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The distance-based approach to the quantification of the world convergences and imbalances - comparisons across countries and factors

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Abstract

The paper presents a general empirical method of distance-based multifaceted systematic identifying of the positions of countries in relation to inequalities and imbalances. In order to understand the world economic relations in their entirety, we decided to analyze twelve most populous countries and eleven macroeconomic, environmental and demographic indicators relevant to them. Our analysis covering the period 1992-2008 attempts to identify core parts of the global economic system and countries that pose a potential risk of instability.

Keywords: global imbalances, convergences, distance-based methodology, complex dynamics, world economy

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1 Introduction

Just a few years ago, there were widespread expectations ((Ben-David, 1996, 2001; Cyrus, 2004)) that a gradual opening of the economies will result in higher intercountry convergence levels in the future. There is a wide spread opinion that the phenomenon of globalization and its implications for increasing interdependence promotes convergence trends in the world. The convergence has been econometrically tested by numerous researchers (Barro and Sala-i-Martin, 1992; Matos and Faustino, 2012; Tykhonenko, 2005) for many years. However, a little evidence has been found for the causal link between the trade liberalization and convergence (Slaughter, 2001). This paper shares the wide-spread anti-convergence view that liberalized trade will even deepen disparities among the countries. The new globalized world, accompanied by the constantly expanding international trade and increasing integration efforts is generally characterized by the high degree of international synchronization of the economic cycles (Artis and Okubo, 2011; Aguiar-Conraria et al., 2011; Allegret et al., 2011). With the progression of globalization, economies becoming increasingly interconnected and interacting as they could hardly exist independently. Due to multi-channel interactions between countries there is an ambiguity in determining a degree of convergence since the choice of factors/indicators compared. The intuition behind imbalances is that their initial phase is quite uncertain. The interactions are creating highly susceptible environment, where it is possible to expect that even tiny initial gap can sow the seed of future major imbalance and risk.

As the basis of a purely economic scope on the world imbalances may be regarded definition of the European Central Bank, which sees them as "*external positions of systemically important economies that reflect distortions or entail risks for the global economy*" (Bracke et al., 2008). Unfortunately, this rather general and somewhat vague definition does not provide direct quantification of characteristics of imbalances. But even if we rely only on an intuitive understanding arising from this definition, we can say that global imbalances represent perhaps the most serious and complex macroeconomic problem (Blanchard and Milesi-Ferretti, 2009) often discussed by the legislators, economists and policy makers. The main reasons why we think of imbalances as a complex system issues spring from the large number of the variables, which seem to be associated with imbalances: savings, investments, external debts, trade and current account imbalances, etc.. But it's not only the economy that's showing signs of imbalances. For example, the wide interest about the unbalanced population growth dates back to classical demographic research works of Malthus and Verhulst (1838) who disputed

about the physical limits and changeover slowing the population growth by the deteriorating environmental conditions. Undoubtedly, the scarcity of natural resources has feedback effects on the long-term progress of the world economy. Currently, the biggest key national economies are not harmonized regarding e.g. their population growth nor an exhaustion of the natural resources.

The structure of the world economy is continuosly changing towards extremely complex system of interconnected entities. In order to understand its nature, although in a very rough and elementary level, we have to deal with a large number of indicators for monitoring the overall situation. Therefore, much effort is needed to experiment with unconventional and innovative empirical ideas and heuristic approaches. In this regard, at least several perspective attempts to study the complex and interrelated economic issues should be mentioned.

The comprehensive long-term view on the world development respecting the population boost under the restricted resources has been presented by Ehrlich and Ehrlich (1990). Unfortunately, more on the narrative than quantitative level. Our study should be seen more in the light of empirical research, where there is interest in the intrinsic complexity. Possibly the most significant empirical effort in which the complexity framework is a center for research, represents the work by Hidalgo et al. (2009). The work focuses on the economic growth analyzed from the perspective of the complexity of the world network with linkages formed by the import and export business data. As another example we could mention the extensive study Hidalgo et al. (2007) dealing with the network techniques applied to evaluate the local comparative advantages of the countries.

Let us return again to the topic topic of imbalances. There is a commonly shared opinion about the origin of the increasing imbalances among countries, which can be explained as follows. According to the economic strategy in international trade and export orientation, two main categories of countries can be distinguished: those with deficits and those accumulating significant surpluses ("mercantilist" economies). Deficit or surplus trade balance, as a part of gross domestic product, directly influences economic growth and consequently economic policy strategy (Brunet and Guichard, 2011). Therefore, if a large emerging economies such as China continue their aggressive mercantilist strategy based on the steadily growing trade balance surpluses (Brunet and Guichard (2011)), the economic partners are facing the permanent accumulation of the trade balance deficits and larger budget deficits. In Gu et al. (2008) it is argued that China displays a high degree of global power and governance and its strategy have globally important consequences for many other actors. This introduces possibility that imbalances across countries

are widening and deepening. In Blanchard and Milesi-Ferretti (2009) it is pointed out that from 2005 till current economic crisis, the global economy is characterized by a an economic boom and international capital flows especially observed in the developed economies. Subsequently, this development has led to much wider gaps in the trade balances and current accounts worldwide. Do we really have so tough problem with existing global imbalances? If so, how we may cope with it ? The views are often diverse and controversial. Many economists (see e.g. Brunet and Guichard (2011); Blanchard and Milesi-Ferretti (2009)) consider imbalances as quite serious and most dangerous threat for the prosperous future. A different view appears in the works Cooper (2007); Popov (2010). The research here is concerned with the deficit and surplus imbalances among countries. In the paper Cooper (2007) it is discussed that current account deficit should not exclusively be perceived as negative for the local economy if it is caused by the expenditures on education, research and development and consumer durables. These three categories should be perceived rather than forms of savings, because they can create surpluses in the future. This is also the reason for the opinion of Popov (2010) that the intervention into economy is not necessary because the imbalances will tend to disappear spontaneously.

There is certainly no doubt that a coupling relationship exists among economic performance, demographic and social trends, and ecological processes. Therefore, in addition to our previous evaluating of current account deficits and accumulation of foreign reserves, we want to place more emphasis on ecological dimension of the problem. Relationships between ecological variables such as CO2 emissions and petrol or consumption has been known already since 1990s thanks to Grossman and Krueger (1991); Beckerman (1992) and others. Recent studies by Jobert et al (2010) treats CO2 emission convergence in the European Union. They used the Bayesian shrinkage estimation method in 22 European countries spanning the years 1971 to 2006. The results confirmed the hypothesis of absolute convergence of per capita CO2 emissions. The research revealed also correlations between the industrial sector in GDP and CO2 emissions. These findings partlially justify our focus on CO2 emissions data. In general, energy-related CO2 production and energy consumption as a potential global climate change factors can be rightly regarded as either causes or manifestations of imbalances.

The aim of this work is to find methods for assessing and interpretation of the multiple data sources. In the paper we consider models of mean distance which aim to monitor and quantify imbalances producing, converging or diverging world economic and contextual aspects. Our study examines eleven most populated countries and the EU15 referred as twelfth country in further sections. The mutual economic positions of the countries are treated

by means of mean distances depending on the eleven entire key macroeconomic indicators (we call factors in what follows) collected over the period from 1992 to 2008. After the formulation of the foundations of our intuitive distance-based methodology we will be focused on the specific tasks and corresponding interpretations. The basic specifics of our view is that it includes not only economic issues, but also concentrates on a holistic understanding of the potential systemic relations.

The paper is organized as it follows. In the section 2 we describe the sources and collection of data, in the section 3 we present the method based on the combination of the data rescaling and calculation of the distances between countries and factors. The supplementary methodological issues are discussed in the subsections 3.1 and 3.2 devoted to the concepts of diversity of distances, and respectively, temporal instability described by means of Lyapunov-type exponents. In section 5 the modified methodology is applied to groups of countries. The results of the investigation and interpretations are given in the section 4. Finally the conclusions are presented.

2 Data

The anual data covering period from 1992 to 2008 has been retrieved from the World Bank databases (World Bank (2012)). For the purpose of our research we analyzed 12 indicators (factors) in the highly populated countries Bangladesh (BAN), Brazil (BRA), China (CHI), India (IND), Indonesia (IDO), Japan (JAP), Mexico (MEX), Nigeria (NIG), Pakistan (PAK), Russia (RUS), United States of America (USA) and the European Union (EU15). The selection represents approximately 60% of the world's population in 2012. The indicators we focus on include: income (INC) carbon dioxide emissions (CO2), current account (CA), energy use (ENU), external debt (EXD), gross national income (GNI), investment (INV), domestic savings (SAV), population (POP), foreign exchange reserves including gold (FER) and oil production (OIL). We should mention that in some items the recorded data were incomplete. The situation has been partially corrected by exclusion of summations of the corresponding factors with proper normalization. These missing data does not exceed more than four percent of the whole dataset. Due to rescaling transformations, which precede calculation of distances between data sequences, in further considerations we will not pay attention to data units which are normally of interest.

3 Method description

The concept of distances is one of the most powerful and versatile tools to study the relative development of countries and factors without absolutizing them. The procedure we aim to utilize to find association relationships in the data may be roughly viewed as a distance-based approach (Zhang et al., 2009). But even though in our case, the analysis focuses attention to high-dimensional time series dataset. Consider the time dependent data matrix $\mathbf{X}$ of elements $X_{ik}(t)$ of $n \times m$ combing the information from the selected factor $k \in \{1, 2, \ldots, m\}$ corresponding to given country $i \in \{1, 2, \ldots, n\}$. As it has been mentioned in the previous section we study the system with $n = 12$, $m = 11$. Because the time dependences $X_{ik}(t)$ are of very different value (units), for the purpose of rescaling we used temporary standardization

$$\hat{X}_{ik}(t) \;=\; \frac{X_{ik}(t) - X_{\min,ik}(t)}{X_{\max,ik}(t) - X_{\min,ik}(t)}\,. \tag{1}$$

In this formula we use the instant (local) maximum and minimum values

$$X_{\max,ik}(t) \;=\; \max_{\tau \in W(t,T)} X_{ik}(\tau)\,, \tag{2}$$

$$X_{\min,ik}(t) \;=\; \min_{\tau \in W(t,T)} X_{ik}(\tau)\,, \tag{3}$$

which are to be recalculated for running time rectangular window defined as a set of observation times in chronological order

$$W(t,T) = \{\, t-T+1,\, t-T+2,\, \ldots, t-1, t \,\}\,. \tag{4}$$

The running window is of the extent T. Thus, in computational practice we are forced to find the best compromise between the more localized focus on the instant data values (small T) or desired statistical power (achieved for higher T). (Clearly, in such formulation, as the time passes, the windows may overlap.) Now because of imposed standardization (local rescaling), the units of X_{ik} become completely irrelevant. At any given t the pairwise properties of the system may be analyzed by means of the Minkowski-type distance

$$D_{ik,jl}(t) = \left[\frac{1}{T} \sum_{\tau \in W(t,T)} \left|\hat{X}_{ik}(t) - \hat{X}_{jl}(t)\right|^p\right]^{1/p}\,, \tag{5}$$

where p is the known index ($p \geq 1$). Because the four-dimensional tensorial form of $D_{ik,jl}(t)$ is too exhaustive for the direct interpretation we have to

perform several steps of the information reduction, e.g. by the summation over the identical factors k. The relations

$$D_{ij}^{\mathrm{cc}}(t) = \frac{1}{m}\sum_{k=1}^{m} D_{ik,jk}(t)\,, \qquad D_{kl}^{\mathrm{ff}}(t) = \frac{1}{n}\sum_{i=1}^{n} D_{ik,il}(t)\,. \tag{6}$$

define an inter-country and inter-factor pairwise mean distances, respectively. This information comprised in $n^2 + m^2$ matrix elements is then aggregated into vectors of n (or m) components

$$D_i^{\mathrm{c}}(t) = \frac{1}{n-1}\sum_{j=1,j\neq i}^{n} D_{ij}^{\mathrm{cc}}(t)\,, \qquad D_k^{\mathrm{f}}(t) = \frac{1}{m-1}\sum_{l=1,l\neq k}^{m} D_{kl}^{\mathrm{ff}}(t)\,. \tag{7}$$

The components are arithmetic mean distances belonging to country (D_i^{c}) or factor (D_k^{f}). Finally, in order to extract the prevailing "smoothed" world trends we propose

$$\overline{D}^{\mathrm{c}}(t) = \frac{1}{n}\sum_{l=1,l\neq k}^{m} D_{kl}^{\mathrm{c}}(t)\,, \qquad \overline{D}^{\mathrm{f}}(t) = \frac{1}{m}\sum_{l=1,l\neq k}^{m} D_{kl}^{\mathrm{f}}(t)\,. \tag{8}$$

However, more credibility can be given to the median description

$$\begin{aligned} D^{\mathrm{cmed}}(t) &= \mathrm{median}\,(D_{11}^{\mathrm{cc}}(t), D_{12}^{\mathrm{cc}}(t)), \ldots, D_{nn}^{\mathrm{cc}}(t))\,, \\ D^{\mathrm{fmed}}(t) &= \mathrm{median}\left(D_{11}^{\mathrm{ff}}(t), D_{12}^{\mathrm{ff}}(t)), \ldots, D_{mm}^{\mathrm{ff}}(t)\right)\,. \end{aligned} \tag{9}$$

A meaningful way to handle data transformed into the variables $D_{ij}^{\mathrm{cc}}(t)$, $D_{ij}^{\mathrm{ff}}(t)$, $\overline{D}^{\mathrm{c}}(t)$, $D^{\mathrm{cmed}}(t)$, $\overline{D}^{\mathrm{f}}(t)$, $D^{\mathrm{fmed}}(t)$ is built-in five-number summary boxplot we use in Fig.1. The hierarchy of above indicators provides a particular view on the different levels of distance coarsening.

In this paper we recognized also additional and very important forms of the classification/organization of the calculated outputs. One of the potential benefits of the single indexed D_i^{c} is that it allows sorting and consequent rating of the countries. When the mean distances are sorted $D_{i_1}^{\mathrm{c}}(t) < D_{i_2}^{\mathrm{c}} < \ldots < D_{i_n}^{\mathrm{c}}(t)$, they build an instant tuple of ranks $i_1(t), i_2(t), \ldots, i_n(t)$, where each country index $i_s \in 1, 2, \ldots, n,\ s \in \{1, 2, \ldots, n\}$). Obviously, using $D_{i_n}^{\mathrm{f}}(t)$, the analogous procedure is applicable to the factors. In the section 4 the economic significance and interpretation is attributed to this formal classification system.

3.1 The properties of the distribution of distances

To gain a comprehensive view of the data structure, the aforementioned generalized averages might not provide gathering of an adequate interpretation.

For example, the process when distance is going to be less dispersed around the central tendency, may indicate an overall level of clustering. Therefore, the methodology should be strengthened by providing the information about the distribution of distances $D_{ik,jl}(t)$ (see e.g.Burghouts et al., 2007). For further convenience of description we introduce the set of indices

$$I_{\mathrm{D}}(t) = \{\, (i,k,j,l);\;\; D_{ik,jl}(t) > 0 \,\}\,, \tag{10}$$

which simply excludes the zero distances from the calculations. It can be divided into the N_{D} data shells of the equal extent Δ_{D} and characterized by their actual cardinalities

$$\begin{aligned} C_r(t) \;\; = \;\; & \mathrm{card}\,\{\, (i,k,j,l)\,;\;\; (r-1)\,\Delta_{\mathrm{D}} < D_{ik,jl}(t) \le r\,\Delta_{\mathrm{D}}\,; \\ & i,j = 1,\ldots,n;\; k,l = 1,\ldots,m \,\}\;, \end{aligned} \tag{11}$$

where $r = 1,\ldots,N_{\mathrm{D}}$ and $\Delta_{\mathrm{D}} = D_{\max}/N_{\mathrm{D}}$, where $D_{\max}$ is a maximum of $D_{ik,jl}(t)$ from all the considered epochs. Thus, the instant probability of the fall of $D_{ik,jl}(t)$ into the bin s may be estimated as

$$\hat{\pi}_s(t) = \frac{C_s(t)}{\sum_{r=1}^{N_{\mathrm{D}}} C_r(t)}\,, \qquad s = 1,2,\ldots,N_{\mathrm{D}}\,. \tag{12}$$

Now the linkage to the Shannon index becomes straightforward

$$\mathrm{SH}(t) = -\frac{1}{\ln(N_{\mathrm{D}})} \sum_{s=1}^{N_{\mathrm{D}}} \hat{\pi}_s(t)\ln(\hat{\pi}_s(t))\,. \tag{13}$$

The Shanon index is normalized, i.e. ranges from zero to one; approaching unity means formation of uniform distribution and approaching zero means evaluation of the minimum of diversity of distances. Alternatively, the binning of distances is not required by the generalized entropy index (Ullah and Giles, 1998)

$$\mathrm{GE}(\alpha,\{D\},t) = \frac{1}{\alpha(\alpha-1)\mathrm{card}(I_{\mathrm{D}}(t))} \sum_{(i,k,j,l)\in I_{\mathrm{D}}(t)} \left[\left(\frac{D_{ik,jl}(t)}{\overline{D}(t)} \right)^{\alpha} - 1 \right]\,, \tag{14}$$

where α is the free parameter we vary. The index refers to the instant mean

$$\overline{D}(t) = \frac{1}{\mathrm{card}(I_{\mathrm{D}}(t))} \sum_{(i,k,j,l)\in I_{\mathrm{D}}(t)} D_{ik,jl}(t)\,. \tag{15}$$

Let us notice a general property: in the case $\alpha \to 1$ the GE index converts to the known Theil index $\mathrm{TH}(t)$ we use as an alternative for the quantification of the heterogeneity and redundancy of $D_{ik,jl}$ distances.

3.2 The Lyapunov-type measures; temporal neighborhood

The short-time stability of the relative positions of the elementary pairs of the system (countries plus their factors) may be quantified by the separation rate defined by the Lyapunov-type exponents

$$\lambda_{ik,jl}(t) = \ln\left(\frac{D_{ik,jl}(t+1)}{D_{ik,jl}(t)}\right) . \tag{16}$$

From the dynamical systems point of view, the two principal systemic aggregates may be defined. The positive

$$\lambda_{+}(t) = \frac{1}{\mathrm{card}(I_{\mathrm{D}}(t))} \sum_{\Lambda_{+}(t)} \lambda_{ik,jl}(t) \tag{17}$$

summing up the positive exponents, which have the meaning of the phase-space expansion.

The opposite side represents negative aggregate score

$$\lambda_{-}(t) = \frac{1}{\mathrm{card}(I_{\mathrm{D}}(t))} \sum_{\Lambda_{-}(t)} \lambda_{ik,jl}(t) . \tag{18}$$

It can be used to relieve symptoms of the instant convergence. The above formulas involve the summation running over the non-intersecting dynamic subsets of four-tuple indices

$$\begin{aligned} \Lambda_{+}(t) &= \{(i,k,j,l)\,;\ \lambda_{ik,jl}(t) > 0, \forall (i,k,j,l) \in I_{\mathrm{D}}(t)\} , \\ \Lambda_{-}(t) &= \{(i,k,j,l)\,;\ \lambda_{ik,jl}(t) < 0\,, \forall (i,k,j,l) \in I_{\mathrm{D}}(t)\} . \end{aligned} \tag{19}$$

4 The results and interpretation

Our actual interpretation of the results is strongly guided by the multiple comparisons of the similarities that exist or existed with the numerical analysis of data objects. In our work, it would be more accurate to speak of a bidirectional influencing between processed information on the one side, and its interpretation on the other side.

Looking at Tab.1, including ranking according to mean distances, three main zones may be identified. The first four positions may be considered as the core of the world economy, the last four are interpreted as *peripheral*. We can clearly observe that the *peripheral* zone of dissimilarity and outliers belongs to countries (factors) weakly coupled to the core. The intermediate

Table 1: The countries and factors sorted according to the mean distances $D_i^{\mathrm{c}}(t)$ and $D_k^{\mathrm{f}}(t)$; horizontal organization od the table: actual annual country with smallest $D_i^{\mathrm{c}}(t)$ is positioned at the most left position, whereas the most peripheral country acquires twelfth position ($n = 12$). Analogous ranking is available for factors. The data that serve the basis for the determination of ranks extracted from the World Bank databases (World Bank, 2012). Because $T = 5$ is the size of the time window from Eq.(4), the initial table entry is shifted forward to the year 1996.

ranking via D_i^{c}

year	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1996	CHI	IDO	BAN	USA	IND	PAK	BRA	JAP	EU15	NIG	MEX	RUS
1997	CHI	IDO	IND	BAN	USA	JAP	EU15	BRA	PAK	MEX	NIG	RUS
1998	EU15	IND	CHI	USA	PAK	BAN	JAP	BRA	IDO	NIG	MEX	RUS
1999	IND	PAK	BAN	USA	MEX	CHI	NIG	EU15	BRA	JAP	IDO	RUS
2000	IND	BAN	PAK	CHI	USA	BRA	MEX	EU15	NIG	JAP	IDO	RUS
2001	PAK	IND	CHI	BAN	BRA	MEX	EU15	USA	JAP	NIG	RUS	IDO
2002	IND	PAK	BAN	BRA	MEX	CHI	EU15	IDO	JAP	RUS	USA	NIG
2003	PAK	IND	CHI	BAN	BRA	MEX	EU15	JAP	IDO	RUS	USA	NIG
2004	IND	PAK	CHI	MEX	BRA	BAN	EU15	JAP	USA	IDO	RUS	NIG
2005	IND	MEX	CHI	PAK	BRA	USA	BAN	JAP	RUS	IDO	EU15	NIG
2006	MEX	CHI	IND	BAN	BRA	USA	PAK	JAP	RUS	IDO	EU15	NIG
2007	MEX	BRA	IND	CHI	PAK	BAN	IDO	USA	JAP	RUS	EU15	NIG
2008	MEX	IND	BRA	IDO	CHI	BAN	PAK	EU15	RUS	NIG	JAP	USA

ranking via D_i^{f}

year	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1996	GNI	ENU	POP	INC	CO2	INV	SAV	OIL	FER	EXD	CA
1997	GNI	POP	ENU	INC	INV	SAV	CO2	OIL	FER	CA	EXD
1998	POP	GNI	INC	ENU	SAV	INV	CO2	OIL	FER	CA	EXD
1999	GNI	INC	POP	ENU	SAV	INV	CO2	OIL	FER	EXD	CA
2000	GNI	INC	ENU	POP	INV	SAV	CO2	FER	OIL	EXD	CA
2001	GNI	ENU	INC	POP	INV	SAV	CO2	FER	OIL	EXD	CA
2002	GNI	ENU	POP	CO2	INC	SAV	INV	CA	FER	OIL	EXD
2003	GNI	ENU	POP	INC	CO2	SAV	FER	CA	INV	OIL	EXD
2004	GNI	INC	ENU	CO2	POP	SAV	FER	INV	OIL	CA	EXD
2005	GNI	INC	ENU	CO2	POP	SAV	INV	FER	OIL	CA	EXD
2006	GNI	INC	INV	SAV	ENU	POP	CO2	FER	OIL	CA	EXD
2007	GNI	INC	INV	SAV	ENU	POP	CO2	FER	OIL	CA	EXD
2008	GNI	INC	INV	ENU	SAV	POP	CO2	FER	OIL	CA	EXD

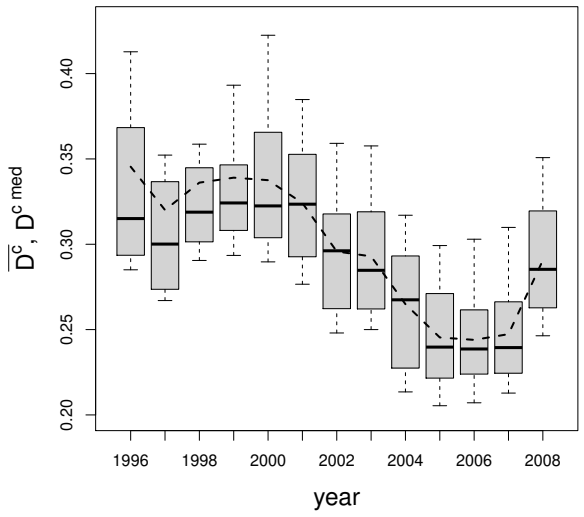
positions in the ranking located between core and periphery, will be called *neutral zone*. It should be noted that the content of zones does not remain static or stable over time. Clearly, the placement in the core (leftmost position in the table) represents the possession of the common features of the

entities compared, it may reflect the synergistic phenomena. Our empirical research has led us to conclude that a periphery can be viewed as a zone of the atypical, *less influential* or *unstable* entities of the global system. We hypothesize that country (or factor) is in accordance with major world coordinates if its mean distance is relatively small, whereas the outliers at large mean distances correspond to the global peripherals and possible sources of imbalances. This hypothetical interpretation of our distance-based categorization is tested by comparing with the main historical facts, policy decisions and high impact economy events. As we shall see in further, the methodology has noticeably good capability to capture, classify and find contexts of the global motions. There will be also an indication of the forecasting performance regarding the sources of the discrepancies and their locations.

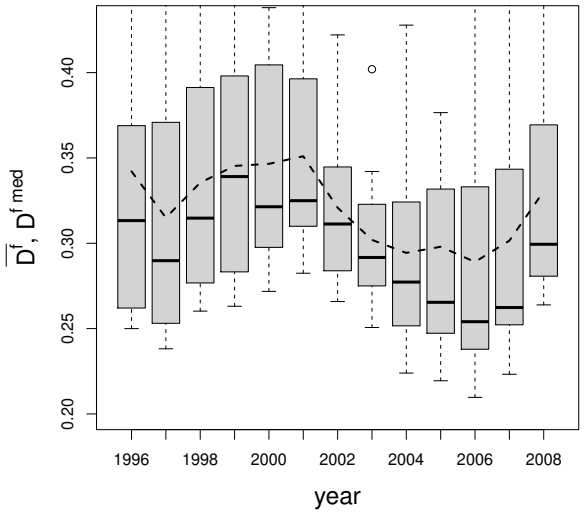
Analyzing the ranks of the particular countries we come to the following conclusions. Since 1996, the countries differed in terms of their ranking in the table. Some of them have not changed their position in general, but some have left the unstable periphery to settle in the core and vice versa.

The ranking on the basis of $D_k^{\mathrm{f}}(t)$ (see Tab.1) shows that external debt and current account as a main factor responsible for the magnifying of the global divergences. Oil production and foreign exchange reserves are also rather destabilizing elements in the global economy. We can conclude that income, gross national income, energy use and population growth are stabilizing core indicators. Further comparison of factors uncovered highest stability of gross national income, which is consistent with the idea of synchronization of the economic cycles. Fig.1 depicts the time evolution of $\overline{D}^{\mathrm{c}}(t)$, $\overline{D}^{\mathrm{f}}(t)$ and $D^{\mathrm{cmed}}(t)$, $D^{\mathrm{fmed}}(t)$ and calculated by means of Eq.(8) and Eq.(9) for $T = 5$ (and also $T = 4$) and $p = 1$ (with check for $p = 2$). Looking again at this figure we see that the period 1992-2005 can be characterized by the relatively strong convergence with respect to the arithmetic and generalized mean. The consecutive period between 2005 and 2007 seemed exhibit stabilization. However, radical turning point occurred in 2008, which corresponds to the U.S. financial crisis affecting the world economy. In the year mentioned, preceded next by Japan, the U.S. occupied the last position in the ranking given in Tab.1. In Tab.2, the neighborhood of the U.S.,Japan and the EU15 as well as an identified cluster of outliers consisting conclusively of all these countries is obvious. The supplementary view on the similarities offer dendrograms in Fig.2. The careful examination shows they are consistent with the ranking comprised in Tab.2.

Because the optimal number and structure of the admissible economic factors is not known a priory, (our intuitive choice is $m = 11$), to sustain our conclusions we tested whether the converging/diverging scenario also remains



(a)



(b)

Figure 1: The dashed lines represent mean calculated from Eq.(8). The median (horizontal line) belongs Eq.(9). The boxplot for countries is constructed by taking statistics on values D_{ij}^{cc}. Part (a) summarizes countries, part (b) includes factors. We see that grouping of inter-country distances provides a more pronounced and less noisy dependence than the same procedure applied to factors.

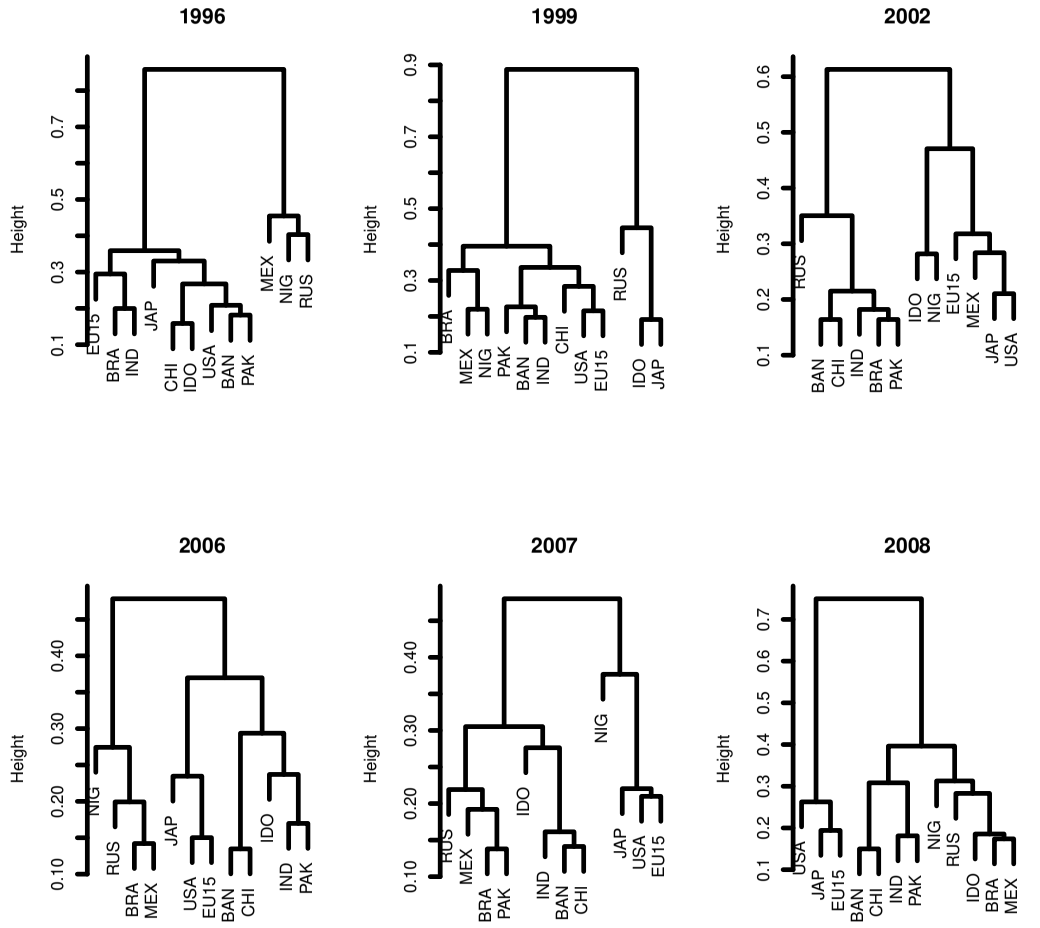


Figure 2: The dendrograms obtained via the Ward linkage method using the effective distance matrix $D_{kl}^{cc}(t)$ [defined by Eq.(6)] as input. See the neighborhood structure depicted in table 2 for the comparison.

Table 2: The monitoring of the variability of a country neighborhood consisting of the nearest neighbors (nn) and their next nearest neighbors (nnn). Calculated for special selection: CHI, USA, EU15 and RUS. The table is interpretable in the following way: e.g. in 1996 the development of China resembles the development of Indonesia and Bangladesh; the distance China and Indonesia is $D_{ij}^{cc} = 0.15$. In the same year (of course including the five years long time window) the (rescaled by the max and min values) the U.S. dynamics resembles the dynamics of Bangladesh ($D^{cc} = 0.18$; its (nnn) is Pakistan). Let us remark here that the neighborhood of China exhibits high persistence and permanence. The situation is consistent with dendrograms depicted in Fig.2.

	CHI			USA			EU15			RUS		
year	$D_{\rm nn}$	nn	nnn	$D_{\rm nn}$	nn	nnn	$D_{\rm nn}$	nn	nnn	$D_{\rm nn}$	nn	nnn
1996	0.15	IDO	BAN	0.18	BAN	PAK	0.21	IND	IDO	0.40	NIG	MEX
1997	0.15	IDO	EU15	0.17	BAN	JAP	0.17	CHI	IND	0.47	NIG	USA
1998	0.17	EU15	IND	0.19	EU15	BAN	0.17	CHI	USA	0.41	IDO	JAP
1999	0.23	EU15	BAN	0.20	BAN	EU15	0.21	CHI	RUS	0.37	IDO	JAP
2000	0.22	BAN	IND	0.19	EU15	BAN	0.19	USA	BAN	0.35	PAK	JAP
2001	0.21	BRA	BAN	0.20	EU15	MEX	0.21	USA	BAN	0.25	PAK	BRA
2002	0.16	BAN	BRA	0.21	JAP	EU15	0.22	BAN	IND	0.23	PAK	IND
2003	0.10	IND	PAK	0.19	JAP	MEX	0.25	JAP	IDO	0.26	PAK	MEX
2004	0.12	IND	BAN	0.18	JAP	PAK	0.25	JAP	IDO	0.23	CHI	MEX
2005	0.14	MEX	BAN	0.16	IND	IDO	0.19	USA	JAP	0.18	MEX	CHI
2006	0.13	BAN	MEX	0.15	IND	EU15	0.15	USA	JAP	0.16	MEX	CHI
2007	0.14	BAN	IND	0.20	IND	EU15	0.20	USA	JAP	0.17	BRA	MEX
2008	0.14	BAN	IND	0.22	EU15	JAP	0.19	JAP	USA	0.20	BRA	CHI

in the $m = 6$ dimensional system with the permuted factors (see Fig.3). The results for the mean distance $\overline{D}^{c}(t)$ are exhibiting sufficient level of the robustness, i.e. they are consistent with the general trend identified by the original higher-dimensional study. The part (b) of the figure involves a partial test of the parameter p ($p = 2$ for comparison) influence; and influence of $z-$score transform (instead of the use of Eq.(1) confirming the trends obtained by the previously selected $p = 1$. From Fig.2 and Tab.2 we can conclude that the position of Japan, the EU15 and the U.S. economies were widely spread in the cluster including a set of developing economies, while Mexico, Nigeria and Russia build up a cluster of outliers seemingly as a consequence of the crisis (Mexico 1994, Russia 1998) or the other overall economy problems (Nigeria). Later on, in the period 1999-2000 the outlier cluster consisted of Russia, Indonesia and Japan seemingly due to the Indonesia crisis in 1997. However, the inclusion of the developed countries (JAP, USA, EU15) into the world core cluster lasted until 1999. Later on, the differences start to appear. In 2002 the differences between the US and China indicators may be quantified by the relative distance 0.6. In 2006 the reduction of this distance

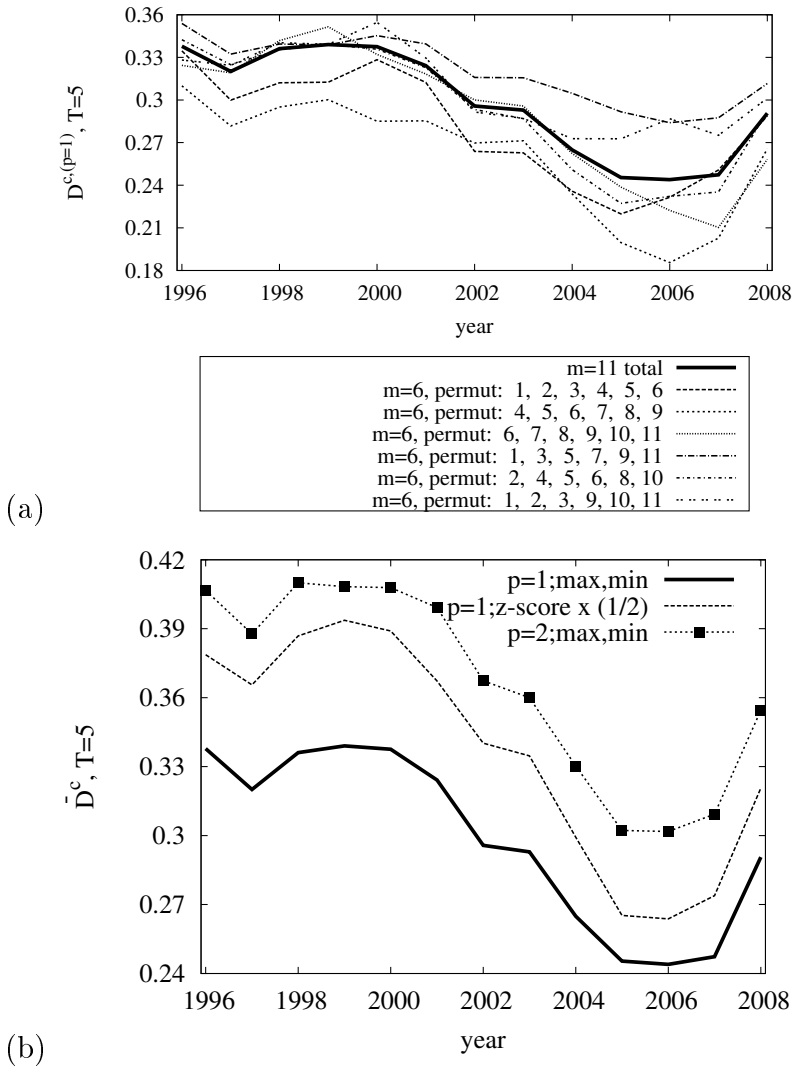


Figure 3: The testing of the robustness of the convergence/divergence scenario with respect to the selection of the factors [part(a)]. The results obtained using Eq.(8). Compared with alternative z-score (standard score) standardization [see part(b)], which replaces the rescaling by means of max, min interval values taken from the matrix $\mathbf{X}$ defined by Eq.(1). The plots demonstrate in part the robustness of the results to differences in data treatment.

occurs, which later turns into a divergence (in 2008 the mean distance 0.75 is attained). In this period the trends reported by the U.S. gets closer to the EU15 and also to Japan. In 2008 all the selected countries form two main clusters: one consisting of the U.S, Japan, the EU15 and another one formed by the remaining countries. These clusters much differ compared to those in 1996 when the new cluster consisting of Mexico, Nigeria, Russia is formed. It is worth noting that during the mentioned period the relative position of the U.S. has changed substantially. From Fig.2 (supplemented by Tab.1) we can clearly see that the U.S., Japan and the EU15 begin to recede from the core; the U.S. has moved from the fourth (in 1996) to the last - twelfth position (in 2008). The ranking on the basis of $D_k^{\mathrm{f}}(t)$ shows that external debt and current account are the main factors responsible for the growth of the global divergences. The comparison of the positions shows highest stability of GNI (or GDP) which is consistent with the idea of the economic cycle synchronization.

According to diversity measures depicted in Fig.5, the originally converging world begins the transition into a more unstable mode in the last period. The unwinding of the imbalances at 2006 become manifested by the increase in disorder indicated by the entropy (see Eqs.13), GE measure (see Eq.14) and Lyapunov-type exponents (see Eqs.(17,18)). The interrelated consistent behavior of the indicators confirms that inherent convergences/divergences are not only caused by a single country or its factor, but they pervade almost every aspect of the world economic activity. The additional facts should be kept in mind bringing together entropy and clustering concepts. Roughly speaking, the less bins are occupied in the approximate distribution functions of distances, the smaller the entropy is, and vice versa. It is thus intuitively reasonable to suppose that if an entropy is going down it is mainly due to mechanisms of clustering and prevailing systemic moves towards smaller distances. Such behavior is typical of the period 1999-2006.

Surprisingly, the Lyapunov-type empirical exponents may provide us with a very effective characterization of the system tendencies. In general, the local Lyapunov exponents (which resemble our definition) are the measures of the instantaneous predictability of the systems. As it is clear from Figs.4 the increase of the Lyapunov-type exponent says that initiation of divergences among countries began already near to 2001 or 2003, which is at least two - three years before identification by means of distance and entropy measures.

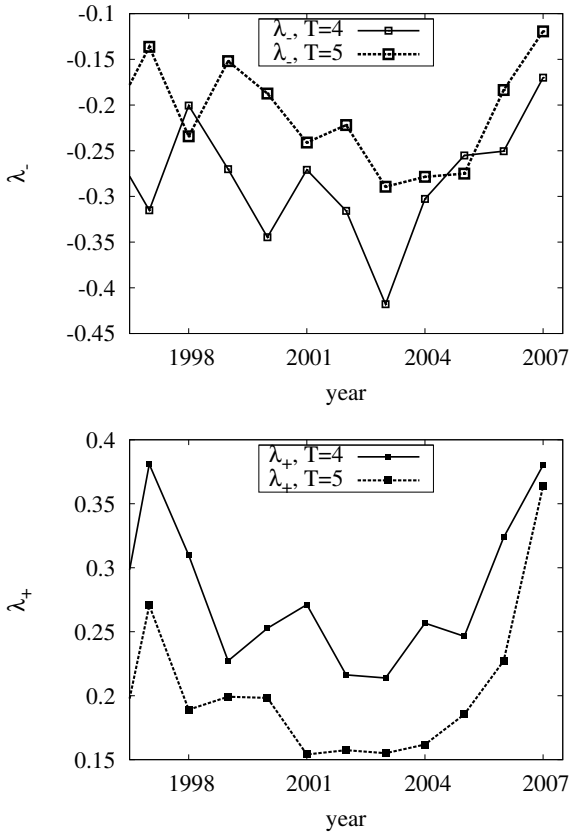


Figure 4: The Lyapunov-type exponents defined by Eq.(17) and Eq.(18). The role of the extent of the time window ($T = 4, 5$) is checked. The shorter the window, the more focused but volatile result. Both window settings ($T = 4, 5$) exhibit rather strong destabilization tendency in the annual period 2003/2004. It may be worth to mention that the inspection of the total arithmetic mean of $\lambda_{ik,jl}(t)$ contributions show growth from the negative (convergence) to the positive (divergence) in the period 2005-2006.

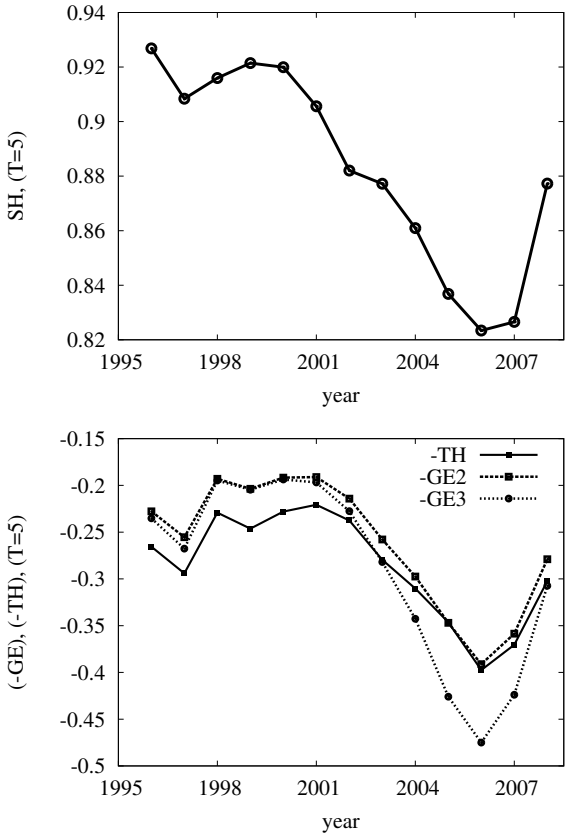


Figure 5: The time evolution of the Shannon index SH(t) as a measure of the diversity of distances calculated for $D_{\max} = 0.9018$, $N_{\rm D} = 10$. The probabilistic measure is consistent with the minus sign generalized entropy index (GE) [see Eq.(14)] and minus sign Theil index (TH). The minus sign is imposed due to obvious reasons. The maximum order (regularity of distribution of distances) belongs to the maximum and GE and TH; GE is calculated for parameters $\alpha = 2, 3$.

5 Analysis of the groups of countries

Until this point we have only placed emphasis on the distances of the countries that appear as elementary entities (except the EU15). The cluster analysis has, however, indicated that there is also the relevance of the groups of countries which exhibit similarity. Therefore, we extended our approach by starting to think about the mean distances of these groups or ranking of the factors which stem from the comparisons of mean distances. For the analysis of the factors belonging to the groups of countries with country indices contained in $\mathcal{G}$ we produced corresponding tables that capture the ranking done on the basis of the mean group distances

$$D_k^{\mathcal{G}\mathrm{f}} = \frac{1}{\mathrm{card}(\mathcal{G})\,(\,n - \mathrm{card}(\mathcal{G})\,)} \sum_{i\in\mathcal{G}}^{n} \sum_{j=1, j\notin\mathcal{G}}^{n} D_{ik,jk}\,, \tag{20}$$

where k runs over the factors. The results of such quantification are discussed in the following subsections.

5.1 Asian countries

According to Tab.1, four representatives of Asian countries (China, India, Pakistan and Bangladesh), with over 2.9 billion inhabitants are located in the core (similarity) zone of the ranking list in long-term. These countries are displayed as the table "neighbors" because of the very similar dynamic pattern of macroeconomic, environmental and demographic indicators. This finding is not so surprising, given that they are located in the near geographical area and serve as members of the various formal regional economic groupings. For example, the South Asian Association for Regional Cooperation (SAARC, 2012) includes the members such as India, Bangladesh and Pakistan and China as an observer. Because this group embodies a major economic power in Asia, it determines the prevailing trends in the evolving world. Gu et al. (2008) argued that China with outwardly oriented economic growth and high impacting strategies has become the primary engine of the global change.

According to Tab.3 capturing the ranking of factors within the Asian group, we conclude that current account and external debt are among most fragile items. Fig.6 indicates that the reason is a very rapid increase of Chinese current account surplus and its external debt exceeding the "world" average. Note here and in further discussions that the "world" average means the average calculated over the twelve countries studied. To avoid any potential ambiguity when referring to the results of our empirical study, we prefer

Table 3: Asian representatives, i.e. China, India, Bangladesh, Pakistan - the ranking of the factors according to the mean distance [see Eq.(20)].

1996	POP	GNI	ENU	INC	CO2	INV	FER	EXD	OIL	SAV	CA
1997	POP	GNI	ENU	INC	CO2	INV	SAV	EXD	OIL	FER	CA
1998	POP	GNI	ENU	INC	EXD	CO2	INV	OIL	SAV	FER	CA
1999	POP	ENU	INC	GNI	CO2	EXD	SAV	FER	INV	OIL	CA
2000	POP	ENU	GNI	INC	EXD	SAV	INV	CO2	FER	OIL	CA
2001	POP	ENU	GNI	INC	CO2	INV	FER	SAV	EXD	OIL	CA
2002	POP	GNI	INC	ENU	CO2	FER	CA	INV	SAV	OIL	EXD
2003	POP	GNI	INC	ENU	CO2	FER	SAV	CA	INV	OIL	EXD
2004	GNI	POP	INC	ENU	CO2	SAV	FER	INV	OIL	CA	EXD
2005	GNI	INC	POP	ENU	CO2	INV	SAV	FER	OIL	EXD	CA
2006	GNI	INC	INV	POP	ENU	SAV	CO2	FER	OIL	EXD	CA
2007	GNI	INC	INV	POP	SAV	ENU	FER	CO2	CA	OIL	EXD
2008	GNI	INC	POP	INV	FER	SAV	ENU	CO2	CA	OIL	EXD

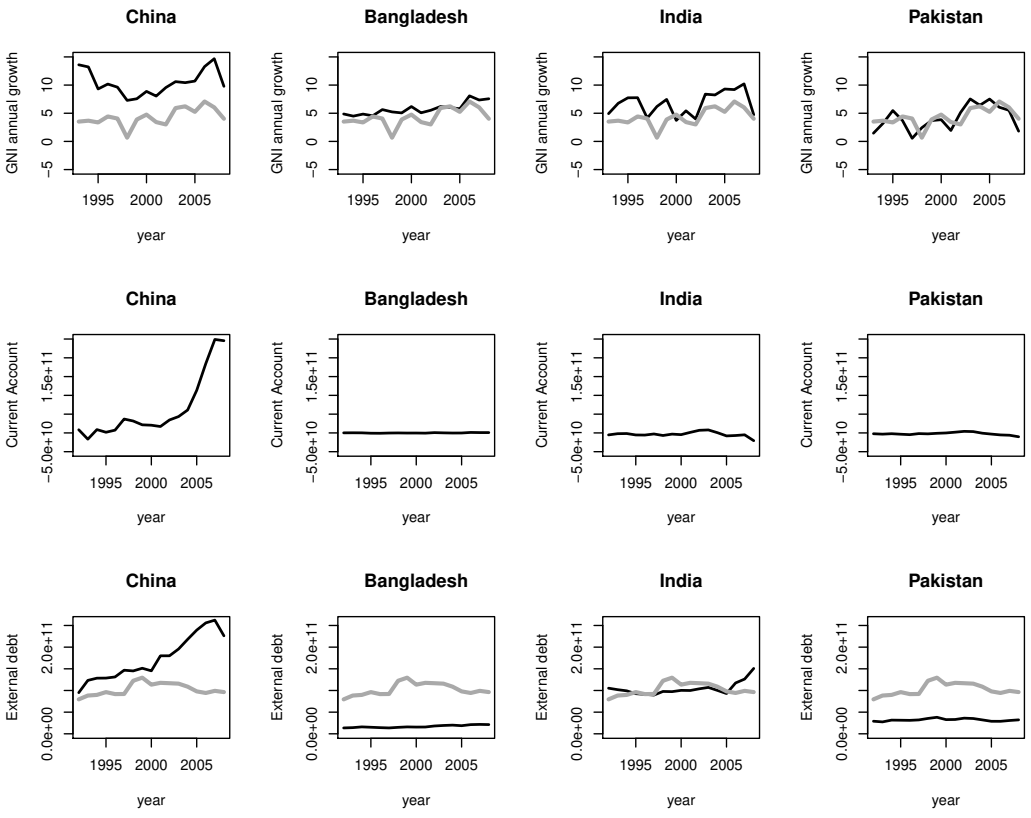


Figure 6: The parts of figure depicting time scenarios of factors in Asian countries. The gray line corresponds to the "world" average.

the term "world" that distinguishes it from the world's total. Specifics of Chinese policies have been analyzed by several authors. For example Brunet

and Guichard (2011) pointed out that Chinese mercantilist strategy destabilizes the entire world. This is justified by the undervaluation of domestic currency, very high trade surpluses, a massive accumulation of foreign reserves, and thereby gains due to rapid economic growth.

The outputs summarized in Tab.3 and Fig.6 confirm the well-known idea that gross national incomes are synchronized. Chinese annual growth of gross national income is higher than the average, because China is typical of its rapid growth. According to Holz (2008) its growth is likely to continue at current rates until 2015 before the gradual slowing. However, the gross national incomes of India and Bangladesh fluctuate slightly above the "world" average, while growth of Pakistan follows the global trends.

CO2 production of this group remains situated in the neutral zone from 1996 to 2006, but it began to move towards the periphery in the period 2007-2008 (see Tab.3). The rank of the energy use factor of Asian countries moved from the core to the intermediate neutral zone in 2002, while the rank of the oil production settled on the periphery throughout the whole period. China's position has been and continues to be specific. China is one of the world's leading oil producers (fourth place) and the second largest consumer of oil. On the contrary, India is not among the top ten oil producers, but it is the fourth largest oil consumer (the U.S. Energy Information Administration U.S. EIA (2011)). The oil production of Asian group is below the "world" average (see Fig.6), which means, it does not seem to meet group needs and probably will preclude further development.

5.2 Latin America

The situation in Latin America studied on the example of Brazil and Mexico is shown in Tab.4). The application of the methodology leads to classification according to which these countries undoubtedly move from the periphery to the core. Remember that these countries were less influential in the nineties. This truly corresponds to their positioning in the peripheral (dissimilarity) zone (see Tab.1). The proposed here distance-based ranking construction also reflects the currency crises and clearly indicates Mexican peso crisis in 1994 (Han et al., 2003). The Brazilian crisis in 1998-99 should be mentioned as well, where the negative impact of the currency crisis is evident.

Brazilian and Mexican gross national income follows the "world" average of this indicator (see Tab.4 and Fig.7). On the other hand, their current account, oil production, as well as external debt remains trapped in the peripheral zone. Brazilian and Mexican external debt is moving beyond the "world" average, especially during and after the currency crisis in the nineties (see Fig.7). The oil production of Brazil moved below the "world" average,

Table 4: Latin America. Brazil plus Mexico - the ranking of factors according to the mean distance [see also Eq.(20)].

1996	POP	ENU	GNI	CO2	INC	OIL	FER	INV	SAV	CA	EXD
1997	POP	ENU	GNI	INC	CO2	OIL	FER	INV	SAV	EXD	CA
1998	POP	GNI	INC	ENU	CO2	EXD	OIL	SAV	FER	INV	CA
1999	POP	ENU	GNI	INC	CO2	EXD	SAV	INV	FER	OIL	CA
2000	POP	GNI	ENU	INC	INV	EXD	SAV	CO2	FER	OIL	CA
2001	POP	GNI	ENU	INC	CO2	INV	SAV	FER	EXD	CA	OIL
2002	POP	GNI	ENU	INC	CO2	FER	CA	SAV	INV	EXD	OIL
2003	POP	GNI	INC	ENU	FER	CO2	SAV	CA	EXD	INV	OIL
2004	POP	GNI	INC	ENU	SAV	CO2	FER	INV	CA	EXD	OIL
2005	GNI	POP	INC	ENU	SAV	INV	CO2	FER	EXD	OIL	CA
2006	GNI	INC	POP	INV	ENU	SAV	CO2	EXD	FER	OIL	CA
2007	GNI	INC	POP	INV	SAV	ENU	FER	CO2	EXD	OIL	CA
2008	GNI	INC	POP	INV	FER	ENU	SAV	CO2	CA	EXD	OIL

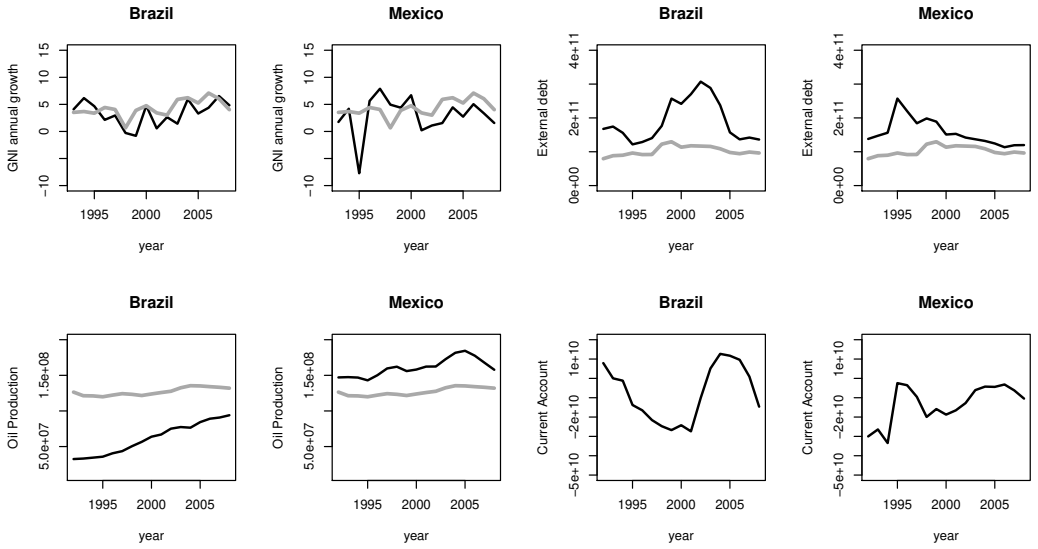


Figure 7: Brazil and Mexico, the dynamics of the factors. The gray line corresponds to the "world" average.

the Mexican production remains above the average, but both countries are gradually approaching the average (Fig.7). According to the U.S. EIA (2011), Brazil is the ninth largest oil producer and the sixth largest oil consumer, in summary, oil must be imported. On the contrary, Mexico is eight largest world oil producer and 11th oil consumer exporting the oil. The numerical analysis enqueues C02 production into the neutral zone almost during the total available dataset time. The rank of the factor of energy use moved from the core (similarity) to the neutral zone (see Tab.4). The ranking of the factors demonstrates that the positions of the and CO2 are relatively

stable compared to the changeovers in the U.S., Japan and the EU15 (see Tab.5).

5.3 The variability of the mean distances: United States, EU15 and Japan

In contrast, the United States shows the opposite trend (see Tab.1). According to the method used, their position is shifting from the core to the peripheral 12th place. It is a radical change towards destabilization. Visible milestone represents dot-com crisis in 2000. The peripheral position of the U.S. is best seen in 2008, when the latest crisis emerged.

By looking through the lens of our methodology, the course of the European Union 15 move appears to be similar to that of the U.S. However, the EU15 was in 12th place at the beginning of the period analyzed. It became a key player in 1998 (see Tab.1). In relation to the economic context, apparently due to culminations of the preparation of the European Monetary Union (the European Central Bank foundation in 1998 and the introduction of the cashless euro in 1999) and the total euro optimism. Nevertheless, the major impact of the EU15 was only a short run. This was followed by the relocation to the unstable peripheral zone mostly occupied by the less influential countries.

Table 5: USA, EU15, JAP - ranking of factors according to the mean distance. EXD absents in all three cases [see also Eq.(20)].

1996	POP	GNI	ENU	INC	CO2	FER	INV	SAV	CA	OIL
1997	POP	GNI	INC	ENU	CO2	INV	SAV	CA	FER	OIL
1998	POP	GNI	ENU	INC	CO2	SAV	INV	CA	FER	OIL
1999	POP	ENU	GNI	INC	CO2	SAV	INV	OIL	CA	FER
2000	POP	ENU	GNI	INC	INV	SAV	CO2	FER	CA	OIL
2001	POP	GNI	ENU	INC	INV	SAV	CA	FER	CO2	OIL
2002	POP	GNI	INC	ENU	FER	INV	CO2	SAV	CA	OIL
2003	POP	GNI	INC	ENU	CO2	FER	CA	INV	SAV	OIL
2004	GNI	POP	INC	CO2	ENU	FER	SAV	CA	INV	OIL
2005	GNI	INC	POP	ENU	CO2	INV	SAV	FER	CA	OIL
2006	GNI	INC	INV	SAV	POP	ENU	CO2	FER	CA	OIL
2007	GNI	INC	INV	POP	SAV	FER	ENU	CO2	CA	OIL
2008	GNI	INC	FER	POP	INV	SAV	CA	OIL	CO2	ENU

On the other hand, Japan as a major Indonesian business partner (the U.S. Energy Information Administration (U.S. EIA (2011)) stated that Japan is a major purchaser of Indonesian natural gas export) is moving from the neutral zone (intermediate) to the periphery (see Tab.1) and it seems that it transmitted the consequences of the Indonesian crisis in the nineties. Then Japan moved closer to the core (eight position), but it is moving into periph-

ery between 2007 and 2008 (10th and 11th position) and is situated next to the U.S.(see Fig.2). Encouragingly, the method outputs are in accordance with Cooper (2010) who stated that the bilateral relationship between the United States and Japan are continually important. As we know, these countries are highly interconnected via the trade in goods and services, but mainly via the capital flows (e.g. foreign private portfolio and direct investment).

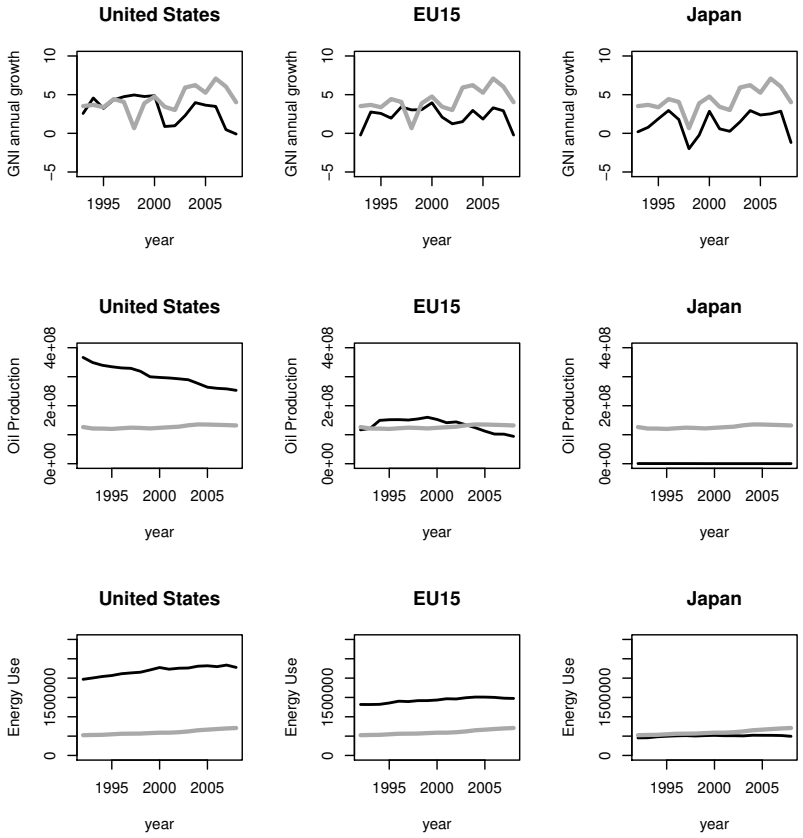


Figure 8: The U.S., the EU15 and Japan. The comparison of the dynamics of factors. The gray line corresponds to the "world" average.

Tab.5 supplemented by Fig.8 shows that countries follow the "world" average dynamics of GNI. However, the energy use and also CO2 emissions are located in the peripheral zone in recent years. Energy use moves from the zone core (in the period 1996 - 2001) into the periphery (2007 - 2008) as it is above the "world" average in the United States and the EU15. The oil production of these developed countries can be characterized as peripheral for almost the entire analyzed period (see Tab.5). According to the U.S. EIA (2011), from this group only the United States belongs among leading

world producers of oil (third position) (see Fig.8). The U.S. remains by far the largest user of oil, and the third position is occupied by Japan. Among the EU15 countries, Germany took eight position, France (13th position), United Kingdom (14th position), Italy (10th position). We summarize that oil production is not responding to oil demand (U.S. EIA, 2011) within this group (selected by clustering).

5.4 Other countries: Indonesia, Russia and Nigeria

Again, it seems that our approach is general enough as it reliably reproduces key features of the systems studied. It correctly reflects the unstable situation by the variable Indonesian rank (see Tab.1). Sudden changes correspond to the unprecedented currency crisis after 1997. We see that after being situated in the core until 1997, the Indonesia moved to the periphery. Tab.6 indicates that factors such as Indonesian current account, total foreign reserves and oil production are located in the peripheral zone. During the 1999-2001, adjusted net national income and gross national income moved into peripheral zone. The explanation can be found in a rapid decline in the GNI growth rate after Indonesian currency crisis (see Fig.9). However, GNI moved to the core and since 2002 it became consistent with the "world" average.

Table 6: Indonesia - ranking of factors maintained using the mean distance [see Eq.(20)].

1996	POP	ENU	GNI	INC	CO2	INV	SAV	FER	CA	EXD	OIL
1997	POP	GNI	INC	ENU	INV	SAV	CO2	CA	FER	OIL	EXD
1998	POP	ENU	EXD	GNI	CO2	INC	OIL	SAV	FER	INV	CA
1999	POP	ENU	EXD	CO2	FER	OIL	CA	SAV	INV	GNI	INC
2000	POP	ENU	EXD	FER	CO2	OIL	SAV	INV	CA	GNI	INC
2001	POP	ENU	CO2	EXD	SAV	INV	FER	OIL	GNI	CA	INC
2002	POP	ENU	GNI	CO2	INV	SAV	INC	EXD	CA	FER	OIL
2003	POP	GNI	ENU	CO2	SAV	INV	INC	EXD	OIL	CA	FER
2004	POP	GNI	ENU	INC	CO2	INV	SAV	EXD	OIL	CA	FER
2005	POP	GNI	ENU	INC	CO2	INV	SAV	EXD	OIL	CA	FER
2006	POP	GNI	ENU	INC	INV	SAV	CO2	EXD	CA	OIL	FER
2007	GNI	INC	POP	INV	ENU	CO2	SAV	FER	EXD	OIL	CA
2008	GNI	INC	POP	INV	ENU	SAV	FER	CO2	CA	OIL	EXD

Apparently, Russia is another country on the list seriously affected by the currency crisis in 1998. It still suffers from an extraordinary transition process. However, the role of Russia in the international economy should not be underestimated at all. The classification used in Tab.1 indicates that Russia is slowly leaving the periphery and its impact is strengthening after 2001. The GNI factor of Russia stands at the core of factors, with the exception of the period 1996-1999, when its GNI has fallen below "world" average.

Table 7: Russia's ranking of factors according to the mean distance [see Eq.(20)].

1996	EXD	FER	OIL	CA	INV	SAV	POP	CO2	INC	GNI	ENU
1997	EXD	FER	CA	SAV	OIL	INV	CO2	ENU	GNI	POP	INC
1998	EXD	OIL	FER	CA	INV	SAV	CO2	GNI	INC	ENU	POP
1999	EXD	INC	FER	OIL	SAV	CA	GNI	INV	CO2	POP	ENU
2000	EXD	GNI	SAV	ENU	INC	FER	INV	CO2	OIL	CA	POP
2001	ENU	GNI	SAV	INC	EXD	INV	CO2	FER	OIL	CA	POP
2002	GNI	INC	ENU	CO2	INV	FER	SAV	EXD	OIL	CA	POP
2003	GNI	ENU	INC	FER	CO2	SAV	INV	OIL	EXD	CA	POP
2004	GNI	INC	ENU	CO2	SAV	FER	INV	OIL	EXD	CA	POP
2005	GNI	INC	SAV	CO2	ENU	INV	FER	OIL	EXD	CA	POP
2006	GNI	INV	SAV	INC	ENU	CO2	FER	EXD	OIL	CA	POP
2007	GNI	INC	SAV	INV	FER	ENU	CO2	EXD	OIL	CA	POP
2008	GNI	INV	FER	INC	ENU	SAV	CO2	EXD	CA	OIL	POP

Table 8: Nigeria - ranking of factors according to mean distance. Because the data for factors INV, SAV are not available, they were also excluded from considerations [see Eq.(20)].

1996	POP	GNI	ENU	FER	EXD	INC	OIL	CA	CO2
1997	POP	GNI	INC	ENU	OIL	FER	EXD	CA	CO2
1998	POP	GNI	ENU	INC	FER	OIL	EXD	CA	CO2
1999	POP	GNI	ENU	INC	CO2	OIL	EXD	FER	CA
2000	POP	ENU	GNI	CO2	OIL	FER	EXD	CA	INC
2001	POP	ENU	GNI	CO2	OIL	EXD	CA	FER	INC
2002	POP	ENU	CO2	GNI	INC	CA	EXD	OIL	FER
2003	POP	ENU	GNI	INC	CO2	EXD	OIL	CA	FER
2004	GNI	POP	ENU	INC	CO2	OIL	EXD	CA	FER
2005	GNI	POP	ENU	INC	CO2	EXD	OIL	FER	CA
2006	GNI	POP	ENU	INC	FER	EXD	OIL	CO2	CA
2007	GNI	POP	INC	ENU	FER	EXD	OIL	CA	CO2
2008	GNI	INC	POP	FER	ENU	EXD	OIL	CA	CO2

Tab.7 tells us that the peripheral zone involves the population and current account factors. This agrees with the fact that the population of Russia is below the "world" average and is presently decreasing. The depopulation of Russia took interest of many authors (Anderson, 2002; Kohler and Kohler, 2002; Zagaitov and Yanovskii, 2007), who discuss the possible reasons for low birth and high death rates. The method yields result that Russian current account appears to be the peripheral factor (see Tab.7). It can be interpreted by the position of Russia as large current account surplus country that have achieved this status after the currency crisis (see Fig.9). The fact that oil production is also situated on the periphery of the table coincides with the uniqueness of Russia as the second largest oil producer (U.S. EIA, 2011).

By reason, Nigeria is ranked on the periphery of the table, it seems has no notable impact on the global development (Tab.1). It is among the poorest countries in the world (see Fig.9). Its population grew fairly rapidly due to

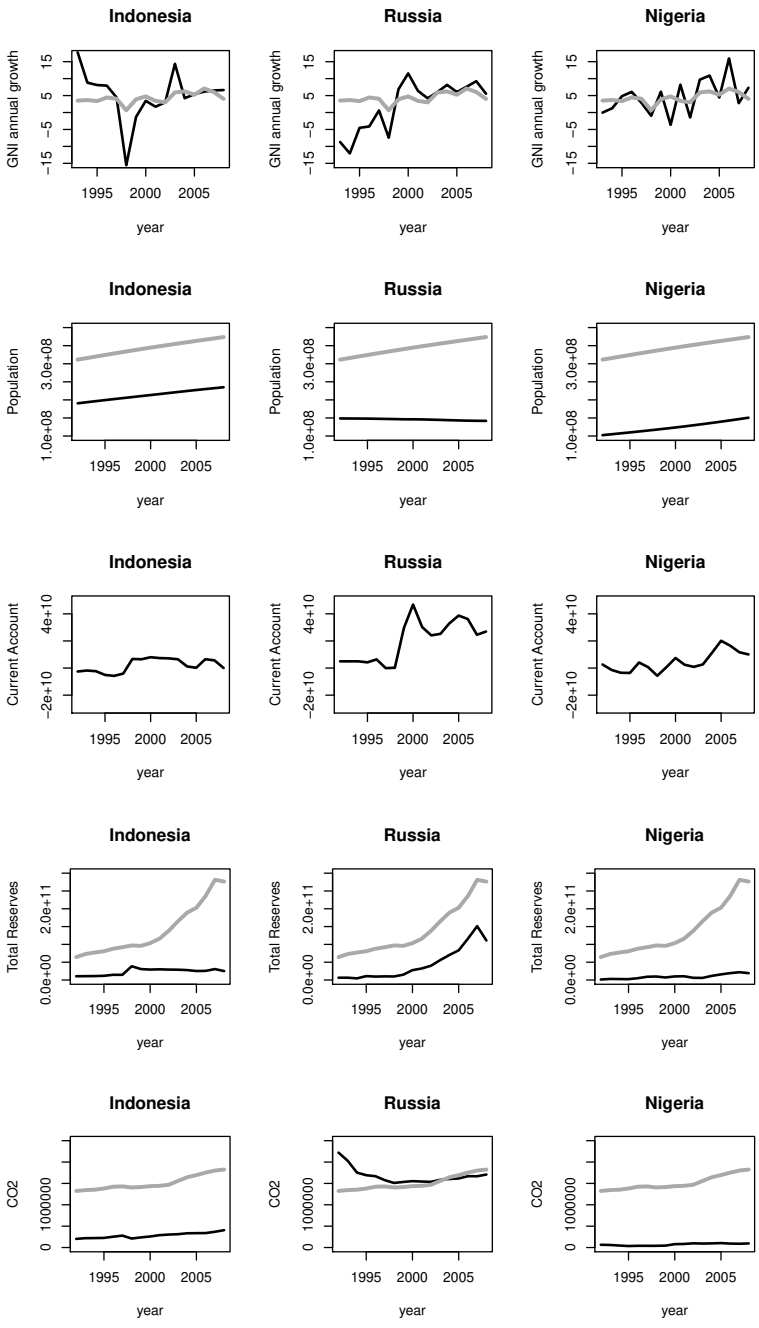


Figure 9: Indonesia, Russia and Nigeria.

development resulting from the economic reforms and rising oil prices (Oshikoya, 2008). As reported by the U.S. EIA (2011), Nigeria is the fifth largest

world oil exporter. Tab.8 shows that its current account, CO2 emissions and total foreign reserves are present in the peripheral zone. Note the consistency between this methodological output and Fig.9. Nigeria is developing country, which may explain why its CO2 emission occurs far below the "world" average.

5.5 The position of U.S., China and EU15

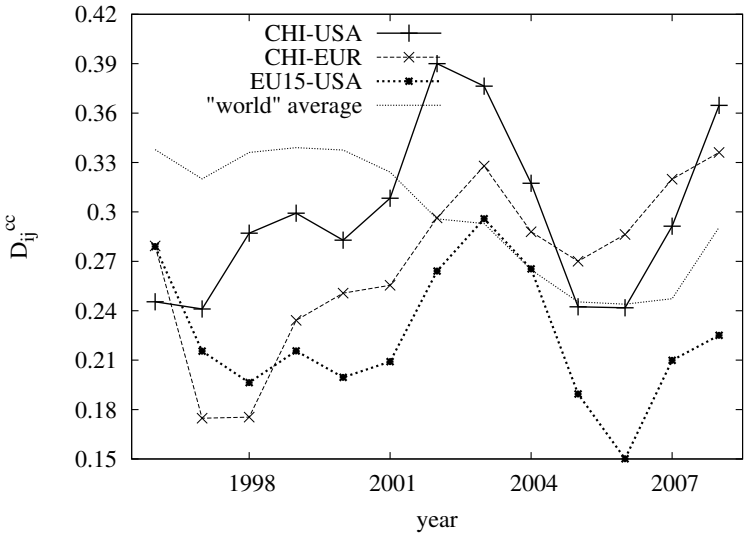


Figure 10: The dynamics of the mean distances China, the U.S., and the EU15. The typical divergence/convergence patterns has been found. The pairs are compared with the much less pronounced course of the "world" average.

As already noted in the introduction, there is a significant imbalance between China and the United States, which permanently attracts the attention of many economists. See for example the works Makin (2008), Brunet and Guichard (2011) or Cooper (2007). Above we exhibited rather promissing ability of the methodology discussed. Therefore, we do not want to miss an opportunity to recognize the often discussed relationship of these two countries. Our interest was also stimulated by Fig.2, which shows that the gap between China and the U.S. is growing, and at the end of the period studied, both countries belong to the remote clusters. Furthermore, the inspection of Tab.1 reveals that the ranks of these countries undergoe transitions between the core and periphery.

We already demonstrated, that the current account, external debt and total foreign reserves are among the main factors that are responsible for the increase of imbalances interlinked to the mean distances. This implies that the mean distance between China and the U.S. increased mainly due to the fact that China accumulated substantial current account surplus and increased volume of the foreign exchange reserves, while the U.S. current account deficit deepened. From Fig.10 we see that the mean distance between these two countries began to be more pronounced and more variable. It is rather interesting that the maximum corresponds to year 2001 when China joined the WTO (WTO, 2012) and the other Member States could no longer apply tariffs on Chinese products, but China has continued to implement monetary dumping and maintained its domestic currency undervalued. This strategy contributed to the creation of even larger trade surpluses, especially with the U.S.. Later, the inter-country distance fallen, but in 2007-2008, there was a relatively sharp increase of the distance between the factors. From Tab.1 we see that this movement may be attributed namely to the factors responsible for the imbalances. It relates to the situation with the China's current account, permanent increase of the surpluses, foreign reserves accumulation and U.S. debt.

The mean distance variability of the U.S. and China is much higher than the variability of the "world" average. Regarding two additional distances (used here for comparative purposes) depicted in Fig.10, we see that they differ in size but they show the shifted versions of the same pattern of movement. Again, the identification of U.S.- EU15 as nearest neighbors is consistent with Fig.2. We see that for a long time, the largest distance is between China and the U.S.. Later, the pair China - EU15 takes over this primacy. The end of the period studied is characterized by the rapid separation of China from U.S..

6 Conclusions

In the paper we demonstrate that distance-based comparative methodology is able to detect and quantify the key features of the highly complex global tendencies, mainly connected with the economic sphere, some of them previously seen as isolated facts. From a technical perspective, in future research, it would be useful to pay more attention to the systematic justification of the most relevant factors, different standardization approaches, types of data weighting with less weighted distant historical terms, and better justified choice of the metrics. By combining an information from the mean distance, distance diversity and temporal stability of distances, we are

led to the conviction that the world is still gradually getting into more imbalanced dynamic regime. Evaluations have revealed that our approach is quite effective way for narrowing the gap between qualitative and empirically derived understanding of the global imbalances. We believe that our method involves even larger potential to provide novel and interesting insights into the understanding of the complex relationship between economic, social and ecological phenomena. In the conclusion, it remains to respond to the most pressing scientific question: "What type of the systemic changes might move us toward better balanced and sustainable world"? We hope that our classification will be particularly useful in this respect, especially with regard to the location of the most striking and notable differences between countries and factors.

References

Aguiar-Conraria, L., Martins, M. M. F. & Soares, M. J. (2011). Synchronization of Economic Sentiment Cycles in the Euro Area: a time-frequency analysis, CEF. UP Working Paper 2011-05.

Allegret, J.-P., & Essaadi, E. (2011). Business cycles synchronization in East Asian economy: Evidences from time-varying coherence study. *Economic Modelling*, 28 (1-2), 351-365.

Anderson, B.A. (2002). Russia Faces Depopulation? Dynamics of Population Decline. *Population and Environment*, 23 (5), 437-464.

Artis, M., & Okubo, T. (2011). Does International Trade Really Lead to Business Cycle Synchronization? - A Panel Data Approach. *The Manchester School*, 79 (2), 318-332.

Barro, R., & Sala-i-Martin, X. (1992). Convergence. *Journal of Political Economy*, 100 (2), 223-251.

Beckerman, W. (1992). Economic growth and the environment: Whose growth? whose environment? *World Development*, 20 (4), 481-496.

Ben-David, D. (1996). Trade and convergence among countries. *Journal of International Economics*, 40 (3-4), 279-298.

Ben-David, D. (2001). Trade liberalization and income convergence: a comment. *Journal of International Economics*, 55 (1), 229-234.

Blanchard, O., & Milesi-Ferretti, G. M. Global Imbalances: In Midstream? *IMF Staff Position Note*, December 22/2009 SPN 09/29 [Cited 28.9.2011].

Bracke, T., Bussiére, M., Fidora, M.,& Straub, R. (2008). A Framework for assessing global imbalances, ECB, No.78/January, 1-51.

Brunet, A., & Guichard, J.-P. (2011). *La visée hégémonique de la Chine. L'impérialisme économique*. Paris, France: L'Harmattan.

Burghouts, G. J., Smeulders, A.W.M., & Geusebroek J.M. (2007). The Distribution Family of Similarity Distances, *Advances in Neural Information Processing Systems*, Vol. 20. `URL:http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.143.8581&rep=rep1&type=pdf`

Cooper, R. N., (2007). Living with global imbalances. *Brookings Papers on Economic Activity*, 38 (2), 91-110.

Cooper, W. H., (2010). U.S.-Japan Economic Relations: Significance, Prospects, and Policy Options. March 11, 2010. CRS Report for Congress Prepared for Members and Committees of Congress.

Cyrus T. (2004). Does convergence cause trade, or does trade cause convergence ? *The Journal of International Trade & Economic Development: An International and Comparative Review*, 13 (4), 143-170.

Ehrlich, P. R., & Ehrlich, A. E. (1990). *The Population Explosion*, London: Hutchinson.

Grossman, G. M., & Krueger, A.B. (1991). Environmental Impacts of a North American Free Trade Agreement. NBER Working Papers 3914

Gu, J., Humphrey, J., & Messner, D. (2008). Global Governance and Developing Countries: The Implications of the Rise of China. *World Development*, 36 (2), 274-292.

Han, K.C., Lee, S.H., & Suk, D.Y. (2003). Mexican peso crisis and its spillover effects to emerging market debt. *Emerging Markets Review*, 4 (3), 310-326.

Holz, C.A. (2008). China's Economic Growth 1978-2025: What We Know Today About China's Economic Growth Tomorrow. *World Development*, 36 (10), 1665-1691.

Hidalgo, C.A. & Hausmann, R. (2009). The building blocks of economic complexity. *PNAS*, 106 (26), 10570-10575.

Hidalgo C.A., Klinger B., Barabási A.-L., & Hausmann R. (2007). The Product Space Conditions the Development of Nations. *Science*, 317 (5837), 482-487. DOI: 10.1126/science.1144581

Jobert, T., Karanil, F., & Tykhonenko, A. (2010). Convergence of per capita carbon dioxide emissions in the EU: Legend or reality ? *Energy Economics*, 32 (6), 1364-1373.

Kohler, H.-P., & Kohler, I. (2002). Fertility Decline in Russia in the Early and Mid 1990s: The Role of Economic Uncertainty and Labour Market Crises. *European Journal of Population*, 18 (3), 233-262.

Makin, A. J. (2008). The Inflexible Yuan and Global Imbalances. *In Global Economy Journal*, 8 (3), 1-10.

Matos, P.V., & Faustino, H.C. (2012). Beta-convergence and sigma-convergence in corporate governance in Europe. *Economic Modelling*, 29 (6), 2198-2204.

Oshikoya, T.W. (2008). Nigeria in the global economy. *Business Economics*, 43 (1), 31-43.

Popov, V., (2010). Global Imbalances: an unconventional view. Munich Personal RePec Archive MPRA. Mai 2010. Number 28110. URL:http://mpra.ub.uni-muenchen.de/28110/

Slaughter, M. J. (2001). Trade liberalization and per capita income convergence: a difference-in-differences analysis. *Journal of International Economics*, 55 (1), 203-228.

South Asian Association for Regional Cooperation - SAARC (2012) URL: http://www.saarc-sec.org/Cooperation-with-Observers/13/

Tykhonenko, A. (2005). La Convergence Réelle dans l'Europe des Quinze: un réexamen a partir de l'approche sur données de panel. *Economie Appliquée*, 58 (3), 23-50.

Ullah, A. & Giles, D. E. A. (1998). *Handbook of Applied Economic Statistics*, CRC Press.

U.S. Energy Information Administration EIA (2011). accessed 16-12-2012, URL:http://www.eia.gov/countries/cab.cfm?fips=ID

Verhulst, P.F. (1838). *Notice sur la loi que la population poursuit dans son accroissement* Correspondance mathématique et physique 10: 113-121. Retrieved 09/08/2009.

World Bank (2012). World Development Indicators (WDI) and Global Development Finance (GDF).

World Trade Organization. 2012. WTO memebers and observes. Cited 17-12-2012. Available online: `http://www.wto.org/english/thewto_e/whatis_e/tif_e/org6_e.htm`

Zagaitov, I.B. & Yanovskii, L.P. (2007). The population of the Russian Federation: Solvency dynamics and depopulation. *Studies on Russian Economic Development*, 18 (1), 94-101.

Zhang, K., Hutter M. & Huidong, J. (2009). A New Local Distance-Based Outlier Detection Approach for Scattered Real-World Data. *Advances in Knowledge Discovery and Data Mining* (pp.813-822), PAKDD'09 Pacific-Asia Conference, Springer-Verlag Berlin, Heidelberg. DOI: 10.1007/978-3-642-01307-2_84