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Measuring Economic Globalization: Entropy-Based Inequality Risk Metric

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Abstract

Many inequality measures have been defined during the last 100 years trying to measure spatial concentration, ranging from Gini or Herfindahl-index and Lorenz-curve to more sophisticated measures such as Theil or Atkinson-Kolm-Sen inequalities. All these metrics result in phenotypic measurements not based on an economic law and ignoring the spatial nature by measuring a phenomenon with an empirical metric. In the following, an intrinsic genotypic metric is presented suitable to measure the degree of economic globalization based on built-in globalization law.

The thermodynamic concept of entropy has different interpretations and according to Boltzmann it is a measure of disorder. The economic system is composed of a multitude of actors which can be compared to a differentiated thermodynamic system. From a paradigmatic interpretation of thermodynamic entropy, we can define risk as a dualistic view of order in an economic system, therefore, the more order (i.e. inequality) that exists in an economic system the more risky the economic system. We will see that the entropic disorder measure of a system can be transposed, defining the inherent risk of an economic system by measuring the inequality or diversity of an attribute (e.g. market share) of a subsystem compared to the whole system. The evolution of risk of an economic system reflects the rational decision of an economic actor to expand sales to other economic areas, reducing the risk of the sales portfolio. The risk is linked to the structural composition and interweavement of the actors of the system leading finally to the Central Theorem of Globalization. Transposing also thermodynamic enthalpy to economy, we can even explain an eventual de-globalization trend by applying the overall economic law of maximizing profit net of risk, which explains the "Why" economy is globalizing or not. Furthermore, this statistical entropy-based metric is also applicable to measure the risk of a political economy's goods supply portfolio composition and the vulnerability of its demand structure. By applying the new defined metric, we will measure the evolution of globalization of the world economic system between 2003 and 2007 applied to the major geographic regions and answer the question: Is economy really globalizing?

Introduction

Measuring globalization is a key task not only of international institutions such as WTO or OECD. Different aggregated globalization indexes are calculated also by e.g. the Swiss Polytechnic Institute (KOF-Index) or consultant companies such as A.T. Kearney. The OECD has even published a handbook on economic globalization indicators giving guidelines to the national statistics offices how to collect data in order to get consistent measures. These specific indicators are calculating globalization mainly under the criteria of

- foreign trade
- foreign direct investment (FDI)
- activity of multinational enterprises (MNE)
- internationalization of technology.

Indeed, traditional statistics lack of describing sufficiently the extension and the effects of globalization and a systemized new approach has to be established. Instead of using Gini or Herfindahl indexes, hereafter a new statistical entropy-based inequality risk metric will be applied, defined according to [1]. The reason is twofold:

- the new measure is not a pure phenotypic indicator measuring the manifestation of an attribute, but it is a genotypic metric linked to the Central Theorem of Globalization, reflecting the underlying law of globalization evolution
- the so defined individual inequality measures can be aggregated within a single risk measure to the subsystems or to the entire system with one single figure measuring the interweavement of economy.

Hereafter, the globalization measure will be applied to the foreign trade matrix (table A2 of WTO), but it can also be used to measure the financial dimension of FDI, including M&A (Merger and Acquisition) as well as WFOE (Wholly Foreign Owned Enterprises) or the risk of the product portfolio of a political economy.

Methodological Approach

In the following, we will apply the globalization measure according to [1] to foreign trade flows. Briefly, from the paradigmatic interpretation of thermodynamic entropy we can define risk as a dualistic view of order in an economic system, therefore the more order (i.e. inequality) that exists in an economic system the more risky the economic system (or vice versa, the more equality a system shows the less risk it presents). Take, for example, the big difference in welfare among different regions being potentially a social bomb. The greater the inequality compared to the riskless state $\psi_{XY}=1$, the larger the risk of an atomic element. Whereas in the here presented context inequality refers rather to a single element of a system, the concept of risk can be aggregated to the entire system by defining risk as the second momentum of the inequalities compared to the attractor 1 (a brief introduction to the algorithm is shown in the appendix 2). This definition is very similar to the statistics variance with the exception that the pole is not the mean but the attractor. We can interpret this risk metric as a statistical entropy measure of the system. According to the Pigou-Dalton Transfer Principle and the interpretation of entropy law, we can state the following

Minimum Risk Principle:
An economic system has the latent tendency to evolve into a state with more equality corresponding to a state with a lower risk.

Risk as a Measure for Globalization

Let us go a step further by applying the Minimum Risk Principle to analyze the foreign trade (corresponding to type 1 globalization according to [1]), i.e. the material globalization dealing with physical flows of a product α, applying to which country exports to which countries, and which country imports from which countries represented by the trade matrix $T^{\alpha}=[t_{XY}]$. For a trade system we can build the market share vector of an economy and calculate the inequality measure ψ_{XY} as the market share of X in Y compared to the overall market share of X. The overall market share of X for e.g. type 1b globalization (globalization of specialties according to [1]) will most probably be similar to the factors proportion according to Heckscher-Ohlin. For economy X we can calculate the risk $r_X(\psi_{XY})$ of its portfolio of activities in the countries Y. The lower the inequalities in each country Y the lower the risk value and therefore the higher the globalization degree of the country X. If the inequality is $\psi_{XY}=1$ for all Y then country X has the same market share in all countries Y and its portfolio of trade-flows is proportional to the market composition according to its competitiveness. Due to the fact that a low risk corresponds to an even-distribution we can now enounce [1] the

Central Theorem of Globalization (CTG):
The lower the risk of an economy or the whole economic system, the more globalized the present economy or the whole economic system for the product under evaluation. Hence, a globalized economic system is less risky.

as well as the

Corollary to the CTG:
Generally, according to the Minimum Risk Principle, systems have the latent tendency to evolve to the state of lower risk. This means of course fueling of globalization because of exporting to other countries and with that decreasing inequality. Therefore the evolution of globalization can be explained with the concept of minimizing risk presented here.

The result of the CTG and its corollary is due to the built-in intrinsic forces of globalization and why globalization will take place independently of new growth opportunities in newly emerging economic regions. We can consider the CTG and its corollary as the basic concept to explain that our economy will globalize naturally with the existing deregulation tendency. This risk metric is a genotypic measure, bearing the intrinsic law of economic globalization.

Maximizing Value Net of Risk

But entropy is not the sole governing physical law of thermodynamics. Indeed, if a transformation happens is determined by free enthalpy. The same is also applicable to economics [1]. Minimizing risk is only one cardinal law (this law models the globalization extension), maximizing profit is the other cardinal one (this law models the final rational acting). Indeed, an economic actor is ready to accept a higher risk if finally it yields a higher profit. Globalization is extending the business scope to new geographic areas, and the aim is

- to increase the profit generation (explicit strategy of profit maximization), and at the same time
- it reduces the risk of the portfolio (implicit law of risk minimization).

The final governing principle of economic globalization is therefore risk deducted value maximization. With this principle we can explain the rational of any economic actor comprising MNE (Multi National Enterprises) and why globalization happens independently of which globalization type 1 (material) and related subtypes (1a, 1b, 1c) or type 2 (financial participation by FDI). It explains why we can have at the same time in different economic regions a progression or a regression of globalization, intended as interweavement of trade network.

Cross-Section Analysis of the year 2007

The upper part of table 1 shows the world trade flow matrix of the year 2007 (source WTO, Table A2) as well as, in the lower part, derived trade shares measures of the geographic regions and relative inequalities calculated according to [1]. Further, according to [1], these world-wide trade flows correspond to the physical, material type 1 globalization flows, comprising the commodities (globalization type 1a), the specialties (globalization type 1b), and the opportunistic cost related (globalization type 1c) flows. This distinction in subtypes is relevant, because they show different patterns as well as different underlying driving logics [1], but the distinction is not necessary for measuring globalization. The single inequalities are then aggregated to a risk measure of each economic region according to the two dimensions of supply portfolio (exports) and demand structure (imports); the matrix contains also geographic intra-trade t_{XX}. The economic regions are: A for North America, B for South and Central America, C for Europe (27), D for Commonwealth of Independent States (former Russian confederation), E for Africa, F for Middle East, G for Asia comprising China, Japan, and other SE Asian countries. These individual “geographic” risk figures are finally aggregated to the world risk index measuring the economic globalization degree, i.e. the extension of the world economic trade system.

Network of world merchandise trade by region (source: WTO International Trade Statistics, Table A2)

2007	North Am	SC Am	Europe	CIS	Africa	Middle E	Asia		
t_{XY}	A	B	C	D	E	F	G	Supply	p_X
A	**951,18**	**130,65**	**328,74**	**12,42**	**27,27**	**50,08**	**352,12**	1852,46	0,14
B	**151,30**	**122,04**	**105,64**	**6,44**	**13,68**	**9,10**	**80,23**	488,43	0,04
C	**458,50**	**80,40**	**4243,56**	**189,05**	**147,71**	**152,92**	**433,67**	5705,81	0,42
D	**23,56**	**6,28**	**287,45**	**103,20**	**6,87**	**16,24**	**59,62**	503,22	0,04
E	**91,87**	**14,62**	**167,55**	**0,94**	**40,47**	**10,53**	**80,88**	406,86	0,03
F	**83,93**	**4,36**	**108,30**	**4,76**	**27,53**	**93,37**	**397,30**	719,55	0,05
G	**756,39**	**92,30**	**714,64**	**79,78**	**91,35**	**150,44**	**1889,82**	3774,72	0,28
Demand	2516,73	450,65	5955,88	396,59	354,88	482,68	3293,64	13451,05	1,00
p_Y	0,19	0,03	0,44	0,03	0,03	0,04	0,24	1,00	

$p_{XY\infty}$	A	B	C	D	E	F	G	p_X
A	0,38	0,29	0,06	0,03	0,08	0,10	0,11	0,14
B	0,06	0,27	0,02	0,02	0,04	0,02	0,02	0,04
C	0,18	0,18	0,71	0,48	0,42	0,32	0,13	0,42
D	0,01	0,01	0,05	0,26	0,02	0,03	0,02	0,04
E	0,04	0,03	0,03	0,00	0,11	0,02	0,02	0,03
F	0,03	0,01	0,02	0,01	0,08	0,19	0,12	0,05
G	0,30	0,20	0,12	0,20	0,26	0,31	0,57	0,28
	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00

Ψ_{XY}	A	B	C	D	E	F	G	$r_X(\Psi_{XY})$
A	2,74	2,11	0,40	0,23	0,56	0,75	0,78	**0,79**
B	1,66	7,46	0,49	0,45	1,06	0,52	0,67	**6,15**
C	0,43	0,42	1,68	1,12	0,98	0,75	0,31	**0,24**
D	0,25	0,37	1,29	6,96	0,52	0,90	0,48	**5,29**
E	1,21	1,07	0,93	0,08	3,77	0,72	0,81	**1,24**
F	0,62	0,18	0,34	0,22	1,45	3,62	2,25	**1,50**
G	1,07	0,73	0,43	0,72	0,92	1,11	2,04	**0,23**
								2,20
$r_Y(\Psi_{XY})$	**0,65**	**6,34**	**0,28**	**5,42**	**1,19**	**1,04**	**0,51**	***2,20***	***$r(\Psi_{XY})$***

Table 1: World trade matrix with inequalities and risk measure for 2007

From the lower part of table 1 we can derive the following observations: high inequalities are usually observable in the domestic economic region of emerging economies. These inequalities ψ_{XY} are comparing subsystems market shares p_{XY} with total market share p_X. The high inequality values originate, for obvious reasons, from being more focussed on home market and having low total market share, e.g. 7.46 for South and Central America or 6.96 for CIS. The aggregated supply risk for each economic region compares the own export structure to the total supply structure and corresponds to the market risk in CAPM (Capital Asset Pricing Model); the same applies to the imports for the demand structure. The analysis shows that the Asian region has with 0.23 the lowest export risk of all geographic regions; hence according to the CTG it is the most globalized region (highest geographic interweavement) followed by Europe with 0.24. South and Central America have with 6.15 the highest risk and therefore the lowest globalization degree being more focussed regionally. Analysing the import side, we discover that Europe has with 0.28 the lowest demand risk value, i.e. the highest demand globalization degree, sourcing worldwide. Again, South and Central America present with 6.34 the highest risk value sourcing more locally. Despite the lowest supply value of 406 b$, Africa with 1.24 has a supply risk value which is lower than Middle East with 1.50, the CIS countries with 5.29, and South and Central America with 6.15, i.e. Africa showing a balanced worldwide supply. The reason might be the type of goods (mainly commodities) which are requested evenly through the world. The total risk value of the economic world trade system in 2007 is 2.20; this value alone does not say anything about the evolution of the globalization degree but has to be seen in the context of trend analysis.

Trend-Section Analysis of Globalization between 2003 and 2007

According to WTO source, world-trade increased during 2003-2007 from 7,290 to 13,451 b$, as shown in figure 1. This evolution of physical, material type 1 globalization has been accompanied by increasing profits of companies and wealth of nations. Now the question: Has only the trade volume increased (between the same economic regions) or has also the globalization degree increased (i.e. the interweavement of old and new economic partners)? For that we refer to tables such as table 1 also for the years 2003 to 2006 calculating for each supply portfolio (row vector) the correspondent inequalities and risk measures. The evolution of risk values of the whole economic trade system during 2003-2007 has diminished from 4.43 to 2.20 documenting the increased globalization degree (figure 2).

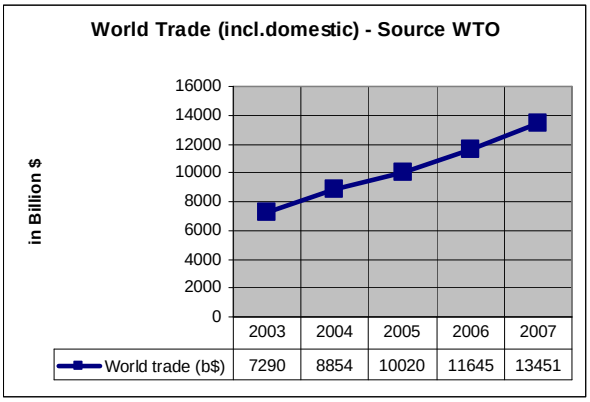

Figure 1: Evolution of world trade 2003-07

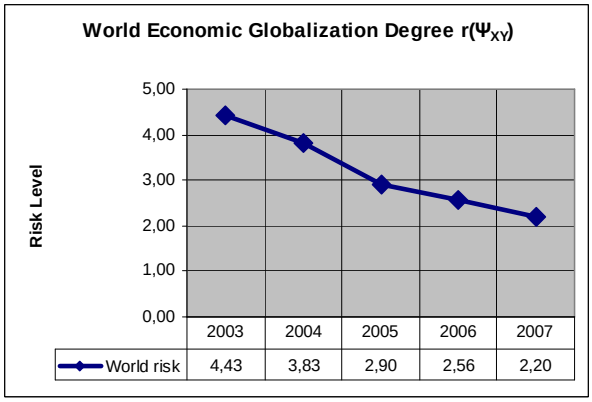

Figure 2: The economic system is globalizing

Furthermore, analyzing the evolution of supply risk (exports) of the different geographic regions (table 2 and figure 3), we notice that the risk level, i.e. the globalization degree, has evolved differently in the different economic regions, despite all geographic regions having steadily increased their trade volume during the period under consideration (compare trade tables of appendix 1). Interesting is, until 2006 Europe with 0.24 was the most globalized region (lowest risk level), only in 2007 being surpassed by the Asian economic region with 0.23 although the European trade figure with 5705 b$ in 2007 is higher than this of Asia with 3774 b$. The Asian economic region has shown between 2003 and 2007 a steadily diminishing risk level (from 0.34 to 0.23) documenting the steadily increasing interweavement of Asian economics with other economic regions, whereas Europe has slightly increased the risk level (from 0.21 to 0.24) not enlarging proportionally the trade network beyond Europe. One reason is the concentration on the Eastern European countries (pertaining to the domestic market). Indeed, the inequality ψ_{XX} of the domestic market has increased from 1.64 in 2003 up to 1.69 until 2006 (compare trade tables of appendix 1) and remaining stable at 1.68 in 2007. The same is also valid for the North American region having increased inequality in the home market from 2.59 to 2.74. In 2003 the CIS region had a supply risk value of 16.16 remaining until 2005 the economic region less globalized. The very fast internationalization of the CIS countries brought the consequence that in 2006 and 2007 South and Central America became the less globalized economic regions.

$r(\Psi_{XY})$	2003	2004	2005	2006	2007	cagr(03-07)
North America	**0,71**	**0,75**	**0,73**	**0,72**	**0,79**	3%
CS America	**9,15**	**9,30**	**8,02**	**7,52**	**6,15**	-9%
Europe	**0,21**	**0,22**	**0,23**	**0,24**	**0,24**	3%
CIS	**16,16**	**12,66**	**8,39**	**6,43**	**5,29**	-24%
Africa	**2,64**	**1,95**	**1,42**	**1,29**	**1,24**	-17%
Middle East	**1,77**	**1,60**	**1,24**	**1,44**	**1,50**	-4%
Asia	**0,34**	**0,31**	**0,28**	**0,25**	**0,23**	-9%
World risk	**4,43**	**3,83**	**2,90**	**2,56**	**2,20**	-16%
World trade (b$)	7290	8854	10020	11645	13451	17%

Table 2: Evolution of supply (export) risk measures during 2003-2007 for macro economic regions

Moreover, it is interesting to observe that all emerging geographic regions have reduced their risk profile with CAGR of -24% to -9% between 2003 and 2007 (table 2), whereas the two main advanced economic regions, namely Europe and North America, have increased it (CAGR +3%), thus they have becoming less globalized regarding trade. The reason, why advanced economies are focussing on their present economic relationships, might be due to the fact that, their product portfolio is composed of rather specific goods, sold to specific regions where yielding a higher profit and a specific growing demand exists (hypothesis to be confirmed). This is the evidence that also in economics entropy alone (attaining minimum portfolio risk) might not be the sole governing law but, according to thermodynamic free enthalpy, also the potential profit generation is a cardinal law, as seems to be obvious. The governing principle describing the essence of human rational is therefore maximizing value net of risk (see [1] for further details). The economic entropy, i.e. the risk measure, is a valid and most suitable genotypic indicator to measure the globalization extension of an economy or of the whole economic system related to an attribute. Interesting will be to see the globalization evolution during the present crisis.

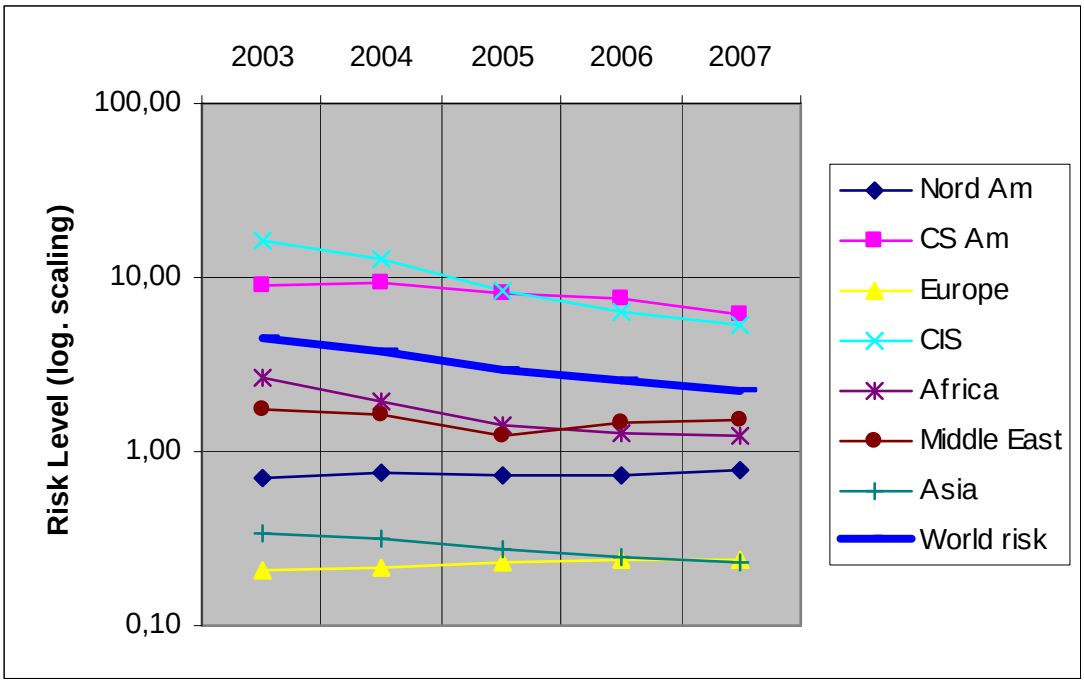

Figure 3: Graphical comparison of evolution of regional risk levels according to table 2

Conclusions

The entropy-based inequality risk metric has been proven to be a suitable indicator to measure the interweavement of an economic trade system. It shows that the world economic trade system between 2003 and 2007 has increased its global interweavement. Nevertheless, the macro-geographic world regions have performed differently: stagnant economic globalization for North America, Europe and Middle East, increasing globalization for the other regions.

Acknowledgement

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References

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Appendix 1: Trade Tables 2003-2006

Network of world merchandise trade by region (source: WTO International Trade Statistics)

2003	North Am	SC Am	Europe	CIS	Africa	Middle E	Asia		
t_{XY}	A	B	C	D	E	F	G	Supply	p_X
A	**653,45**	**60,09**	**191,01**	**4,06**	**11,94**	**20,68**	**221,44**	1162,67	0,16
B	**75,62**	**49,55**	**46,39**	**2,83**	**4,84**	**4,16**	**28,48**	211,87	0,03
C	**323,12**	**42,43**	**2500,25**	**64,82**	**82,26**	**84,74**	**253,41**	3351,03	0,46
D	**12,30**	**4,58**	**97,70**	**39,78**	**2,63**	**6,52**	**27,04**	190,55	0,03
E	**31,55**	**4,28**	**84,63**	**0,58**	**19,79**	**2,98**	**27,88**	171,69	0,02
F	**42,46**	**2,04**	**48,46**	**1,82**	**8,98**	**33,94**	**149,06**	286,76	0,04
G	**446,35**	**27,77**	**345,57**	**17,36**	**31,61**	**60,28**	**986,83**	1915,77	0,26
Demand	1584,85	190,74	3314,01	131,25	162,05	213,30	1694,14	7290,34	1,00
p_Y	0,22	0,03	0,45	0,02	0,02	0,03	0,23	1,00	

$p_{XY\infty}$	A	B	C	D	E	F	G	p_X
A	0,41	0,32	0,06	0,03	0,07	0,10	0,13	0,16
B	0,05	0,26	0,01	0,02	0,03	0,02	0,02	0,03
C	0,20	0,22	0,75	0,49	0,51	0,40	0,15	0,46
D	0,01	0,02	0,03	0,30	0,02	0,03	0,02	0,03
E	0,02	0,02	0,03	0,00	0,12	0,01	0,02	0,02
F	0,03	0,01	0,01	0,01	0,06	0,16	0,09	0,04
G	0,28	0,15	0,10	0,13	0,20	0,28	0,58	0,26
	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00

Ψ_{XY}	A	B	C	D	E	F	G	$r_X(\Psi_{XY})$
A	2,59	1,98	0,36	0,19	0,46	0,61	0,82	**0,71**
B	1,64	8,94	0,48	0,74	1,03	0,67	0,58	**9,15**
C	0,44	0,48	1,64	1,07	1,10	0,86	0,33	**0,21**
D	0,30	0,92	1,13	11,60	0,62	1,17	0,61	**16,16**
E	0,85	0,95	1,08	0,19	5,19	0,59	0,70	**2,64**
F	0,68	0,27	0,37	0,35	1,41	4,05	2,24	**1,77**
G	1,07	0,55	0,40	0,50	0,74	1,08	2,22	**0,34**
								4,43
$r_Y(\Psi_{XY})$	**0,55**	**9,28**	**0,27**	**16,33**	**2,60**	**1,39**	**0,56**	***4,43***	***$r(\Psi_{XY})$***

Network of world merchandise trade by region (source: WTO International Trade Statistics)

2004	North Am	SC Am	Europe	CIS	Africa	Middle E	Asia		
t_{XY}	A	B	C	D	E	F	G	Supply	p_X
A	**740,78**	**71,54**	**215,79**	**5,41**	**15,07**	**25,28**	**249,23**	1323,10	0,15
B	**93,30**	**67,86**	**58,97**	**3,54**	**7,26**	**5,11**	**38,01**	274,05	0,03
C	**367,72**	**50,91**	**2990,20**	**88,22**	**97,78**	**104,85**	**308,63**	4008,31	0,45
D	**15,54**	**4,79**	**137,45**	**55,13**	**3,66**	**9,13**	**35,27**	260,97	0,03
E	**42,72**	**6,82**	**100,78**	**0,74**	**22,95**	**3,93**	**40,54**	218,48	0,02
F	**54,57**	**2,91**	**63,73**	**2,18**	**12,46**	**43,74**	**198,26**	377,85	0,04
G	**535,19**	**38,86**	**434,15**	**25,31**	**44,38**	**74,94**	**1238,43**	2391,26	0,27
Demand	1849,82	243,69	4001,07	180,53	203,56	266,98	2108,37	8854,02	1,00
p_Y	0,21	0,03	0,45	0,02	0,02	0,03	0,24	1,00	

$p_{XY\infty}$	A	B	C	D	E	F	G	p_X
A	0,40	0,29	0,05	0,03	0,07	0,09	0,12	0,15
B	0,05	0,28	0,01	0,02	0,04	0,02	0,02	0,03
C	0,20	0,21	0,75	0,49	0,48	0,39	0,15	0,45
D	0,01	0,02	0,03	0,31	0,02	0,03	0,02	0,03
E	0,02	0,03	0,03	0,00	0,11	0,01	0,02	0,02
F	0,03	0,01	0,02	0,01	0,06	0,16	0,09	0,04
G	0,29	0,16	0,11	0,14	0,22	0,28	0,59	0,27
	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00

Ψ_{XY}	A	B	C	D	E	F	G	$r_X(\Psi_{XY})$
A	2,68	1,96	0,36	0,20	0,50	0,63	0,79	**0,75**
B	1,63	9,00	0,48	0,63	1,15	0,62	0,58	**9,30**
C	0,44	0,46	1,65	1,08	1,06	0,87	0,32	**0,22**
D	0,29	0,67	1,17	10,36	0,61	1,16	0,57	**12,66**
E	0,94	1,13	1,02	0,17	4,57	0,60	0,78	**1,95**
F	0,69	0,28	0,37	0,28	1,43	3,84	2,20	**1,60**
G	1,07	0,59	0,40	0,52	0,81	1,04	2,17	**0,31**
								3,83
$r_Y(\Psi_{XY})$	**0,59**	**9,43**	**0,27**	**12,83**	**1,91**	**1,22**	**0,53**	***3,83***	***$r(\Psi_{XY})$***

Network of world merchandise trade by region (source: WTO International Trade Statistics)

2005	North Am	SC Am	Europe	CIS	Africa	Middle E	Asia		
t_{XY}	A	B	C	D	E	F	G	Supply	p_X
A	**824,19**	**86,69**	**237,98**	**6,67**	**17,57**	**34,09**	**270,02**	1477,21	0,15
B	**117,93**	**86,23**	**67,67**	**5,76**	**9,57**	**6,42**	**47,53**	341,11	0,03
C	**397,81**	**58,41**	**3201,27**	**108,54**	**111,93**	**121,96**	**332,05**	4331,97	0,43
D	**19,32**	**6,83**	**178,08**	**61,66**	**4,93**	**10,63**	**40,02**	321,47	0,03
E	**60,22**	**8,22**	**127,80**	**0,92**	**26,49**	**5,12**	**48,59**	277,36	0,03
F	**66,27**	**3,12**	**86,87**	**3,10**	**15,46**	**54,17**	**280,79**	509,78	0,05
G	**607,53**	**51,47**	**498,48**	**36,91**	**54,13**	**88,97**	**1423,94**	2761,43	0,28
Demand	2093,27	300,97	4398,15	223,56	240,08	321,36	2442,94	10020,33	1,00
p_Y	0,21	0,03	0,44	0,02	0,02	0,03	0,24	1,00	

$p_{XY\infty}$	A	B	C	D	E	F	G	p_X
A	0,39	0,29	0,05	0,03	0,07	0,11	0,11	0,15
B	0,06	0,29	0,02	0,03	0,04	0,02	0,02	0,03
C	0,19	0,19	0,73	0,49	0,47	0,38	0,14	0,43
D	0,01	0,02	0,04	0,28	0,02	0,03	0,02	0,03
E	0,03	0,03	0,03	0,00	0,11	0,02	0,02	0,03
F	0,03	0,01	0,02	0,01	0,06	0,17	0,11	0,05
G	0,29	0,17	0,11	0,17	0,23	0,28	0,58	0,28
	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00

Ψ_{XY}	A	B	C	D	E	F	G	$r_X(\Psi_{XY})$
A	2,67	1,95	0,37	0,20	0,50	0,72	0,75	**0,73**
B	1,65	8,42	0,45	0,76	1,17	0,59	0,57	**8,02**
C	0,44	0,45	1,68	1,12	1,08	0,88	0,31	**0,23**
D	0,29	0,71	1,26	8,60	0,64	1,03	0,51	**8,39**
E	1,04	0,99	1,05	0,15	3,99	0,58	0,72	**1,42**
F	0,62	0,20	0,39	0,27	1,27	3,31	2,26	**1,24**
G	1,05	0,62	0,41	0,60	0,82	1,00	2,12	**0,28**
								2,90
$r_Y(\Psi_{XY})$	**0,60**	**8,15**	**0,28**	**8,55**	**1,35**	**0,83**	**0,55**	***2,90***	***$r(\Psi_{XY})$***

Network of world merchandise trade by region (source: WTO International Trade Statistics)

2006	North Am	SC Am	Europe	CIS	Africa	Middle E	Asia		
t_{XY}	A	B	C	D	E	F	G	Supply	p_X
A	**905,30**	**107,30**	**279,30**	**8,30**	**21,70**	**42,10**	**314,10**	1678,10	0,14
B	**135,00**	**111,50**	**86,40**	**6,10**	**11,30**	**7,90**	**61,80**	420,00	0,04
C	**430,30**	**66,60**	**3651,50**	**141,60**	**120,20**	**128,90**	**366,40**	4905,50	0,42
D	**24,20**	**7,60**	**246,50**	**80,30**	**5,70**	**13,30**	**45,60**	423,20	0,04
E	**79,80**	**11,30**	**148,10**	**1,40**	**32,80**	**6,30**	**72,60**	352,30	0,03
F	**72,30**	**4,40**	**102,80**	**3,00**	**20,90**	**71,60**	**339,60**	614,60	0,05
G	**708,30**	**69,50**	**603,80**	**49,70**	**69,90**	**111,40**	**1638,50**	3251,10	0,28
Demand	2355,20	378,20	5118,40	290,40	282,50	381,50	2838,60	11644,80	1,00
p_Y	0,20	0,03	0,44	0,02	0,02	0,03	0,24	1,00	

$p_{XY\infty}$	A	B	C	D	E	F	G	p_X
A	0,38	0,28	0,05	0,03	0,08	0,11	0,11	0,14
B	0,06	0,29	0,02	0,02	0,04	0,02	0,02	0,04
C	0,18	0,18	0,71	0,49	0,43	0,34	0,13	0,42
D	0,01	0,02	0,05	0,28	0,02	0,03	0,02	0,04
E	0,03	0,03	0,03	0,00	0,12	0,02	0,03	0,03
F	0,03	0,01	0,02	0,01	0,07	0,19	0,12	0,05
G	0,30	0,18	0,12	0,17	0,25	0,29	0,58	0,28
	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00

Ψ_{XY}	A	B	C	D	E	F	G	$r_X(\Psi_{XY})$
A	2,67	1,97	0,38	0,20	0,53	0,77	0,77	**0,72**
B	1,59	8,17	0,47	0,58	1,11	0,57	0,60	**7,52**
C	0,43	0,42	1,69	1,16	1,01	0,80	0,31	**0,24**
D	0,28	0,55	1,33	7,61	0,56	0,96	0,44	**6,43**
E	1,12	0,99	0,96	0,16	3,84	0,55	0,85	**1,29**
F	0,58	0,22	0,38	0,20	1,40	3,56	2,27	**1,44**
G	1,08	0,66	0,42	0,61	0,89	1,05	2,07	**0,25**
								2,56
$r_Y(\Psi_{XY})$	**0,59**	**7,67**	**0,28**	**6,57**	**1,24**	**1,00**	**0,54**	***2,56***	***$r(\Psi_{XY})$***

Appendix 2: The mathematics to compute globalization

Let us define

$$\psi_{XY} = \frac{p_{XY}}{p_X}$$

where ψ_{XY} is a measure of inequality or diversity of a subsystem ($X \cap Y$) compared to the system X where $p_{XY}>0$ and $p_X>0$ is the attribute (market shares in our case). Further, let us define the risk function of a single element,

$$r_{XY} = (\psi_{XY} - 1)^2 = \left(\frac{p_{XY}}{p_X} - 1 \right)^2$$

interpreted as inequality of a characteristic $\psi_{XY}=p_{XY}/p_X$ within a system compared to the riskless state $\psi_{XY}=1$ of the system. Let us define the following world supply/demand or origin/destination matrix of trade for a product α

$$T^{\alpha} = \begin{bmatrix} t^{\alpha}_{AA} & t^{\alpha}_{AB} & \dots & t^{\alpha}_{AZ} \\ t^{\alpha}_{BA} & t^{\alpha}_{BB} & \dots & t^{\alpha}_{BZ} \\ \dots & \dots & \dots & \dots \\ t^{\alpha}_{ZA} & t^{\alpha}_{ZB} & \dots & t^{\alpha}_{ZZ} \end{bmatrix} = \left[t^{\alpha}_{XY} \right]$$

The trade flows are represented by the quadratic matrix T^{α} where each element t_{XY} denotes the physical quantity of the product α exported from the country of origin X to the country of destination Y. The corresponding inequality matrix ψ^{α} for the trade matrix T^{α} is

$$\psi^{\alpha}_{\infty} = \begin{bmatrix} \psi^{\alpha}_{AA} & \psi^{\alpha}_{AB} & \dots & \psi^{\alpha}_{AZ} \\ \psi^{\alpha}_{BA} & \psi^{\alpha}_{BB} & \dots & \psi^{\alpha}_{BZ} \\ \dots & \dots & \dots & \dots \\ \psi^{\alpha}_{ZA} & \psi^{\alpha}_{ZB} & \dots & \psi^{\alpha}_{ZZ} \end{bmatrix} = \left[\psi^{\alpha}_{XY} \right]_{\infty}$$

Where each element of ψ^{α} is computed as

$$\psi^{S\alpha}_{XY\infty} = \frac{p_{XY\infty}}{p_X} = \frac{t^{\alpha}_{XY} \,/\, t^{\alpha}_{\bullet Y}}{t^{\alpha}_{X\bullet} \,/\, t^{\alpha}_{\bullet\bullet}} = \frac{t_{XY} \cdot t_{\bullet\bullet}}{t_{\bullet Y} \cdot t_{X\bullet}}$$

The elements $\psi_{XY}>0$ of the quadratic matrix ψ^{α} represent the market share diversity ratios of all supply economies X for a certain product α. The rows correspond to the inequality vectors ψ_X for the economies X.

$$\psi^{\alpha}_{X} = \left[\psi^{\alpha}_{XA}, \psi^{\alpha}_{XB}, \dots, \psi^{\alpha}_{XZ} \right]$$

The corresponding risk $r(\psi_X)$ of the portfolio of activities of economy X can be defined as

Risk of a Portfolio:

The risk $r_X(\psi_{XY})$ of a portfolio ψ_X of inequalities is the 2nd momentum of the elements belonging to the inequality vector relative to the attractor 1

$$r(\psi^{\alpha}_{X}) = \frac{\sum_{y=A}^{Z} (\psi^{\alpha}_{Xy} - 1)^2}{card(Z)}$$

where the value 1 means equality and card(Z) is the number n of elements from A to Z of the inequality row vector.

Extending the concept of risk from an economy X to all economies corresponding to the whole trade matrix T^{α} we can compute the risk of the economic system

$$r(\psi^{\alpha}_{\infty}) = \frac{\sum_{x=A}^{Z} r(\psi^{\alpha}_{x})}{card(Z)}$$

And generalizing for a competitive system with m competitors and n customers

$$r(\psi^{\alpha}) = \frac{\sum_{i=1}^{m} \sum_{j=1}^{n} (\psi^{\alpha}_{ij} - 1)^2}{m \cdot n}$$

The inverse value of risk defines the statistical entropy of the economic trade system. The same concepts can also be applied to type 2 globalization dealing with FDI (Foreign Direct Investments). It may also apply to which goods are produced (or demanded) by which country calculating the portfolio risk of goods composition regarding supply and demand of a political economy.