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# Using Complex Network Analysis to Assess the Evolution of International Economic Integration: The cases of East Asia and Latin America

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# Using Complex Network Analysis to Assess the Evolution of International Economic Integration: The cases of East Asia and Latin America

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**Abstract**

Over the past four decades the High Performing Asian Economies (HPAE) have followed a development strategy based on the exposure of their local markets to the presence of foreign competition and on an outward oriented production. In contrast, Latin American Economies (LATAM) began taking steps in this direction only in the late eighties and early nineties, but before this period these countries were more focused in the implementation of import substitution policies. These divergent paths have led to sharply different growth performance in the two regions. Yet, standard trade openness indicators fall short of portraying the peculiarity of the Asian experience, and to explain why other emerging markets with similar characteristics have been less successful over the last 25 years. This paper offers an alternative perspective on the issue by exploiting recently-developed indicators based on weighted network analysis. This allows us to investigate the whole structure of international trade relationships and to determine both the position of HPAE countries in the network and its evolution over time. We show that HPAE countries are more integrated into the world economy, as they have moved – over the past 25 years – from the periphery of the network towards its core. In contrast, the LATAM region seems to be loosing presence within the network or, at best, its integration process has remained stagnant.

**JEL Classification**: F10, D85.

**Keywords**: International trade, High Performing Asian Economies, Latin American Economies, Development, Growth, Networks, Complex Weighted Networks, World Trade Web, Centrality.

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# 1 Introduction

Over the past four decades two groups of countries have occupied center stage in the discussion of economic development and, more specifically, regarding the economic policies that lead to stable and consistent economic growth. These two groups have been generally referred to as the High Performing Asian Economies (HPAE) and the Latin American Economies (LATAM).[1] The focus of the discussion, comparisons, and conclusions presented in the literature has evolved over time. Initially the studies focused on the implementation of diverging economic policies, during the seventies and eighties, and the resulting economic boom of the "Miracle East Asian Economies" (World Bank, 1993) and the economic recession in the LATAM economies referred to as the "Lost Decade" (De Gregorio and Lee, 2004). During the mid eighties and early nineties, the LATAM countries moved away from the imports substitution policies and adopted more market friendly policies that resemble, to some extent, those of the HPAE countries. During this period the research efforts addressed the potential for economic growth in countries that implemented policies in favor of liberalization of trade flows and financial flows. Finally, during the mid and late nineties, researchers exploited the similarities between the two regions during the crises observed at the end of the decade in an effort to understand the vulnerabilities of emerging economies (Kaminsky and Reinhart, 1998; Barro, 2001; De Gregorio and Lee, 2004). Notwithstanding all that, it is important to emphasize that two pieces of evidence robustly emerged over the past four decades. First, the Asian countries have posted impressive economic growth rates, on average, compared to the poor ones observed in Latin America and, second, the Asian economies have proved to be more stable than Latin American ones.

This paper is not focused on analyzing the specific differences and/or similarities in economic policies, growth, and stability across these two regions or within the regions. The current study takes these characteristics as given and instead poses a different question, one related to the relationship that exists between economic development and international economic integration. Is it possible to show, in other words, that the implementation

[1] The composition of these groups varies within the literature but generally includes a sub-sample of the countries listed in the first two columns of Table 1. The third (HPAE) and fourth (LATAM) columns of the same table list the countries considered in this study.

of different economic policies and the contrasting experiences of economic growth and stability observed in the HPAE and LATAM countries is associated with different degrees of international economic integration? Furthermore, is it possible to assess international economic integration by analyzing the data beyond the standard trade openness measures (total trade to GDP ratio and/or average tariffs on imports)?

The present work exploits recently-developed indicators based on weighted network analysis to provide a more in-depth understanding of the meaning of international economic integration. The main advantage of network indicators over standard openness measures such as trade to GDP ratios is the ability to go beyond first-order relationships (bilateral trade measures) and to capture the whole structure of relationships that form the World Trade Network (WTN). For example, one can study trade flows between any two (or more) countries that trade with a given one (i.e., trade relationships which are two-steps away) and to assess the length of trade chains occurring among a set of countries. This allows one to assess the specific characteristics of the trade linkages characterizing HPAE and LATAM countries. By doing so, it is possible to show that the early efforts towards more liberalized markets in HPAE countries have resulted in a deeper integration into the world economy; moreover those economies have moved from the peripheral position they occupied in the 1970s towards the core of the WTN, and in some cases can now be considered part of its core.

The paper is organized as follows. First, in section 2, a brief overview of the different macroeconomic performances observed across the two regions is presented. The following part, section 3, reviews the literature on complex networks and is followed by the main body of the paper, where the methodology of the study is explained, and results are discussed. Finally, section 5 summarizes the findings and concludes the paper.

## 2 Comparative Economic Performance: HPAE vs. LATAM

It would be hard to depict an all-inclusive historical perspective for the different experiences observed across the HPAE and the LATAM regions. The literature includes several studies that have undertaken this task and presented detailed discussions regarding the different policies implemented/followed and the outcomes observed for each case[2]. Furthermore, there are also numerous studies that have specialized in the analysis of individual country and or region-specific case studies and have provided relevant insights to specific characteristics that have played key roles in determining the development path followed by the country/region in question[3]. In this section we present a brief overview, from a macroeconomic perspective, of the key differences/characteristics observed between the HPAE and the LATAM regions and we refer the reader, to the extent that is deemed necessary, to other existing studies that present a more detailed discussion of the specific attributes of the data.

Macroeconomic indicators —as used in Weeks (2000); De Gregorio and Lee (2004); De Gregorio (2006)— represent a useful starting point to gain some insights on the comparative performance of the two regions. Actually, a strong argument regarding the different paths followed by them can be built by simply examining the evolution of the GDP per capita. Figure 1 presents the levels for GDP per capita (region averages) over the last four decades. As pointed out by De Gregorio and Lee (2004), the plain conclusion drawn from this comparison is that the HPAE countries have closed the gap with their counterparts in LATAM, and in some cases they have surpassed them. According to the data shown in Figure 1, during the seventies the average GDP per capita of the LATAM countries was almost four times of that observed in the HPAE countries, that gap has since closed down to the point that in the year 2000 this ratio was almost equal to one. This is the result of the impressive growth rates observed in the HPAE countries over the last three decades of the past century. The different rates of growth of HPAE economies vis-à-vis LATAM ones are depicted in Figure 2: they were close to 10% per year on average for the former, whereas the latter region displays an average growth of 4% per year.

Higher rates of growth in the HPAE region have been accompanied by a higher macroeconomic stability. As a proxy for stability, Figure 3 presents the rates of inflation observed in the two regions (Fischer, 1993). The hyperinflation observed in LATAM can be associated with the mismanagement of the economy by governments that pursued irresponsible

[2]See Sachs (1985) and Lin (1989) for early comparisons between Latin America and East Asia. More recent studies include Weeks (2000), Krasilshchikov (2006) and De Gregorio and Lee (2004).

[3]See De Gregorio (1992, 2006); Amsden (1989, 1994); Edwards (1995); Rodrick (1995); Singh (1998); Gavin and Perotti (1997); Stiglitz (2001); Park and Lee (2002); Lora and Panizza (2002); Weiss and Jalilian (2004).

and unsustainable macroeconomic policies implemented throughout the late seventies and the beginning of the eighties[4]. Contrary to the LATAM countries, the HPAE countries tamed inflation during the sixties and consistently adopted sound economic policies thereafter.

Trade openness provides another important source of difference across the two regions. The early liberalization of key sectors occurred in HPAE countries during the sixties and seventies resulted in foreign competition and provided the incentive for the development of new technologies during the eighties. These adjustments allowed the region to move toward the production of capital-intensive goods and to break the dependence on the export of resource-based and labor intensive products. In the same period, LATAM countries continued to implement import substitution programs targeted at intermediate and capital goods.[5] These divergent trends towards the liberalization and openness continued until the late eighties, when LATAM economies started implementing policy reforms that involved substantial liberalization in both trade and financial flows, accompanied by privatization and deregulation of centralized sectors.

The ratio of total trade (exports plus imports) to GDP is a common measure of trade openness and integration[6]. When comparing this ratio across the two regions —as done in Figure 4— it is evident that the value for LATAM economies has been and still is substantially below that of the HPAE region. Nonetheless, it is also clear that since the liberalization of the late 1980s LATAM countries have increased their openness: in fact, the share of total trade to GDP moved from 25% in 1990 to 50% in 2004. The fact that the gap keeps widening in the 1990s despite the policy change in Latin America corroborates the idea that HPAE economies implemented a more coherent set of industrial policies, which have led to economic stability, increased technological capabilities, and deeper integration

[4]Fischer (1993) argues that high rates of inflation are the summary statistics for mismanagement of the economy, at the macroeconomic level, and the inability of governments to implement sound economic policies. This point of view is also implied by Corbo and Rojas (1993) in their study of macroeconomic instability in Latin America.

[5]See IDB (2001); Pack (2001); Messerlin and Laird (2002); Gereffi (2002); Weiss and Jalilian (2004) for in-depth discussions of these issues and policies. Weiss and Jalilian (2004) emphasize the differences in the production networks of HPAE countries, arguing that the large proportion of the Asian high technology exports is due to their presence in the production networks of highly sophisticated products. This point has also been exploited recently in the literature of complex networks by Hidalgo et al. (2007) where they explain why poor countries have trouble developing more competitive exports due to their lack of mobility within the product space.

[6]De Gregorio and Lee (2004) and De Gregorio (2006) have used this measure of openness in studies that deal with the HPAE and the LATAM regions specifically.

(Rodrik, 2004). Previous studies, like Tipton (1998) and other recent country-case analyses have argued that the impressive economic development of the HPAE countries increased their presence in world trade. Thus far, these claims have been based on the analysis of specific industries which have flourished in these countries. The rest of the paper presents a different perspective of integration, one that is based on the evolution of the WTN, and more specifically on the evolution of the HPAE and LATAM countries within that network over the past 25 years. Moreover, despite the fact that the ratio of total trade to GDP for LATAM countries displays an upward trend after 1990, thus hinting at increased international integration, we will show that measures based on network indicators suggest otherwise.

## 3 Network Analysis: A Brief Overview

Sociologists and psychologists have employed network analysis for the study of social interactions among people and/or groups since the beginning of the last century. Pioneering studies in this area include those by Milgram (1967) where he studied the structure of the network of social acquaintances and Granovetter (1974) with his analysis of job market interactions. The application outside of the social realm began with the contributions of physicists, mathematicians, and computer scientists as they studied the structure and evolution of a diverse set of networks like power grids, neural networks, protein interactions, train routes and airline connections, as well as the internet and the World Wide Web (see Watts and Strogatz, 1998; Barabási, 2002; Newman, 2003; Pastos-Satorras and Vespignani, 2004, among others). A number of powerful statistical tools for the analysis of network structures emerged from these studies and now these methods have allowed for the expansion of the analysis to social and economic systems. Recent studies in these areas include those by Goyal et al. (2006); Kali and Reyes (2007*a*); Currarini et al. (2007); Hidalgo et al. (2007); Battiston et al. (2007) where the interaction among academics through co-authorship, trade linkages among countries, friendship networks based on individuals preferences, networks within the "product space", and credit chains and bankruptcy propagation are studied, respectively, using complex network methods.

Regarding international trade specifically, using network analysis for the study of interactions among countries through trade flows was an idea put forward by sociologists and political scientists. Snyder and Kick (1979) used international trade data and employed network analysis to classify 118 countries into a core-periphery structure. Other studies that explored the core-periphery structure using aggregated trade data include Nemeth and Smith (1985) and Smith and White (1992), while some other studies, like Breiger (1981) and Kim and Shin (2002) use disaggregated international trade data.

More recently, in the area of econophysics, a number of papers have characterized, from a purely descriptiveperspective, the statistical properties of the WTN. Studies in this literature include Serrano and Boguñá (2003); Garlaschelli and Loffredo (2004, 2005); Fagiolo et al. (2007). Their findings show that the WTN is very symmetric and features a core-periphery structure. Furthermore, there seems to emerge a "rich club phenomenon", where countries that have higher trade intensities trade a lot among themselves. Finally, and somewhat surprisingly, the overall network structure is fairly stationary through time.

Beside these descriptive contributions, Kali and Reyes (2007*a*,*b*) have used country-specific network indicators to explain macroeconomic dynamics phenomena like economic growth and financial contagion.

As mentioned by Fagiolo et al. (2007), the appeal for using complex network analysis for the study of international economic integration emerges from the fact that a network approach is able to recover the whole structure of the web of trade interactions and, by doing so, it allows for the exploration of connections, paths, and circuits. When exports and imports to GDP ratios are used to characterize the degree of integration into the world economy of a given country, only first-order trade relationships are captured. Network analysis, on the other hand, accounts for higher-order trade relationships and therefore results in a more in-depth picture of integration. For example, it is possible to specify the countries that hold a (more/less intense) trading relationship among themselves but that also trade with another given common country; assess the length and the intensity of trade chains; and characterize the importance of a given country in the trade network. The study of these properties, as shown by Kali and Reyes (2007*a*,*b*), can go beyond the description of stylized facts and can lead one to assess the degree of international economic integration for the overall network, as in some of the studies listed above. In this study we focus on a specific set of countries, namely HPAE and LATAM, and exploit network properties to assess and compare their degree of international economic integration.

## 4 Methodology, Data and Results.

The data used to carry out the study are extracted from the COMTRADE database. We use bilateral trade data for 171 countries over the 1980–2005 period to build the trade matrix for the countries considered in the analysis. In the resulting matrix, columns represent importing countries, while rows denote exporting countries. This matrix is used to build the adjacency ($A$) and weighted adjacency ($W$) matrices needed for the computation of the network indicators. The adjacency matrix simply reports the presence of a trade relationship between any two countries, therefore we set the generic entry for the matrix as $a_{ij}^t = 1$ if and only if exports of country $i$ to country $j$ (defined as $e_{ij}^t$) are strictly positive in year $t$. This binary analysis is then complemented by a weighted approach whereby trade links are given values proportional to their intensity. Fagiolo et al. (2007) have shown that the majority of network indicators for the WTN are very robust to different weighting procedures. For example, one can use the actual trade flow as the weight for each link, $w_{ij}^t = e_{ij}^t$, or a scaled measure such as exports to GDP, i.e. $w_{ij}^t = e_{ij}^t / GDP_i^t$. For the current study we use the actual trade flows for the benchmark analysis and provide some discussion, for robustness purposes, for GDP-scaled trade flows.

It should be noted that trade flows generate, by default, a weighted and directed network. Following Fagiolo et al. (2007) we employ a weighted undirected network (WUN) approach since the WTN is sufficiently symmetric, and this approximation allows us to simplify the analysis quite a bit.[7] Hence, the A matrix is made symmetric by setting $a_{ij}^t = a_{jt}^t = 1$ if any of $e_{ij}^t$ or $e_{ji}^t$ is positive. Similarly, we replace the original weighted entries $w_{ij}^t$ by $\frac{1}{2}\left(e_{ij}^t + e_{ji}^t\right)$ and then divide all entries by the maximum value in $W$, which does not introduce any biases in the analysis but ensures that $w_{ij}^t \in [0, 1]$ for all $(i, j)$ and $t$.[8]

To assess the economic integration of a given country we base the analysis upon three different pillars. We start with first-degree connectivity using node degree, node strength,

[7]The results for the symmetry index, as computed by Fagiolo (2006), range between 0.006 (lowest) and 0.013 (highest) for the period 1980 to 2005. The symmetry index ranges from 0 to 1, where zero denotes full symmetry and 1 represents maximum asymmetry.

[8]See Onnela et al. (2005).

and node disparity. Clustering and higher-order connectivity measures are then proposed as a second step, while random-walk betweenness centrality represents the highest order indicator considered in the study. In order to keep the exposition of the paper simple and fluent we present a non-technical discussion of these measures in the text and refer the reader to the technical appendix and/or the proper technical papers in the literature of networks where these indicators, their properties, and their derivations are discussed in detail.

### 4.1 First Degree Connectivity

This section explores the extent to which countries are more or less connected in terms of the number of trading partners that each country has and the intensities of their interactions. The number of connections that a given node has within a network is referred to as node degree, while the sum of all the valued interactions is referred to as node strength. Node degree and node strength for country $i$ are computed as follows[9]:

$$d_i = \sum_j a_{ij} \tag{1}$$

$$s_i = \sum_j w_{ij} \tag{2}$$

Node degree and node strength are first-order indicators since they only exploit the first degree connections of a given country. Node degree, $d_i$, would simply represent the number of trading partners that country $i$ has. Additionally, we define node disparity among (concentration of) $i$'s weights as follows:

$$h_i = \frac{(N-1)\sum_j \left(\frac{w_{ij}}{s_i}\right)^2 - 1}{N-2} \tag{3}$$

The same countries used for the macroeconomic comparisons between the HPAE and LATAM regions are used for the computation of these indicators, but when deemed necessary we refine our sample and discuss specific cases. This is done in order to avoid the

[9] In what follows, time superscripts are suppressed to simplify the notation.

possibility of generalizing results to the whole region that are only applicable, or driven by, one country. Table 2 presents the results, in levels and as a percent-rank analysis, for all the three indicators while Figures 5–7 show averages across the two regions. It should be noted that for the node disparity analysis, a lower node disparity is associated with a lower degree of trade concentration, while a higher percent rank for node degree and node strength is associated with a higher degree of connectivity within the network (relative to all the 170 other countries in the network) due to a higher number of trading partners and/or a higher intensity in the connections (i.e. trade flows). The results are clear and can be considered as the first piece of evidence regarding the association of development and integration into the world economy. The HPAE region, even without considering the results for China, rank higher in both node degree and node strength distributions and there is a clear increasing pattern, while the results for LATAM show either a decline or a constant position within the network. It is possible to conclude that the HPAE countries, relative to the LATAM economies, have observed a consistent increase in the number of trading and the intensity of their trade flows. Not surprisingly the results for node disparity show a higher degree of trade disparity (trade concentration) for the LATAM region. This is consistent with the argument regarding how the volume of trade has increased for both regions, but for LATAM this increase has been heavily biased towards a few number of trading partners, while for the HPAE countries these increases have been distributed among a higher number of trading partners and therefore present a lower level trade concentration, even more so for China than for the rest of the region. The graph in Figure 7 shows that these results hold even when Mexico, a country that concentrates eighty percent of its international trade with the US, is excluded from the LATAM region. This finding coincides with those reported by Kali et al. (2007), where they argue that the positive effects on economic growth of being better connected into the WTN emerge from expansion of potential markets and competition, as well as the possibility of being exposed to technological spillovers, as the number of trading partners increases.

## 4.2 Clustering Patterns and Connectivity of Trading Partners

We now consider network measures that take into consideration second-order characteristics. The first measure we introduce is clustering, which similarly to node strength takes into consideration the strength of the links between nodes $i$ and $j$ but adds the strength of the links between nodes $i$ and $h$ and between nodes $j$ and $h$ to the analysis. In other words it considers the complete triplets within the network and the intensities of the links among them. We follow Onnela et al. (2005) and Fagiolo (2007) to compute the weighted clustering coefficient for each country as follows:

$$C_i = \frac{\frac{1}{2}\sum_{j\neq i}\sum_{h\neq(i,j)} w_{ij}^{\frac{1}{3}} w_{ih}^{\frac{1}{3}} w_{jh}^{\frac{1}{3}}}{\frac{1}{2}d_i(d_i-1)} \tag{4}$$

Clustering allows for the assessment of the degree to which a country tends to build more (number and intensity wise) relationships with countries that themselves trade with each other taking into consideration the intensity of second-order relationships. The clustering coefficient of country $i$ then depends on the number of triples and on the intensity of the relationships that form them. The percent-rank results for node clustering are reported in the first panel of Table 3 and Figure 8 plots the averages for the regions. Once again, there is a clear increasing pattern for the HPAE countries and a flat one for the LATAM region. Furthermore, the correlation between clustering and node strength (averages) is positive for both regions for the overall period considered for the analysis, but in 1980 this correlation was 0.77 for the LATAM countries and 0.64 for the HPAE economies and in the year 2005 these correlations are 0.96 and 0.98, respectively. These high and positive correlations suggests that in both regions countries with high-intensity trade relationships are typically involved in highly-interconnected triples. And the emergence of these cliques is somehow more recent in the HPAE region since the correlation was lower in the seventies and values have since then caught up. Two other second-degree network measures are the weighted average nearest-neighbor degree (WANND) and the average nearest-neighbor strength (ANNS). These two measures allow for the analysis of specific characteristics of the neighbors of a given country and both are related to the so-called assortativity of each node. That is, whether country $i$ trades with countries that themselves are connected to many other countries (i.e., WANND), and/or is it associated with trading partners that themselves have low/high trade intensities. The computation of these indicators is as follows,

$$ANNS_i = d_i^{-1} \sum_j a_{ij} s_j \tag{5}$$

$$WANND_i = s_i^{-1} \sum_j w_{ij} d_j \tag{6}$$

A higher number for both indicators suggests that country $i$ is more likely associated with trading partners that themselves are well connected into the WTN, either because of their number of trading partners or for the intensity of their trading relationships. The results for the analysis are presented in Table 3 and for comparison purposes Figures 9 and 10 present the regional averages for ANNS and WANND, respectively. In both cases, the results point in the direction of similar patterns for both regions. The ANNS has been consistently falling, while WANND has been increasing. In essence both regions have been establishing connections with less intensively connected countries, with respect to trade volumes, but with countries that have a higher number of trading partners. Intuitively this result makes sense, since both regions already traded, and did it intensively, with the developed economies in the seventies, but over the past three decades they have established trading relationships among themselves and with other developing and/or poor countries that tend to have a high number of trading partners. The correlations between node strength and ANNS, and node degree and WANND, have been negative for both regions for the whole sample period. For the case of node strength vs. ANNS, the correlation has been around -0.50 for the past 35 years, while for the HPAE countries has been around -0.60, suggesting that both regions have established trading relationships with similar types of countries (i.e. with countries that have a lower node strength). Regarding node degree vs. WANND, the correlation is also negative for both regions through the period considered but its magnitude has remained around -0.20 for the LATAM region while for the HPAE economies it has gone from -0.31 to -0.77. This result, in conjunction with the relatively higher node-degree increase observed for the HPAE countries, suggests that the countries in this region have not only established more connections than the LATAM countries, but these new links connect them to countries that are not so heavily connected into the WTN.

### 4.3 Random-Walk Betweenness Centrality

Recent studies, Newman (2005) and Fisher and Vega-Redondo (2006) among others, have looked at node centrality by incorporating weights and directionality of the relationships among nodes within a network. They compute a measure of centrality based on the random-walk principle. Newman (2005) developed a measure of centrality for a binary and undirected network, which is extended to directed and weighted networks in Fisher and Vega-Redondo (2006). The technical appendix goes through the intricacies of the estimation, here it should suffice to say that random-walk betweenness is a measure of node centrality that captures the effects of the magnitude of the relationships that a node has with other nodes within the network as well as the degree/strength of the node in question. Newman (2005) offers an intuitive explanation for random-walk betweenness centrality (RWBC): he assumes that a source node sends a message to a target node; the message is transmitted initially to a neighboring node and then the message follows an outgoing link from that vertex, chosen randomly, and continues in a similar fashion until it reaches the target node. In the original measure presented by Newman (2005) the probabilities assigned to outgoing edges are all equal but in Fisher and Vega-Redondo (2006) these probabilities are determined by the magnitude of the outgoing trading relationships. Hence links that represent greater magnitude for a trading relationship will be chosen with higher probability. Random-walk betweenness centrality exploits (randomly) the whole length of the trade chains present in the network for country $i$ and, therefore, is the highest degree measure considered in the analysis since it goes beyond the analysis of trading partners that have one or two degrees of separation from country $i$.

The RWBC is a measure that allows for the characterization of the core-periphery structure of the WTN and also permits the identification of the countries in the core and the periphery. Using a percent-rank analysis, the network is divided into core countries (C), inner-periphery countries (I-P), secondary-periphery countries (S-P), and outside of the periphery countries (O). A country is classified as a C, I-P, S-P, or O according to where it lies within the RWBC distribution for the overall network (171 countries). A country is classified as a "C" country if its RWBC is above the $95^{th}$percentile, "I-P" if it is above the $90^{th}$ but below the $95^{th}$ percentiles, "S-P" if it is above the $85^{th}$ but below the $90^{th}$ percentiles, and "O" otherwise. The results for the HPAE and the LATAM regions, as well as the results for India and the average for the G7 countries are presented and discussed here. The reason to include the G7 and India, a recent globalizer, is for the purpose of comparisons. HPAE countries have attained a higher level of integration within the WTN and it is interesting to analyze their relative position with respect to other countries. Table 4 presents the evolution using the core-periphery classification while the averages of the percent-rank distribution for India, the G7, the HPAE, and the LATAM countries are presented in Figure 11. The clear picture that emerges is that the gap, according to RWBC, between the G7, the HPAE (with and without China) and India has been closing while that between all these regions and the LATAM economies has remained.

It should be noted that when analyzed independently, one country that clearly diverges from the path of the LATAM region is Brazil. The results for this country (Table 4) show that Brazil is clearly among the top countries according to RWBC but it is also true that its initial value in 1980 was already high. Argentina's, Chile's, and Mexico's, RWBC have remained constant, but the result for Venezuela shows that this country is moving away from the core of the WTN. All of the LATAM countries, except for Brazil, are currently at or below the $80^{th}$ percentile of the distribution, while countries like China and Korea are above the $95^{th}$ percentile and can be considered as part of the core of the network along with the G7 countries. The only HPAE country that is outside $80^{th}$ percentile is the Philippines, and to some extent it can be argued that its degree of integration has stalled. It should be noted that the argument regarding the integration of India into the WTN seem to be well founded. This country has moved up in the RWBC rankings, consistently.

### 4.4 Overall Network Indicators and Robustness Check

As mentioned before, there are other studies that have analyzed the overall characteristics of the WTN[10]. Given the undirected and weighted approach used here for the computation of the network indicators, our results are comparable to those discussed in Fagiolo et al. (2007). They used the international-trade database provided by Gleditsch (2002)

[10] See Serrano and Boguñá (2003); Garlaschelli and Loffredo (2004, 2005); Kali and Reyes (2007*a*); Fagiolo et al. (2007) among others.

for the 1981 - 2000 period and computed, for 159 selected countries, a set of network measures that include several of the indicators computed in the current analysis. In their study they showed the robustness of their results to different weighting procedures (i.e. actual trade flows vs. trade flows divided by GDP). The results reported in their paper serve for comparison since here we used actual trade flows as the weights for trade links between countries. Therefore, for comparison and robustness purposes, we compare our overall network indicators with those reported in their paper. Tables 5 and 6 report the population averages for the indicators computed here and some simple correlation results, respectively. The conclusions reached regarding the properties of the overall network are very similar. Fagiolo et al. (2007), based on population averages, report a slightly increasing pattern for node degree but fairly constant levels for node strength (around 0.20) and for the correlation (around 0.50) between these two indicators through time. Similar to the kernel distributions presented in this study for node degree and node strength presented in Figure 12, Fagiolo et al. (2007) report a bimodal distribution for node degree, while for node strength there is no bimodality and instead they observed a heavily left-skewed distribution. Based on their results for ANNS and WANND, they conclude that the WTN is a dissasortative network, given the weakly negative correlation observed between WANND-node degree and ANNS-node strength. Once again this result matches the ones for the analysis carried out in this paper. Table 6 reports the correlation between these indicators and there is evidence for a weakly negative correlation, which is more evident for ANNS-node strength than for WANND-node degree. Finally, our centrality results match those reported in their paper, specifically for the patterns observed for China and Korea, two countries that according to the results discussed above and those discussed in their study, have moved towards the core of the periphery.

## 5 Concluding Remarks

The HPAE and the LATAM regions have been at the center of academic and policy oriented research and discussions. The growth path that the HPAE economies followed during the last 25 years, the 1998 financial crisis notwithstanding, results in this experience being considered as a “growth miracle”; on the other hand the LATAM region has been characterized by low growth and a volatile economic environment. The success of the HPAE regions has been linked to the early adoption of a consistent set of policies based on the integration of the region in the world economy, not only increasing export participation, but also bringing the benefits of competition and knowledge spillovers. The LATAM region, has recently followed the example by starting the implementation of market oriented policies during the mid nineties. But this move comes after decades of import substitution policies coupled with large public intervention in the economy.

The aim of the paper has been to assess the degree of international integration enjoyed by countries in the two regions, which is the results of the two development strategies. The paper goes beyond the standard measures of openness (exports plus imports to GDP) and uses a complex network approach to provide a more in-depth understanding of international economic integration by capturing the whole structure of trade relationships. In fact, while openness has been substantially increasing in both regions over the past 25 years, network indicators point towards a significant difference in the degree of integration and its dynamic. The recurrent pattern emerging throughout the paper is one of continuously increasing integration for the HPAE regions —a result that is consistent with the increase in the total trade to GDP ratio— whereas LATAM economies have not improved much their position within the network. Moreover, at least in the case of Venezuela there is evidence that this country is moving away from the core of the WTN, which contrasts dramatically with the increased ratio of total trade to GDP. The HPAE region is involved in more and more intense trade relationships than the LATAM region and this has resulted in a higher degree of integration into the WTN.

From a policy point of view, our results show quite clearly that it is not only the degree of openness that matters for the economic performance of countries, but also (and above all) their positioning within the network of international trade flows. This conclusion is corroborated from the fact that the overall WTN display a core-periphery setup, so that peripheral countries do suffer from a sort of marginalization. Consistently with some recent results in the field of economic geography (see Ottaviano et al., 2002, p.411) we interpret our results as suggesting that such a polarized structure is not necessarily the most efficient outcome, and that a more balanced structure of trade relations would allow (developing) countries to exploit more completely the gains from trade. Moreover, the position of HPAE countries within the WTN has implications that may affect the functioning of international organizations like the WTO. In fact, this rise in economic integration —both in terms of number and intensity of trade relationships— enhances the "presence" of HPAE economies and this could lead to pressure for changes in international trade policies and in the rules of current and future trade negotiations rounds.

The use of network analysis enables one to uncover interesting patterns, otherwise not identified through standard trade openness measures: this suggests a new and fruitful route for the study of international trade that may well go beyond aggregate flows. As a next step it would be interesting to disaggregate trade flows and check the evolution of the place occupied by the two regions in the network of trade flows for different classes of products. This would provide evidence that can be used to support arguments regarding how the HPAE countries have moved, or are moving, to the center of the networks for capital and high-skill labor intensive goods, while the LATAM region, which remains specialized on the production and exports of resource based and low-skill labor intensive goods, may or may not be at the center of the network of such products given that many other countries participate in these markets.

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## Data Appendix

The bilateral trade data are extracted form the COMTRADE database housed by the United Nations (UN). The database contains more than 200 countries as reporters and more than 250 as partners. After eliminating regional and income aggregations, and other classifications (free trade zones, neutral zones and unspecified origin), the database has been reduced to participating countries for the WTN for the period of 1980 - 2005. Before performing the analysis, a decision has to be made with respect to countries that stop existing or begin existing after the breakup of a given original country (for example the USSR and Yugoslavia), or because these countries reported their trade flows as one for some of the periods considered (this is the case for Belgium and Luxembourg). In this paper, for simplicity, the following groups are considered as one node (reporter and partner):

- **Belgium - Luxembourg:** Belgium and Luxembourg
- **Czechoslovakia**: Czech Republic and Slovak Republic
- **Eritrea - Ethiopia**: Eritrea and Ethiopia
- **Yugoslavia, FR**: Croatia, Macedonia, Yugoslavia, Slovenia, Serbia/ Montengegro
- **Russia**: Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazahkstan, Kyrgyz Republic, Lithuania, Latvia, Moldova, Russian Fed., Tajikistan, Turkmenistan, Ukraine, Soviet Union, and Uzbekistan.

The aggregation of these nodes into one, for every column, has been simply done to avoid a sudden change in the number of nodes in the network that could have resulted in structural network changes even though the trade flows did not changed so dramatically. An alternative would be to drop these countries from the analysis, and only consider countries that existed throughout the whole 1980 - 2005 period, but we believe that this could lead to a greater loss of information than the one that could result from the aggregation. In the end the trade data for the study includes 171 countries for the 1980 - 2005 period. Given the stationarity of the network properties, reported in previous studies and confirmed here, we only perform the analysis for 1980, 1985, 1990, 1995, 2000, 2004, and 2005.

The data for GDP per capita and the trade shares as percentage of GDP are extracted from the Penn World Table 6.2, while the data for inflation is computed from Consumer Price Indices extracted from the International Financial Statistics (IFS) Database, housed at the International Monetary Fund (IMF).

## Technical Appendix

Let us assume that the underlying graph is weighted and undirected. Let $A$ be the adjacency matrix and $W$ be the weighted matrix that define the valued links of the graph. Then the node degree, strength and disparity for node $i$ are computed as follows:

$$d_i = \sum_j a_{ij} = A_{(i)}1, \tag{A.1}$$

$$s_i = \sum_j w_{ij} = W_{(i)}1. \tag{A.2}$$

$$h_i = \frac{(N-1)\sum\limits_j \left(\frac{w_{ij}}{s_i}\right)^2 - 1}{N-2} = \frac{(N-1)\frac{1}{s_i^2}\sum\limits_j (w_{ij})^2 - 1}{N-2} = \frac{(N-1)\frac{W_{(i)}^{[2]}}{\left(W_{(i)}1\right)^2} - 1}{N-2} \tag{A.3}$$

where 1 is an $N$-vector of ones. Regarding average nearest neighbor strength (ANNS) and weighted average of nearest neighbor degree (WANND) of $i$ , these are as follows:

$$ANNS_i = d_i^{-1}\sum_j a_{ij}s_j = d_i^{-1}\sum_j\sum_h a_{ij}w_{jh} = \frac{A_{(i)}W1}{A_{(i)}1}, \tag{A.4}$$

$$WANND_i = s_i^{-1}\sum_j w_{ij}d_j = s_i^{-1}\sum_j\sum_h w_{ij}a_{jh} = \frac{W_{(i)}A1}{W_{(i)}} \tag{A.5}$$

We follow Onnela et al. (2005) for the computation of the (weighted) clustering coefficient,

$$C_i = \frac{\frac{1}{2}\sum_{j\neq i}\sum_{h\neq(i,j)} w_{ij}^{\frac{1}{3}} w_{ih}^{\frac{1}{3}} w_{jh}^{\frac{1}{3}}}{\frac{1}{2}d_i(d_i-1)} = \frac{\left(W^{\left[\frac{1}{3}\right]}\right)^3_{ii}}{d_i(d_i-1)}, \tag{A.6}$$

where $W^{\left[\frac{1}{k}\right]} = w\{w_{ij}^{\frac{1}{k}}\}$ ,which is the matrix obtained after taking the $k$-th root of each entry. This index ranges in [0,1] and reduces to the clustering coefficient for a binary network when the weights become binary. It takes into consideration all of the edges in a complete triple, while ignores weights not participating in any triangle, and is invariant to weight permutation for a given triple.

Finally, we follow Newman (2005) and Fisher and Vega-Redondo (2006) for the computation of random-walk betweenness centrality, RWBC. Consider a generic node $i$ for which we want to compute the RWBC and an impulse generated from a different node $h$, that works its way through the network in order to get to target node $k$. Let $f(h,k)$ be the source vector $(N \times 1)$, such that $f_i(h,k) = 1$ if $i = h$, $f_i(h,k) = -1$ if $i = k$, and 0 otherwise. Newman (2005) shows that the Kirchoff's law of current conservation implies that:

$$v(h,k) = [D - W]^{-1} f(h,k), \tag{A.7}$$

where $v(h,k)$ denotes the $N \times 1$ vector of node voltages, $D = diag(s)$ and $[D - W]^{-1}$is computed using the Moore-Penrose pseudo-inverse. Then, this implies that the intensity of the interaction flowing through node $i$ originated from node $h$ and getting to target node $k$, is determined by:

$$I_i(h,k) = \frac{1}{2} \sum_j |v_i(h,k) - v_j(h,k)|, \tag{A.8}$$

where $I_h(h,k) = I_k(h,k) = 1$. Therefore RWBC for node $i$ can be computed as:

$$RWBC_i = \frac{\sum_h \sum_{k \neq h} I_i(h,k)}{N(N-1)}. \tag{A.9}$$

# Tables and Figures

Figure 1: Real GDP per capita

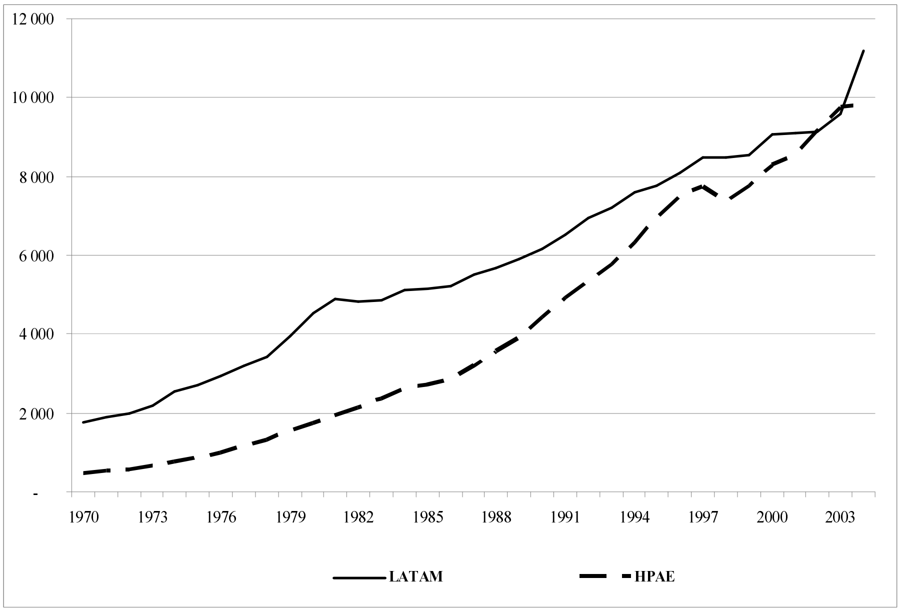


Figure 2: Real GDP per capita growth rates

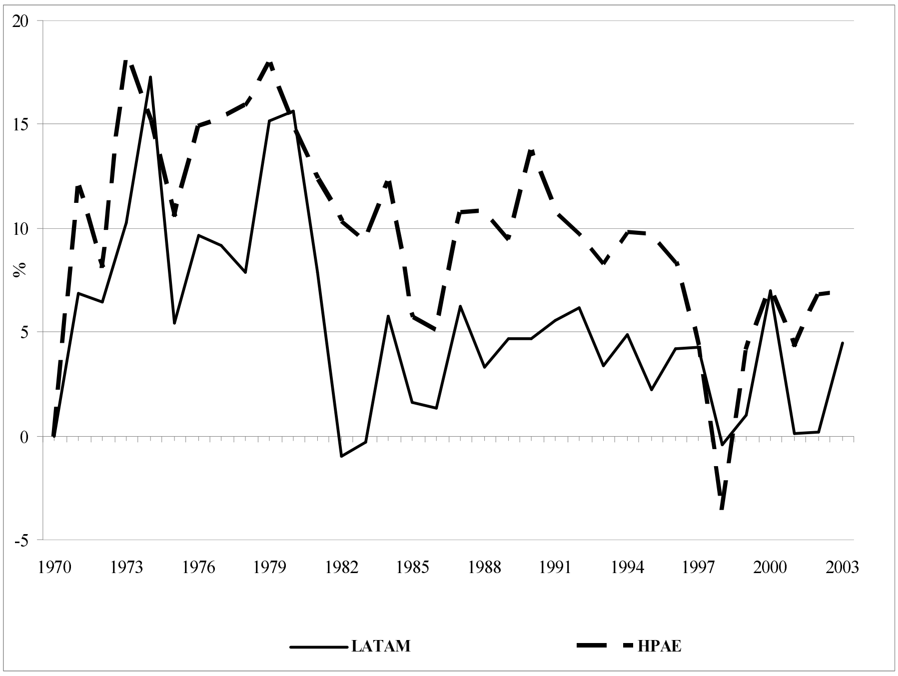

Figure 3: Inflation rates

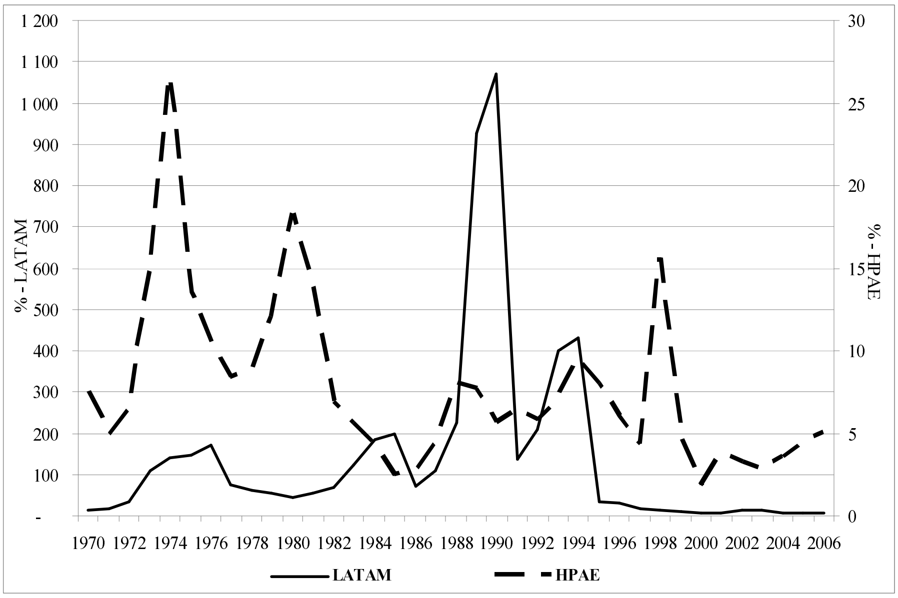


Figure 4: Total trade to GDP ratios

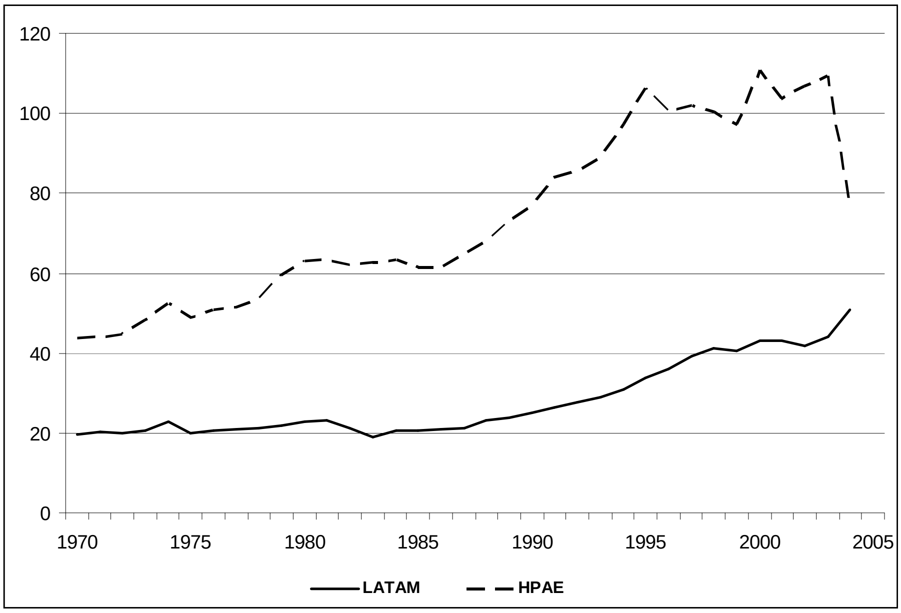

Figure 5: Node degree (% rank of distribution)

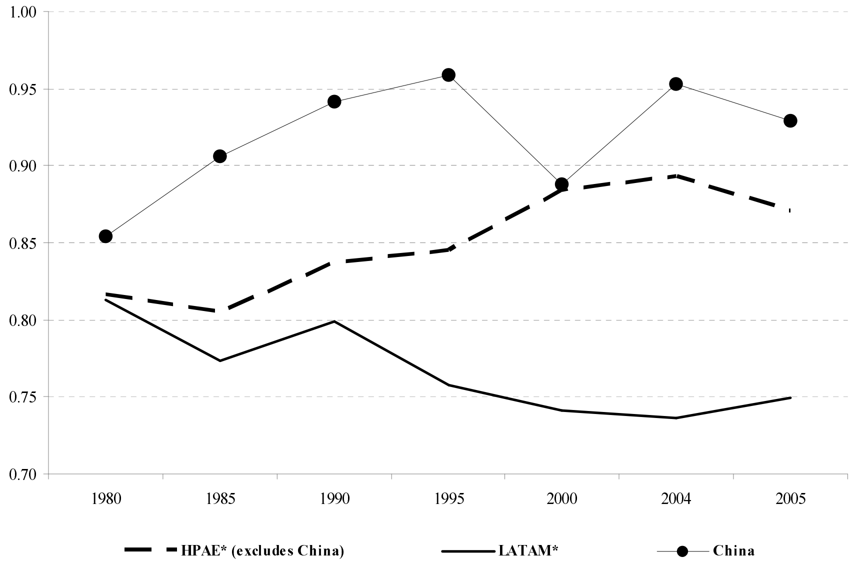


Figure 6: Node strength (% rank of distribution)

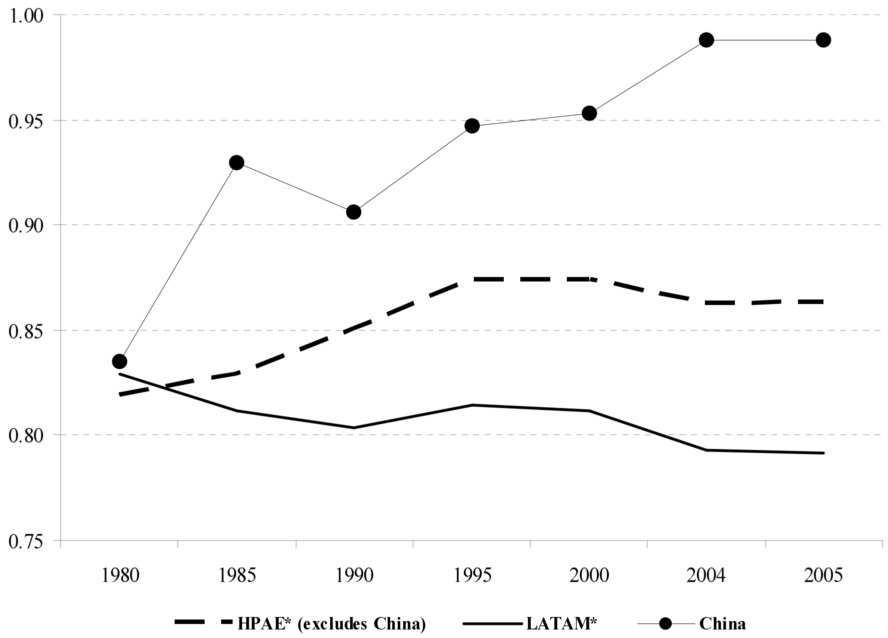

Figure 7: Node disparity (level)

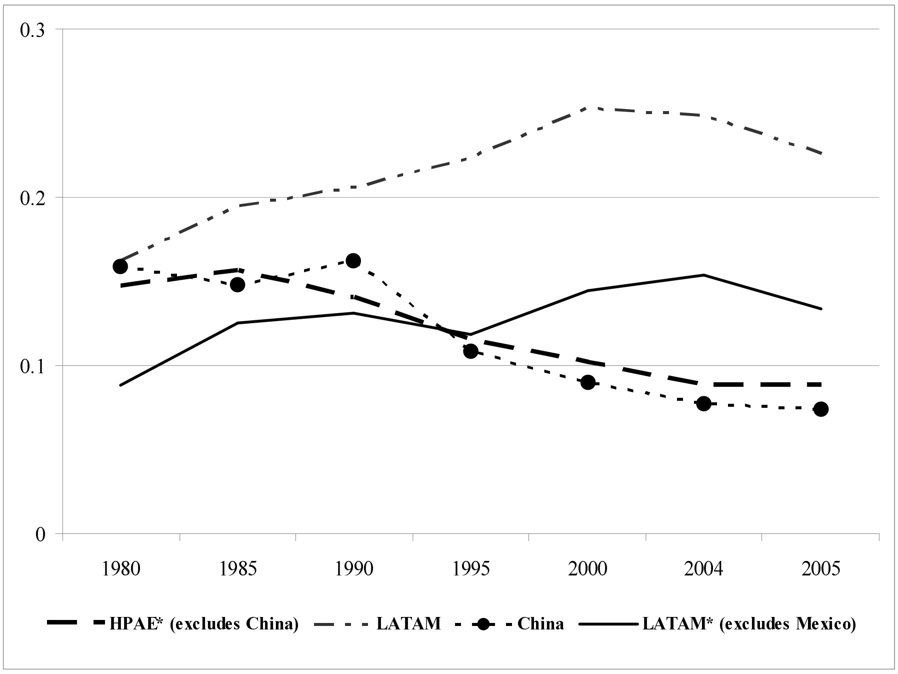


Figure 8: Node clustering (% rank of distribution)

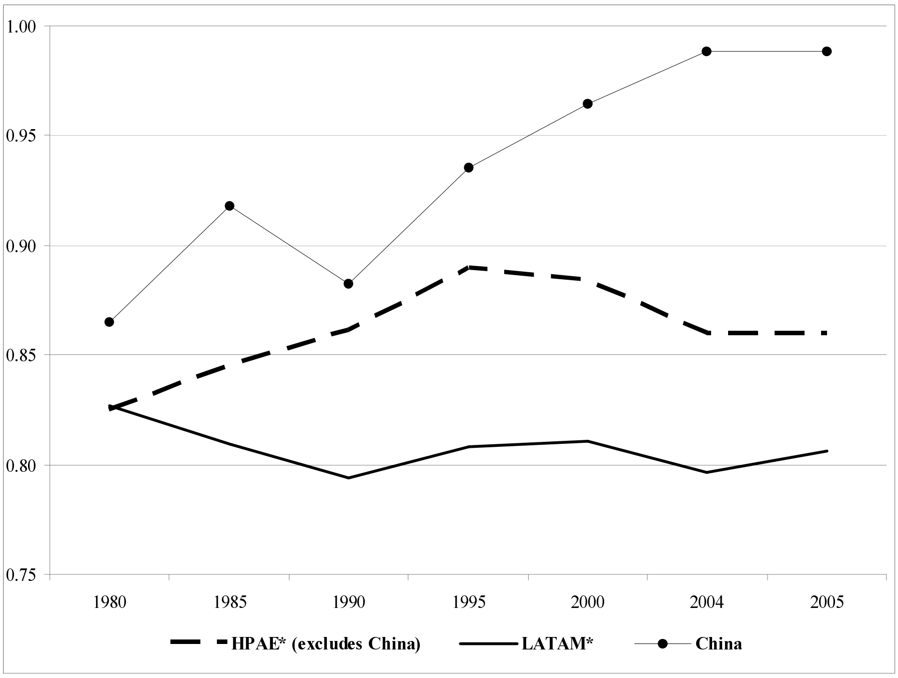

Figure 9: Average nearest neighbor strength (level)

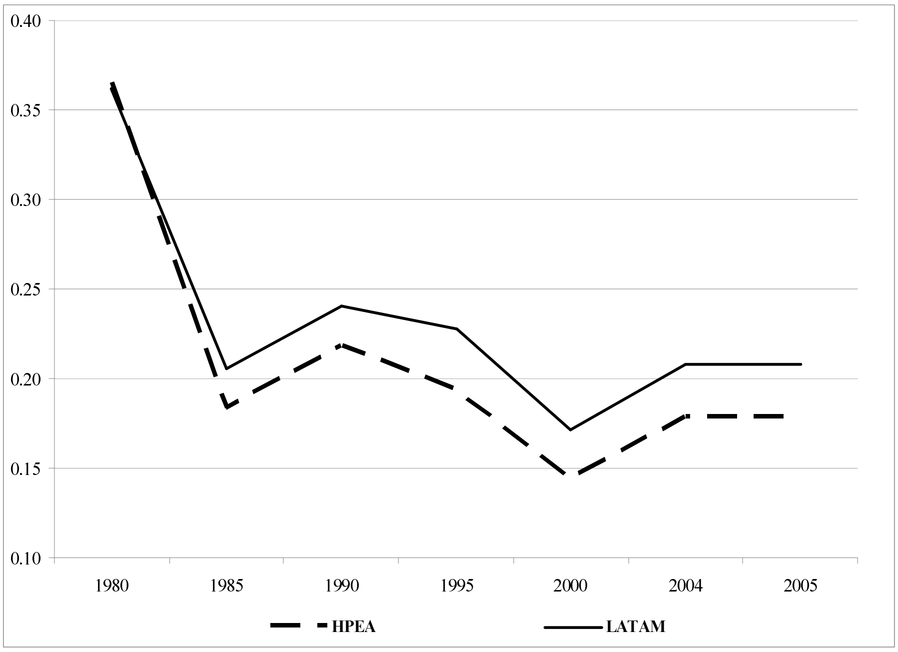


Figure 10: Weighted average nearest neighbor degree (level)

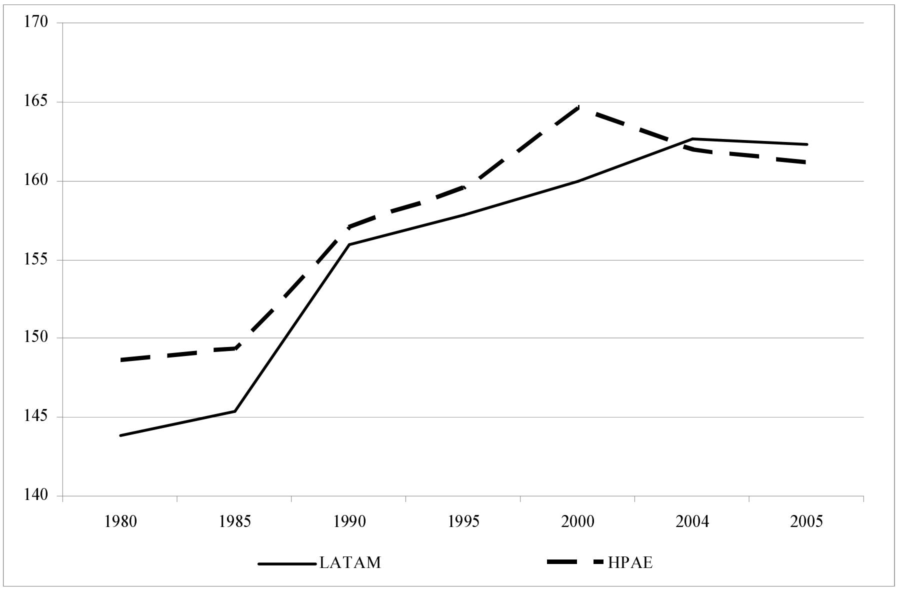

Figure 11: Random-walk betweenness centrality (RWBC) (% rank of distribution)

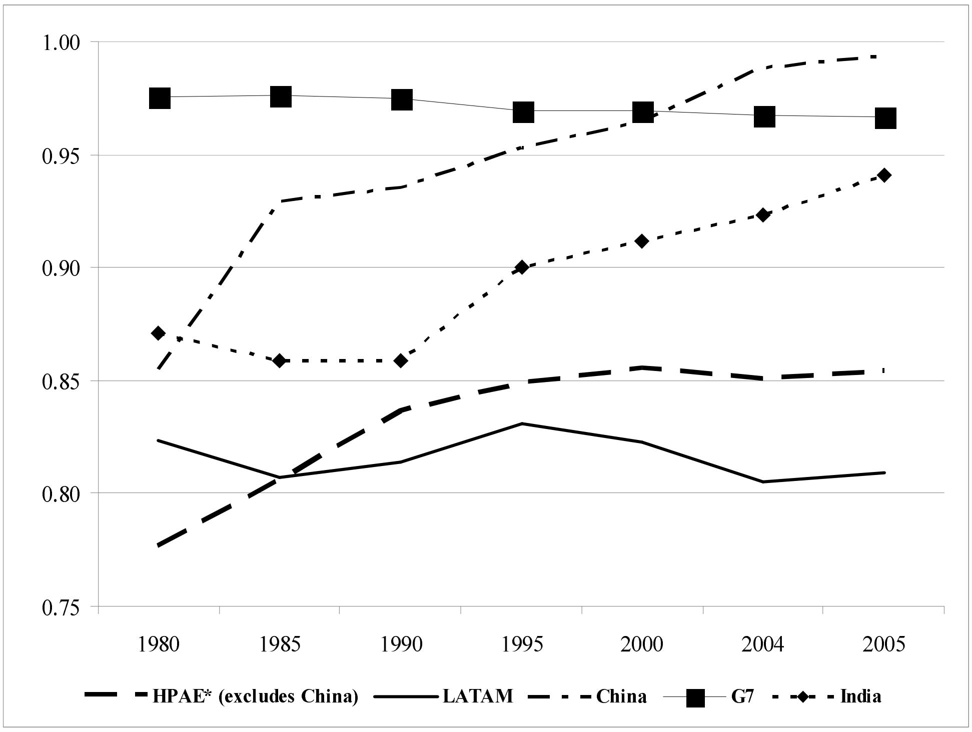


Figure 12: Node degree and node strength kernel densities for the overall network

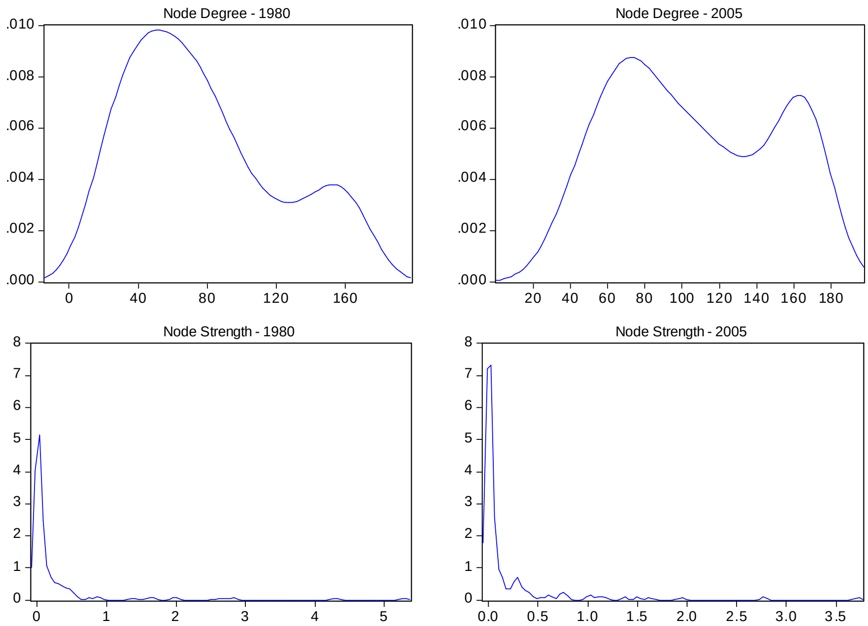

Table 1: Regions and countries

| **East Asia** | **Latin America** | **HPAE** | **LATAM** |
|---|---|---|---|
| China | Argentina | China | Argentina |
| Hong Kong | Bolivia | Indonesia | Brazil |
| Indonesia | Brazil | Korea | Chile |
| Korea | Chile | Malaysia | Mexico |
| Malaysia | Colombia | Philippines | Venezuela |
| Philippines | Costa Rica | Thailand | |
| Singapore | Dominican Republic | | |
| Taiwan | Ecuador | | |
| Thailand | El Salvador | | |
| | Guatemala | | |
| | Haiti | | |
| | Honduras | | |
| | Jamaica | | |
| | Mexico | | |
| | Nicaragua | | |
| | Panama | | |
| | Paraguay | | |
| | Peru | | |
| | Trinidad and Tobago | | |
| | Uruguay | | |
| | Venezuela | | |

Table 2: Results for Node Degree, Node Strength and Node Disparity

| | 1980 | | 1990 | | 2000 | | 2005 | |
|---|---|---|---|---|---|---|---|---|
| Node Degree | | | | | | | | |
| Country | level | % rank | level | % rank | level | % rank | level | % rank |
| Thailand | 139 | 0.859 | 155 | 0.859 | 169 | 0.924 | 170 | 0.929 |
| Philippines | 124 | 0.818 | 126 | 0.788 | 151 | 0.788 | 154 | 0.765 |
| Malaysia | 122 | 0.812 | 162 | 0.912 | 165 | 0.865 | 167 | 0.876 |
| Korea, Rep. | 146 | 0.876 | 156 | 0.865 | 168 | 0.888 | 167 | 0.876 |
| Indonesia | 97 | 0.718 | 119 | 0.759 | 170 | 0.953 | 169 | 0.906 |
| China | 133 | 0.854 | 167 | 0.941 | 168 | 0.888 | 170 | 0.929 |
| Venezuela | 90 | 0.816 | 107 | 0.694 | 116 | 0.624 | 121 | 0.629 |
| Mexico | 128 | 0.829 | 147 | 0.829 | 149 | 0.776 | 154 | 0.765 |
| Chile | 93 | 0.700 | 121 | 0.782 | 140 | 0.741 | 138 | 0.712 |
| Brazil | 152 | 0.900 | 160 | 0.876 | 163 | 0.824 | 168 | 0.888 |
| Argentina | 124 | 0.818 | 138 | 0.812 | 140 | 0.741 | 149 | 0.753 |
| Node Strength | | | | | | | | |
| Country | level | % rank | level | % rank | level | % rank | level | % rank |
| Thailand | 0.171 | 0.765 | 0.266 | 0.859 | 0.249 | 0.871 | 0.321 | 0.876 |
| Philippines | 0.164 | 0.753 | 0.101 | 0.771 | 0.165 | 0.824 | 0.144 | 0.782 |
| Malaysia | 0.289 | 0.818 | 0.282 | 0.865 | 0.367 | 0.900 | 0.401 | 0.894 |
| Korea, Rep. | 0.447 | 0.888 | 0.609 | 0.929 | 0.606 | 0.929 | 0.787 | 0.941 |
| Indonesia | 0.398 | 0.871 | 0.221 | 0.829 | 0.192 | 0.847 | 0.260 | 0.824 |
| China | 0.320 | 0.835 | 0.493 | 0.906 | 0.811 | 0.953 | 1.948 | 0.988 |
| Venezuela | 0.362 | 0.853 | 0.121 | 0.788 | 0.090 | 0.759 | 0.091 | 0.729 |
| Mexico | 0.463 | 0.894 | 0.343 | 0.882 | 0.622 | 0.935 | 0.614 | 0.912 |
| Chile | 0.118 | 0.700 | 0.076 | 0.741 | 0.069 | 0.735 | 0.106 | 0.735 |
| Brazil | 0.479 | 0.906 | 0.251 | 0.847 | 0.222 | 0.859 | 0.299 | 0.841 |
| Argentina | 0.230 | 0.794 | 0.090 | 0.759 | 0.098 | 0.771 | 0.106 | 0.741 |
| Node Disparity | | | | | | | | |
| Country | level | % rank | level | % rank | level | % rank | level | % rank |
| Thailand | 0.087 | 0.265 | 0.109 | 0.388 | 0.087 | 0.300 | 0.075 | 0.229 |
| Philippines | 0.143 | 0.541 | 0.138 | 0.547 | 0.122 | 0.535 | 0.091 | 0.371 |
| Malaysia | 0.127 | 0.465 | 0.128 | 0.488 | 0.116 | 0.506 | 0.095 | 0.406 |
| Korea, Rep. | 0.138 | 0.494 | 0.156 | 0.606 | 0.094 | 0.376 | 0.088 | 0.359 |
| Indonesia | 0.241 | 0.800 | 0.171 | 0.647 | 0.090 | 0.341 | 0.092 | 0.376 |
| China | 0.159 | 0.612 | 0.162 | 0.629 | 0.090 | 0.324 | 0.074 | 0.218 |
| Venezuela | 0.151 | 0.576 | 0.296 | 0.894 | 0.307 | 0.935 | 0.311 | 0.900 |
| Mexico | 0.456 | 0.965 | 0.502 | 0.982 | 0.687 | 0.994 | 0.596 | 0.982 |
| Chile | 0.072 | 0.135 | 0.079 | 0.182 | 0.068 | 0.147 | 0.066 | 0.171 |
| Brazil | 0.064 | 0.065 | 0.090 | 0.241 | 0.090 | 0.347 | 0.061 | 0.124 |
| Argentina | 0.067 | 0.088 | 0.061 | 0.071 | 0.113 | 0.494 | 0.094 | 0.400 |

Table 3: Results for Node Clustering, Node ANNS and Node WANND

| | 1980 | | 1990 | | 2000 | | 2005 | |
|---|---|---|---|---|---|---|---|---|
| Node Clustering (Weighted Clustering $*10^5$) | | | | | | | | |
| Country | level | % rank | level | % rank | level | % rank | level | % rank |
| Thailand | 0.157 | 0.724 | 0.339 | 0.859 | 0.147 | 0.876 | 0.220 | 0.859 |
| Philippines | 0.278 | 0.776 | 0.100 | 0.782 | 0.108 | 0.853 | 0.070 | 0.788 |
| Malaysia | 0.524 | 0.806 | 0.282 | 0.847 | 0.302 | 0.906 | 0.332 | 0.888 |
| Korea, Rep. | 1.493 | 0.894 | 2.558 | 0.947 | 0.994 | 0.941 | 1.776 | 0.941 |
| Indonesia | 2.608 | 0.924 | 0.431 | 0.871 | 0.082 | 0.841 | 0.135 | 0.824 |
| China | 1.172 | 0.865 | 0.575 | 0.882 | 1.478 | 0.965 | 6.813 | 0.988 |
| Venezuela | 1.843 | 0.906 | 0.139 | 0.800 | 0.035 | 0.782 | 0.044 | 0.776 |
| Mexico | 1.454 | 0.888 | 0.595 | 0.888 | 0.935 | 0.935 | 1.014 | 0.929 |
| Chile | 0.145 | 0.712 | 0.041 | 0.747 | 0.013 | 0.741 | 0.037 | 0.753 |
| Brazil | 0.879 | 0.847 | 0.229 | 0.835 | 0.094 | 0.847 | 0.163 | 0.847 |
| Argentina | 0.279 | 0.782 | 0.023 | 0.700 | 0.014 | 0.747 | 0.015 | 0.724 |
| Node Average Nearest-Neighbor Strength (ANNS) | | | | | | | | |
| Country | level | % rank | level | % rank | level | % rank | level | % rank |
| Thailand | 0.304 | 0.147 | 0.205 | 0.147 | 0.142 | 0.106 | 0.176 | 0.076 |
| Philippines | 0.339 | 0.188 | 0.253 | 0.212 | 0.159 | 0.218 | 0.195 | 0.235 |
| Malaysia | 0.343 | 0.206 | 0.196 | 0.094 | 0.144 | 0.135 | 0.179 | 0.124 |
| Korea, Rep. | 0.285 | 0.129 | 0.200 | 0.129 | 0.140 | 0.065 | 0.176 | 0.094 |
| Indonesia | 0.421 | 0.282 | 0.266 | 0.235 | 0.141 | 0.082 | 0.178 | 0.112 |
| China | 0.498 | 0.418 | 0.188 | 0.059 | 0.139 | 0.053 | 0.167 | 0.012 |
| Venezuela | 0.442 | 0.318 | 0.296 | 0.300 | 0.206 | 0.376 | 0.248 | 0.371 |
| Mexico | 0.324 | 0.176 | 0.215 | 0.165 | 0.158 | 0.206 | 0.193 | 0.218 |
| Chile | 0.428 | 0.306 | 0.262 | 0.224 | 0.172 | 0.265 | 0.218 | 0.294 |
| Brazil | 0.276 | 0.100 | 0.198 | 0.118 | 0.147 | 0.165 | 0.178 | 0.118 |
| Argentina | 0.339 | 0.182 | 0.231 | 0.188 | 0.172 | 0.259 | 0.202 | 0.247 |
| Node Weighted Average Nearest-Neighbors Degree (WANND) | | | | | | | | |
| Country | level | % rank | level | % rank | level | % rank | level | % rank |
| Thailand | 142.94 | 0.329 | 155.93 | 0.441 | 163.29 | 0.565 | 159.84 | 0.329 |
| Philippines | 149.11 | 0.547 | 160.57 | 0.706 | 167.67 | 0.947 | 165.00 | 0.712 |
| Malaysia | 145.25 | 0.406 | 150.72 | 0.218 | 166.61 | 0.865 | 158.89 | 0.288 |
| Korea, Rep. | 144.70 | 0.400 | 159.85 | 0.676 | 162.85 | 0.535 | 161.93 | 0.435 |
| Indonesia | 154.86 | 0.765 | 161.40 | 0.771 | 164.84 | 0.682 | 159.77 | 0.324 |
| China | 154.89 | 0.771 | 153.36 | 0.329 | 162.63 | 0.524 | 161.61 | 0.400 |
| Venezuela | 142.26 | 0.300 | 157.56 | 0.518 | 156.74 | 0.235 | 164.24 | 0.612 |
| Mexico | 155.34 | 0.776 | 164.84 | 0.941 | 167.89 | 0.971 | 167.87 | 0.959 |
| Chile | 144.47 | 0.394 | 157.84 | 0.547 | 159.75 | 0.359 | 163.31 | 0.524 |
| Brazil | 136.40 | 0.147 | 152.77 | 0.306 | 157.19 | 0.253 | 157.54 | 0.212 |
| Argentina | 140.62 | 0.247 | 146.63 | 0.153 | 158.09 | 0.288 | 158.54 | 0.265 |

Table 4: Results for Random-Walk Betweenness Centrality

| | 1980 | | | 1990 | | | 2000 | | | 2005 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Country | level | % rank | location | level | % rank | location | level | % rank | location | level | % rank | location |
| Thailand | 0.0393 | 0.776 | O | 0.0651 | 0.888 | S-P | 0.0813 | 0.900 | I-P | 0.0931 | 0.900 | I-P |
| Philippines | 0.0227 | 0.671 | O | 0.0229 | 0.712 | O | 0.0289 | 0.735 | O | 0.0246 | 0.700 | O |
| Malaysia | 0.0373 | 0.771 | O | 0.0439 | 0.835 | O | 0.0649 | 0.882 | S-P | 0.0692 | 0.888 | S-P |
| Korea, Rep. | 0.0458 | 0.841 | O | 0.0811 | 0.929 | I-P | 0.1179 | 0.924 | I-P | 0.1435 | 0.959 | C |
| Indonesia | 0.0431 | 0.824 | O | 0.0386 | 0.818 | O | 0.0486 | 0.835 | O | 0.0494 | 0.824 | O |
| China | 0.0569 | 0.855 | S-P | 0.0941 | 0.935 | I-P | 0.1809 | 0.965 | C | 0.3252 | 0.994 | C |
| Venezuela | 0.0621 | 0.888 | S-P | 0.0391 | 0.824 | O | 0.0476 | 0.824 | O | 0.0300 | 0.729 | O |
| Mexico | 0.0418 | 0.812 | O | 0.0440 | 0.841 | O | 0.0569 | 0.865 | S-P | 0.0527 | 0.841 | O |
| Chile | 0.0250 | 0.712 | O | 0.0241 | 0.729 | O | 0.0281 | 0.729 | O | 0.0308 | 0.747 | O |
| Brazil | 0.0755 | 0.912 | I-P | 0.0650 | 0.882 | S-P | 0.0802 | 0.894 | S-P | 0.1036 | 0.912 | I-P |
| Argentina | 0.0402 | 0.794 | O | 0.0345 | 0.794 | O | 0.0423 | 0.800 | O | 0.0450 | 0.818 | O |
| *G7 (average)* | 0.3235 | 0.976 | C | 0.3318 | 0.975 | C | 0.2885 | 0.970 | C | 0.2568 | 0.966 | C |
| *India* | 0.0215 | 0.871 | S-P | 0.0206 | 0.859 | S-P | 0.0287 | 0.912 | I-P | 0.0345 | 0.941 | I-P |

Table 5: Overall network properties

| | Degree | Strength | Disparity | Clustering | ANNS | WANND | Centrality |
|---|---|---|---|---|---|---|---|
| 1980 | 77.30 | 0.248 | 0.172 | 1.539 | 0.606 | 146.29 | 0.0382 |
| 1990 | 84.71 | 0.187 | 0.163 | 0.849 | 0.453 | 155.45 | 0.0372 |
| 2000 | 105.46 | 0.142 | 0.153 | 0.209 | 0.259 | 160.48 | 0.0384 |
| 2005 | 106.05 | 0.177 | 0.154 | 0.363 | 0.325 | 161.53 | 0.0385 |

Table 6: Correlations

| | Degree–Strength | WANND–Degree | ANNS–Strength | Clustering–Strength |
|---|---|---|---|---|
| 1980 | 0.570 | -0.037 | -0.395 | 0.967 |
| 2000 | 0.489 | 0.230 | -0.376 | 0.979 |
| 2005 | 0.510 | 0.084 | -0.406 | 0.973 |