ECONOMICS WEB INSTITUTE

HIERARCHY STRUCTURES IN WORLD TRADE

by Valentino Piana (2004)

Contents

News: **A policy based on this paper, leading to more integration** NEW!

News: *A new paper based on this one, presented at the Conference on World Trade at Princeton University, on the dynamics of the system*

News: A paper on Russia trade policy quoting this contribution

---

Introduction

A new technique of analysis of trade values reveals the asymmetric structure of relationships among countries. The structure of world trade is characterised by bilateral **absence of relations** (82%) and **dominance** (40% in non-absent relationships), **weak dominance** (of two types: 24% and 22% respectively), whereas **symmetric integration** is just the 6% of non-absent relationships (the 5.th case in ranking) with 21 relationships.

US and **Germany** are both at the heart of the hierarchical system, strongly connected with most country in the world as they are.

The place of each country is evaluated not on the base of its shares in world exports and imports but, instead, of country's "strength balance" with its partners.

The applied network analysis allows for a graph representation of world trade structures as well as for further quantitative indicators.

All **data** are freely available in this MS Excel file, so you can better follow the present discussion and make further experiments.

The basic idea

In political foreign relationships, **major trade partners are particularly important countries**. The bounded-rational ministries tend to care more about them and keep preferential lines of contact. The national industries strive to match their requirements and meet them constantly.

To be a major trade partner of a country means to have an open potential for influencing and being influenced.

Needless to say, there are many other elements to take into consideration (foreign direct investment, language similarity, historical linkages, legal and military pacts, political distance in government orientation,...) but a concise expression of the reality of the "balance of strength" between two nations can be grasped from trade data purposefully interpreted.

In particular, two basic roles can turn out to be particularly relevant.

First, if a certain country B is a major market of for the exports of a country A, the economic conditions of B (recession, recovery,...devaluation / revaluation of the currency,...) will significantly affect the exports of A, thus - if they do not constitute a too small amount - its GDP, finally the conditions of its labour market (unemployment) and the market of goods (consumption, investment,...).

If, for instance, the country B decides to protect its domestic market through tariff (and non tariff) barriers, it is likely that country A will heavily suffer and will try to negotiate.

Second, if a certain country B is a top component in the imports of country A, this means that A "needs" the B supply and it is sensitive to possible disruption in its intensity. It will be heavily affected by to large fluctuations of the relative exchange rate. A revaluation of B currency would imply a rising cost of B products, which represent a large share in A import, hurting all the people needing those goods, if they cannot fastly and easily substitute this supply with those coming from other countries.

These relations are not necessarily symmetric: to be a major exporter for B does not mean automatically that B is a major receiver of our exports. B could be so little in terms of GDP and of total imports that its share on our total exports could well be too small.

For instance, Indonesia needs USA since they are both one of its major export market and one of its major import source. But the reverse is not true: Indonesia is not among the major partners of US. Thus, *prima facie*, US can influence Indonesia politics - or can be tempted to do it - much more than the reverse.

On the opposite, France (F) and Germany (G) are symmetrically linked in a perfect integration: F represents a major export market for G as well as G represents a major export market for F; F is a major provider for G as well as G represents a major import source for F. They need each other.

In all, the entire spectrum of relationships from integration to dominance is as wide as **16 different patterns**, in detailed described below.

The basic idea of this paper is to **take the major import and export partners** for a large number of nations, to **build the matrix of these relationships**, to allocate the emerging patterns of diadic relationships between any two countries into 16 possible types.

The **synthetic outputs** are four:

1. the **ranking** of occurrences of the **16 patterns** on a global scale;

2. **two maps of world trade network**;

3. an overall "**Strength Index**" for each country;

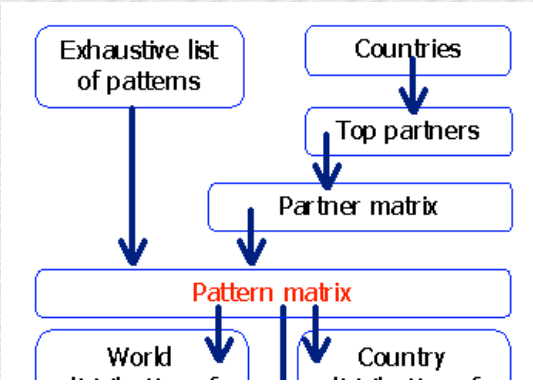
4. three "**Importance Indexes**" for each country.

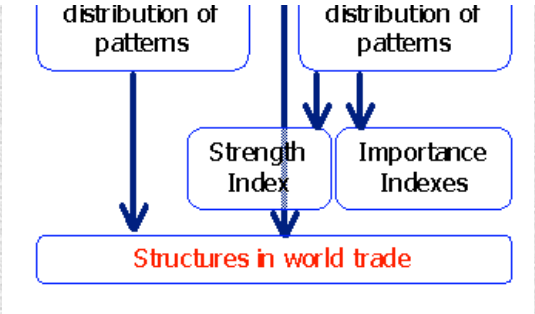
The analytical output is the **identification of the role of each country in the world trade network**.

The results offer hints for **policies** aimed at **economic integration** and/or at strengthening the role of a country up to **local and global dominance**.

The steps of the analysis

The present analysis proceeds across 8 steps, visualized in the following chart and shortly described below:





The main steps are the following:

1. Identifying 16 patterns of diadic relationships, which represents an exhaustive list of all possible patterns;

2.1 Choosing countries included in the analysis;
2.2 Identifying major import and export parners of each country in a given reference year;
2.3. Building two world-wide "Partner matrices", one for imports and the other for exports;

3. Obtaining the "Pattern matrix", which allocates for each couple of countries their relations to one of the 16 patterns;

4. Counting the frequency of patterns for each country;
5. Evidencing the distribution of patterns in the world;

6. Computing Overall "Strength Index" for each country through a numerical conversion of patterns into "strength scores";

7. Computing further "Importance Indexes";

8. Drawing maps of world trade hierarchies.

In the present version, we have taken 64 major countries and for each, **the top 5 countries from which its imports come** and **the top 5 to which it exports.** The reference year is 1998. More details can be found in the Appendix 1.

Throughout this paper, we shall call "world" this set of 64 countries. For a larger number of countries see this other paper of ours.

The exhaustive list of 16 patterns of trade relations

The "Dependence" word can be used to indicate a situation in which a country needs the other, while the other can ignore it. "Dominance" is when we can ignore a country that needs us. "Integration" is when we need each other. "Absence" is when we can ignore each other.

But these "strength balances" apply separatedly to exports and imports.

Accordingly, the relationship between two countries can turn out to be of as much as 16 different patterns. How is it possible? Well, trade relations - between a first country A and a second country B - can be characterized by four conditions, each of which can be "true" or "false":

1. "For B, A is a major export destination"

2. "For B, A is a major import source"

3. "For A, B is a major export destination"

4. "For A, B is a major import source".

These propositions are logically independent, since each one can be true or false independently from the values of the others.

For each proposition, we build a binary variable that will take the value of 1 if the proposition is true and zero in the opposite case.

The "binary description" of a two-countries pattern can be obtained simply by nearing the four binary variables in the same order as we presented them. For instance the binary description 1100 means that, for B, A is both a major export destination and a major import source while, for A, B isn't important. We shall call this relationship the "dominance" of A over B.

In naming these patterns, we care about the situation of A against B, so e.g. we call "dependence" the situation in which A is completely weaker than B.

In short, these are the exhaustive list of the 16 patterns:

Name	Binary description	Qualitative description
Absence of relationships	0000	The countries "ignore" each other
Source dependence	0001	B is an important provider for A
Destination dependence	0010	B is an important market for A
Dependence	0011	B is very important to A, but the reverse is not true
Source dominance	0100	A is an important provider of B, but A can ignore B
Source integration	0101	They both need each other as providers
Mono out-integration	0110	One flow is important for both: the exports of A to B
Dependent source interconnection	0111	A depends on B, but B needs A's supply as source
Destination dominance	1000	A is an important destination for B, while A can ignore B
Mono in-integration	1001	One flow is important for both: the exports from B to A
Destination integration	1010	They both need each other as exporters
Dependent destination interconnection	1011	A depends on B, but B needs A market as destination
Dominance	1100	A is very important to B and can afford to ignore it
Dominant source interconnection	1101	A is very important to B but A needs B as a source
Dominant destination interconnection	1110	A is very important to B but A needs B as a destination
Integration	1111	They need each other on an equal foot.

"Integration" - as a word appearing in more than one pattern - means that there is reciprocity. "Interconnection" means that there are three 1s, i.e. there is a strong relation between the two countries. "Mono" means that the same flow of goods and servicies is important for both.

We gave a red colour to four "clear-cut" situations, described with one word only, without adjectives.

Partner matrix

Partner matrix expresses - for each country - which are its main 5 trade partners (by rows), thus it allows to describe for each country (in column) the list of the countries for which it is a major partner (that can be empty and of any length).

In this vein, we build the "export partner matrix" as in this snapshot form:

	Algeria	Argentina	Australia	Austria	Bangladesh	Belgium	Brazil
Algeria	0	0	0	0	0	0	0
Argentina	0	0	0	0	0	0	1
Australia	0	0	0	0	0	0	0
Austria	0	0	0	0	0	0	0
Bangladesh	0	0	0	0	0	0	0
Belgium	0	0	0	0	0	0	0
Brazil	0	1	0	0	0	0	0
Bulgaria	0	0	0	0	0	0	0
Cameroon	0	0	0	0	0	1	0
Canada	0	0	0	0	0	0	0
Chile	0	1	0	0	0	0	1
China	0	0	0	0	0	0	0
Colombia	0	0	0	0	0	0	0
Czech Rep	0	0	0	1	0	0	0
Denmark	0	0	0	0	0	0	0
Ecuador	0	0	0	0	0	0	1
Egypt	0	0	0	0	0	0	0
Finland	0	0	0	0	0	0	0
France	0	0	0	0	0	1	0
Germany	0	0	0	0	0	0	0

A figure of 1 means that, for the country in row, the country in column is a major export target. For instance, you see that Chile does not primarily export to Algeria, but rather to Argentina.

The full matrix is here, included in the MS Excel file that you can use to follow and extend the entire analysis.

The "import partner" matrix is formally identical to the export partner matrix: a figure of 1 means that for the country in row, the country in column is a major import provider.

Through both partner matrices, you can trace the trade flows that are more relevant for the involved countries, maybe using the instruments of social network analysis and graph theory.

Pattern matrix

Through a simple algorithm, we can obtain, mixing information from both import and export, the "Pattern matrix", comprehending the pattern of relationships involving each couple of countries. For instance, you can see that Argentina and Brazil are characterized by the "integration" pattern (1111 in our previous "binary description").

	Algeria	Argentina	Australia	Austria	Bangladesh
Algeria	0000	0000	0000	0000	0000
Argentina	0000	0000	0000	0000	0000
Australia	0000	0000	0000	0000	0000
Austria	0000	0000	0000	0000	0000
Bangladesh	0000	0000	0000	0000	0000
Belgium	0000	0000	0000	0000	0000
Brazil	0000	1111	0000	0000	0000
Bulgaria	0000	0000	0000	0000	0000
Cameroon	0000	0000	0000	0000	0000
Canada	0000	0000	0000	0000	0000
Chile	0000	1011	0000	0000	0000
China	0000	0000	1100	0000	0100
Colombia	0000	0000	0000	0000	0000
Czech Rep	0000	0000	0010	0001	0000
Denmark	0000	0000	0000	0000	0000

Here you see a partial snapshot of the "pattern matrix", collecting all the diadic relationships between any couple of countries. The full matrix is a square of 64x64 (rows x columns).

Browse this matrix in the Excel file and you'll discover a lot about the relationships between countries! Which countries are dominated by yours? With which countries do you have a "Source dependence" pattern?

The position of one specific country can be grasped looking at the intricated structures it belongs, and carefully interpret it, together with a more in-depth analysis of the concentration of its trade flows.

The overall results: the ranking of patterns and two maps of the world

Now we get our main result: the distribution of frequency of the 16 patterns of diadic relationship and their ranking in the world [1].

Name	Binary description	N. occurrences	% of not-absent relation-ships	% of all relationships
Absence of relationships	0000	1646	-	82%
Dominance	0011	148	40%	7%
Dependence	1100	148	40%	7%
Source dominance	0001	89	24%	4%
Source dependence	0100	89	24%	4%
Destination dominance	1000	82	22%	4%
Destination dependence	0010	82	22%	4%
Integration	1111	21	6%	1%
Dominant destination interconnection	1011	12	3%	0%
Dependent destination interconnection	1110	12	3%	0%
Mono in-integration	0110	10	3%	0%

Mono out-integration	1001	10	3%	0%
Dominant source interconnection	0111	7	2%	0%
Dependent source interconnection	1101	7	2%	0%
Destination integration	1010	1	0%	0%
Source integration	0101	0	0%	0%
Total		**2016**	**100%**	**100%**

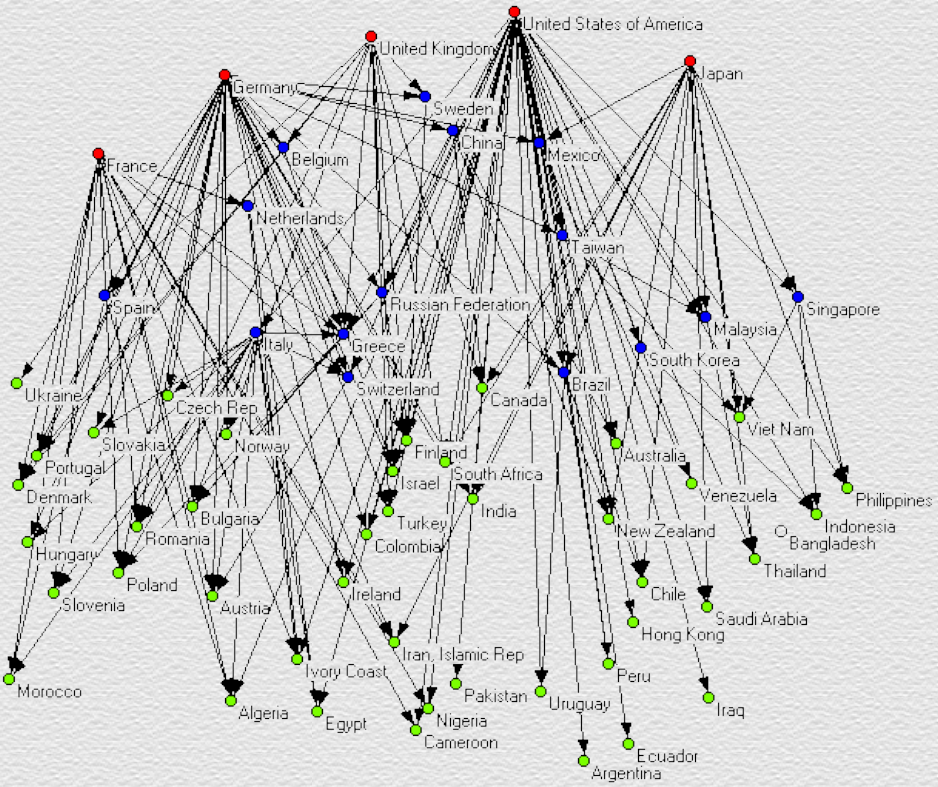
This table is a huge concentration of information, as you can understand recalling the entire procedure. At the same time, it gives very clear-cut results.

The **absence of relationships** dominates the world economy, apart from all rhetoric of "globalization", with 1646 occurrences (82% of the total). Most countries live far away from each other, possibly maintaining kind diplomatic relationships but activating just minor trade exchange flows [2].

Dominance is the most widespread (non-absent) relationship. A few countries are crucial for others that they do not need. The dominant countries can exert significant external pressure on dominated ones. And data demonstrate that this is the most common situation in non-unrelated countries.

Almost all the countries in the world are involved in one (or more) Dominance and/or Dependence relationships, as you can see in this graph [3]:

Map of world dominance relations



By using three colours, we visualize three categories, widely used in "world systems" analysis, for which this paper is able to provide a clear-cut definition:

a. the "core" - in red - constituted by countries that are only in Dominant position,

b. the "periphery" - in green - constituted by countries that are only in Dominated position,

c. the "semi-periphery" - in blue - constituted by countries that are dominant with respect to a one or more contries but that are dominated versus one or more other countries.

Needless to say, these relationships expresses a material and objective base for "strength balances" that can be modified by subjective political and social leadership, as in the case of "benign" dominance, e.g. supportive of aid. At the same time, it would be very interesting to see how internally the different social groups take advantage or suffer from their country's position as well as how the political system is influenced by such relations, e.g. in two-party systems how one is more favourable to a "dominant" country and the other rather oppose it.

The heavy weight of "Dominance relationships" in international trade is magnified by the fact that in world ranking follow four relationships that one can collectively call **"weak dominance" of a country over another**: Source dependence (and its

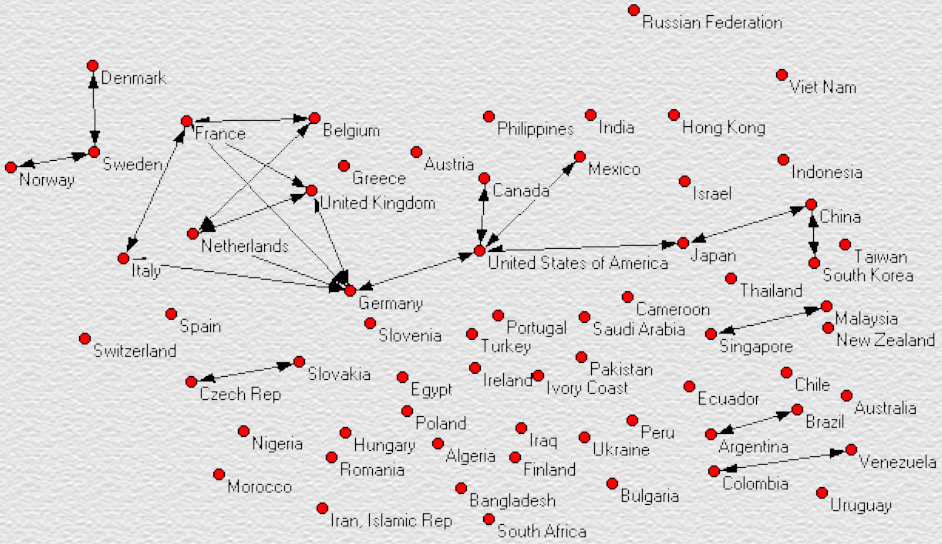
mirror Source dominance) and Destination dependence (and its mirror Destination dependence) - two uncomplete but still heavily asymmetric relationships.

Source dominance, i.e. when the dominated countries needs our good and we do not need anything, is slightly more diffused than Destination dominance, i.e. when they need us as a market for exports and we do not need anything.

Summing up the strong and the weak dominance relationship one arrives up to 319, the 86% of non-absent relationships.

After them, the data ranking shows "Integration" with 21 relationships (the 6% of non-absent relationships).

Here you are the graph of "Integration relationships":



These are the horizontal linkages that keeps the world together. The countries connected have succeed in establishing strong bi-lateral relationships where each needs the other. Four main explanations comes to mind:

1. an **intentional trade policy** coupled with attractive trade conditions for private operators;
2. the **complementarity in production capabilities** (agriculture, manufacture, oil, services,...) as well as intra-industry trade;
3. the persistence of **historical links** (e.g. previous common state structure);
4. a large stock of **Foreign Direct Investments**, generating flows in both directions of raw materials, manufactured and semi-manufactured goods.

One can clearly sees several countries of the European Union, among which France and Germany, once-enemies in several wars (of which two World Wars). A lesson for others?

NAFTA countries are already integrated while embryos of regional integration are present in Latin America and, even more developed, in East Asia.

Going on with the other patterns in descending order, after Integration there are only patterns that account for **less than 1%** each of total relationships (absent and non-absent).

In particular, one finds now the four kinds of interconnection and two forms of weaker integration (characterized by one major flow of goods / services that is very important for both). It's not perhaps surprising that that flow is often a flow of oil.

Finally, on the bottom of ranking, you find two kinds of relationships that are almost or completely absent: Destination integration and Source integration. Once again, integration is hard!

A synthetic Strength Index

The world is complicated, isn't? It's even "complex", somebody would argue. And the structures that emerge from our - very basic - analysis are already of some intriguing degree of articulation. Following the method of dynamically alternating phases of "simplification" and of "complexification", we suggest now to take a straight way: to build a one-dimension "Strength Index" to measure and compare nations.

We shall give reasonable, although somewhat arbitrary, "strength balance" scores to each pattern, then count how many relations a country has of each kind, and sum up. Technically, we shall compute a linear combination of the number of

relationships a country has - weighted with the "strength balance" score of that pattern. In this way, we shall produce a ranking of the strength of all countries in the world.

We propose the following scores:

Name	Binary description	Score
Absence of relationships	0000	0
Dependence	0011	1
Source dependence	0001	2
Destination dependence	0010	2
Dependent source interconnection	0111	3
Dependent destination interconnection	1011	3
Integration	1111	4
Destination integration	1010	4
Source integration	0101	4
Mono out-integration	0110	4
Mono in-integration	1001	4
Dominant destination interconnection	1110	5
Source dominance	0100	6
Destination dominance	1000	6
Dominant source interconnection	1101	6
Dominance	1100	7

If a country has many dominant relationships, it will have a higher overall "Strength Index" than if it were often dominated.

Needless to say, reducing multiple dimensions to just one can distort results and linear combination can generate dubious equivalences among the elements (in this case, the patterns). It's a cost we can pay, since you can change everything and recalculate your Strength Index - and the rest of the analysis is not so banal!

At any rate, data shows how the relationships each country has with all the others in the world are distributed in the 16 patterns. By applying scores, one gets the following "Strength Index" values and ranking [4]:

Strength Index

Country	Strength Index
United States of America	363
Germany	355
France	206
Italy	203
United Kingdom	201
Japan	190
China	119
Netherlands	117
Russian Federation	64
Spain	62
Singapore	59
South Korea	59
Hong Kong	55
Brazil	50
Taiwan, Province of China	49
Belgium	39
Australia	36
Mexico	35
India	31
Saudi Arabia	30
Austria	29
Sweden	27
Argentina	23
Colombia	23
Turkey	23

Venezuela	22
Bangladesh	20
Nigeria	20
Poland	20
Hungary	19
Ireland	19
Ecuador	18
Greece	18
Malaysia	18
Chile	16
Indonesia	16
Norway	16
Thailand	16
Ukraine	16
Switzerland	15
Cameroon	14
Czech Rep	14
Peru	14
Slovakia	14
Canada	13
Denmark	13
Iraq	13
Uruguay	13
Egypt	11
Morocco	11
Pakistan	11
Philippines	11
Viet Nam	11
New Zealand	10
Portugal	10
Iran, Islamic Rep	9
Algeria	8
Bulgaria	8
Israel	8
Romania	8
South Africa	8
Slovenia	7
Ivory Coast	6
Finland	5

USA and Germany are the most powerful countries in the world trade. They are substantially at the same level of strength. The second-rank dominant countries comprehend France, Italy, UK, and Japan. China and the Netherlands precede the Russian Federation, Spain, Singapore, South Korea, Hong Kong. Then there is a gradual decline in "Strength Index", the more so the more "peripherical" are the countries.

Three further Importance Indexes

By construction the number of countries that are major partners is fixed at five but this leaves free the number of countries for which a given one is a major partner. Indeed, an easy index of the importance of a country is the number of nations for which the first is a major trade partner. If it is high, this means that there are many countries that "look at it".

US, for instance, are a major partner of 48 countries that consider it as top export destination, whereas there are 50 countries for which US are a top import source.

Indeed, we constructed two indexes of "importance", by counting how many countries consider a given one as a top export destination or as an import provider. A last index counts the number of countries that consider the given one as a top trade partner, in import or in export or both.

Results for all included countries and the relative ranking is available in the

sheet "Importance Indexes" of this Excel file.

Preliminary conclusions

The "global market" is not an homogenous aggregate in which every country tries to keep and increase its share. It's a complicated structure in which certain countries are dominant and exert a disproportionate influence over others, with many degrees and qualifications. Local interactions and far-reaching jumps connect the roles of each countries in a hierarchical architecture with many nuances but also a lot of hard facts.

The simplifying assumption of the IS-LM macroeconomic analysis of a national economy - where the "Rest of the World" is considered an homogeneous aggregate to trade with - should, for the analysis of certain phenomena, leave room for more articulated landscapes. International business cycles and their diffusion in the world economy follow interesting and characteristic paths through the trade structures.

Trade policy should not overlook **the current position** of each country involved and the **directions that its political leadership would like to give to the relationship with its neighbours and all the other countries in the world**, by keeping into account and modify know-how and decision-making processes of trading agents.

For instance , the target of more Integration can easen by the adoption of new trade policies, like bilateral import promotion or international proximity trade.

Appendix 1. The list of the countries, data sources, and suggestions for your own contribution

In the present paper, we included in the analysis 64 large countries in the world. They represent about 97% of global GDP and 85% of global population.

In the specific terms of "major trade parters", it is a very "closed" group since the 98.4% of major trade relations generated from these countries are oriented to other nations included within this set. The external countries receive only 5 major export flows out of 320 (64x5) and 5 major import flows out of 320.

The full list of included countries is the following:

1	Algeria	33	Malaysia
2	Argentina	34	Mexico
3	Australia	35	Morocco
4	Austria	36	Netherlands
5	Bangladesh	37	New Zealand
6	Belgium	38	Nigeria
7	Brazil	39	Norway
8	Bulgaria	40	Pakistan
9	Cameroon	41	Peru
10	Canada	42	Philippines
11	Chile	43	Poland
12	China	44	Portugal
13	Colombia	45	Romania
14	Czech Rep	46	Russian Federation
15	Denmark	47	Saudi Arabia
16	Ecuador	48	Singapore
17	Egypt	49	Slovakia
18	Finland	50	Slovenia
19	France	51	South Africa
20	Germany	52	South Korea
21	Greece	53	Spain
22	Hong Kong	54	Sweden
23	Hungary	55	Switzerland
24	India	56	Taiwan, Province of China
25	Indonesia	57	Thailand
26	Iran, Islamic Rep	58	Turkey
27	Iraq	59	Ukraine
28	Ireland	60	United Kingdom
29	Israel	61	United States of America
30	Italy	62	Uruguay
31	Ivory Coast	63	Venezuela
32	Japan	64	Viet Nam

Needless to say, we would like to enlarge this dataset, so if you would like to help

us, just send us an e-mail.

Moreover, we would like to repeat for other years the same analysis - and your help would be welcomed!

For the moment, all data are referred to 1998, except for Australia (2000), New Zealand, Nigeria, Pakistan, Egypt, Belgium, Cameroon, Ecuador, Hungary, Romania, Russia, Slovakia, South Africa (2002), Mexico, Venezuela (2003).

Last but not least, the main data source for our exercise has been The Economist book "Pocket World in Figures - 2001 Edition", together with directly several central statistical offices and central banks.

NOTES

[1] Please note that certain relationships are the mirror of others, so their number is the same as them. In sums, one has to avoid double counts.

[2] The wide presence of "Absent relationships" depends in part from the very method we used. To deepen this question, one should look at theoretical minimum and maximum of this measure.

[3] This graph and the following has been obtained using our data with this free **graph theory software**: V. Batagelj, A. Mrvar: Pajek − Program for Large Network Analysis. Home page: http://vlado.fmf.uni-lj.si/pub/networks/pajek/

[4] These results would numerically change with the inclusion of the countries that have been left out from the analysis.

Main page
Essays