Co-Fluctuations[*]

Jean Imbs[†]
New York University & University of Lausanne

First version.
(Job Market Paper)

November 1998

Abstract

This paper studies the determinants of the international synchronization of business cycles. Surprisingly, countries that trade more do not appear to have more synchronized cycles once other factors are accounted for. On the other hand, the extent of co-fluctuations increases quite robustly with the income level, so that two rich countries are unconditionally more synchronized. We develop a model where this happens because the world moves from an unstable steady state with full international specialization to a stable symmetric one. Similar countries produce similar goods and as a result experience sectoral shocks that are of equal importance. By contrast, different income levels reflect differences in production patterns, where the North produces manufactures and the South agricultural goods. Since there is no particular reason why stochastic developments in those two sectors should be correlated with one another, we should expect less cyclical comovement between a rich and a poor country. Finally, the model is consistent with the tendency for trade amongst developed countries to be mostly intra-industry.

[*] I benefited from insightful conversations with Ramses Abul Naga, Frank Portier and Romain Wacziarg. I am grateful to seminar participants at the University of Lausanne and in particular to Jean-Pierre Danthine and Philippe Bacchetta. I am of course solely responsible for any error.
[†] DEEP, University of Lausanne, Lausanne Switzerland 1015. Jean.Imbs@hec.unil.ch

"It is just not credible that the United States, or for that matter Europe, can remain an oasis of prosperity una¤ected by a world that is experiencing greatly increased stress", Alan Greenspan, Testimony before the Committee on the Budget, U.S. Senate, September 23rd 1998.

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 signi…cant proportion of its exports target the Japanese market, the rest of Asia cannot but su¤er 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-‡uctuations, 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 o¤ers no de…nite answer to the question of what drives the international business cycles: building on Backus, Kehoe and Kydland (1994), some argue that trade in intermediate goods channels domestic developments to foreign suppliers; some introduce rigidities whereby policy surprises meant to a¤ect domestic demand do have e¤ects across the border[3]; others …nally argue that there is a signi…cant common component to the international business cycle. Usual examples include the oil shocks, convergence in economic policies or integrated capital markets.

This paper makes a …rst attempt at discriminating between these, and in so doing provides an original view on the generation of international cycles. We provide evidence on the determinants of co-‡uctuations, measured

[1] As is well-known, the …gure 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 di¤usions of economic ‡uctuations.

[3] See for instance Hornstein and Praschnick (1997) and Kollmann (1998) respectively.

by GDP bilateral correlations for 136 countries taken from the Summers-Heston dataset. Figure 1 reports those of the correlations that are positive[4], sorted geographically for lack of a better univariate 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, geographic proximity and membership to international agreements, of a trade or a monetary nature, but of course stays mute about their relative importance[5]. The next section presents detailed evidence on the determinants of the international synchronization of business cycles. The punchline concerns the importance of the level of income, as measured by GDP in the poorer country of the pair under study, which enters positively even after controlling for bilateral trade and a large set of other variables[6]. Thus, countries become unconditionally more synchronized as they grow: given a level of bilateral trade, two rich countries co-fluctuate more than two poor ones, or than one poor and one rich, for that matter. We interpret this as resulting from similarities in the economic structures of developed economies, whose production structures have evolved endogenously to similar patterns.

Our explanation of the international business cycle belongs therefore to the last category above, in that it relies -though in an original way- on the existence of common shocks. However, it does not rule out alternative models grounded on trade-based transmission mechanisms, but quantifies as precisely as possible their relative importance, and brings the focus on a novel approach. There is wide empirical support for the fact that production structures are evolving to a common pattern, documented for instance in the

[4] Correlations are computed using first-differences of GDP, and unit-root tests were used to isolate a sub-sample of 61 countries where such filtering is legitimate. Multivariate regressions were conducted using the thus reduced sample. The correlations reported are limited to the positive subset for clarity of exposition. If more trade leads to more synchronization, it is indeed difficult to explain what leads to a negative correlation. Conclusions of the multivariate analysis remain however unchanged when including negative correlations, and that is because highly correlated sub-groups of countries are positively correlated.

[5] An important omission is Foreign Direct Investment, for which data is very incomplete. We shall come back to this issue when discussing our results.

[6] These include distance between main cities, a dummy variable for adjacency, continental dummy variables and dummy variables for the EMS, the EU, NAFTA, the ASEAN and the Andean Pact.

literature on intra-industry trade[7]: the novelty in this paper is to relate that evidence to international ‡uctuations. This is done in a two-country three-sector model where …rms decide to enter a monopolistically competitive market in the North or in the South. When making their choice, …rms balance higher pro…ts -generated by standard demand linkages- against congestion costs, that are assumed to be convex in the number of local …rms. We show that there are two asymmetric equilibria, where most of the heterogenous good is produced in one country, yet consumed in both, and one symmetric equilibrium. Further, because of congestion costs, the asymmetric equilibria are unstable, whereas the symmetric one is stable. Thus, the economy eventually reaches a state where the share of the manufactured heterogenous good is equal in both countries. Insofar as manufacturing production is subjected to speci…c stochastic developments[8], aggregate economies will be more correlated in the symmetric case.

The rest of the paper is structured as follows. Next section presents the empirical evidence. Section 3 presents a model of endogenous structural change. Section 4 concludes.

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

[8] The issue whether unexpected developments occur mostly at the sectoral or at the country level is in our opinion open. Papers by Stockman (1988) and Costello (1993) provide evidence in favor of country e¤ects. In a recent paper, Wolf and Ghosh (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 our assumption.

2 The Determinants of Co-Fluctuations

In this section, we present evidence on the determinants of the international synchronization of business cycles. From a theoretical point of view, the issue has mostly focused on the generation of positive international GDP correlations - the celebrated quantity puzzle coined by Backus, Kehoe and Kydland (1995)- for in the standard international real business cycle model, resources go wherever the return to capital is highest and thus generate negatively correlated international ‡uctuations as soon as technological developments are imperfectly correlated. This has given rise to numerous sophisticated attempts to remedy that theoretical defect[9]. However, here we look at the determinants of cross-sectional variation in the degree of synchronization, and disregard the issue of what mechanism is at the source of positive correlations of outputs. Thus, while related, most theoretical models of the international business cycle will hardly have any implications relevant to our purposes. In the seminal work of Backus, Kehoe and Kydland (1995), it is for instance not clear how the degree of output synchronization will change as bilateral trade rises with the share of foreign goods in domestic production, and obtaining a clear answer becomes increasingly di¢cult with the sophistication of the models used to explain positive GDP correlations. We think of these experiments as the theoretical counterpart to our empirical approach, and potentially as a way to discriminate between di¤erent mechanisms.

Empirically, there are surprisingly few candidates to determine the degree of synchronization between two countries. Canova and Dellas (1993) …nd weak evidence supporting the importance of trade interdependence for outputs cross-correlations, and Schmitt-Grohe (1998) shows that it is blatantly insu¢cient to explain correlation between U.S and Canadian business cycles. Although restricting her analysis to developed countries, Baxter (1995) argues trade is for the most part in capital rather than in goods. Therefore it ought to be an ingredient in dynamic stochastic general equilibrium models of the international business cycle, thus pointing to foreign

[9] A very incomplete list includes for instance Kollmann (1998), who argues that positive correlations are a consequence of nominal rigidities, whereby domestic changes in the money supply have e¤ects on domestic demand, on the foreign price level and thus on foreign demand. In Kraay and Ventura (1997), foreign booms boost domestic employment through their e¤ect on labor-intensive commodity prices. Ambler, Cardia and Zimmermann (1998) make domestic capital reallocation possible by introducing multisector economies.

direct investment as an important explanatory variable. A third approach relies on the existence of a signi…cant common component to international cycles. Canova (1993) 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 …nd signi…cant evidence in support of a world business cycle. Focusing on a particular episode, Backus and Gali (1995) contend that the most important mechanism at play appears to work through interest rates, likely to become increasingly inter-connected with globalization of world capital markets. A fourth view, that we follow, consists in arguing that the degree of exposure to the world business cycle varies across countries. For instance, following the lines in Rodrik (1996), exposure may increase with the degree of openness. Keller (1997) or Imbs (1998a) show for instance that di¤usion of technology occurs with more intensity between trading partners and close neighbors. Finally, as we will contend, exposure to common shocks might increase with industrialization of the productive structure.

We …rst report anecdotal evidence, based on the whole Summers-Heston dataset so as to shed preliminary light on the issue. We then turn to rigorous multi-variate analysis.

2.1 Correlations Matrices

Figure 1 reports the positive bilateral correlations between Gross Domestic Product (GDP) growth for 136 countries in the Summers-Heston dataset, presented in the original geographic ordering[10]. As illustrated in Figure 2 as well, there is a large majority of positive correlations amongst the 9180 pairs, a con…rmation if need be of the so-called quantity puzzle, and highly correlated sub-groups tend to be positively correlated. Thus including negative correlations will not modify substantially our results, a fact we …nd reassuring given the di¢culty of …nding an explanation for negatively correlated ‡uctuations. Three clusters of countries stand out: correlations within Europe, between Europe and the Americas, and within the Americas

[10] Augmented Dickey-Duller tests reject the presence of a unit-root for 75 of these countries. We however disregard this issue in this sub-section, essentially for illustrative purposes.

appear higher than in the rest of the world[11]. This leaves room for several explanations.

First, geography, proximity or common 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 …xed exchange rate regime imposes policy discipline that leads to conformity in business cycles. Membership to international agreements could also confer some credibility liable to foster trade or investment ‡ows. 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, as often put forward, it could be because they trade that countries are more synchronized, and this in either one of three ways: through more exposure to world cycles, through intense bilateral trade in goods, or …nally through trade in capital or foreign direct investment. If it is openness or trade in goods that is indeed decisive, it becomes hard to explain why Asia is so weakly synchronized, since for instance in 1980, average trade within Asia was almost three times higher than intra-American trade[12]. Figure 3 illustrates this point more generally: there, pairs are ordered by the degree of openness[13], and as is plain to see, no de…nite pattern appears. Of course, measures of openness give a very imperfect picture of bilateral trade intensity: we use instead data on bilateral exports between 61 countries of the Summers-Heston sample, and present a plot of the relation with GDP correlations in Figure 4. If apparently statistically signi…cant, the correlation is surprisingly small, at around 0.28 using 1970 trade data[14]. Thus, explanations based on di¤usion through trade in goods seem to …nd some support in the data, though to an extent that remains unexplored, a fact that motivates inclusion of a bilateral trade variable in our multivariate analysis.

[11] The Summers-Heston dates go from 1950 to 1992. Most countries have data from 1958 on. Correlation coe¢cients are of course estimated with error. Our arbitrary discretization into di¤erent ranges is meant to -imperfectly- re‡ect signi…cance levels. Back of the envelope computations show that, given an average number of 35 observations, a correlation above 0.3 is indeed signi…cant at the 5% level.

[12] 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 form Frankel and Wei (1995).

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

[14] The numbers using 1980 and 1990 trade data are 0.32 and 0.26, respectively.

The issue of foreign direct investment (FDI) is more problematic, be it only for lack of general enough data. Wei (1995) uses a dataset reporting foreign direct investment originating from the five largest source countries. However, it is of course insufficient to construct a bilateral FDI variable at the same level of generality as the rest of the analysis[15]. Further, even if such data did exist, it is not obvious to us what the relevant measure would be: insofar as its impact presumably varies a lot with the characteristics of the receiving country, FDI levels ought to be normalized somehow, perhaps by the level of GDP at the receiving end, or by the total amount of FDI received[16]. In Table 1, we report FDI stocks originating in France, Germany, Japan, the U.K. and the U.S, both in levels and in proportion of the GDP in the receiving country. There is of course no claim that the latter measure is the relevant one in a theory of diffusion through FDI[17]; rather, it is meant as an example illustrating the extreme sensitivity of the ranking in destination countries to the measure chosen. To take only one -striking- example, FDI towards the U.S. is the most important in levels for all four countries in Table 1, but never appears in proportion of the U.S GDP. Furthermore, a non-negligible number of developing countries enters the ranking, both in levels and in shares, including Argentina, Iran, Gabon, Zimbabwe or Malaysia[18]. Thus the claim that most FDI occurs amongst developed countries ought to be qualified -or at least clarified- somewhat: while it is true in levels, a tiny variation in Japanese FDI say to Vanuatu is likely to have tremendous effects on the receiving economy, in spite of the small amount. We think of this evidence as an illustration of the difficulty in finding relevant information on FDI, as well as the appropriate way to interpret it; furthermore it will help justifying the probable robustness of the results in this paper to inclusion of an hypothetical bilateral FDI variable.

An alternative hypothesis contends that cycle synchronization independently reflects similarities in the productive structures of the correlated countries. If, as argued by numerous authors, stochastic developments at the

---

[15] 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.

[16] Given the state of data on FDI, this last specification, though of crucial relevance to understanding diffusions of crises, remains for now inaccessible at the level of generality we endeavor.

[17] This is however the measure used in Borensztein, De Gregorio and Lee (1995), who attempt to estimate the growth effects of FDI.

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

source of aggregate fluctuations occur at the sectoral level, economies with a large number of common sectors will display correlated cycles. Since total value added as measured by GDP is the best aggregate approximation of the degree of industrialization, and thus of the likelihood that two countries share a large number of sectors, we choose in Figure 5 to order correlations according to the level of GDP in 1960 in each country. While not rigorously established, we think of the matrix in Figure 5 as the most striking result in the paper: each cell representing one bilateral GDP correlation almost perfectly fade to clearer shades of gray as one moves down the distribution of income. Thus, rich countries' business cycles are more correlated. Next section presents multivariate regressions that propose to verify whether this is a robust result. Given the apparent weak role played by trade in goods, and unclear evidence on FDI flows, our prior is that results documented in Figure 5 remain true unconditionally.

2.2 Cycles Synchronization and GDP Levels

In this part, we present formal confirmation of the evidence based on correlation matrices. We will conclude that the significance of trade in accounting for the degree of synchronization in cycles is weak at best, and mostly for Europe. On the other hand as expected, our results promote the level of income as an important unconditional determinant of GDP correlations, and that with both statistical and economic significance. The data is reduced to 61 countries, where bilateral trade data exists[19] and augmented Dickey-Fuller tests could not reject the hypothesis of a unit-root in GDP[20]. The countries, listed in appendix C, are used to compute 1830 bilateral correlations between GDP growth rates, our dependent variable. Correlations matrices direct our choice as to what variables ought to be included on the right-hand side: bilateral trade, aggregate income level, geographic and institutional variables. Table 2 presents results corresponding to different specifications. Regression (i) includes the level of bilateral trade in 1970, the sum of GDP in the two countries and their difference[21], and several

[19] The data comes from Frankel and Wei (1995). Bilateral trade is equal to the sum of exports in both directions.

[20] Augmented Dickey-Fuller tests were run with the number of lags that maximized the significance level of the autoregressive coefficient away from one, i.e. the results are biased towards rejection of the unit-root hypothesis.

[21] Country j is always the poorer of the pair, so that the difference is positive. This turns out useful in interpreting the results.

geographic variables. Ideally, one would want to discriminate between pairs of countries where both countries are rich, both are poor, and instances where they have very di¤erent income levels. This is the justi…cation for including both the sum and the di¤erence of GDPs. For all country pairs (i, j), both Y_i+Y_j and Y_i-Y_j enter signi…cantly, though with opposite signs. Trade enters signi…cantly in levels, with substantial economic signi…cance as well: a one-standard-error increase in bilateral trade results in a correlation higher by 0.0156. Quite surprisingly, the distance variable[22] matters positively, which points to probable mis-speci…cation. Adjacency and continental dummy variables for Europe and the Americas all enter signi…cantly and with the expected signs. Remarkably enough given the relative small number of independent variables, almost half of the cross-sectional variation in cycle synchronization is explained with merely bilateral trade, income and geographic considerations.

The coe¢cients on Y_i+Y_j and Y_i-Y_j are almost equal and of opposite signs. Thus, Y_j, income level in the poorer country, should impact positively GDP correlations, while the sign of Y_i is ambiguous. Regression (ii), where Min(Y_i,Y_j) and 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 coe¢cients remain strikingly similar between regressions (i) and (ii), 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. In particular, our preferred interpretation is that GDP correlations are higher when both countries are rich; allow only one country to become poorer, and the impact on synchronization becomes insigni…cant.

As was already apparent from Figure 4, replacing the level of bilateral trade by its logarithm improves the overall performance of the estimation, as con…rmed in regression (iii). Furthermore, it makes the coef…cient on distance insigni…cant, a result more plausible than the previous positive estimates. Regression (iv) replaces the continental variables with dummies constructed using membership to several free trade agreements without remarkable consequences, except for the interesting fact that all the action is concentrated in the European Union[23]. The logarithm of trade and Min(Y_i,Y_j) remain both statistically and economically signi…cant. An increase of the income of the poorer country by one standard deviation,

[22] The distance between main cities.
[23] Artis and Zhang (1996) obtained a similar result.

quite a substantial move, say from Ethiopia to Brazil in 1960, results in an increase of the correlation by 0.06. Similarly, a one-standard-error increase in bilateral trade intensity in 1970 results in a coe¢cient higher by 0.026.

The last three speci…cations in Table 2 check whether the trade and income variables enter non-linearly. This is simply veri…ed by including quadratic expressions in the estimations. First, as is evident from the three regressions, the relation with the income variable is concave: richer countries are indeed unconditionally more correlated, but to an extent that diminishes as they grow richer. As will become clearer, the model developed in the next section interprets this non-linearity as resulting from the presence of congestion costs that make industrialization increasingly costly[24]. Further, regressions (vi) and (vii) show the relation with bilateral trade to be convex, signi…cant at the 5% con…dence level only, and with only weak economic importance: using the estimates in (vii), a one-standard-error increase in bilateral trade results in an increase of merely 0.009 in GDP correlation. This is a very surprising result, given the omnipresence of arguments linking bilateral trade to globalization of cycles, as well as the relative importance of the income variable. Notice furthermore that the distance variable enters independently in regression (vii), with the expected negative sign. It is also very signi…cant, and along with the adjacency dummy variable, seems to exhaust all geographic considerations. Finally, regression (vii) explains close to half of the variability in GDP correlation, with a substantial increase from speci…cation (i).

While it is not clear to us what theory underpins such claims, reverse causality appears to have been an issue in the few papers tackling similar issues -though in a di¤erent context. In particular, Frankel and Rose (1998) regress bilateral GDP correlations on measures of bilateral trade, and use the positive estimate to argue that a monetary union, insofar as it may boost trade, is likely to make member countries more synchronized ex-post. In their estimation, they took particular care of reverse causality, arguing that "countries are likely to link their currencies deliberately to those of their most important trading partners" and "exchange rate stability could cause both high trade and co-ordinated business cycles". We have argued elsewhere[25] that in our opinion, the issue is more that of an omitted

[24] Industrialization is modeled as an increase in the size of the sector that produces a heterogenous good. Because of convex congestion costs, augmenting the share of the economy hit by common shocks -industry, as opposed to a traditional sector- becomes increasingly costly as the economy industrializes.

[25] See Imbs (1998b).

variable bias. Further, running instrumental estimation as they do, using bilateral distance and dummy variables for adjacency and the use of a common language seems inappropriate, insofar as at least the …rst two cannot be excluded from the estimation, as evident for instance in regression (vii)[26]. Third, it is not clear to us that there is indeed an issue of reverse causality: if anything, models of international ‡uctuations predict that trade will be high precisely when business cycles are out of phase[27]. Finally, our estimates of the e¤ect of trade on cycle synchronization are already strikingly small: they would only become smaller once the hypothetic bias is controlled for. As for the income variable, it seems harder still to see how reverse causality could be an issue. However, we present in Table 3 estimations that are meant to take these potential defects into account. To do this, we compute GDP correlations based on the second half of the sample only, from 1975 to 1992, and regress those on the level of trade in 1970, and income in 1960, thus in essence taking "lags" of the independent variables. Further, we include a dummy variable representing membership to the European Monetary System, the only …xed exchange rate regime between 1975 and 1992 in the sample, meant to correct for the omitted variable bias described in Frankel and Rose (1998). Quite strikingly, coe¢cients remain of the same order of magnitude, and R-squares remain high, at around 0.25. Despite the fact that correlation coe¢cients are now computed with substantial error[28], the same variables still explain more than a quarter of cross-sectional variability in synchronization[29].

Table 4 completes the speci…cation search by verifying that the trade, income and geographic variables enter the estimation independently rather than through pairwise interaction. None of the interaction variables included in the estimation seemed to matter, with one notable exception. As is clear

[26] Frankel and Rose (1998) actually do not present results on non-linear estimations. However, at least the adjacency variable can never be excluded from the set of independent variables.

[27] This is for instance the case in Backus et al (1994), where more trade will take place if technology shocks are negatively correlated. Note that this does not mean that this type of models have any prediction as to what happens when bilateral trade increases.

[28] Using at most 18 observations.

[29] In Imbs (1998b), we used quarterly data for 21 OECD countries to argue that the Frankel and Rose (1998) results arose from …xed e¤ects, that caused jointly intense bilateral trade and correlated cycles. While we think they are still at play here as far as the coe¢cient on trade, they probably do not impinge on our main result, the importance of income level for GDP correlation. To verify this rigorously would imply running estimation of (vii), say, in …rst-di¤erences, an impossible task given the brevity of the time series.

from regressions (i) and (ii), bilateral trade matters more in explaining cycle synchronization within Europe. Further, this interaction variable actually exhausts the explanatory power of trade. Thus, if trade matters for cycle synchronization, it is in Europe. This is interesting in at least two ways: …rst, it casts yet more doubt on the claim that it is through trade that ‡uctuations cross borders in general. Second, insofar as the main di¤erence between Europe and other free-trade areas or clusters of developed countries is the presence of a …xed exchange rate regime, this points to substantial real e¤ects of monetary arrangements, either on trade or directly on ‡uctuations. Those were already alluded to in Artis and Zhang (1996) and Frankel and Rose (1998), and potentially still fall victim to the …xed e¤ect criticism in Imbs (1998). Some sensitivity analysis is conducted in Table 5, where the trade variable is constructed using bilateral exports in 1980, and income levels in 1975. All the results carry through. Notice that the coe¢cients on $Min(Y_i, Y_j)$ remained stable and signi…cant at the 1% con…dence level at least in all twelve speci…cations in this paper: this is true of no other variable.

3 A Model of Endogenous Structural Change

In this part, we present a model illustrating our main empirical finding. 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 agriculture. 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[30]. Insofar as our explanation for GDP correlations relies on differences in the productive structure of the economy, we need a model of endogenous structural change. 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[31], 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. We choose to develop our illustrating model in their framework, though 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[32] level of expenditures, which in turn increases with the number of goods produced locally[33] - 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, we want to model precisely the opposite mechanism: as they grow, countries are increasingly likely to produce the same type of goods. We reverse the agglomeration result by introducing some congestion costs of entry that increase convexly with the

[30] 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.

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

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

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

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 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. Interestingly, our model also predicts that countries with similar income levels trade mostly within industries, a well-documented fact.

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 ($i = 1...K + K^*$), 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 a 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 very similar to BMO. We begin with a description of demand.

3.1 Demand

We shall assume that in each period consumers derive utility from the consumption aggregate C, defined as follows:

$$C = C_T^{1-\alpha} C_M^{\alpha}$$

where $C_M = \left(\sum_{i=1}^{K+K^*} C_i^{\sigma}\right)^{\frac{1}{\sigma}}$ is the aggregate Northern[34] consumption of all manufacture varieties, C_T is Northern consumption of the traditional good

[34] The model is described for the North. Characteristics in the South are isomorphic.

T and $0 < \sigma < 1$. With these notations, $\frac{1}{1-\sigma}$ is the elasticity of substitution between varieties of the manufactured good. Each period, the consumer maximizes her utility by solving simultaneously two problems: given a level of -Northern- expenditures E she first chooses how much of M and T to consume, and then allocates the remaining E^M across different varieties of the manufacture. Solution to the first problem very standardly yields

$$C_T = \left(\frac{1-\alpha}{\alpha}\right)\left(\frac{p_M}{p_T}\right) C_M$$

where p_M and p_T are the prices of M and T, respectively. Furthermore, consumers choose C_i, the demand for each variety, to maximize C_M taking as given the level of expenditure on M, E^M. Optimization requires that

$$C_i = p_i^{-\frac{1}{1-\sigma}}\, p_M^{\frac{\sigma}{1-\sigma}}\, E^M \qquad (1)$$

where $p_M = \left(\sum_{i=1}^{K+K^*} p_i^{\frac{\sigma}{\sigma-1}}\right)^{\frac{\sigma-1}{\sigma}}$ is the price index associated with the heterogenous manufactured good[35]. It is easy to see that $p_M C_M = E^M$, and thus:

$$E = p_T C_T + E^M = \frac{1-\alpha}{\alpha} E_M + E_M = \frac{1}{\alpha} E_M$$

The expression can be used in (1) to solve for expenditures on manufactures E^M and obtain

$$C_i = p_i^{-\frac{1}{1-\sigma}}\, \frac{\alpha E}{\sum_{i=1}^{K+K^*} p_i^{\frac{\sigma}{\sigma-1}}} \qquad (2)$$

Notice that because of Chamberlinian competition, a given variety i is produced by one firm only: when deciding of its pricing strategy, the firm will take into account demand arising from both the North and the South.

[35] The price index is not completely accurate since there are transport costs. For clarity of exposition, this inexactitude is taken care of later, when analyzing firms' pricing policy.

3.2 Supply and Pricing

We assume that labor is immobile. One unit of T is produced with constant returns using one unit of labor. Thus pro…t maximization in the T sector requires that $p_T = w$ ´ 1, where the nominal wage has been normalized to one. We assume ¾ units of labor are required to produce one unit of M_i. Pro…t maximizing …rms in the M sector set price equal to marginal cost, keeping in mind that they face the demand function in (2). Each …rm is assumed to act atomistically, and thus fails to recognize that individual pricing impacts the price index p_M. The …rm that produces variety i chooses p_i and $p_i^¤$, the price of variety i in the South, to maximize pro…ts subject to (2), where pro…ts $¦_M$ are given by:

$$¦_M = (p_i\, C_i ¡ w\, ¾\, C_i) + (p_i^¤\, C_i^¤ ¡ w\, ¾\, ¿\, C_i^¤)$$

Transport costs decrease in $0 < ¿ < 1$, and the de…nition for $C_i^¤$ follows directly from (2). Pro…ts are maximized for

$$p_i = p = 1 \text{ and } p_i^¤ = p^¤ = ¿$$

Using the price rule, maximized pro…ts are:

$$¦_M = (1 ¡ ¾)\,\frac{®E}{K + ¿^{\frac{¾}{¾ ¡ 1}} K^¤} + (1 ¡ ¾)\,\frac{¿^{\frac{¾}{¾ ¡ 1}} ®E^¤}{¿^{\frac{¾}{¾ ¡ 1}} K + K^¤}$$

Introducing $S_K = \frac{K}{K + K^¤}$, $S_E = \frac{E}{E + E^¤}$ and $µ = ¿^{\frac{¾}{¾ ¡ 1}}$ maximized Northern pro…ts can be rewritten

$$¦_M = \frac{®(1 ¡ ¾)(E + E^¤)}{K + K^¤} ½ \frac{S_E}{S_K + µ(1 ¡ S_K)} + \frac{µ(1 ¡ S_E)}{µS_K + (1 ¡ S_K)} ¾ \qquad (3)$$

It is easy to compute the equivalent expression for Southern pro…ts, and obtain

$$¦_M^¤ = \frac{®(1 ¡ ¾)(E + E^¤)}{K + K^¤} ½ \frac{µS_E}{S_K + µ(1 ¡ S_K)} + \frac{1 ¡ S_E}{µS_K + (1 ¡ S_K)} ¾ \qquad (3')$$

3.3 Equilibrium

3.3.1 Free-Entry Condition

In the absence of a …xed cost of entry in the manufacturing sector, an in…nite number of …rms 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 ´. We choose to model ´ as a quadratic function of S_K. This is to re‡ect 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 e¢ciently scarce resources towards further innovation[36]. Furthermore, the convexity assumption draws on the …nding that countries with similar income levels display conformity in their cycles, but to an extent that decreases as income rises. In the model, income disparities are re‡ected by di¤erences in the extent of industrialization: therefore, given an initial level of North-South income disparity, it ought to be relatively more costly for rich pairs of countries to achieve convergence to the same productive structure -i.e. convergence in income levels. This will be captured by convex congestion costs: then, the cost of Southern catching-up rises with Southern income level. Finally, ´ 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 ´ units of labor to produce one unit of capital, so that capital grows according to[37]

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

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

[36] 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 e¤ects roughly cancel." The di¤erence here is that the former e¤ect is assumed local.

[37] The particular functional form is of course chosen for computational convenience. We however think the main intuition carries through in more general settings.

We assume that payment of η confers a perpetual monopoly on the variety exploited, and thus secures the present value of all future profits[38] generated by exploitation of i, V. In equilibrium, the following must hold:

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

By definition at the steady state, $\dot{E} = \dot{E}^* = \dot{S}_K = 0$. The expression for Northern profits (3) shows that Π_M falls at the rate $K + K^*$ grows[39], g. Furthermore, intertemporal utility maximization yields the standard Euler equation $\frac{\dot{E}}{E} = r - \rho$, 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.

3.3.2 Expenditures

By definition, expenditures equal income net of investment. Northern agents own all local labor and capital[40], and derive income from rental of factors or production. Investment corresponds in the model to labor hired in the capital sector, L_I. Thus,

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

We show later under what conditions the number of steady states is limited to 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, we focus on the asymmetric case where all innovation is Northern:

[38] 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.

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

[40] 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.

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

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

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

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

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.

3.4 Steady State Analysis and Stability

3.4.1 Steady States

We seek to characterize situations where the local share of world capital remains constant, i.e. $\dot{S}_K = 0$. It is easy to see that at a steady state thus defined $S_K\,(1 - S_k)\,(g - g^*) = 0$ 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[41].

[41] As mentioned, we focus on Northern industrialization for the latter asymmetric case.

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

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

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

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

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

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

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 very mild conditions described in appendix A, 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, we supposed that all new varieties were 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 $\Pi^* < \eta^*(\rho + g)$. 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

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

In appendix B, we show 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 $\text{Max}\left(\frac{1}{4a}; \theta_1\right) < \theta < \theta_2$, there are two steady states. The characteristics of the third -asymmetric- one are easy to infer from what precedes.

3.4.2 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. We now show that the former applies in the symmetric and the latter in the asymmetric case. The appendix provides an expression for $-(S_K) = \frac{|}{|^{¤}} - \frac{´}{´^{¤}}$ derived from (7) and (8), that measures relative Northern profits net of relative costs. If $- > 0$, is it more profitable to invent and produce new manufactures in the North. On the other hand,

$$-(1) = A(1) + B(1) + C + D(1) + E < 0$$

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 $-(S_K) < 0$, that is until the world reaches the symmetric equilibrium where $-(S_K) = 0$ by definition.

To examine stability of the symmetric steady state, we need to determine how $-(S_K)$ 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

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

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.

3.4.3 Income Levels

We 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 $PY = wL + \gamma K$, where

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

Thus using the equivalent Southern definitions,

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

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

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

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. We have shown 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.

4 Conclusion

This paper provides novel evidence on the determinants of the synchronization of business cycles. Against many pundits' views, we find that the extent of bilateral trade has very little to do with GDP correlations, except perhaps for European countries. On the other hand, we document the fact that pairs of countries with higher aggregate income level experience business cycles that are unconditionally more synchronized. This finding is interpreted in a model where international income disparities correspond to differences in production patterns, and thus to different degrees of exposure to common stochastic developments. In our opinion, the approach developed here opens the way to various extensions. On the modeling front, we 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 relative unimportance of trade factors should lead to rejection of some theoretical transmission mechanisms, while the significance of both geographic and income considerations may help select others. More generally, models of the international cycle often have predictions on bilateral correlations of various variables, such as the price level or real money balances. The empirical approach developed here could be fruitfully extended to other macroeconomic aggregates. On the empirical front, it is easy to imagine how a similar study based on lagged rather than contemporaneous correlations could help bring in focus the issue of lagged international diffusion of crises and expansions. Trade factors might play a very different role there.

Appendix

A. 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

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

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

where:

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

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

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

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

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

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 $S_K < \frac{1}{2}$.

B. 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:

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

$$+ (a+1)\frac{L}{K+K^*} < 0 \qquad (9')$$

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 $\theta < \theta_2$.

C. Countries in the Sample

Algeria
Argentina
Australia
Austria
Belgium
Bolivia
Brazil
Canada
Chile
China
Colombia
Denmark
Ecuador
Egypt

Ethiopia
Finland
France
Ghana
Greece
Hong Kong
Hungary
Iceland
India
Indonesia
Iran
Ireland
Israel
Italy
Japan
Kenya
Malaysia
Mexico
Morocco
Netherlands
New Zealand
Nigeria
Norway
Pakistan
Paraguay
Peru
Philippines
Poland
Portugal
S Africa
Saudi Arabia
Singapore
South Korea
Spain
Sudan
Sweden
Switzerland
Taiwan
Thailand
Tunisia

Turkey
U.K.
U.S.A.
Uruguay
Venezuela
W Germany
Yugoslavia

References

Ambler, Steve, Emanuela Cardia and Christian Zimmermann (1998), International Transmission of the Business Cycle in a Multi-Sectoral Model, CREFE Working Paper No. 60, Université du Québec à Montréal.

Artis, Michael and Wenda Zhang (1996), Business Cycles, Exchange Rate Regimes and the ERM: Is There a European Business Cycle?, European University Institute Working Paper No. 96/55.

Backus, David and Jordi Gali (1995), International Factors in the Recessions of the Early Nineties, mimeo., New York University

Backus, David, Patrick Kehoe and Finn Kydland (1994), Dynamics of the Trade Balance and the Terms of Trade: the J-Curve?, American Economic Review, vol. 84, no. 1, 84-103.

Backus, David, Patrick Kehoe and Finn Kydland (1995), International Business Cycles: Theory and Evidence, in: Thomas Cooley, ed., Frontiers of Business Cycle Research, Princeton University Press, 331-356.

Balassa, Bela (1966), Tari¤ Reductions and Trade in Manufactures Among Industrial Countries, American Economic Review, vol. 56, no. 3, 466-473.

Balassa, Bela (1979), Intra-Industry Trade and the Integration of Developing Countries in the World Economy, in: Herbert Giersch, ed., On the Economics of Intra-Industry Trade (Mohr, Tubingen), 245-270.

Baldwin, Richard, Philippe Martin and Gianmarco Ottaviano (1998), Global Income Divergence, Trade and Industrialization: The Geography of Growth Take-O¤s, NBER Working Paper No. 6458.

Barro, Robert and Xavier Sala-I-Martin (1995), Economic Growth, New York: McGraw Hill.

Baxter, Marianne (1995), International Trade and Business Cycles, NBER Working Paper No. 5025.

Borenzstein, Eduardo, Jose De Gregorio and Jong-Wha Lee (1995), How Does Foreign Direct Investment A¤ect Economic Growth?, NBER Working Paper No. 5057.

Canova, Fabio (1993), Sources and Propagation of International Business Cycles: Common Shocks or Transmission?, CEPR Discussion Paper No. 781.

Canova, Fabio and Harris Dellas (1993), Trade Interdependence and the International Business Cycle, Journal of International Economics, vol. 34, 23-47.

Costello, Donna (1993), A Cross-Country, Cross-Industry Comparison of Productivity Growth, Journal of Political Economy, vol. 101, no. 2, 207-222.

Fatas, Antonio (1997), EMU: Countries or Regions? Lessons from the EMS Experience, European Economic Review, vol. 41, 743-751.

Forni, Mario and Lucrezia Reichlin (1997), National Policies and Local Economies: Europe and the US, mimeo.

Frankel, Je¤rey and Shang-Jin Wei (1995), Open Regionalism in a World of Continental Blocks, mimeo.

Frankel, Je¤rey and Andrew Rose (1998), The Endogeneity of the Optimum Currency Area Criteria, Economic Journal, vol. 108, no. 449, 1009-1025, July.

Ghosh, Atish and Holger Wolf (1996), Texas or Textiles? Geographic versus Sectoral Shocks in the U.S. Business Cycle, mimeo.

Hornstein, Andreas and Jack Praschnick (1997), Intermediate Inputs and Sectoral Comovement in the Business Cycle, Journal of Monetary Economics, Vol. 40, 573-595

Imbs, Jean (1998a), Di¤usion, Leadership and the Speed of Adoption, mimeo., New York University.

Imbs, Jean (1998b), Fluctuations, Bilateral Trade and the Exchange Rate Regime, mimeo. New York University.

Keller, Wolfgang (1997), Trade and the Transmission of Technology, mimeo., University of Wisconsin Madison.

Kollmann, Robert (1995), The Correlation of Productivity Growth across Regions and Industries in the United States, Economic Letters, vol. 47, 437-443.

Kollmann, Robert (1998), Explaining International Comovements of Output and Asset Returns: The Role of Money and Nominal Rigidities, mimeo. University Paris XII, August.

Kraay, Aart and Jaume Ventura (1997), Trade and Fluctuations, mimeo.

Krugman, Paul (1991), Increasing Returns and Economic Geography, Journal of Political Economy, vol. 99, no. 3, 483-499.

Krugman, Paul (1996), Pop Internationalism, Cambridge, MA: MIT Press.

Krugman, Paul and Maurice Obstfeld (1997), International Economics: Theory and Policy, Addison Wesley Longman, Inc.

Krugman, Paul and Anthony Venables (1995), Globalization and the Inequality of Nations, Quarterly Journal of Economics, vol. 110, no. 4, 857-880.

Krugman, Paul and Anthony Venables (1996), Integration, Specialization and Adjustment, European Economic Review, vol. 40, 959-967.

Lumsdaine, Robin and Eswar Prasad (1997), Identifying the Common Component in International Economic Fluctuations: A New Approach, NBER Working Paper No. 5984.

Marx, Karl and Friedrich Engels (1848), The Communist Manifesto, in David McLellan, ed., The World's Classics.

Rodrik, Dani (1996), Why Do More Open Economies Have Bigger Governments?, NBER Working Paper No. 5537.

Schmitt-Grohé, Stephanie (1998), The International Transmission of Economic Fluctuations: E¤ects of U.S. Business Cycles on the Canadian Economy, Journal of International Economics, vol. 44, 257-287.

Stockman, Alan (1988), Sectoral and National Aggregate Disturbances to Industrial Output in Seven European Countries, Journal of Monetary Economics, vol. 21, 387-409.

Wei, Shang-Jin (1995), Attracting Foreign Investment: Has China Reached Its Potential?, China Economic Review, vol. 6, no. 2, 187-199.

Figure 1

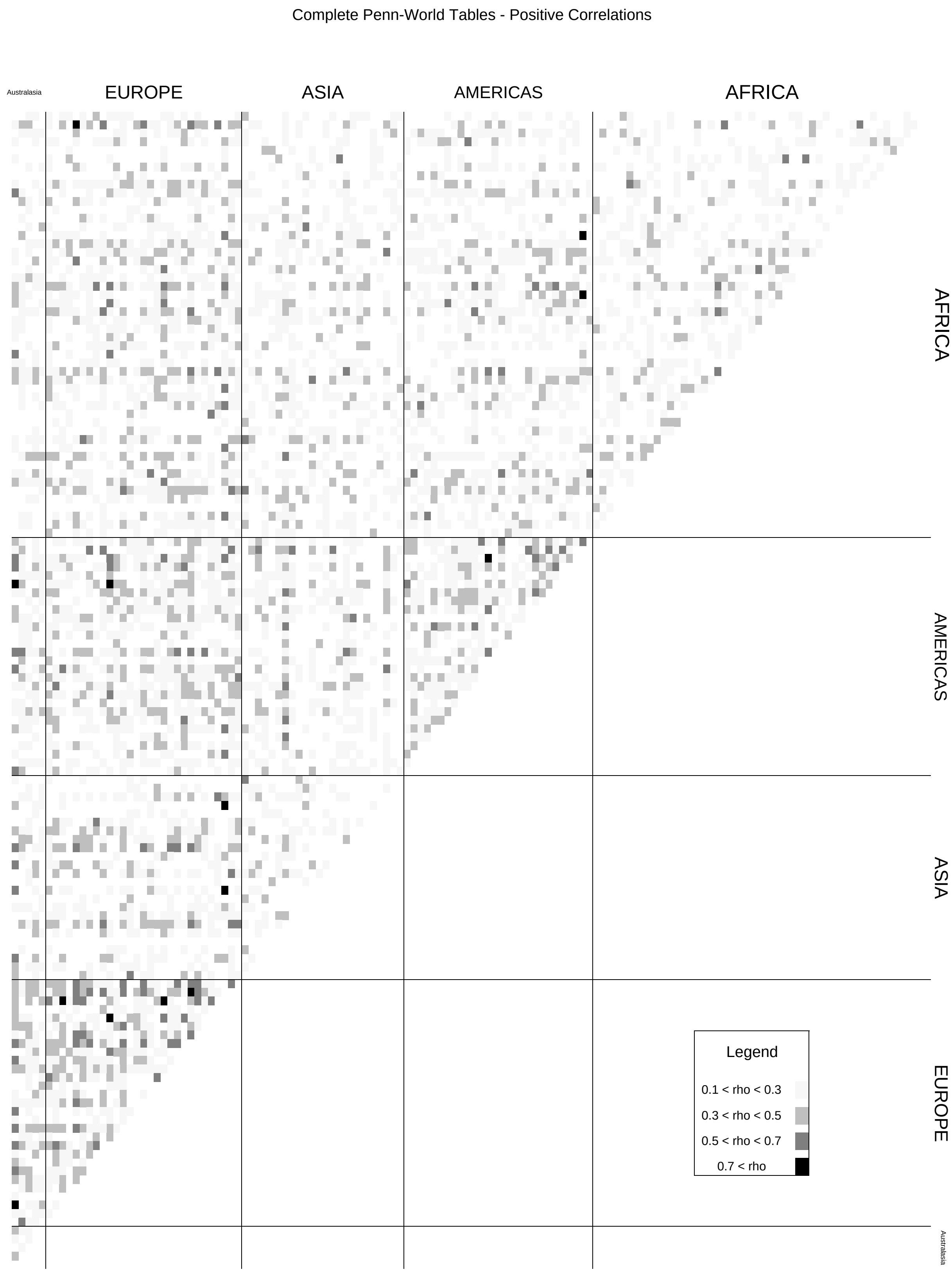
Complete Penn-World Tables - Positive Correlations
Australasia
EUROPE
ASIA
AMERICAS
AFRICA
AFRICA
AMERICAS
ASIA
EUROPE
Australasia
Legend
0.1 < rho < 0.3
0.3 < rho < 0.5
0.5 < rho < 0.7
0.7 < rho

Figure 2

Complete Penn-World Tables - Negative Correlations

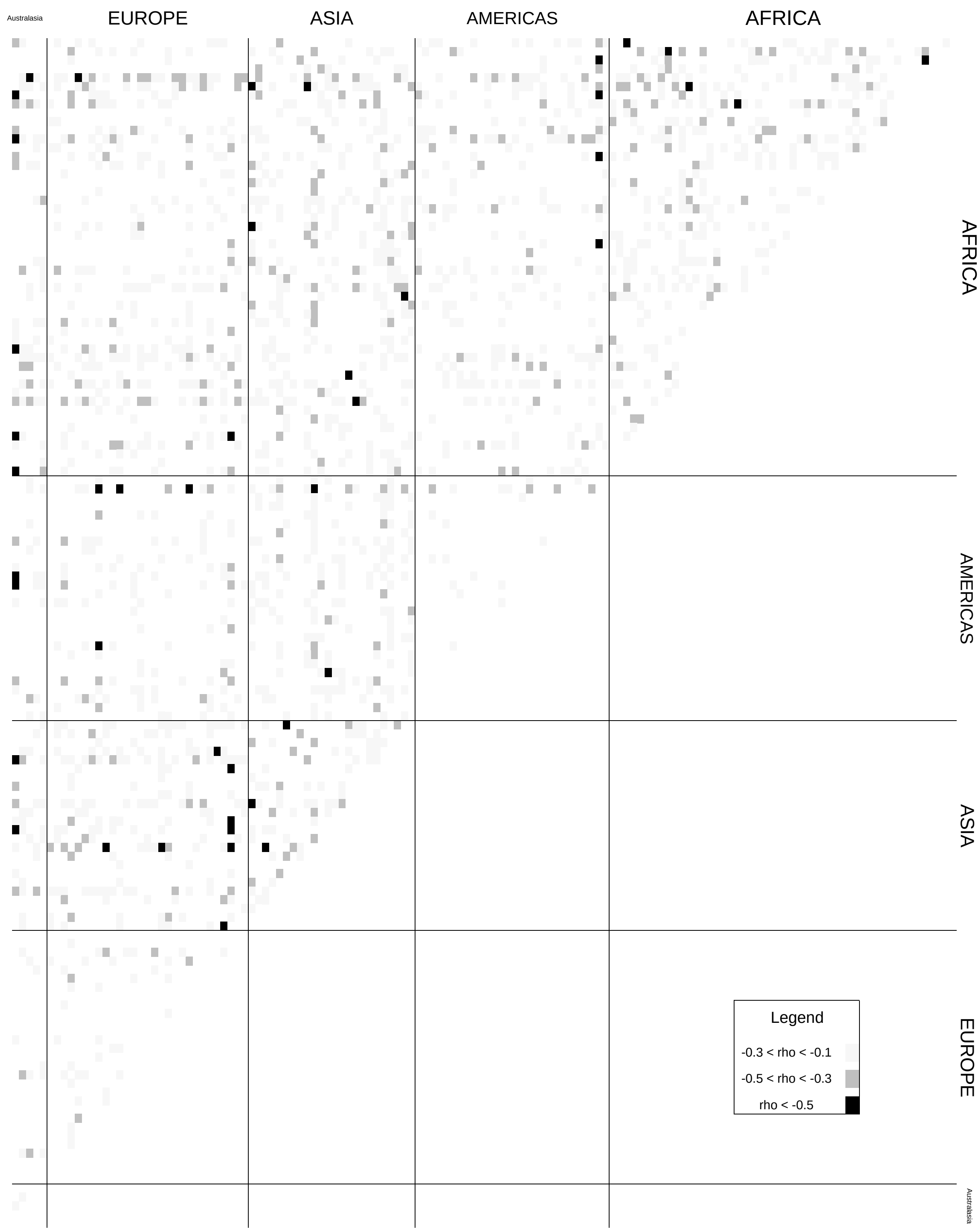

Figure 3

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

Figure 4: Positive GDP Correlations and Bilateral Trade in 1970

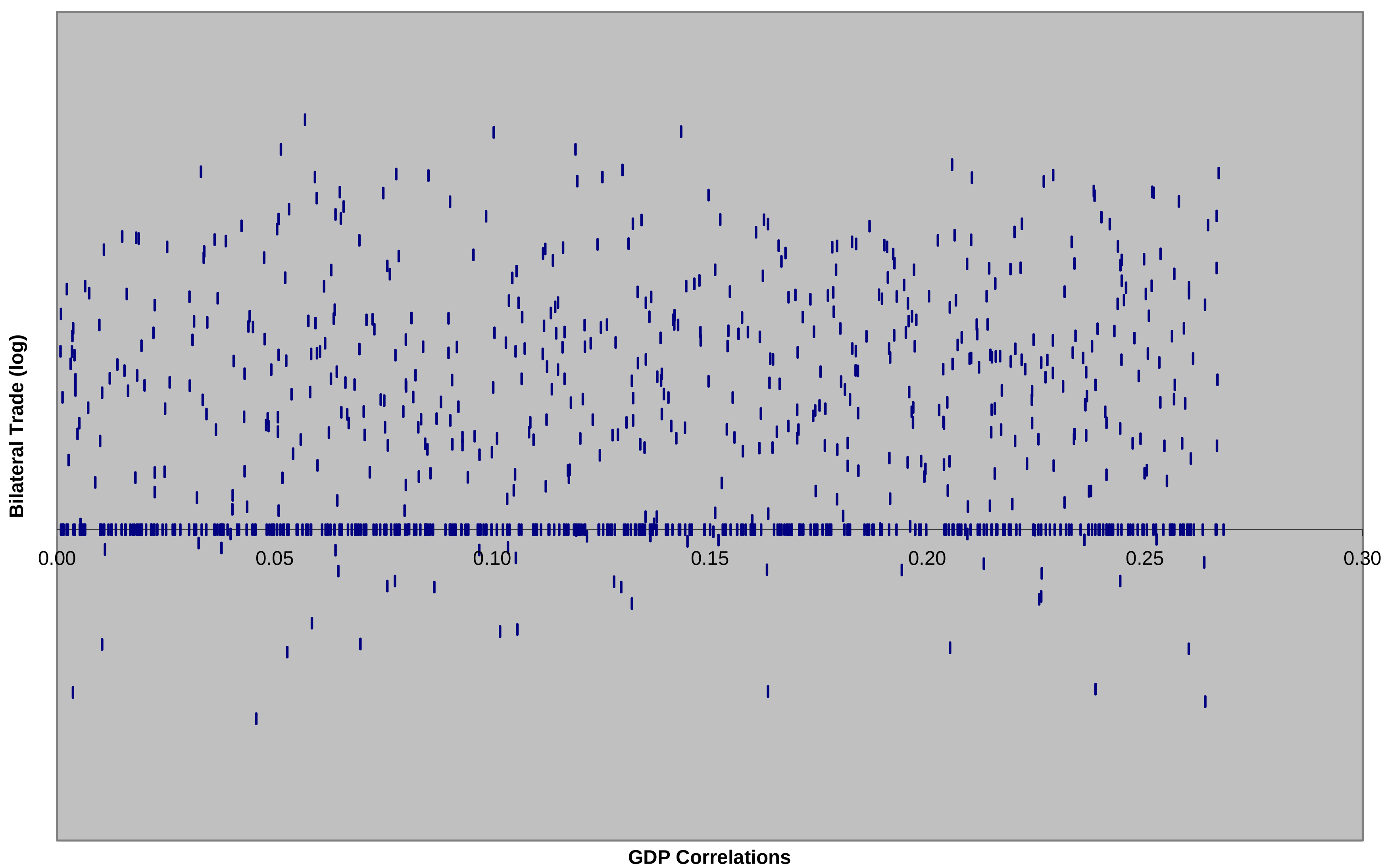

Figure 5

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

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

	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)
Trade variables							
X70	1.62×10^{-5} [4.12]**	1.6×10^{-5} [4.13]**					
ln(X70)			0.012 [4.66]**	0.012 [4.70]**	0.007 [2.79]**	-0.039 [0.83]	-0.003 [0.56]
$\ln(X70)^2$						0.002 [2.73]**	0.002 [2.49]*
Income variables (1960)							
Y_i+Y_j	2.06×10^{-5} [11.31]**						
Y_i-Y_j	-2.18×10^{-5} [8.46]**						
Min (Y_i, Y_j)		4.25×10^{-5} [10.82]**	3.55×10^{-5} [8.95]**	3.96×10^{-5} [11.60]**	6.81×10^{-5} [9.56]**	7.51×10^{-5} [10.29]**	9.61×10^{-5} [8.87]**
Max (Y_i, Y_j)		-1.35×10^{-6} [0.65]					
Min $(Y_i, Y_j)^2$					-5.24×10^{-9} [5.19]**	-6.50×10^{-9} [6.09]**	-8.96×10^{-9} [6.22]**
Geographic variables							
Distance	3.10×10^{-6} [2.59]**	2.94×10^{-6} [2.46]*	7.42×10^{-7} [0.82]				-3.48×10^{-6} [2.86]**
Adjacency	0.112 [3.89]**	0.113 [3.94]**	0.111 [4.02]**	0.129 [4.92]**	0.121 [4.37]**	0.110 [3.96]**	0.103 [3.73]**
Europe	0.084 [4.43]**	0.085 [4.48]**	0.058 [3.21]**		0.043 [2.65]**	0.039 [2.42]*	0.006 [0.32]
America	0.065 [2.82]**	0.066 [2.89]**	0.055 [2.36]*		0.031 [1.35]	0.032 [1.36]	0.017 [0.69]
Africa	0.024 [0.63]						
Asia	-0.033 [1.54]						
Institutional variables							
EU				0.083 [5.99]**			
Nafta				-0.036 [0.31]			
Asean				0.050 [1.11]			
Andean Pact				-0.043 [1.10]			
R-Square	0.465	0.463	0.469	0.474	0.480	0.482	0.486

Left-hand side variable is the correlation of GDP growth in countries i and j between 1950 and 1992. Estimation with Huber-White standard errors. T-statistics are reported in brackets. * indicates significance level at the 5% level, ** at the 1% level.

Table 4 : Interaction Analysis

	(i)	(ii)	(iii)
Trade variables			
ln(X70)	-0.003 [0.48]	-0.010 [1.47]	-0.008 [1.17]
$ln(X70)^2$	0.002 [2.29]*	9×10^{-4} [1.11]	-3.17×10^{-4} [0.36]
Income variables (1960)			
Min (Y_i, Y_j)	1×10^{-4} [8.65]**	1.1×10^{-4} [9.31]**	1.07×10^{-4} [8.37]**
Min $(Y_i, Y_j)^2$	-9.71×10^{-9} [6.52]**	-1.14×10^{-8} [6.49]**	-1.46×10^{-8} [6.36]**
Geographic variables			
Adjacency	0.078 [1.94]	0.099 [2.34]*	0.114 [2.71]**
Distance	-4.29×10^{-6} [2.97]**	-5.26×10^{-6} [3.44]**	-4.29×10^{-6} [2.71]**
Europe	0.005 [0.25]	-0.141 [3.02]**	-0.117 [2.46]*
Interaction variables			
ln(X70) x Adjacency	0.007 [0.49]	0.009 [0.68]	0.007 [0.51]
Min (Y_i, Y_j) x Adjacency	2.23×10^{-7} [0.01]	-1.4×10^{-5} [0.66]	-1.72×10^{-5} [0.79]
ln(X70) x Distance	1.46×10^{-7} [0.25]	1.17×10^{-6} [1.82]	5.22×10^{-7} [0.78]
Min (Y_i, Y_j) x Distance	2.01×10^{-10} [0.28]	-1.03×10^{-10} [0.12]	6.18×10^{-10} [0.69]
ln(X70) x Europe		0.040 [4.15]**	0.030 [2.89]**
Min (Y_i, Y_j) x Europe		-2.06×10^{-6} [0.16]	2.83×10^{-6} [0.22]
Min (Y_i, Y_j) x ln(X70)			5.55×10^{-6} [2.51]*
R-Square	0.486	0.496	0.499

Left-hand side variable is the correlation of GDP growth in countries i and j between 1950 and 1992. Estimation with Huber-White standard errors. T-statistics are reported in brackets. * indicates significance level at the 5% level, ** at the 1% level.

Table 3 : Lagged Estimations

		(i)	(ii)
Trade variables			
	ln(X70)	0.023 [6.21]**	0.002 [0.35]
	$\ln(X70)^2$		0.003 [2.95]**
Income variables (1960)			
	Min (Y_i, Y_j)	2.23×10^{-5} [4.33]**	5.55×10^{-5} [4.26]**
	Min $(Y_i, Y_j)^2$		-5.53×10^{-9} [2.92]**
Geographic variables			
	Adjacency	0.138 [4.18]**	0.117 [3.51]**
	Distance	-2.99×10^{-6} [2.39]*	-4.28×10^{-6} [2.88]**
	EMS	0.192 [3.62]**	0.146 [2.72]**
R-Square		0.259	0.257

Left-hand side variable is the correlation of GDP growth in countries i and j between 1975 and 1992. Estimation with Huber-White standard errors. T-statistics are reported in brackets. * indicates significance level at the 5% level, ** at the 1% level.

Table 5 : Sensitivity Analysis

	(i)	(ii)
Trade variables		
ln(X80)	0.0045 [2.36]*	-0.012 [2.49]*
ln(X80)^2		1.74×10^{-3} [3.02]**
Income variables (1975)		
Min (Y_i, Y_j)	2.71×10^{-5} [12.68]**	5.55×10^{-5} [9.03]**
Min (Y_i, Y_j)^2		-2.80×10^{-9} [5.17]**
Geographic variables		
Adjacency	0.121 [4.75]**	0.121 [4.72]**
Distance	-5.22×10^{-7} [0.64]	-1.89×10^{-6} [1.91]
Europe	0.036 [2.08]*	0.013 [0.72]
America	0.052 [2.61]**	0.031 [1.47]
R – Square	0.465	0.475

Measures of bilateral trade are taken in 1980, and income variables in 1975. The rest of the estimations is conducted as previously.