The Convergences and Imbalances - the Distance-based Comparisons of Countries and Factors

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Abstract

The paper presents very general empirical method of distance-based multifaceted systematic identifying of the positions of countries in relation to inequalities and global imbalances. In order to understand the world economic relations in their entirety, we decided to analyse 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.

Key words: global imbalances, convergence, divergence, distance-based methodology, complex dynamics, world economy.

JEL Classification: F41, F44, F62

1 Introduction

Just a few years ago, there were widespread expectations (Ben-David, 1996, Ben- David 2001, Cyrus, 2004) that a gradual opening of the economies will result in higher inter-country convergence levels in the future. There is a general 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, Sala-i-Martin, 1992, Matos, 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, Okubo, 2011, Aguiar-Conraria et al., 2011, Allegret, Essaadi, 2011). With the progression of globalization, economies have become 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.

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 specific of our view is that it includes not only economic issues, but also concentrates on a holistic understanding of the potential systemic relations.

2 Global Imbalances

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, 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 is not only the economy that is 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 the 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 or an exhaustion of the natural resources.

The structure of the world economy is continuously changing toward 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.

The comprehensive long-term view on the world development respecting the population boost under the restricted resources has been presented by (Ehrlich, Ehrlich, 1990). Unfortunately, it is 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 in the centre for research represents the work by (Hidalgo et al., 2009). The work focuses on the economic growth analysed 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 by (Hidalgo et al., 2007) dealing with the network techniques applied to evaluate the local comparative advantages of the countries.

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, Guichard, 2011). Therefore, if large emerging economies such as China continue their aggressive mercantilist strategy based on the steadily growing trade balance surpluses (Brunet, Guichard, 2011), the economic partners are facing the permanent accumulation of the trade balance deficits and larger budget deficits. In paper by Gu et al. (2008) it is argued that China displays a high degree of global power and governance and its strategy has globally important consequences for many other actors. This introduces possibility that imbalances across countries are widening and deepening. 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, Guichard, 2011, Blanchard, Milesi-Ferretti, 2009) consider imbalances as quite serious and most dangerous threat for the prosperous future.

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. Relationship between ecological variables such as CO2 emissions and petrol or consumption has been known already since 1990s thanks to Beckerman (1992) and others. Recent studies by Jobert et al. (2010) treat CO2 emission convergence in the European Union. The research revealed also correlations between the industrial sector in GDP and CO2 emissions. These findings partially 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.

3 Data

The annual data covering period from 1992 to 2008 has been retrieved from the World Bank databases (2012). For the purpose of our research we collected data of eleven highly populated countries. They are forming the set

Countries = {BAN (Bangladesh); BRA (Brazil); CHI (China); IND (India); IDO (Indonesia); JAP (Japan); MEX (Mexico); NIG (Nigeria); PAK (Pakistan); RUS (Russia); USA (United states of America); EU15 (European Union)}

This selection represents approximately 60% of the world's population in 2012. The factors we focus are comprised in the set

Factors = {INC (income); CO2 (carbon dioxide emissions); CA (current account); ENU (energy use); EXD (external debt); GNI (gross national income; INV (investment); POP (population); SAV (domestic savings); FER (foreign exchange reserves including gold; OIL (oil production)}

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. Note that missing data does not exceed more than four percent of the whole dataset. Due to effect of rescaling transformations, which precede calculation of distances between data sequences we will not pay attention to data units which are normally of interest. Note here and in further discussions that the label "world" is used in reference to twelve countries and eleven factors selected.

4 Method Descriptions

The concept of distances is one of the most powerful and versatile tools to study the relative development of the countries and their factors. The procedure we aim to utilize to find association relationships in the data is called here *distance-based approach* in analogy with Zhang et al. (2009). But even though in our case, the analysis focuses attention to high-dimensional time series dataset. Consider the data organized into time dependent matrix $X(t)$ of the elements $X_{ik}(t)$ of $n \times m$. The matrix involves the information corresponding to given country $i \in \{1,2,\ldots,n\}$ and factor $k \in \{1,2,\ldots,m\}$.

As it has been mentioned in the previous section we study the system of the extent $n = 12$, $m = 11$. Because the time dependencies $X_{ik}(t)$ are of very different value (units), for the purpose of the rescaling we used temporary standardization

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

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

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

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

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

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

This running window is of the extent T. From the computational viewpoint we are forced to find the best compromise between the localized focus on the instant data values (small T) or desired statistical power (achieved for sufficiently high 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 analysed by means of the Minkowski-type distance

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

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

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

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

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

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

$$\overline{D}^{\mathrm{c}}(t) = \frac{1}{n} \sum_{i=1}^{n} D_i^{\mathrm{c}}(t), \qquad \overline{D}^{\mathrm{f}}(t) = \frac{1}{m} \sum_{k=1}^{m} D_k^{\mathrm{f}}(t). \tag{8}$$

5 Results and Discussions

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

Tab. 1, part (a) organizes the distance-based transforms of the macroeconomic data in the following format

$$
\begin{array}{lllll}
year & country_1 & country_2 & \dots & country_n \\
\dots & \dots & \dots & \dots & \dots \\
t-1 & i_1^{\mathrm{c}}(t-1), & i_2^{\mathrm{c}}(t-1), & \dots, & i_n^{\mathrm{c}}(t-1) \\
t & i_1^{\mathrm{c}}(t), & i_2^{\mathrm{c}}(t), & \dots, & i_n^{\mathrm{c}}(t) \\
t+1 & i_1^{\mathrm{c}}(t+1), & i_2^{\mathrm{c}}(t+1), & \dots, & i_n^{\mathrm{c}}(t+1) \\
\dots & \dots & \dots & \dots & \dots
\end{array} \tag{9}
$$

The cross-country comparisons, comparisons of the remarkable macroeconomic events and international policies on one side with the ranking of the countries in the table Eq. (9) on another side yields to the following data interpretation.

The ordering presented in Tab. 1 implies the possible identification and distinguishing of three main relatively *persistent zones* of the countries. The first (say four) positions (small mean distances) i_1^{c}, i_2^{c}, …, i_4^{c} are interpreted as a *core* of the "world" economy, the last four positions i_{n-4}^{c}, i_{n-3}^{c}, …, i_n^{c} (large mean distances) can be considered as *peripheral* occupied by the outliers. The intermediate positions in the ranking located between the *core* and *periphery* represent *neutral zone*. In other words, the core (leftmost position in the table) represents the possession of the common features and conformity of the entities included. The data indicate the moderate degree of the persistence of these zones for almost all observation times. Some of the countries have not changed their positions in general, but some have left the unstable periphery to settle in the core and vice versa.

The ordering which exploits $D_k^{\mathrm{f}}(t)$ (Tab. 1) presents EXD and CA as a peripheral factors responsible for the magnifying of the global divergences. OIL and FER are also other, less peripheral elements. On the other hand, the GNI, ENU, POP are the indicators, which belong to the core. The finding is consistent with the idea of the synchronization of the economic cycles (Artis, Okubo, 2011, etc.).

Tab. 1 The countries and factors sorted according to the mean distances $D_i^c(t)$ and $D_k^f(t)$

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_k^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

Source: Own calculations

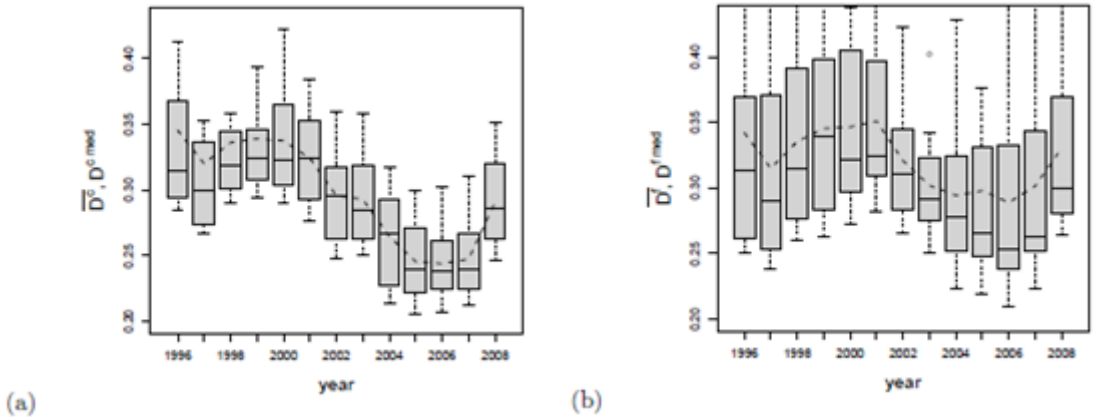
Notes: actual annual country with the smallest $D_i^c(t)$ is positioned at the most left position, whereas the most peripheral country acquires twelfth position (n=12). Analogous ranking is available for factors. The data that serve the basis for the determination of ranks extracted from the World Bank databases.

Fig.1 depicts the time evolution of $\overline{D}^c(t)$, $\overline{D}^f(t)$ and $D^{cmed}(t)$, $D^{fmed}(t)$ and distances calculated by means of Eq.(8). We used setting $T=5$ and also $T=4$ for the comparative purposes. The $p=1$ distance variant is altered with Euclidean form $p=2$. Looking again at this figure we see that the period 1992-2005 can be characterized by the relatively strong convergence identified by the arithmetic and also 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. occupies the last position in the ranking from Tab.1.

Because the optimal number of the admissible economic factors is not known a priory, (our intuitive choice is $m=11$), we tested whether the converging/diverging scenario remains in the $m=6$ dimensional system with the permuted factors. The results for the mean distance $\overline{D}^c(t)$ exhibit certain level of robustness, i.e. they are consistent with the general trend identified by the original higher-dimensional study. The series of the comparisons has been done: comparison with

the model $p = 2$, as well as with the model where the minimum/maximum standardization from Eq.(1) is replaced with the $z-$score transform.

According to Tab. 1, the position of Japan, the EU15 and U.S. economies occurs as neutral, while Mexico, Nigeria and Russia are classified as outliers. The ordering apparently reflects Mexico crisis (1994), and crisis in Russia (1998). It also clearly uncovers the overall economy problems (Nigeria). Later on, in the period 1999-2000 we see that the outliers' positions are occupied by Russia, Indonesia and Japan. The result corresponds to Indonesia crisis in 1997. Until 1999 the positions of the developed countries $\{JAP, USA, EU15\}$ fluctuate close to the "world" core. Later on, more dramatic differences start to appear. The U.S., Japan and the EU15 begin to recede from the core. In 2006 certain reduction of the distances occurs, which later turns into a divergent process. Table shows that in this period the dynamics of U.S. resembles dynamics of EU15 and Japan. It is worth noting that during the total investigated period the relative position of the U.S. has changed substantially. The U.S. has moved from the fourth (in 1996) to the last - twelfth position (in 2008).



Notes: The dashed lines represent mean calculated from Eq.(8). The boxplot for countries is constructed by taking statistics on values D_{ij}^{cc}. Part (a) summarizes countries, part (b) includes factors.

Fig. 1 Boxplot of inter-country and inter-factor mean distances
Source: Own calculations

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

As noted in the introduction, there is a significant imbalance between China and the United States, which permanently attracts the attention of economists. See for example works by Makin (2008), Brunet and Guichard (2011) or Cooper (2007). Above we exhibited rather promising ability of the methodology discussed. Therefore, we do not want to miss an opportunity to recognize often discussed relationship of these two countries. The inspection of Tab.1 reveals that the ranks of these countries are also variable with the possible transitions between the core and periphery.

We have already shown, that the current account, external debt and total foreign reserves are among the main factors that are responsible for the increase of imbalances and distance. 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.

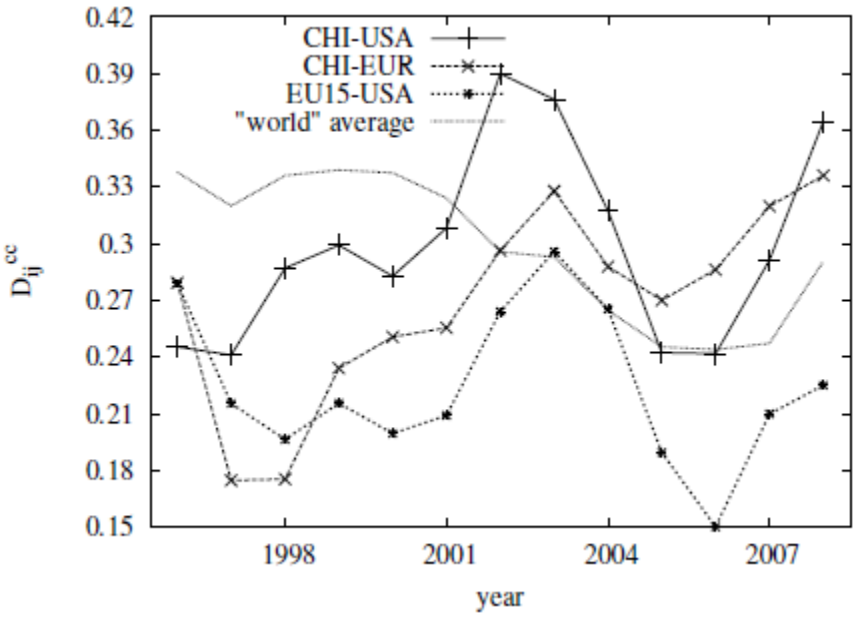


Fig. 3 The dynamics of the mean distances of the China, the U.S. and the EU15
Source: Own calculations

Notes: We display the dynamics of the inter-country pair mean distances China-USA, China-EU15 and EU15-USA; we display also the evolution of the mean distance $\overline{D^c}$, i.e. "world" average.

From Fig.3 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 World Trade Organization (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 fell, but in 2007-2008, there was a relatively abrupt increase of the mean distance between 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 pair distances depicted in Fig.3, we see that they differ in size but show the shifted versions of the same pattern of the movement. For a long time, the largest distance corresponds to the mutual positions of China and the U.S. Later, the pair CHI - EU15 takes on this role. The end of the period is characterized by the domination of the distance of the U.S. and China.

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, investigated here mainly from the economic perspective, some of them previously perceived 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 information from the distances and ranking of corresponding tuples we are led to the conclusion that the world is still gradually getting into more imbalanced regime. Evaluations have revealed that our approach is quite effective way for the narrowing the gap between qualitative and empirically derived understanding of the global imbalances. We believe that proposed method involves even larger potential to provide novel and interesting insights into the understanding of the complex relationship between economic, social and ecological phenomena.

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