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What kind of 'world order'? An artificial neural networks approach to intensive data mining

Massimo Buscema [a,b], Guido Ferilli [c], Pier Luigi Sacco [c,d,*]

[a] Semeion Research Center, Via Sersale, 117, 00128 Rome, Italy
[b] University of Colorado, Denver, United States
[c] IULM University, Via Carlo Bo, 1, 20143 Milan, Italy
[d] MetaLAB (at) Harvard, Harvard University, Cambridge, MA, United States

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ABSTRACT

In this paper, we present an innovative data processing architecture, the Activation & Competition System (ACS), and show how this methodology allows us to reconstruct in detail some aspects of the fine grained structure of global relationships in the world order perspective, on the basis of a minimal dataset only consisting of the values of five publicly available indicators for 2007 for the 118 countries for which they are jointly available. ACS seems in particular to qualify as a valuable tool for the analysis of inter-country patterns of conflict and alliances, which may prove of special interest in the current situation of global strategic uncertainty in international relations.

1. Introduction

The global scenario of today is more complex than ever. For the first time in its whole history, the US have recently been involved at the same time in three different war theaters in three different countries (Kurth, 2010), in the company of most other major Western nations, and the geography of conflict has been further escalating since then. The economic and cultural leadership of the West is openly challenged by once emerging countries which, despite what it was boldly claimed not long ago by influential thinkers such as Fukuyama (1992), far from adopting the market democracy ideology as their socio-organizational paradigm, are on the contrary deploying alternative ones, based on their own traditions and schemes of thought. Global networks of alliances and hostilities are becomingly increasingly blurred and deeply layered. In this multi-polar world with its 'multiple modernities' (Casanova, 2011), hard to predict discontinuities (van Notten et al., 2005), and collapsed decision-making timing (Comes et al., 2014), the famous and controversial thesis of Huntington (1996) that we are facing a 'clash of civilizations' is often read by non-Westerners as a conceptual shorthand, as a reflex of the West's hard-to-die attitude of thinking that any global narrative that challenges their own is, ipso facto, an oppositional one (Yije, 2010) – and thus ultimately as an instrumental theoretical construct which has been shaped up to serve specific ideological purposes (Adib-Moghaddam, 2008), and which may be possibly supported only from a Western perspective serving Western interests (Fox, 2001). A common basis for a true dialogue in terms of cultural values is indispensable for future peaceful coexistence (Anthony, 2010), as the persistence of oppositional narratives on the Western side naturally paves the way to dialectic, and often armed counterparts (Aydin and Özen, 2010). Issues of cultural and value diversity at the global scale cannot be eluded any longer, and how they are tackled largely influences actual as well as future scenarios. A clear example of a much debated contribution in this vein is Sørensen (2006), who considers the current world order as transitional, with open-ended future developments whose unfolding basically depends on whether or not less privileged countries and populations will be given a possibility to take part in it more actively, and on fairer terms.

The crucial role of value and cultural systems in this context is that they act as filters that allow a specific cataloging, reading and interpretation of events according to a coherent, meaningful structure, whose inclusionary vs. exclusionary implications in terms of intercultural dialogue largely depend on their testimonials, and on the social support they manage to gather (Levine, 2011). Different systems may imply mutually incoherent and even oppositional renditions of the same events, and possibly feed 'toxic narratives' based on stereotypical attributions about the 'other' (Ringmar, 2006), and support prolonged, disruptive conflict, especially when combined with situations of poverty, fear and exclusion of either party (Sen, 2008). The approach of Democratic

* Corresponding author at: IULM University, Via Carlo Bo, 1, 20143 Milan, Italy
E-mail addresses: m.buscema@semeion.it (M. Buscema), guido.ferilli@iulm.it (G. Ferilli), pierluigi.sacco@iulm.it, pierluigi@metalab.harvard.edu (P.L. Sacco).

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Peace Theory (Rummel, 1975-1981; Doyle, 2011; Huth and Allee, 2002) highlights the role of shared democratic values in curbing the escalation and violence of conflict, and in establishing a solid basis for peace. Although the theory has been at the center of lively debate and controversy (Henderson, 2002; Rosato, 2003), and although claims of reverse causality from peace to democracy have been equally supported (James et al., 1999), the role of democratic values and institutions in the construction of a more peaceful world order is hard to deny (Cederman, 2001; Gleditsch, 2002).

In this paper, we develop a methodologically innovative approach, in the spirit of the methodological proposal of Beck et al. (2000), who point out that the complexity of the world order can only be addressed through an entirely novel computational approach with respect to traditional statistical tools. To this purpose, we introduce an innovative artificial neural network tool, the Activation and Competition System (ACS) developed by Buscema (2014), Buscema et al. (2013), Buscema and Sacco (2013), and we apply it to the analysis of the structure of global alliances and conflicts in terms of relative differences in cultural and value orientations that may be publicly observed and measured. The main purpose of this paper is therefore to illustrate how the use of an innovative tool may generate, on the basis of publicly available information, valuable insights that improve our understanding of global world order patterns.

More specifically, as our source of public data we consider a set of socio-cultural indicators linked to market democracy and in particular to Popper's notion of an 'open society'. Unlike conventional approaches, that put forward a specific research question drawn from theoretical discussion and test it empirically, we propose here a perspective for generating research questions through a new way of interrogating data. The current structure of the world order is driven by so many multidimensional relationships between variables that aspiring to discern it through simple conceptual schemes à la Huntington proves to be untenable. Reasoning in terms of socio-political 'blocks' may be a useful simplification for the media, but scientific analyses require counter-intuitive stages of extrapolation where data are not simply addressed as a way to falsify hypotheses, but are interrogated as a filter to open up new ways of looking at reality, in a fully systemic perspective (Saritas and Nugroho, 2012).

In this paper, our empirical benchmark builds, as anticipated, upon the notion of open society orientation in the Popper (1945) sense, and our data interrogation concerns an investigation of how countries' relative, multi-dimensional attitudes toward open society allow us to reconstruct the networks of global alliances and hostilities. We measure open society orientation in terms of five publicly accessible indicators of common use. Our computational approach allows us to show how, once filtered in terms of open society orientations, global alliance networks from the vantage points of different countries have intrinsically different properties depending on countries' relative socio-cultural profiles, in a way that lends support to a (properly qualified) Democratic Peace perspective. In this respect, it may be stimulating to read our results in relation to those of Ward et al. (2007), who still make use of more traditional statistical techniques. From the perspective of relatively open societies, which maintain an articulated attitude toward inter-cultural relationships, the structure of global alliances and hostilities is a complex, nuanced one, where the role of non-allied but apparently non-hostile countries is crucial in strategic terms. Conversely, for non-open societies, which tend to define inter-cultural relations strictly in terms of conformity/non-conformity to their own value and cultural orientations, the global structure has a binary character: non-allies are just enemies, and very little mediation between the two fields turns out to be possible. It is this basic feature that, in our opinion, sheds some light upon why democratic societies are more effective in managing conflict through non-violent channels: they have at their disposal a larger relational menu of possibilities, which allows a more fine-tuned modulation of diplomatic and negotiation strategies to tackle and to solve disputes (Beriker, 2009), and a more stable basis for multilateral alliances (Pilster, 2011).

We think that the new analytical tools presented in this paper can be useful in developing new approaches to understand the complex socio-political dynamics of the world order, and to debunk ideological, over-simplified narratives such as the 'clash of civilizations' one, that finds, with few exceptions (such as Charron, 2010), little empirical support once put to test (Mostafa and Al-Hamdi, 2007; Ellis, 2010). We thus aim at contributing to a new approach to rigorous, evidence-based scenario analysis for public decisions in the many fields where such issues matter (Volkery and Ribeiro, 2009), from conflict resolution to international cooperation and intercultural dialogue, and so on.

Although the paper's main focus is the presentation of a new data mining tool, we think that the best way to appreciate its analytical value added is to present at first the problem and the data that we will use to put it at work, and gradually work out the technical aspects, first in terms of basic intuitions and then in its full-fledged formulation, as the argument develops. Therefore, the remainder of the paper is organized as follows. In Section 2 we carry out a brief partial review of research on world order and global alliances, arguing that this literature needs some fresh analytical insight to overcome ideological narratives such as the clash of civilizations one. In Section 3, we discuss issues of data availability and data mining for the analysis of the structure of the world order, and present our own database and methodology. Section 4 presents the ACS tool. In Section 5, we introduce our main results and discuss them. Section 6 concludes.

2. Alliances, conflict, polarization: the grammar of the world order

The clash of civilizations theory is not the most compelling way to analytically tackle world order issues (Chirot, 2001; Henderson and Tucker, 2001). Nevertheless, it has affirmed itself as a political myth, that is, a self-fulfilling prophecy which, rather than having an explanatory value, becomes an overarching narrative with major appeal to media and ideological commentators (Bottici and Challand, 2006; Bantimaroudis and Kampanellou, 2007), and a social phenomenon in itself (Welch, 1997) – and thus, turns out to be, according to cases, what the relevant actors make of it (Houghton, 2009) to influence the political agenda (Aisha, 2003), rather than a logical construct with precise empirical correlatives and solid scientific ambitions (Henningsen, 2014).

On the other hand, a certainly important aspect of Huntington's thesis is that it has sparked a vast literature which, in order to put the thesis at test, has significantly revamped interest toward the role of interacting civilizations in determining the structure of the world order (Russett et al., 2000), the usefulness of clear-cut statistical hypothesis testing (Chiozza, 2002; Tusicisny, 2004), and the socio-anthropological foundations of inter-cultural conflict (Senghaas, 1998), among others. The literature on world order emphasizes the role of a constellation of factors, which are difficult to be reunited in a compact, simple theoretical statement about the causes of alliance formation, polarization, and conflict. Among the factors leading to alliance formation, we find an intent to stabilize an otherwise potentially chaotic global arena (Saperstein, 1992) through boundedly rational strategies of domination and counter-domination (Faber, 1990), which may possibly lead to sophisticated forms of multi-spatial meta-governance (Jessop, 2012). Alliance formation may moreover be responsive to specific governance factors, such as sharing security costs as a response to increasing internal social demands (Kimball, 2010), or to specific strategic needs such as sending public, costly signals of intentions of military cooperation (Warren, 2010).

The literature agrees on the idea that the logic of alliance formation is multilateral, and that alliances themselves have to be assessed as a whole in terms of minimum winning coalition solutions to strategic interaction problems (Fordham and Poast, 2014), that their dynamics is affected by cultural factors and value systems that impinge upon key aspects of alliance conduct such as sensitivity to discrepancy detection, shaping attributions, and prompting reactions (Kumar and Nti, 2004),

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and that alliance formation itself is endogenously coevolving with conflict management (Kimball, 2006). In the relationship between alliance and conflict, the other concurrent aspect is polarization, whose effect on conflict itself may be nonlinear (Wallace, 1973; Vasquez and Kang, 2012), may insist on both economic and political dimensions (Hegre, 2008), as well as on ethnic-cultural ones (Forsberg, 2008), and calls for easing and mediation by institutions (Esteban and Schneider, 2008) and civil society (Lachmann, 2011; Pérez-Diaz, 2014). These results shed a particular light on the role of democratic socio-political settings in stabilizing conflict and ensuring peaceful alliances, due to a comparatively larger openness to compromise and mutual concessions (Dixon, 1993; Mousseau, 1998), and on universalistic attitudes in securing mutual acknowledgement of interests in global arenas (Wallensteen, 1984; Blanton, 2006).

Research on alliances, conflict, and polarization therefore suggests to select socio-economic indicators of democratic openness, rather than cultural and value orientations à la Huntington, as a benchmark to test country attitudes in the overall context of world order structure. It is possible that, in doing so, the emergent global geometry of alliances and rivalries would not reproduce straightforward Western-Muslim contrapositions, but possibly more nuanced, articulated patterns that reflect more accurately the interplay of the many factors at work (e.g. Bremer et al., 2003) in determining dyadic and, more interestingly, n-adic international relationships, cross-cutting cultural blocks. For instance, as argued e.g. by Peterson (2014), the exclusive logic of preferential trade agreements may be enough to spark conflictual tensions in triadic interactions – and this is an obvious example where nearby, culturally homogeneous countries could find themselves on different sides because of contingent economic and political reasons. Similar findings emerge when studying the conduct of major powers, whose activism is mainly responsive to observable features such as resources and incentives, rather than to values and cultural orientations (Chiba et al., 2014). One could think that this fine grained, contingent level of analysis basically prevents the possibility of drawing out a compact, coherent picture of world order patterns due to the excessive focus on detail – and especially one with a powerful narrative. However, our computational approach enables us to organize this apparently fragmented set of factors into coherent global pictures, which do not lend themselves to easy generalizations, but turn out to be richer in terms of both accuracy and predictive power. In particular, the methodological vision upon which democratic peace theory is built is the natural conceptual reference for our analysis, which is centered upon detecting global patterns of (association- and concordance-adjusted) multi-dimensional similarities within an attribute space. What determines the structure of the world order is not an absolute set of socio-economic orientations as a 'clash of civilizations' perspective would have it, but their relative, complex juxtaposition in the overall global organization. As Rummel (1970, p. 10) puts it, "it is not a nation's absolute attributes and behaviors that are important, but rather how his attributes and behaviors compare with others… The relative similarity and differences between nations affect their relative behavior toward each other". Specifically [Rummel (1971), p. 4], "knowledge that a country with a left democratic government is poor and Catholic will not generally be sufficient to explain a nation's international behavior. These characteristics have different behavioral consequences depending on their distribution in the system, behavioral expectations and norms, and on who is the behavioral object". This is the philosophy that guides our approach, as it will be illustrated in the following two sections.

3. An intensive data mining approach to world order analysis

Most quantitative analyses of the structure of alliances and conflict found in the literature work with long time series and relatively large databases (e.g. Beck et al., 1998; Giebler and Reid Sarkees, 2004), and this tendency is likely to be reinforced with the ongoing 'big data' revolution (Kitchin, 2014). We apparently live in an epoch of 'data deluge', although new, unprecedented issues of data integrity emerge (Lagoze, 2014). We therefore expect that, in a crucial, delicate field such as that of world order analysis, even a small level of superiority in data processing techniques might prove to be crucial (Weinberger, 2011), and therefore the big data momentum can grow even bigger if possible (Gleditsch et al., 2014).

However, one of the most intuitive – and apparent – drawbacks of such an abundance is of course the increasing difficulty in selecting the relevant information in a flood of data: A problem that might prove to be more challenging than *lack* of information itself (Power, 2014). Therefore, another possible route that should be taken into account, not as an alternative to *extensive* data mining but as a complementary strategy, is that of *intensive* data mining – that is, extracting the highest amount of useful information from a limited amount of data, possibly originated from a public, well-known, easily available source. In some circumstances, access to too many data may cause analysts to overlook the informational potential of what is easily at hand – often for free. On the other hand, building up meaningful inferences from a small informational base is no easier task than working with very large databases, and may possibly require even more sophisticated techniques. Whereas much effort is provided into refining techniques for extensive data mining, less attention has been devoted so far to intensive data mining. We aim at filling this gap here.

The careful combination of extensive and intensive rounds of data mining may be very useful for policy design, at various stages: problem and agenda setting, design, fine tuning, monitoring, verification, and so on. Whereas intensive data mining works at best in the definitional and monitoring phases, extensive data mining proves to be most useful in phases of operational design, fine tuning, and verification. Intensive data mining may provide a sound basis for a 'nonlinear' approach to policy design, that dispenses with intuitively sensible but empirically unwarranted assumptions and theories, while at the same time allowing to test the influence of subtle interrelations that in conventional approaches would be easily regarded as noise or as groundless speculations (Lebow, 2010).

In this paper, we take an extreme approach to intensive data mining. We consider just five publicly available indicators, using their values for year 2007 only, for all the countries for which they are jointly available. This minimal dataset offers a simple empirical approximation of a Popperian open society, and functions as a filter of socio-cultural country attitudes. We introduce a Neural Networks Associative Memory, the Activation & Competition System (ACS), that allows us to carry out an analysis of complex world order patterns in terms of networks of global alliances and conflicts which is entirely built on the (adjusted) multi-dimensional similarities of the indicators in the dataset at the country level, in the spirit of the field approach presented in Rummel (1970, 1971) as a methodological basis for quantitative international relations analysis. We are aware that this is an extreme test with virtually no precedents in the literature. On the other hand, we want to emphasize how intensive data mining of a small number of data from reliable sources may be a useful complement to extensive data mining carried out on large sets of heterogeneous and not always reliable data.

We consider in particular the five following indicators, with the links to the corresponding reports for the year 2007 containing the data used in our study.

The United Nations Development Program (UNDP) Human Development Index (HDI; 2007 values accessible at http://hdr.undp.org/sites/default/files/reports/268/hdr_20072008_en_complete.pdf) has been developed and published since 1990. It is a composite index, aggregating several different sources of information on disparate but complementary aspects of human quality of life, focusing on the ends rather than on the means of development and progress. Quality of life is identified with the opportunity of enjoying a long, healthy and creative life: In other words, it goes beyond the instrumental level of being able to survive effectively, to stress that a worthwhile life calls for the full expression of human potential. Consequently, improving the well-being

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of people also calls for widening both their choice menus and their awareness of the existence and implications of such choices. Specifically, the index puts together: Life expectancy at birth, on the health and demographics side; the adult literacy rate and the tertiary gross enrolment ratio, on the educational side; and the (log of) per capita GDP at purchasing power parity, on the standard of living side. HDI is very much resonant to Amartya Sen's (1999) capability-based approach to welfare analysis and policy. The accomplishment of quality of life goals then depends, on the one side, on capability acquisition, and on the other side on its enjoyment, both in the work and leisure dimensions of life.

The World Economic Forum (WEF) Global Competitiveness Index (GCI; 2007 values accessible at http://www3.weforum.org/docs/WEF_AnnualReport_2007-08.pdf) has been published since 1979. WEF is a private foundation, globally known for its yearly meetings at Davos, Switzerland, gathering most of the top world leaders in fields such as business, politics, research, and the media, to discuss the most relevant issues of the world's policy agenda. The GCI is a very composite index, aiming at providing a synthetic measure of a country's economic competitiveness through the evaluation of a variety of relevant dimensions that together concur to define the manifold notion of 'competitive potential'. The current version of the index draws on Michael Porter's (1990) three stage characterization of economic development: cost-driven, investment driven, and innovation-driven. The index incorporates variables that are related to the three stages, organized by building blocks such as the efficiency of public and private institutions, infrastructural endowment, stability of the macroeconomic environment and levels and quality of health and primary education (first stage); level and quality of higher education and training, market efficiency and ability to incorporate technological progress into economic value chains (second stage); development and articulation of the business culture and level of innovation (third stage). Overall, this amounts to computing and aggregating almost one hundred different variables, yielding one of the most ambitious and broad-ranging indicators available today, which presents, among other things, significant overlaps with some of the other indexes considered in the present paper.

The Heritage Foundation (HF) and Wall Street Journal Economic Freedom Index (EFI; 2007 values accessible at http://mtweb.mtsu.edu/medlin/Index%20of%20Economic%20Freedom%202007.pdf) is published yearly since 1995. The HF is an authoritative conservative think tank founded in 1973, which is on the forefront of the policy debate in the USA, fully embracing the doctrine of market freedom and efficiency as the golden path toward individual and collective well-being. The EFI consequently measures the degree to which each specific country paves the way to free initiative in a variety of different fields. Specifically, the EFI focuses on ten different types of 'freedom' as characteristic of a free market economy: business, trade, fiscal and monetary freedom, government size, investment and financial freedom, property rights, freedom from corruption, labor freedom. Coherently with the tenets of the free markets approach, size of government, for instance, is regarded to be a social *cost* and therefore a limitation to freedom, and a similar reasoning holds, likewise, for fiscal burden and so on. Unlike HDI and GCI, that are presented in principle as 'objective' measurement scales – although this turns out to be highly controversial in practice – the EFI makes no attempt to legitimate itself in this vein. It is the expression of a ideologically connoted group of researchers. It explicitly evaluates the performance of countries in terms of distance from an ideal benchmark. Therefore, it has less pretension to be regarded as a 'scientific' output in the proper sense of the word, although the technical and methodological standards followed to build it do not differ very much, procedurally, from those of the other indexes, and are based on technical and professional knowledge of high quality according to academic criteria.

The Transparency International (TI) Corruption Perception Index (CPI; 2007 values accessible at http://www.transparency.org/research/cpi/cpi_2007) is published yearly since 1995. TI is an international organization founded in 1993 to fight the social diffusion and acceptance of corruption at a global scale. It is based on a vast global network of national chapters, currently over 90 and expanding, which involve local leaders in all fields. The CPI ranks around 180 countries by means of the aggregation of expert assessments and opinion surveys. It is based on a variety of different sources coming from several independent institutions, varying from year to year according to availability. There is a quite significant overlap between the CPI and one component of the EFI – the one that, in the latter's terminology, is called 'Freedom from Corruption'. The data sources from which the two indexes are built, however, are independent, and this adds interest to have both in our sample. There is also some overlap between the CPI and the GCI – specifically, data on corruption used in the latter are one of the sources of the former, which however also draws from several other sources; thus, once again, it is convenient to consider both.

The Reporters Sans Frontières (RSF) Press Freedom Index (PFI; 2007 values accessible at https://rsf.org/en/worldwide-press-freedom-index-2007) is published yearly since 2002. RSF is an association founded in France in 1985, which gradually defined its mission toward the promotion and defense of freedom of press worldwide. RSF has been awarded the Sakharov prize for freedom of thought by the European Parliament in 2005. The PFI is based on questionnaires compiled by a vast global network of partner organizations, correspondents, and experts, and tracks any kind of direct or indirect attacks or threats to freedom of journalistic expression that may have happened locally during the period of reference. Like CPI, FPI is a perception index and therefore all the limitations and methodological complexities entailed by this kind of indicator occur here as well. Consequently, critical remarks analogous to those aimed at CPI apply in principle to PFI.

The informational base chosen for our analysis is widely used, despite for each of its components one can find conceptual limitations and methodological flaws (see Buscema et al., 2015b for a critical review). Although the five indexes are a reasonable proxy for an 'open society' orientation, they deliver very little direct information as to the factors and variables that directly pertain to the structure and dynamics of global alliances and conflicts. Therefore, we implicitly assume that our empirical filter is able to produce meaningful inferences about the structure of the world order as of 2007, by means of the indirect information on global alliances and conflicts which is embedded in the (adjusted) multi-dimensional similarity patterns of the five indicators for all countries for which such information is available. Needless to say, working with richer sets of indicators might yield different, equally valuable insights. But, as we shall see, this very limited evidence base contains more information than one might imagine, if properly interrogated, and we regard this as a promising test for the use of ACS in detecting world order patterns from publicly available information.

4. Activation and Competition System (ACS)

ACS is an auto-associative artificial neural network (ANN), developed by Buscema (2014), Massini (2012), Buscema et al. (2013), Buscema and Sacco (2013), and endowed with an uncommon architecture: Any couple of nodes is not linked by a single value, but by a vector of weights, where each vector component comes from a specific metric. Such 'bio-diversity' of combinations of metrics delivers interesting results when each metric describes different and consistent details of the same dataset. In this situation, the ACS is an appropriate algorithm that forces all the variables to compete among themselves, in different respects.

The ACS algorithm, therefore, is based on the weights matrices of other algorithms. ACS will use these matrices as a complex set of multiple constraints to update its units in response to any input perturbation. ACS, consequently, works as a dynamic, non-linear associative memory. Whenever any input is set on, ACS will activate all its units in a dynamic, competitive and cooperative process at the same time. This process will end up when the evolutionary negotiation among all the units will find

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its natural attractor. The ACS ANN is a complex kind of C.A.M. system (Content Addressable Memory). Compared to the classic associative memory (Hinton and Anderson, 1981; McClelland and Rumelhart, 1988, chapter 2 and Grossberg, 1976, 1980), ACS presents the following new features:

- The ACS algorithm works using simultaneously many weights matrices, coming from different algorithms and/or ANNs;
- The ACS algorithm recall is not a one-shot reaction, but an evolutionary process where all its units negotiate their reciprocal value.

The structure of the ACS algorithm, and its weight matrices in particular, are computed as follows.

M = Number of Variables-Units;
Q = Number of weights matrices;
$i, j \in M$;
$k \in Q$;
$W^k_{i,j}$ = value of connection between the ij-th and the j-th units of the k-th matrix;
Ecc_i = global excitation to the i-th unit coming from the other units;
Ini_i = global inhibition to the i-th unit coming from the other units;
E_i = final global excitation to the i-th unit;
I_i = final global inhibition to the i-th unit;
$[n]$ = cycle of iteration;
$u_i^{[n]}$ = state of the i-th unit at cycle n;
$H^{[n]}$ = amount of units updating at cycle n;
δ_i = delta update of the i-th unit;
$Input_i$ = value of the i-th external input : $-1 \le Input_i \le +1$;
$N^{[E]}_{k,i}$ = number of positive weights of the k-th matrix to the i-th unit;
$N^{[I]}_{k,i}$ = number of negative weights of the k-th matrix to the i-th unit;
Max = Maximum of activation : $Max = 1.0$;
Min = Minimum of activaction : $Min = -1.0$;
$Rest$ = rest value : $Rest = -0.1$;
$Decay_i^{[n]}$ = Decay of activaction of the i-th unit at cycle n : $Decay_i^{[n=0]} = 0.1$;
α = scalar for the E_i and I_i net input to each unit;
β = scalar for the external input;
ε = a small positive quantity close to zero.

$$Ecc_i = \alpha \cdot \sum_k^Q \frac{\sum_i^M u_i^{[n]} \cdot W^k_{i,j}}{N^{[E]}_{k,i}} \qquad W^k_{i,j} > 0;$$

$$Ini_i = \alpha \cdot \sum_k^Q \frac{\sum_i^M u_i^{[n]} \cdot W^k_{i,j}}{N^{[I]}_{k,i}} \qquad W^k_{i,j} < 0;$$

$$E_i = Ecc_i + \beta \cdot Input_i \qquad Input_i > 0;$$
$$I_i = Ini_i + \beta \cdot Input_i \qquad Input_i < 0;$$
$$\delta_i = \left(Max - u_i^{[n]}\right) \cdot E_i + \left(u_i^{[n]} - Min\right) \cdot I_i - Dec_i \cdot \left(u_i^{[n]} - Rest\right);$$
$$H^{[n]} = \sum_i^M \delta_i^2;$$
$$u_i^{[n+1]} = u_i^{[n]} + \delta_i;$$
$$Dec_i^{[n+1]} = Dec_i^{[n]} \cdot e^{\left(u_i^{[n]} \cdot u_i^{[n]}\right)};$$

$H^{[n]}$ is the cost function of ACS to be minimized. Consequently, when $H^{[n]} < \varepsilon$, the algorithm terminates. The ACS System is implemented by a specific research software patented by Semeion Research Center (Buscema, 2014), and has already found meaningful applications in the medical field, in particular for the selection of appropriate genetic markers to discriminate two different medical conditions which proved to be difficult to sort out by means of traditional statistical tools, due to the high nonlinearity of the underlying data generating processes (Buscema et al., 2015a, 2015b). This paper provides its first application to the international relations field, which, for very different reasons, also displays a very high level of intrinsic nonlinearity.

One may notice that the ACS ANN seems to be partially inspired to a precedent ANN presented by Grossberg (1987). But their differences are so marked that we need to present ACS as a new ANN. Specifically,

- ACS works using simultaneously many weights matrices from different algorithms, whereas Grossberg's IAC uses only one weight matrix;
- ACS weights matrices represent different mappings of the same dataset, and all the units (variables) are processed in the same way, whereas Grossberg's IAC just works when the dataset presents only a specific kind of architecture;
- The ACS algorithm can use any combination of weights matrices, from any kind of algorithm. The only constraint is that all the values of every weights matrix have to be linearly scaled into the same range (typically between −1 and +1), whereas Grossberg's IAC can work only with static excitations and inhibitions.
- Each ACS unit tries to learn its specific decay value during its interaction with the other units, whereas Grossberg's IAC works with a static decay parameter for all the variables;
- The ACS architecture is a circuit with symmetric weights (vectors of symmetric weights) that manages datasets of any kind of variables (Boolean, categorical, continuous, etc.), whereas Grossberg's IAC can work only with specific types of variables.

The dataset to which we apply our ACS architecture consists of the 5 indicators listed and described in Section 3 above, as applied to the 118 countries for which all of them are available. We consider the values of the five indicators for the year 2007 only. The database entries consist of the published 2007 values of the 5 indicators, as available online from the respective websites. They have been subsequently normalized within the unit interval following the procedure described in detail in Buscema and Sacco (2016). The database with the normalized values is available to interested readers upon request to the authors.

As to the battery of algorithms (and the corresponding weight matrices) that we use as a basis for the ACS to work upon, we select the following three and explain the reasons for this choice as follows:

- The Linear Correlation Algorithm, in order to define the linear strength of association between any couple of countries:

$$W^{[L]}_{i,j} = \frac{\sum_{k=1}^N \left(x_{i,k} - \bar{x}_i\right) \cdot \left(x_{j,k} - \bar{x}_j\right)}{\sqrt{\sum_{k=1}^N \left(x_{i,k} - \bar{x}_i\right)^2 \cdot \sum_{k=1}^N \left(x_{j,k} - \bar{x}_j\right)^2}};$$
$$-1 \le W^{[L]}_{i,j} \le 1; \qquad i, j \in [1, 2, \ldots, M];$$
where :
M = Number of the Countries.

- The Prior Probability Algorithm, in order to define the tendency of any couple of countries to present a similar or an opposite attitude with respect to the five indicators:

$$W^{[P]}_{i,j} = -\ln \frac{\frac{1}{N^2} \cdot \sum_{k=1}^N x_{i,k} \cdot \left(1 - x_{j,k}\right) \cdot \sum_{k=1}^N \left(1 - x_{i,k}\right) \cdot x_{j,k}}{\frac{1}{N^2} \cdot \sum_{k=1}^N x_{i,k} \cdot x_{j,k} \cdot \sum_{k=1}^N \left(1 - x_{i,k}\right) \cdot \left(1 - x_{j,k}\right)};$$
$$-\infty \le W^{[P]}_{i,j} \le +\infty; \quad x \in [0, 1]; \quad i, j \in [1, 2, \ldots, M].$$

- The Auto Contractive Map Algorithm (AutoCM), a new type of Artificial Neural Network, which finds out the deep multi-dimensional similarities among countries, via a matrix of weights that clusters and prototypes all the countries with all of their attributes (indicators) in a new topological space (for AutoCM equations, properties and previous applications see Buscema and Grossi, 2008; Buscema et al., 2008a, 2008b, 2014).

To make the matrices comparable, their weights for each of the three algorithms have been scaled into the unit interval following the same procedure referenced to above. The ACS algorithm then works on

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networks where every node (country) is connected to any other by means of a vector of 3 different weight values, each one representing a different metric. Once a country is chosen as the prototype, ACS takes the matrices of the three algorithms as multiple constraints to determine how other countries compete in their matching of the prototype. In other words, in our ACS approach we measure the relative positioning of countries with respect to a reference model (country) in our attribute space from three different vantage points simultaneously: strength of association, concordance, and multi-dimensional similarity. Resonance in the attribute space according to the three metrics therefore reflects a multi-faceted, context-dependent notion of likeness that cannot be reasonably accounted for by simple explanatory narratives such as the 'clash of civilizations' one.

It is useful to stress that although the database on which we work in this paper has a static nature (it includes values for one single year, 2007), the nature of the analysis carried out by ACS has an implicit dynamic nature, in that the system performs a dynamic negotiation among variables in virtual time until they settle down into a dynamically stable state. This feature of ACS has the purpose of extracting valuable latent information from the data, which would be likely read as noise by traditional statistical techniques but that instead, through the dynamic negotiation process, can be effectively recognized as a precursor of possible change, as it reflects into the pattern of associations among variables generated by ACS. Therefore, despite our analysis refers to data from a single year, the inferences that we draw from it may be read as having a partial dynamic character in terms of emerging trends.

5. Open society orientations and the geometry of the world order

Working on our minimal dataset, the ACS classifies countries in terms of their 'mutual resonance' with respect to the five indicators – an approach that can be interpreted in terms of a search for democratic value commonalities, coherently with a Democratic Peace Theory framework. Countries are not put together on the basis of their mere similarity in the indicators' scores, but rather on the basis of the implied 'socio-political-economic model' that lies behind their relative positioning in the field of variability of the five indices according to the combined results of the three metrics used by ACS (association, concordance, multi-dimensional similarity). As already remarked, here we do not make use of any kind of specific information concerning the institutional or political characteristics of the various countries, e.g., whether they have democratic regimes or not, or what are the countries with which they maintain diplomatic relationships, etcetera. Also, it must be kept in mind that the maps that we are generating refer to the state of the world in 2007.

In technical terms, we classify a country as 'sympathetic' with respect to a given, reference one, whenever once the trained ACS receives as input the profile of the reference country with maximum level of activation, the country to be compared receives in turn a relatively high level of activation (i.e. a highly positive activation value). Accordingly, we classify as 'anti-sympathetic' the countries that are given a relatively high level of inhibition (i.e. a highly negative activation value) once the reference one is maximally activated. Finally, we define as 'neutral' those countries that are neither activated nor inhibited when the reference one is activated. In the maps, we represent activation with the color red, inhibition with green, and indifference with black. Different gradations of color mean different strengths of activation: the brighter the color, the stronger the activation.

'Sympathetic' countries 'resonate' (Van Atta and Rummel, 1970): That is, they are characterized by a similar 'phase' with respect to the five indicators, despite the fact that they may differ as to levels of social and economic development, as well as to their cultural orientations in terms of religion, gender policy, secularization, and so on (although they tend to further converge as a consequence; see e.g. Gibler and Wolford, 2006). Peterson and Graham (2011) provide an interesting argument for 'resonance' between sympathetic countries in the field of human rights. Sympathetic countries may be implicitly ascribed to a same alliance network, whereas 'anti-sympathetic' countries define implicit conflict networks. Neutral countries may be thought of as opportunistically playing a role according to circumstances, without binding prior commitments; or, more rarely, as norm entrepreneurs (Goetschel, 2011). We begin by exploring the alliance-conflict map that is generated by the activation of the USA, and then contrast it with an analogous map generated by the activation of Pakistan. The USA map is reported in Fig. 1.

Fig. 1 draws a 'blurred' and fairly complex picture (see e.g. Cullather, 2009), one with little resemblance to clash-of-civilization-inspired ones, and which also largely overcomes the shaky logic of 'rogue' states (Caprioli and Trumbore, 2005). Absolute differences in cultural and value orientations are not the main driver, at the advantage of global networking concerns. This seems coherent, for instance, with the finding that, in terms of the global alliance strategy against terrorist threats, the USA essentially care about directing foreign aid toward countries where security threats concern USA interests specifically, and not interests of allies (Boutton and Carter, 2014), and thus following opportunistic rather than ideological criteria. The success of such strategies, however, strongly depends on the wider structure of the ally's rivalries, rather than on the dyadic relation itself (Boutton, 2014), thus confirming the importance of a global multi-dimensional similarity analysis, that simultaneously captures the entire structure of relations like in the present paper.

As expected, the Western block is compactly highly sympathetic to the USA: The 'more Western' Commonwealth countries such as Canada, Australia and New Zealand, plus the South African block (South Africa, Namibia and Botswana), and the whole of Europe (including the former Socialist countries now part of the EU). We also find Western-leaning countries (as of 2007) such as Turkey, Japan and South Korea, Brazil and Chile, the UAE, and even Kenya, Madagascar and Mongolia. Other South American countries such as Argentina, Peru and Colombia are still substantially sympathetic although to a lesser degree, and the same holds for Central American countries (with the major exception of Mexico). Venezuela and Paraguay rank low in the sympathy scale, although still with a positive sign, whereas Mexico lies on the verge of neutrality, marking a sharp distance from its prominent neighbor. Of the former Soviet states, Ukraine and Kazakhstan are mildly sympathetic. Among the Muslim countries, it is worth noticing the mild sympathy of ones like the Jordan Republic (which provides a clear illustration of the role of indirect rivalry factor in guiding USA foreign aid-driven alliances; see Rudloff et al., 2013), Algeria, Mauritania, Malaysia and Indonesia and, to an even lesser degree, Morocco, and the substantial neutrality of Libya, Tunisia, Saudi Arabia, and Mali. Finally, of great interest is the neutral position of Russia and India (as well as the neutral position of Myanmar and Cambodia on the one side, and of most Caucasian states on the other). Coming to the anti-sympathetic sphere, its champions are, with little surprise, countries like Pakistan (and recent history shows how well grounded this 2007-based scenario was), Nepal, Bangladesh, Nigeria, Chad, and Ethiopia (which, at least for Muslim anti-sympathetic countries such as Nigeria and Bangladesh and possibly Chad, might be linked to urban poverty as a detonating factor; see Mousseau, 2011). For many Muslim countries that play a prominent conflictual role on the international scene, such as for instance Iran, Iraq, Afghanistan or Sudan, it is not possible to draw inferences due to lack of data concerning one or more indicators. Also worthy of mention is the moderately but substantially anti-sympathetic position of China, as well as those of Uzbekistan, Syria, Cameroon and Mozambique (and the relatively less anti-sympathetic position of Egypt).

Although most of the information charted above can be easily derived from conventional methods of analysis and data sources commonly used in political science, it is in our opinion quite remarkable that they can be substantially replicated by means of a small, non-specific empirical basis like the one used in the present paper. For instance, Ventura (2014) derives, by making use of a large and diversified database of

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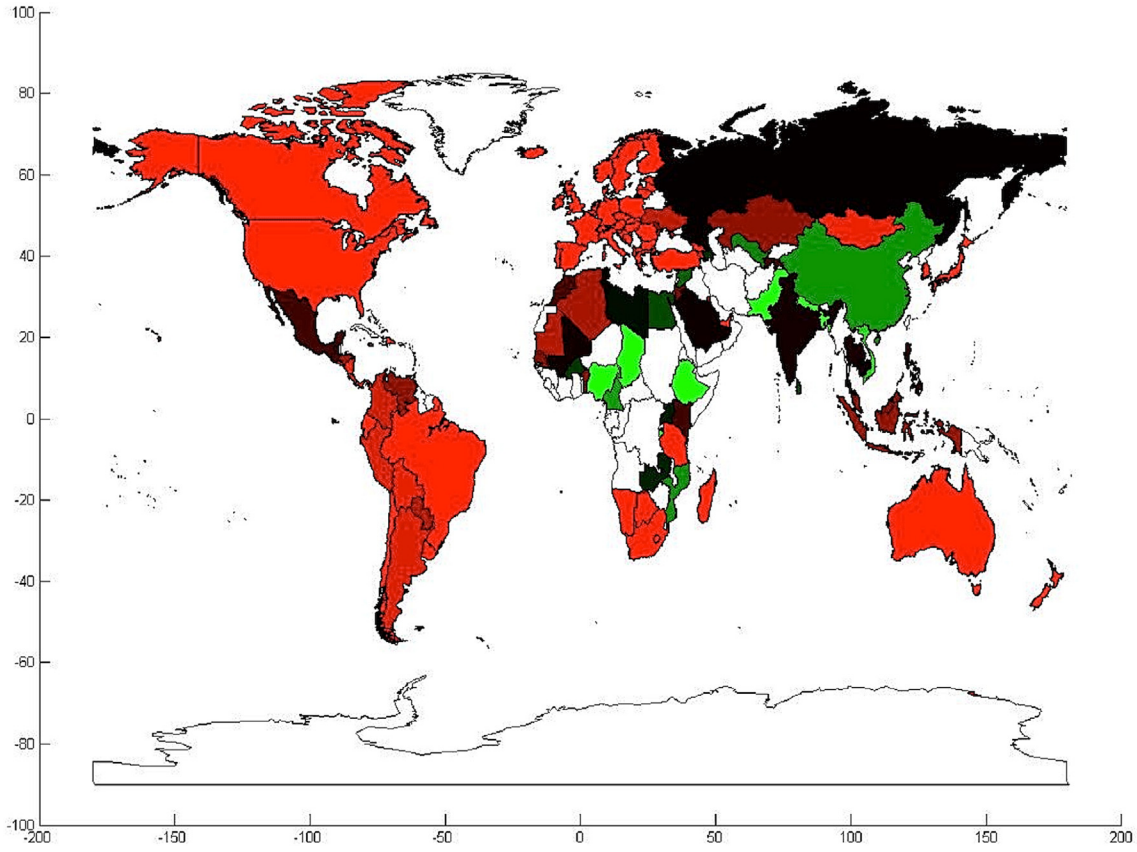

Fig. 1. The 2007 global pattern from the USA vantage point.

sources that are quite independent of our own, a global map of the USA alliances/rivalries which, keeping into account the evolution of the world scenario between 2007 and 2014, still reflects many of the indications that can be drawn from Fig. 1 in our paper, and in particular characterized the USA system of alliances as a very nuanced modulation of levels of alliance/rivalry with different countries. Moreover, there are some fine-grained details of our Fig. 1 that challenge conventional wisdom (let alone 'clash of civilization' mappings). Think for example of Algeria, which somewhat surprisingly turns out to resonate sympathetically with the USA. Although Algeria is certainly a country that is strongly rooted in the Muslim quadrant, and certainly on the opposite side to the USA in the West-Muslim field, it is a matter of fact that President Bouteflika has been the first Algerian President to visit the USA in 16 years (in 2001), followed up by a continuing activity aimed at the strengthening of the USA-Algeria bilateral relationships (Quandt, 2002), while at the same time building a vast network of initiatives with most of the outstanding countries of the Western European block (including France, its former colonial ruler). It is also to be stressed that Algeria officially condemned the 2001 terrorist attacks on NY and Washington, and that it has been playing an active role in the international countervailing action against terrorism. Also, it has to be recalled that Algeria played a substantial role in the release of USA hostages in the 1980 Iranian crisis, and in the solution of the Iranian-Iraqi war. Again, it is surprising that such kind of a fine-grained position in terms of the geometry of international relationships can be traced just on the basis of the five indicators, for most of which the Algerian rankings and values apparently have very little in common with the USA ones, but that acquire a new meaning once framed within the (relative) attribute field perspective characteristic of the Democratic Peace approach. Or consider, on the other hand, the somewhat surprising 'coldness' of sympathy between USA and Mexico. Due to the physical proximity of the two countries and to the size of the (legal and illegal) flows of people and goods among them, this is a particularly complex and delicate relationship, based on the so called 'grand bargain' (e.g. Storrs, 2006) according to which the USA accept to ease their policy enforcement toward irregular immigrant workers of Mexican origin and provide economic and financial aid to the partner country, whereas on the other side Mexico commits to curbing illegal immigration and transborder trafficking. The relationship, however, is threatened by a substantial asymmetry in terms of resources and power, that truly prevents the onset of a real cooperation and only leaves room for a wary form of partnership (e.g. Domínguez and Fernández de Castro, 2009).

Also the neutral positions of the USA with respect to Russia and India deserve some special attention. In the case of Russia, it is interesting to notice that the extremely complex nature of this relationship is classified by the ACS as a neutral one as of 2007. In prospective terms, this evaluation looks very interesting, as it somewhat balances between the deteriorating mood during the ending phase of the Bush-Putin era (think e.g. of the 2007–08 crisis sparked by the USA's action for new defensive installments in Poland and Czech Republic) and the upheaval of goodwill sparked by the Obama-Medvedev joint statement of a 'fresh start' in the USA-Russia relationships, in the context of a situation that still maintains all of its basic criticalities. In particular, classifying the relationship as neutral as of 2007 seems to forecast an open-ended, uncertain evolution – whereas from the 2007 vantage point, conventional wisdom would have probably made a call for plain anti-sympathy. As a matter of fact, the current situation of the USA-Russia relation is quite problematic, but for reasons that have mostly materialized very recently, such as the Ukrainian crisis and the resurgence of westward Russian expansionism, breaking a relatively long phase of distension. In the same vein, openings of new scenarios for cooperation between USA and China launched by President Obama should have been taken with a grain of salt in that, in view of the 2007 level of anti-sympathy between the two countries, effective cooperation would have called for some more relative convergence in the current degrees of orientation to openness – not to speak of the simultaneous EU-China increasing

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level of strategic coordination that breaks the USA unipolar leadership (Scott, 2007). Finally, the neutral character of the relationship between USA and India can be explained to a large extent in terms of the strong military alliance between the latter and Russia, although the partnership with the USA has been improving, leading to a civilian nuclear agreement in 2008. The historical strategic closeness of India to the former Soviet Union has thus evolved into a much more complex and articulated position, in which India maintains a delicate and important attitude of equanimity with respect to the two superpowers.

Looking at the global order from the Pakistan's vantage point delivers markedly different results, not only, and quite obviously, in terms of the differing geography of sympathy and anti-sympathy, but first, and foremost, in terms of the gradation of the relationships (Fig. 2). Whereas the spectrum of American relationships is extremely blurred and articulated, the Pakistani one is as hard edged as possible: Countries are either close friends or plain enemies, without compromise. The network of sympathetic countries extends to part of Muslim Africa, Syria and Saudi Arabia, China, Russia, and Vietnam, ruling out the 'moderate' West African Muslim block and the whole of South America. It is particularly interesting to discuss, although briefly, the degree of anti-sympathy that emerges between Pakistan and countries like Algeria, with which relationships are good on diplomatic and political terms. On the one side, misalignment is largely due to the fact that the mediating position taken by Algeria substantially conflicts with the Pakistani uncompromising view of the world as of 2007, placing it on the opposite side. On the other hand, Pakistan has been sometimes supporting claims that go against Algerian interests, such as in the case of their support of Moroccan vindications upon Western Sahara. It is interesting to remark how, in 2007, the USA policy of massive financial aid to Pakistan was strongly criticized by analysts on the basis of its ineffectiveness to counter al-Qaida growth in the region (Lobe, 2007): a strategy which finds little support in our maps, given the strong anti-sympathetic interaction between the two countries.

Pretty much the same pattern emerges for Egypt, which is still anti-sympathetic to the USA but much less so than Pakistan. In particular, it turns out that when Egypt is evaluated from the USA vantage point, the former looks moderately anti-sympathetic, whereas from the opposite viewpoint the USA look entirely anti-sympathetic. This remark suggests that evaluations of sympathy are asymmetrical: In this specific example, the USA tend to 'resonate with' Egypt substantially more than Egypt tends to 'resonate with' the USA. Similar queries conducted for countries that are strongly sympathetic to the USA produce maps that are substantially replicating the American one, thus indicating a substantial stability in the ACS estimations. It is interesting to notice, moreover, how the map looks the same as the Egypt or Pakistan one from the Chinese vantage point: Same sharp borders between friends and enemies, and, more interestingly, same *actual* geography of friends and enemies. This leads us to think that the structure of the world order seems to be still characterized, as of 2007, by an incumbent Western-focused power network – that tries to expand its connections dialectically also across areas with different cultural orientations, which maintain a moderate and open position – and an alternative, composite field, that tries to contrast the former. The dividing line is not characterized, as Huntington would put it, by apparent cultural differences, but by the level of democratic orientation, as the Democratic Peace Theory would suggest. The more moderate states belonging to oppositional cultures resonate to some degree to the Western network, thereby keeping some distance from the more radical countries, for which the only possible reliable partners are those which are fully and indisputably aligned with their own positions.

A final, interesting remark has to do with the map emerging from the Indian vantage point. As we have already remarked, India maintains a

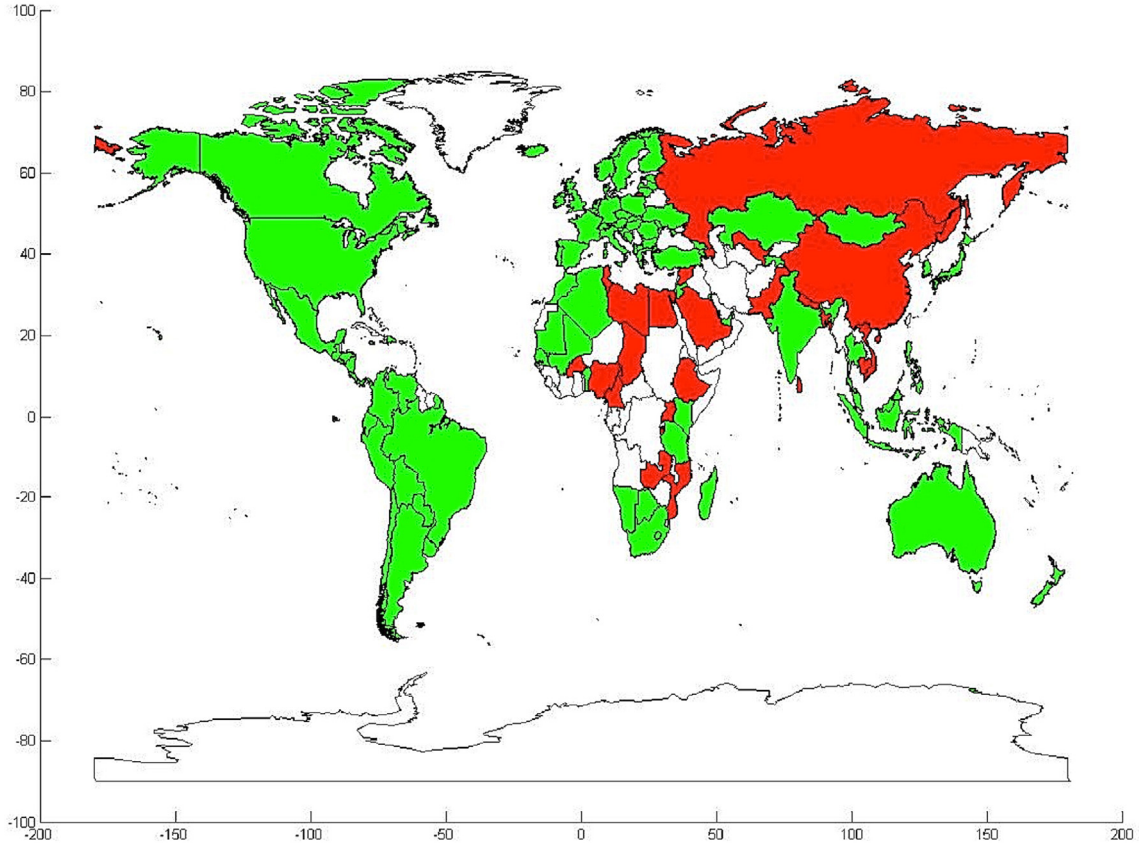

Fig. 2. The 2007 global pattern from the Pakistan vantage point.

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very complex attitude, characterized by a sort of tactical positioning just in the middle ground between USA and Russia, and by a substantial conflict with China, also due to long-lasting territorial disputes. Once again, the picture is very sharp edged. In this case, however, most countries lie in the anti-sympathetic quadrant, the only ones on the sympathetic side being Burundi, Chad, Ethiopia, and Gambia: That is to say, very poor and somewhat marginal African countries. This seems to suggest that the Indian equanimity position, although tactically clever, makes it very difficult to develop a consistent, stable network of alliances, and marks in particular a distance between both the Western bloc and the alternative one, where longtime enemies such as China and Pakistan play a major role. It is remarkable that this information can be deduced from the analysis of the five indicators and does not need any actual knowledge of the history of political or even military relationships and conflicts between countries.

6. Conclusion

In this paper, we have introduced a new computational tool, ACS, as the basis of an innovative approach to global analysis of the world order based on intensive data mining on a small set of indicators, which taken together stand as a proxy of open society orientation, and thus, indirectly, of market democracy. Rather than developing a simple theoretical hypothesis to be put to test through data, we have pursued a focused data interrogation in the spirit of Beck et al. (2000) about relative (adjusted) multi-dimensional similarities across a field of country attributes (Rummel, 1971), to organize empirical information in new, unexpected ways that can be conducive to new evidence-driven theoretical hypotheses with challenging implications (Bezold, 2010). We believe that our results can be fruitfully employed to this purpose in future research and in policy design in a context of potentially disruptive transformation (Cagnin et al., 2013) and of elusive, multi-layered dynamics of international relations (Lee, 2015). Our original data-processing architecture has allowed us to draw rather articulate inferences on some aspects of the fine-grained structure of the world order as of 2007, starting from an informational base with little or no content concerning political and diplomatic aspects of the international relations between countries. This suggests that the dimensions spanned by open society orientation (transparency, freedom of press, economic competitiveness, human development and economic freedom), in their multifaceted aspects, are a reliable predictor of some key aspects of the structure of the world order. This implication contradicts visions of the world order that are built upon narratives of contrast of absolute cultural and value orientations such as Hutchinson's clash of civilizations, and provide support to a Democratic Peace Theory approach, showing in particular how not only democratic countries tend to form stable alliances, but also that they develop a very rich and nuanced spectrum of international relationships, against the clear-cut dichotomic positions of more authoritarian countries.

But how these attitudes evolve over time? Would the China and India of 2016 still be as hard edged in their map of global alliances as they were in 2007, for example? Or, on another level, can we say that, for instance, at times of surging military conflict the map becomes sharper, and that at times of peace a subtler geography of relationships emerges – and how this differs for democratic vs. non-democratic countries? This kind of questions cannot be addressed in the context of the present paper, that intentionally only refers to data from a single year, 2007. This is a purposeful choice, not dictated by lack of available data (the chosen indexes are publicly available for any recent year), but from the interest in carrying out an extreme experiment in intensive data mining. Our approach can be easily extended to deal with time series, and this will be the object of future research, that will allow us to tackle questions such as those highlighted above. On the other hand, as already remarked, even in its present formulation our analysis is not entirely static, in that the nature of the inferences produced by ACS, because of their implicit dynamic nature, also contains an element of trend extrapolation, although a more precise understanding of this feature is to be sought in future work.

Another interesting field of inquiry is how the logic of alliances and oppositions works for countries from relatively similar geographical positions and political, social and cultural backgrounds. If the notion of 'blocks' à la Huntington is too simplistic, what are the key variables that shape up the field? Are they stable in time or do they change according to periods and scenarios? This is another sort of questions that is difficult to tackle according to conventional methods, although, as we have seen, the Democratic Peace Theory approach provides an interesting framework of reference to start from.

And finally, what is the consequence of choosing a certain set of indicators as the filter rather than another? Here, we have chosen five indicators that jointly make a proxy of an open society, and thus we have implicitly chosen to focus on market democracy as the benchmark, but what about choosing others? And for what kind of problems, to yield what expected insights and results? We could go on at length introducing more questions and avenues for future research, but we stop here for brevity.

As a final note, it should be remarked that the scope of the present article does not allow us a detailed examination of the many implications that our map analysis brings about in terms of relationships between a reference country and all the remaining ones, on the basis of specific data, literature and local information sources. In the paper, we have limited ourselves to a sketchy analysis concerning two polar countries in the global arena: the USA and Pakistan, and a more cursory one for Egypt, China, and India. We intend to pursue this analysis further in future research, together with comparative analyses of global maps from given country vantage points for different, carefully chosen years. For example, having chosen 2007 as our reference year immediately sparks curiosity as to possible modifications of the maps after the outbreak of the global crisis in 2008, or after the escalation of radical Islamic military terrorism in the last few years. We leave these and other inquiries for future research, and hope that intensive data mining can be increasingly considered as an option of interest for specific aspects of future analyses of the world order.

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Massimo Buscema is Director of Semeion Research Center in Rome and Full Professor Adjoint at University of Colorado at Denver. He researches and consults internationally in the field of theory and applications of artificial neural networks and evolutionary algorithms. Associate Editor of Quality and Quantity, member of the editorial board of Substance Use and Misuse.

Guido Ferilli is Assistant Professor and Director of the Cultural Industries and Complexity Observatory at IULM University, Milan. His research focuses upon economics, applied quantitative methods to the social sciences and European programmes. Researches and consults internationally in the fields of cultural policy design and local development.

Pier Luigi Sacco is Professor of Economic Policy at IULM University in Milan, Senior Researcher at MetaLAB (at) Harvard and Visiting Scholar at Harvard University. He researches and consults internationally in the fields of cultural economics, game theory and strategic policy design. Member of the Editorial Board/Scientific Committee of: International Journal of Cultural and Creative Industries, Creative Industries Journal, Quality and Quantity, Mind and Society.

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