{a(z)}{A} \ [X_1 + X_2] \ \left(\frac{r}{\alpha}\right)^{\frac{\alpha}{\alpha-1}} \tag{6}$$

5.3.1 Solving for the Distribution of Labor

Economic structure -and sectoral trade flows- do not depend on the realization of high-frequency shocks, but rather on long-run technological progress and capital deepening. Given the long-run nature of the argument, trade is assumed to be balanced, which implies

$$\int_{z_2}^{N} p_1^2(z) \ X_2(z)dz = \int_0^{z_1} p_2^1(z) \ X_1(z)dz \tag{7}$$

where z_2 defined by $p_2^2(z_2) = p_1^2(z_2)$ denotes the limiting exported variety. Given firms' profit maximization and the expression for prices, this can be rearranged to yield:

$$X_2 \ = \frac{A \ \theta \ z_1}{\int_{z_2}^{N} \frac{dz}{E\{\frac{1}{a(z)}\}}} \ X_1 \equiv \xi \ X_1 \tag{8}$$

We are now equipped to solve for the equilibrium of this economy. Using (8) in (6),

$$L(z) = \frac{a(z)}{A} \ (1+\xi) \ X_1 \ \left(\frac{r}{\alpha}\right)^{\frac{\alpha}{\alpha-1}} \tag{9}$$

Aggregating over sectors, and letting $L = \int_{z_1}^{N} L(z)\ dz$, we have

$$X_1 = \frac{A\ L}{(1+\xi)\ \left(\frac{r}{\alpha}\right)^{\frac{\alpha}{\alpha-1}}\ \int_{z_1}^{N} a(z)\ dz} \tag{10}$$

which can be substituted back into (9) to simplify into

$$L(z) = a(z)\ L\ \left(\int_{z_1}^{N} a(z)\ dz\right)^{-1} \tag{11}$$

Unsurprisingly since consumers demand an equal quantity of each variety, sectoral labor input decreases with sector-specific productivity, and increases with the pool of labor available in the aggregate. Similarly, the threshold variety z_1 enters positively: as z_1 increases, the number of sectors effectively produced domestically falls, so that labor input in each variety can be higher.

5.3.2 Solving for Aggregate Output

Domestic aggregate real production is given by

$$Y = \int_{z_1}^{N} \frac{p_1^1(z)\ Y(z)}{p_1^1(1)}\ dz = E\{\frac{1}{a(1)}\}\ A\ L\ \frac{\int_{z_1}^{N} \frac{dz}{E\{\frac{1}{a(z)}\}}}{\int_{z_1}^{N} a(z)\ dz}\ \left(\frac{K(z)}{L(z)}\right)^{\alpha} \tag{12}$$

where aggregate output is measured in terms of good 1 without loss of generality and the second equality makes use of (11) and the definitions of prices and sectoral output. Given the choice of units, $p_1^1(1) = \frac{1}{E\{a(1)\}\ A}$, and the first-order condition on labor can be rearranged to yield $\left(\frac{K(z)}{L(z)}\right)^{\alpha} = \frac{w}{1-\alpha}$, so that the capital labor ratio is constant across sectors. Letting $K = \int_{z_1}^{N} K(z)\ dz$, (12) can be rewritten as

$$Y = E\{\frac{1}{a(1)}\}\ A\ K^{\alpha}\ L^{1-\alpha}\ \frac{\int_{z_1}^{N} \frac{dz}{E\{\frac{1}{a(z)}\}}}{\int_{z_1}^{N} a(z)\ dz} \tag{13}$$

5.3.3 Model-Implied Output Correlation

By symmetry, and since the domestic economy is small, and does not affect patterns of production in the rest of the world, foreign output can be written as

$$Y^* = E\{\frac{1}{a(1)}\}\ A^*\ K^{*\alpha}\ L^{*1-\alpha}\ \frac{\int_{0}^{N} \frac{dz}{E\{\frac{1}{a^*(z)}\}}}{\int_{0}^{N} a^*(z)\ dz} \tag{14}$$

where a star denotes a foreign variable and $a^*(z)$ is foreign sectoral productivity. Thus, the correlation ρ between foreign and domestic aggregate outputs is equal to

$$\rho \equiv corr\ \ (Y, Y^*) = corr\ \ \left[\left(\int_{z_1}^{N} a(z)\ dz \right)^{-1} ; \left(\int_{0}^{N} a^*(z)\ dz \right)^{-1} \right] \qquad (15)$$

Let $W = \int_{z_1}^{N} a(z)\ dz$ and $W^* = \int_0^N a^*(z)\ dz$. We are interested in obtaining an expression for the correlation coefficient between $\frac{1}{W}$ and $\frac{1}{W^*}$. Since the occurrence of a sector-specific shock follows a Bernouilli distribution with probability λ, W and W^* follow binomial distributions with parameters $(N - z_1, \lambda)$ and (N, λ), respectively. In addition, to avoid degenerate cases, at least one domestic shock is assumed to occur, so that the correlation coefficient ρ cannot take zero values, and the inverse distribution of both W and W^* is well defined.[36] Furthermore, by definition the joint distribution of W and W^* follows a hypergeometric distribution with parameters $(N, w^*, \frac{N-z_1}{N})$, where w^* is the -parametrically given- total number of shocks that hit the world economy. Since there is at least one domestic shock, $w^* > z_1$ so that the inverse joint distribution exists. The intuition is straightforward: the joint probability that there are w domestic shocks and w^* foreign shocks is given by a random draw without replacement of w^* out of a maximum of N shocks, of which $N - z_1$ are domestic and z_1 are foreign. It is well known that for large values of $N - z_1$ and z_1 such that $\frac{N-z_1}{N}$ remains constant in the limit, a hypergeometric distribution with parameters $(N, w^*, \frac{N-z_1}{N})$ converges to a binomial distribution with parameters $(w^*, \frac{N-z_1}{N})$.[37] Thus, as the number of sectors in the world economy rises while keeping constant the size of the domestic economy relative to the rest of the world, the joint distribution of W and W^* tends to a binomial distribution.[38] Furthermore, Johnson, Kotz and Kemp (1993) provide approximations for the first and second moments of the inverse singly truncated binomial distribution, that can be used to obtain an

[36] In other words, W and W^* must follow singly truncated Binomial distributions, with the zero class omitted. See Johnson, Kotz and Kemp (1993), p.136.

[37] See Johnson, Kotz and Kemp (1993), page 255.

[38] This is actually a binomial distribution truncated in zero given the constraint imposed on w^*.

approximate expression for the covariance between $\frac{1}{W}$ and $\frac{1}{W^*}$, as in

$$
\begin{aligned}
cov(\frac{1}{W},\frac{1}{W^*}) &\simeq \frac{1}{\frac{N-z_1}{N}w^* - \frac{z_1}{N}} - \frac{1}{(N-z_1)\,\lambda-(1-\lambda)}.\frac{1}{N\lambda-(1-\lambda)} \\
&= \frac{(w^*+1-N\lambda\Delta)\ \ z_1+N\ \ (\Delta^2-w^*)}{\Delta\ \lambda(w^*+1)\ \left[z_1-\frac{\Delta}{\lambda}\right]\ \left[z_1-N\frac{w^*}{w^*+1}\right]}
\end{aligned} \tag{16}
$$

with $\Delta = N\lambda - (1-\lambda)$. Appendix B shows that the covariance decreases in z_1 for non-extreme values of λ, the probability that a sectoral shock occurs. Furthermore, Johnson, Kotz and Kemp (1993) provide an approximation for the variance of $\frac{1}{W}$, such that

$$
Var(\frac{1}{W})\ Var(\frac{1}{W^*}) \simeq
$$

$$
\frac{(1-\lambda)\ \ (N-z_1-1)\ \ (N-z_1-2)}{\left[(N-z_1)^2\ \ \lambda-(1-\lambda)\,(N-z_1)\right]^2\ \ \left[(N-z_1)\,\lambda-(2-\lambda)\right]}.
$$

$$
\frac{(1-\lambda)\ \ (N-1)\ \ (N-2)}{\left[N^2\ \lambda-(1-\lambda)N\right]^2\ \ \left[N\lambda-(2-\lambda)\right]} \tag{17}
$$

$Var(\frac{1}{W})\ Var(\frac{1}{W^*})$ rises in z_1. Thus, combining (16) and (17) confirms that the correlation between $\frac{1}{W}$ and $\frac{1}{W^*}$ decreases in z_1, which means domestic aggregate fluctuations become increasingly synchronized with the rest of the world's cycle as the range of common sectors expands. This happens as z_1 falls, and domestic aggregate productivity rises to catch up with the world frontier.

6 Conclusion

This paper provides novel evidence on the determinants of the synchronization in business cycles in a multivariate context. The results point to an intuitive and important determinant of the extent of aggregate co-fluctuations, that is often neglected: whether countries share similar indutries. This variable turns out to have robust effects across a variety of specifications, measurement strategies and conditioning sets.

Thus, low-frequency structural changes are illustrated to have substantial bearing on the nature of high-frequency cycles. This is the paper's first contribution.

A small open economy model of Ricardian trade with sector-specific shocks is proposed, where aggregate cycles are shown to synchronize as countries grow richer, and more diversified. This is the paper's second contribution.

7 Appendices

7.1 Appendix A: Geographic Coverage

Algeria
Angola
Argentina[b]
Australia[b,c]
Austria[b,c]
Bangladesh
Barbados
Belgium
Belize
Benin
Bolivia[b]
Botswana
Brazil[b]
Bulgaria
Burkina
Burundi
Cameroon
Canada[b,c]
Cape Verde
Central Africa
Chad
Chile[b]
China
Colombia[b]
Comoros
Congo
Costa Rica
Cyprus
Czechoslovakia
Denmark[b,c]
Djibouti
Dominican Rep
Ecuador[b]
Egypt[b]
Ethiopia[b]
Fiji
Finland[b,c]
France[b,c]
Gabon
Gambia
E Germany
W Germany[b,c]
Ghana[b]
Greece[b,c]
Guatemala
Guinea
Guinea-Bissau
Guyana
Haiti
Honduras
Hong Kong[b]
Hungary[b]
Iceland[b,c]
India[b]
Indonesia[b]
Iran[b]
Iraq
Ireland[b,c]
Israel[b]
Italy[b,c]
Ivory Coast
Jamaica
Japan[b,c]
Jordan
Kenya[b]
S Korea[b]
Lesotho
Liberia
Luxembourg
Madagascar
Malawi
Malaysia[b]
Mali
Malta
Mauritania
Mauritius
Mexico
Morocco
Mozambique
Myanmar
Namibia
Nepal
Netherlands[c]
N Zealand[b,c]
Nicaragua
Niger
Nigeria[b]
Norway[b,c]
Oman
Pakistan[b]
Panama
Papua NG
Paraguay[b]
Peru
Philippines[b]
Poland[b]
Portugal[c]
Puerto Rico
Reunion
Romania
Rwanda
El Salvador
Saudi Arabia
Senegal
Seychelles
Sierra Leone
Singapore[b]
Somalia
S Africa[b]
Spain[b,c]
Sri Lanka
Sudan
Suriname
Swaziland
Sweden[b,c]
Switzerland
Syria
Taiwan
Tanzania
Thailand[b]
Togo
Trinidad Tobago
Tunisia[b]
Turkey[b,c]
Uganda
U Kingdom[b,c]
Uruguay[b]
U States[b,c]
USSR
Venezuela[b]
Western Samoa
Yemen
Yugoslavia[b]
Zaire
Zambia
Zimbabwe

The table reports the 136 countries used in the Penn-World tables.

b: reduced sample of 49 countries where data on trade and sectoral employment are available.

c: reduced OECD sample of 21 countries, making use of the International Financial Statistics

7.2 Appendix B

I first show that the coefficient on z_1 at the numerator of $cov(\frac{1}{W}, \frac{1}{W^*})$ in equation (16) is negative:

$$w^* + 1 - N\lambda\Delta < 0 \Longleftrightarrow w^* < \lambda^2 N(N+1) - N\lambda - 1 \tag{B1}$$

This last inequality is always verified, as $w^* < N$ by definition, and $N < \lambda^2 N(N+1) - N\lambda - 1$ for all $0 < \lambda < 1$.

Next use (16) to compute $D = \frac{\partial cov(\frac{1}{W}, \frac{1}{W^*})}{\partial z_1}$:

$$D = \Delta\lambda(w^* + 1)\left(w^* + 1 - N\lambda\Delta\right)\left(z_1 - \frac{\Delta}{\lambda}\right)\left(z_1 - N\frac{w^*}{w^* + 1}\right) \tag{B2}$$

$$-\Delta\lambda(w^* + 1)\left[\left(w^* + 1 - N\lambda\Delta\right)\ z_1 + N\ \left(\Delta^2 - w^*\right)\right]\left(z_1 - \frac{\Delta}{\lambda} + z_1 - N\frac{w^*}{w^* + 1}\right)$$

Using (B1), $0 \geq \frac{\partial cov(\frac{1}{W}, \frac{1}{W^*})}{\partial z_1}$ whenever three sufficient conditions are verified:

$$\frac{\Delta}{\lambda} \geq z_1, \text{ i.e. } \lambda \geq \frac{1}{N - z_1 + 1} \tag{B3}$$

$$N\frac{w^*}{w^* + 1} \geq z_1, \text{ i.e. } w^* \geq \frac{z_1}{N - z_1} \tag{B4}$$

$$w^* \geq \Delta^2, \text{ i.e. } \frac{\sqrt{w^*} + 1}{N + 1} \geq \lambda \tag{B5}$$

Condition (B3) simply requires the probability of a sectoral shock not be too small. Note that this also implies $\Delta > 0$. Condition (B4) is actually easily satisfied, as I assumed $w^* > z_1$ so that there is at least one shock specific to the domestic economy, and $z_1 > \frac{z_1}{N-z_1} \Rightarrow z_1 < N - 1$. Thus (B4) is verified in non-degenerate case where the domestic economy has more than one sector. Condition (B5) ensures that the probability of a sectoral shock not be too close to one.

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Table 1: Summary Statistics

Sample of 49 countries	Obs	Mean	Std. Dev.	Min	Max
Output Correlation (Growth Rates)	1176	0.114	0.188	-0.479	0.739
Output Correlation (Band Pass filtered)	1176	0.087	0.205	-0.611	0.723
Sector (1970)	1176	0.749	0.150	0.197	0.990
Sector (1980)	1176	0.733	0.156	0.182	0.990
Sector (1989)	1176	0.703	0.190	0.042	0.989
Trade Intensity 1970 (rel. total output)	765	0.0013	0.0042	1.83×10^{-6}	0.0908
Trade Level 1970	765	229.7	1078.5	0.026	22191.7
Trade Level 1980	869	1089.8	4641.4	0.033	87320.0

Sample of 21 countries	Obs	Mean	Std. Dev.	Min	Max
Output Correlation (qrtly. growth rates)	210	0.265	0.173	-0.326	0.756
Output Correlation (yrly. growth rates)	210	0.231	0.203	-0.387	0.739
Output Correlation (BP filtered – qrtly)	210	0.127	0.208	-0.706	0.742
Output Correlation (BP filtered – yrly)	210	0.198	0.234	-0.559	0.723
Sector (1970)	210	0.819	0.122	0.370	0.990
Sector (1980)	210	0.825	0.119	0.386	0.990
Sector (1989)	210	0.811	0.131	0.330	0.989
Trade Intensity 1970 (rel. total output)	206	0.0031	0.0051	2.93×10^{-6}	0.0352
Trade Level 1970	206	704.69	2055.8	0.043	22191.7
Trade Level 1980	208	3544.56	9296.3	0.251	87320.0

Table 2: Sample of 49 Countries – GDP Growth Rate Correlations

	(i)	(ii)	(iii)	(iv)	(v)
Constant	0.117 [13.16]**	0.072 [3.89]**	0.064 [4.37]**	-0.114 [4.07]**	-0.111 [3.16]**
Trade Intensity 1970	9.67 [1.92]*	3.016 [1.38]	2.988 [1.40]		3.089 [1.54]
S 1970				0.307 [8.25]**	0.256 [5.51]**
Min (Y_i, Y_j)		3.82×10^{-5} [9.13]**	3.66×10^{-5} [9.47]**		2.70×10^{-5} [6.70]**
Max (Y_i, Y_j)		-2.62×10^{-6} [0.86]			
Distance		-2.87×10^{-6} [2.09]*	-3.11×10^{-6} [2.30]*		-3.07×10^{-6} [2.30]*
Border		0.112 [3.34]**	0.114 [3.43]**		0.096 [2.82]**
R-Square	0.045	0.167	0.166	0.059	0.198
Condition Number	4.891	40.796	20.528		

Dependent variable is GDP growth bilateral correlation between countries i and j, over 1950-1992. 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.

Table 3: Sample of 21 Countries – GDP Growth Rate Correlations

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Constant	0.188	0.107	-0.302	0.225	0.172	-0.081
	[11.93]**	[3.11]**	[4.07]**	[17.00]**	[5.85]**	[1.09]
Trade Intensity 1970	14.86	11.25	8.29	13.59	10.27	8.44
	[5.12]**	[3.46]**	[2.69]**	[5.60]**	[3.64]**	[2.85]**
S 1970			0.589			0.364
			[6.04]**			[3.68]**
Initial Min (Y_i, Y_j)		2.30×10^{-5}	1.03×10^{-5}		1.66×10^{-5}	8.66×10^{-6}
		[3.02]**	[1.38]		[2.61]*	[1.34]
Distance		-4.65×10^{-7}	-2.65×10^{-6}		-1.06×10^{-6}	-2.41×10^{-6}
		[0.20]	[1.15]		[0.54]	[1.27]
Border		0.016	0.008		0.027	0.022
		[0.25]	[0.91]		[0.43]	[0.34]
R-Square	0.142	0.179	0.280	0.158	0.182	0.233

(i)-(iii) use yearly data, (iv)-(vi) use quarterly data. Dependent variable is GDP growth bilateral correlation between countries i and j, over 1950-1992 for yearly data and 1959:1-1993:4 for quarterly data. Estimation with Huber-White standard errors, with t-statistics reported in brackets. * indicates significance level at the 5% level, ** at the 1% level.

Table 4: Robustness: Band Pass Filtered GDP correlations (49 Countries - yearly)

	(i)	(ii)	(iii)	(iv)	(v)
Constant	0.097 [11.07]**	0.032 [1.52]	0.045 [2.63]**	-0.067 [2.24]*	-0.033 [0.84]
Trade Intensity 1970	8.81 [2.05]*	3.440 [1.80]	3.481 [1.76]		3.526 [1.84]
S 1970				0.205 [5.26]**	0.114 [2.27]*
Min (Y_i, Y_j)		2.93×10^{-5} [6.57]**	3.16×10^{-5} [7.61]**		2.73×10^{-5} [6.07]**
Max (Y_i, Y_j)		3.87×10^{-6} [1.24]			
Distance		-2.22×10^{-6} [1.44]	-1.87×10^{-6} [1.22]		-1.85×10^{-6} [1.21]
Border		0.091 [2.28]*	0.088 [2.21]*		0.080 [1.98]*
R-Square	0.033	0.110	0.109	0.022	0.114

Dependent variable is the cross-section of bilateral correlations between GDP cyclical components as implied by the band-pass filter in countries i and j, over 1950-1992. Estimation with Huber-White standard errors, with t-statistics reported in brackets. * indicates significance level at the 5% level, ** at the 1% level.

Table 5: Robustness: Band Pass Filtered GDP correlations (21 Countries)

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Constant	0.153	0.005	-0.295	0.095	0.055	-0.121
	[8.30]**	[0.12]	[2.99]**	[5.55]**	[1.31]	[1.16]
Trade Intensity 1970	15.89	10.58	8.41	10.45	10.00	8.73
	[4.79]**	[3.11]**	[2.42]*	[3.03]**	[2.90]**	[2.41]*
S 1970			0.432			0.254
			[3.62]**			[2.01]*
Initial Min (Y_i, Y_j)		4.03×10^{-5}	3.09×10^{-5}		9.93×10^{-6}	4.41×10^{-6}
		[4.64]**	[3.67]**		[1.25]	[0.56]
Distance		-7.20×10^{-8}	-1.67×10^{-6}		3.58×10^{-7}	-5.85×10^{-7}
		[0.03]	[0.65]		[0.17]	[0.28]
Border		0.005	0.002		-0.022	-0.027
		[0.07]	[0.03]		[0.39]	[0.43]
R-Square	0.122	0.211	0.253	0.064	0.073	0.090

(i)-(iii) use yearly data, (iv)-(vi) use quarterly data. Dependent variable is the cross-section of bilateral correlations between GDP cyclical components as implied by the band-pass filter in countries i and j, over 1950-1992 for yearly data and 1959:1-1993:4 for quarterly data. Estimation with Huber-White standard errors, with t-statistics reported in brackets. * indicates significance level at the 5% level, ** at the 1% level.

Table 6: Robustness: Alternative Trade Measures

	(i) – 1970	(ii) – 1980	(iii) - 1970	(iv) - 1980	(v) - 1970	(vi) - 1980	(vii) – T^2
Constant	-0.104 [2.98]**	-0.120 [3.85]**	-0.300 [4.11]**	-0.278 [3.75]**	-0.073 [1.00]	-0.059 [0.80]	0.119 [1.55]
Trade	1.77×10^{-5} [4.64]**	4.12×10^{-6} [4.35]**	1.64×10^{-5} [3.33]**	4.19×10^{-6} [3.18]**	1.98×10^{-5} [3.86]**	4.92×10^{-6} [3.82]**	10.304 [2.31]**
S 1970	0.254 [5.45]**	0.256 [6.18]**	0.594 [6.24]**	0.559 [5.87]**	0.363 [3.75]**	0.338 [3.52]**	0.204 [6.70]**
Min (Y_i, Y_j)	2.56×10^{-5} [6.46]**	2.81×10^{-5} [7.49]**	1.33×10^{-5} [1.85]	1.35×10^{-5} [1.88]	1.12×10^{-5} [1.75]	1.16×10^{-5} [1.80]	0.080 [1.05]
Distance	-3.26×10^{-6} [2.47]*	-2.26×10^{-6} [1.92]	-4.02×10^{-6} [1.86]	-3.24×10^{-6} [1.52]	3.73×10^{-6} [2.15]*	-3.53×10^{-6} [2.07]*	
Border	0.102 [3.17]**	0.087 [2.78]**	0.051 [0.83]	0.044 [0.73]	0.058 [1.06]	0.048 [0.90]	
R-Square	0.202	0.168	0.281	0.281	0.247	0.256	0.255

(i)-(ii) use yearly data for 49 countries, (iii)-(iv) use yearly data for 21 countries and (v)-(vi) use quarterly data for 21 countries, when computing the dependent variable. Odd columns use bilateral trade levels in 1970, even columns use data in 1980. Column (vii) uses T^2 to measure trade intensity. Dependent variable is the cross-section of bilateral correlations between GDP growth rates in countries i and j, over 1950-1992 for yearly data and 1959:1-1993:4 for quarterly data. Estimation with Huber-White standard errors, with t-statistics reported in brackets. * indicates significance level at the 5% level, ** at the 1% level.

Table 7: Robustness: Alternative Measures of Economic Structure

	(i) - 1980	(ii) - 1989	(iii) - 1980	(iv) - 1989	(v)	(vi)
Constant	-0.106 [3.12]**	-0.021 [0.68]	-0.096 [1.32	-0.020 [0.30]	0.397 [3.97]**	0.307 [4.15]**
Trade Intensity (1970)	2.90 [1.46]	2.94 [1.41]	8.02 [2.69]**	8.72 [2.94]**	2.44 [7.28]**	7.59 [1.69]
S	0.251 [5.60]**	0.135 [3.28]**	0.372 [3.90]**	0.279 [3.15]**	0.121 [3.52]**	0.194 [5.53]**
Initial Min (Y_i, Y_j)	2.65×10^{-5} [6.63]**	3.02×10^{-5} [7.35]**	1.01×10^{-5} [1.57]	1.01×10^{-5} [1.57]	0.026 [0.40]	0.124 [1.88]
Distance	-2.59×10^{-6} [1.95]	-2.85×10^{-6} [2.12]*	-2.19×10^{-6} [1.15]	-1.72×10^{-6} [0.89]	-0.023 [2.54]**	
Border	0.097 [2.90]**	0.100 [2.98]**	0.027 [0.41]	0.024 [0.36]	0.028 [0.72]	
R-Square	0.199	0.179	0.234	0.217	0.123	0.150

(i)-(ii) use yearly data for 49 countries, (iii)-(iv) use quarterly data for 21 countries and (v)-(vi) use again yearly data for 49 countries, when computing the dependent variable. Columns (i) and (iii) use a measure of sectoral similarities in 1980, columns (ii) and (iv) use a measure in 1989. Column (v) uses an index of sectoral similarities based on two-digit sectoral Value Added for all economic activities. Column (vi) uses the same index, combined with the alternative measure of trade, T^2. The dependent variable is the cross-section of bilateral correlations between GDP growth rates in countries i and j, over 1950-1992 for yearly data and 1959:1-1993:4 for quarterly data. Estimation with Huber-White standard errors, with t-statistics reported in brackets. * indicates significance level at the 5% level, ** at the 1% level.

Table 8: Robustness: Sub-Periods and Endogeneity

	(i) - FD	(ii) - BP	(iii) - FD	(iv) - BP
Constant	-0.161 [1.28]	-0.328 [2.98]**	-0.061 [0.80]	-0.124 [1.17]
Trade Intensity (1970)	1.58 [0.36]	2.92 [0.55]	12.72 [2.99]**	7.42 [1.53]
S	0.465 [2.80]**	0.530 [3.74]**	0.328 [3.25]**	0.254 [2.01]*
Initial Min (Y_i, Y_j)	2.27×10^{-5} [2.13]*	-5.74×10^{-5} [0.59]	4.96×10^{-6} [0.74]	4.93×10^{-6} [0.59]
Distance	-2.34×10^{-6} [0.72]	8.08×10^{-7} [0.27]		
Border	-0.018 [0.21]	0.008 [0.11]		
R-Square	0.043	0.073	0.223	0.089

The dependent variable is computed using quarterly data in all estimations, but correlations are computed omitting the 1973:1 – 1986:4 period in (i)-(ii). (iii) and (iv) are run using Distance and Adjacency as instruments for Trade. Furthermore, first-differences are used in (i) and (iii), while the Band-Pass filter is used in (ii) and (iv). Estimation with Huber-White standard errors, with t-statistics reported in brackets. * indicates significance level at the 5% level, ** at the 1% level.

Figure 1: Output Correlations and Import Share in BKK

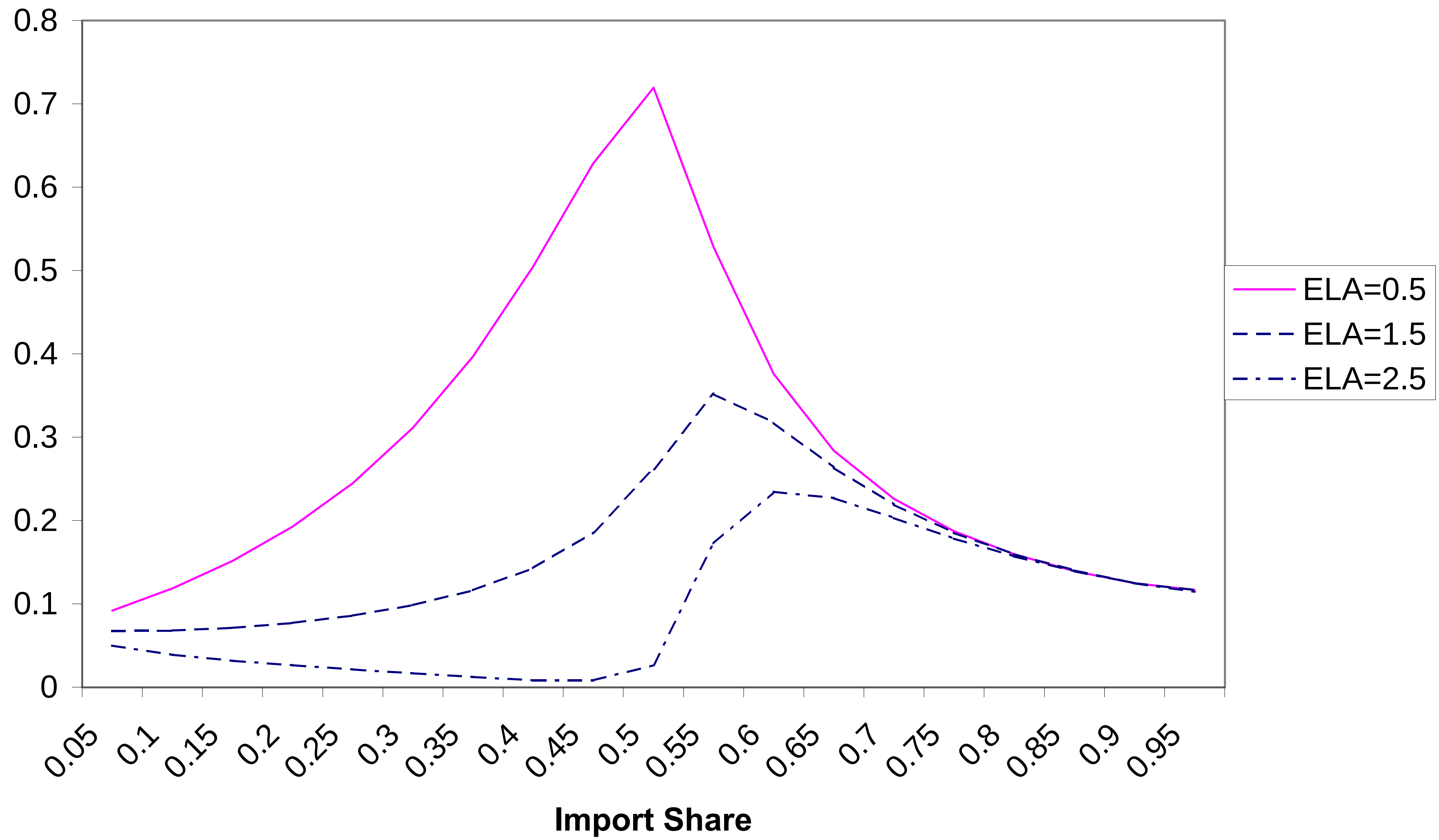


Figure 2: Openness in the Penn-World Tables

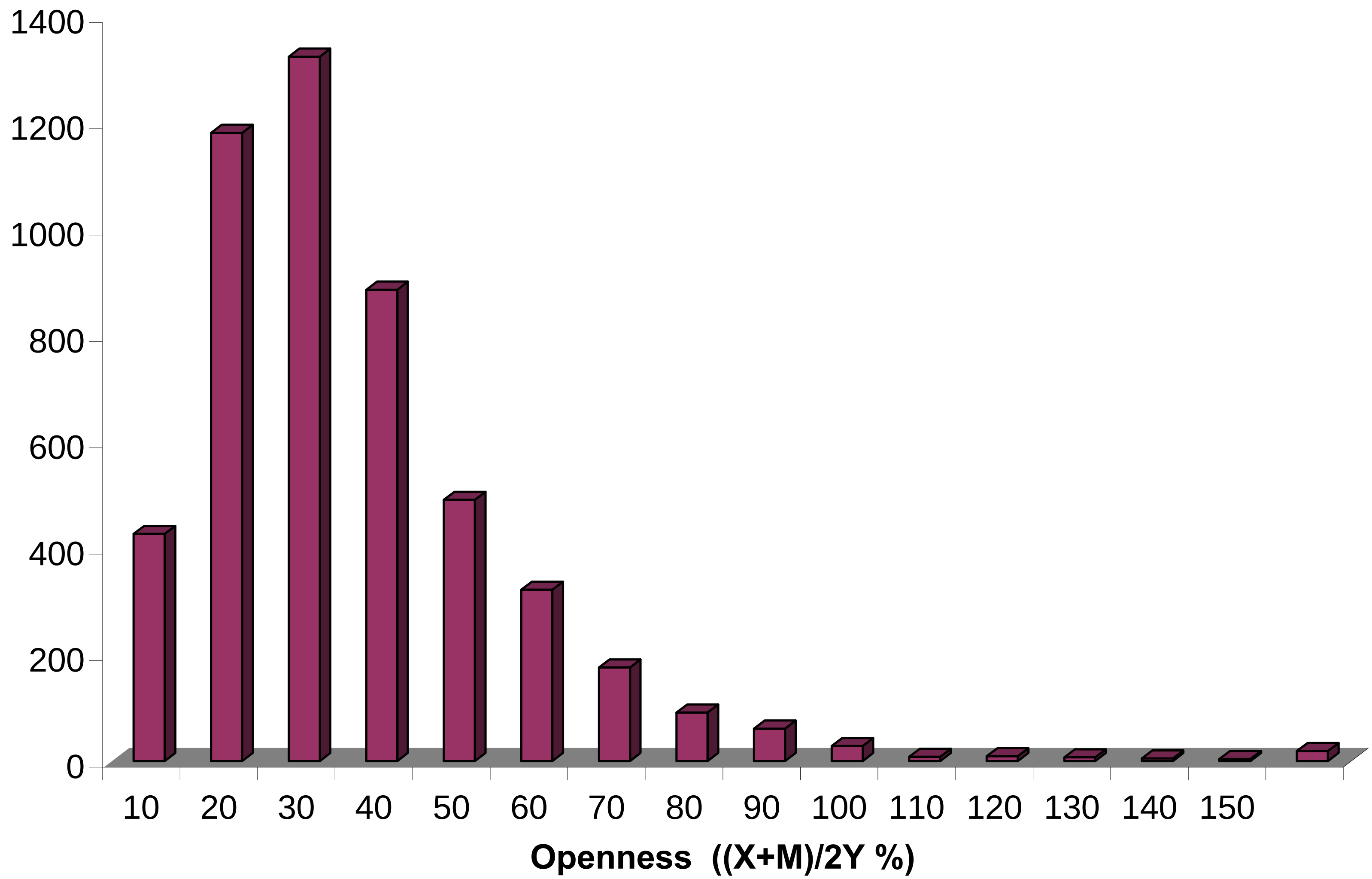
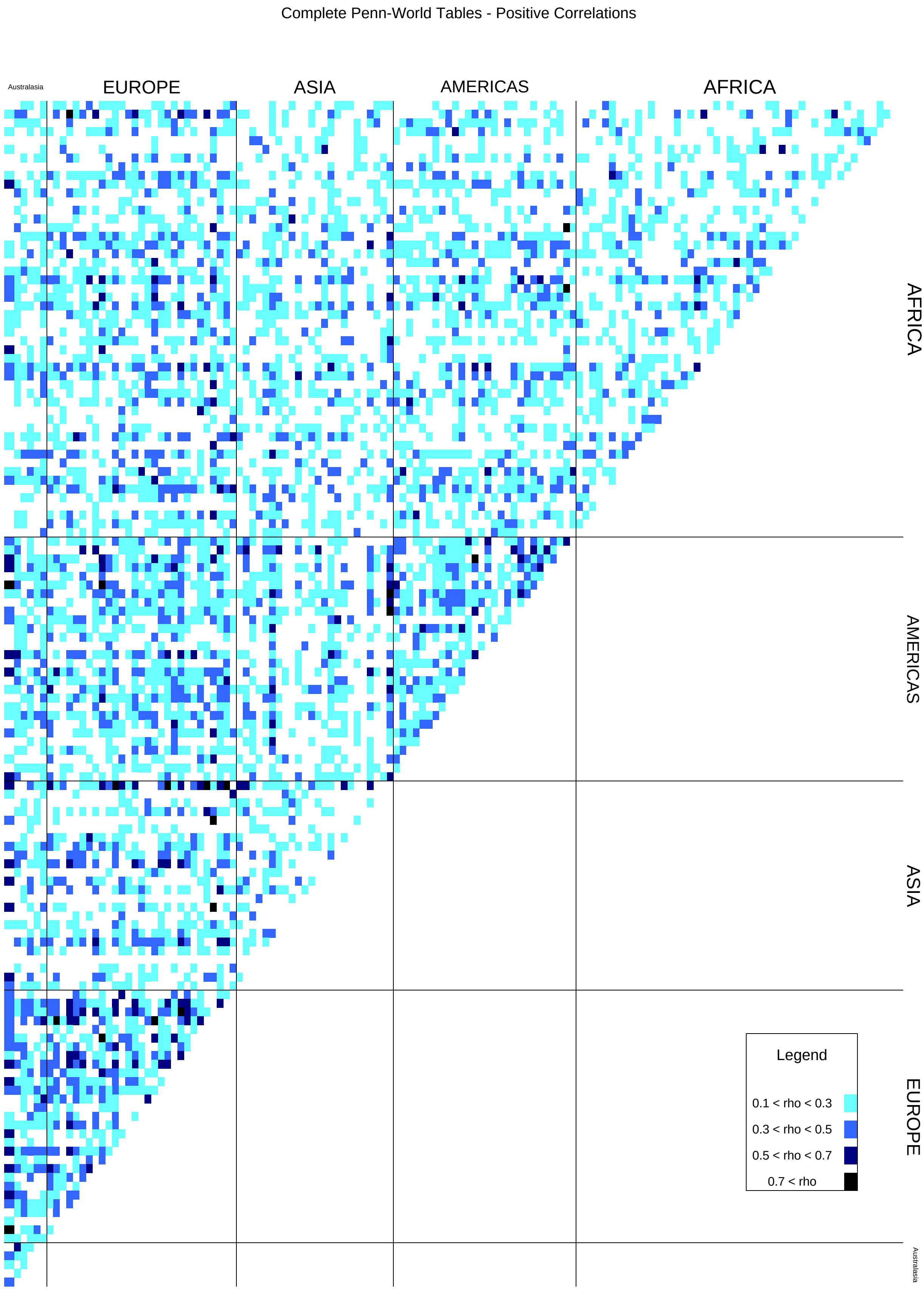


Figure 3



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

Figure 4

Complete Penn-World Tables - Negative Correlations

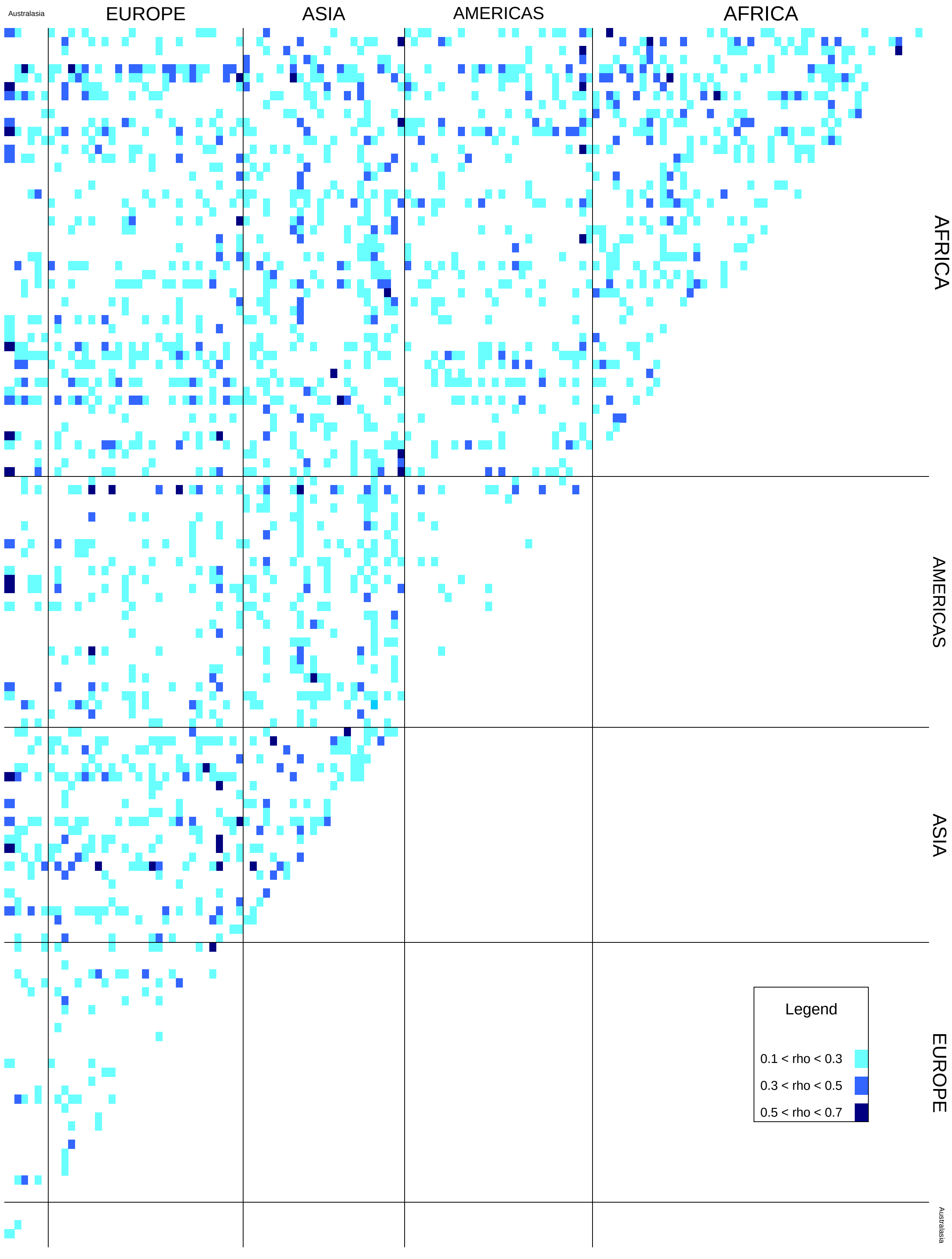


Figure 5

Complete Penn-World Tables - Positive Correlations ordered by GDP in 1960