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REGULAR ARTICLE

Testing the convergence hypothesis: a longitudinal and cross-sectional analysis of the world trade web through social network and statistical analyses

Lucio Biggiero[1] · **Roberto Urbani**[2]

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Abstract
Different theoretical perspectives support opposite views on convergence: although the dominant view is that convergence is the inevitable outcome of globalization, divergentists (that is, world-system economists and, potentially, also evolutionary geographic ones) argue that convergence forces could be annihilated by the need to keep power relationships within the international division of labor. Even when limiting the convergence issue to international trade, the debate has so far been inconclusive, because various studies have dealt with different and/or short time series or selected too small and different sets of countries. Moreover, none of these studies have analyzed trade patterns and have instead been limited to the aggregate value. Here, through a social network analysis, we examine the world trade patterns from 1980 to 2016 (1980–1992, 1993–2007 and 2008–2016) of at least 164 countries, which have been divided into import and export patterns and into four groups of countries: from core countries to far periphery ones. We test the convergence hypothesis in two directions: the level and trend of convergence, and its possible determination by means of structural or economic globalization, measured in terms of exchanges density and economic values, respectively. We have found that the convergence hypothesis only seems to be confirmed when considering the pure structural aspect and core countries. Conversely, economic convergence—which also includes the structural dimension—has been found to be high for core countries and to increase over time. Moreover, our analysis shows that economic globalization influences convergence, albeit in a strongly *negative* way. Therefore, our findings seem to support divergentists and the convergence hypothesis should be rejected.

✉ Roberto Urbani
rurbani@luiss.it

Lucio Biggiero
lucio.biggiero@univaq.it

1 Department of Industrial Engineering, Information and Economics, University of L'Aquila, Via G. Mezzanotte s.n., Località Acquasanta, 67100 L'Aquila, Italy

2 Department of Business and Management, LUISS University (IT), Roma, Italy

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1 Introduction

The issue of inter-country convergence covers many fields, ranging from international economics to industrial economics, finance, etc., since countries may converge or diverge on any aspect of economic life—and moreover, on any aspect of social life. Indeed, since economies and societies are complex systems made up of interdependent and co-evolving networks, globalization and convergence are therefore complex phenomena, and it is not surprising that the research on both issues has found it hard to reach a shared and sound conclusion. In general, the convergence hypothesis (hereafter CH) is grounded on the effects of globalization (Williamson 1996), which is a somewhat multifaceted phenomenon on its own, because it may occur in a differentiated way in many economic and social spheres (Ritzer 2007). The idea that, whenever and wherever it happens, globalization pushes so toward a progressive inter-country convergence has stimulated a vast amount of literature. Convergence can be narrowly interpreted as approaching the same goal or value or, more broadly speaking, as reducing reciprocal distances—that is, increasing similarity, in terms of a given parameter. The parameters that are traditionally considered in economic analyses are those of technology (number of patents, innovations, etc.), per-capita income and/or growth rate. However, there are many other parameters beyond of the economic field that are used for sociological or political studies, namely, cultural convergence, the structure of education systems, mass media control, engagement in international governmental, non-governmental institutions, etc.

Even when the analysis is limited to the economic sphere, it is difficult to overestimate the relevance of CH. If such a hypothesis were to be confirmed, several consequences, in terms of, for example, world development forecasts, would follow. International economic policies would thus receive a crucial indication about cyclical or anti-cyclical effects because countries with a higher convergence degree (hereafter CD) are more likely to react in a similar way to the same policies and vice versa. However, we will come back to these issues in more detail in discussion and conclusions section. The acceleration of globalization has further emphasized the issue of convergence, because it seems that its typical features—the growth of world trade, the reduction of trade barriers, decreasing transportation costs, the accentuated role of international economic institutions, to name just a few of the most important ones—affect, especially in developing countries, the income growth rate and the world trade amount and extension, which in turn increase the number of partner countries, as well as social and economic inequality. All this is clearly believed to reduce the distances between countries, and thus, increase convergence. In this vein, we refer to CH as the concept that globalization has increased the convergence of world trade, which is the specific field of our present investigation.

It is possible to identify three approaches to economic convergence on which CH can rely: two are completely opposite each other, and the other one is still waiting for its specific position to be developed. CH is generally supported by modernization theorists (Barro and Sala-I-Martin 1992; Durlauf 1996; Krugman 1991; Meyer 2000; Quah 1993, 1996), who substantially agree with mainstream economists on the idea of the parallel growth of all nations, pushed by the powerful forces of economic development and technological innovation (Barro and Sala-I-Martin 2004; Sengupta 2011). Modernization theories are deeply rooted in mainstream economics, that is, in optimal equilibrium-based neoclassical economics. The reason for this is very clear: there is no unequal exchange in an optimal equilibrium-based approach, because such an approach would otherwise not be optimal. It could be sub-optimal, but only temporarily, that is, just the time necessary for equilibrium-adjustment forces to operate. Furthermore, even though differential competitive advantages would force countries to specialize in different sectors, their positions would need to be symmetric, at least at the highest aggregate level, and thus, CD would need to be perfect. Finally, the magic, invisible force would lead to development where it was delayed, because free markets, sooner or later, match any unsatisfied demand, and companies relocate to low-cost countries. Applied economists are aware of the many "frictions" on real markets, such as entry barriers, tariffs, scarcity of skilled workers (Quah 1993, 1996). However, genuine modernization theorists (Armstrong and Taylor 2000; Krugman 1995; Martin and Sunley 1996, 1998) would argue that all these hurdles are only temporary, because economic convenience and balancing mechanisms inevitably prevail. As we will see, they found confirmation of CH, because their applied studies were conducted on the most advanced countries, and they employed rather simplified methods. We can therefore call this group of authors "convergentists."

Two theoretical perspectives are in contrast with CH: the world-system theory (Babones and Chase-Dunn 2012; Chase-Dunn et al. 2000; Chase-Dunn and Grimes 1995; Wallerstein 2000, 2004) and the dependence theory (Abhijeet 2016; Manning and Gills 2013; Smith 1979). The former underlines that the world's economy has traditionally been divided into three groups of countries: core counties, which correspond to the most developed countries, periphery ones, which refer to the least developed countries, and a semi-periphery group of intermediate-level countries. According to the world-systems theory, globalization has always been compatible with marked differences in the world's trade structures between the three groups, and there is no reason to believe that the recent acceleration stage has shortened such distances. The dependence theory is even more radical as it argues that, as long as capitalism is the universal economic regime, there will be a marked difference between the three groups. In other words, the core countries can maintain their leading position and maintain their high living standard just because there are periphery countries. The core countries develop at the expense of the periphery ones. Therefore, for the theorists who belong to these two groups, there is no reason to support CH. We can therefore call such theorists "divergentists."

However, there is also a third research stream that lies somewhere in the middle between convergentists and their opponents: that of the evolutionary economic geography theory (Boschma and Frenken 2006; Boschma and Lambooy 1999; Boschma and Martin 2010; Coe et al. 2008a, b). This theoretical perspective departs substantially from standard economics (and standard economic geography), and it underlines the path dependency in which each country is entrapped from the time of their structuring into an institutional, social and economic realization. This specificity would prevent or hinder any inter-country uniformity to a great extent, as hypothesized by CH. Indeed, this group of economists has not yet specifically dealt with CH, but just with the concept of convergence, and only in reference to technology (Boschma and Martin 2010).

However, a review of these different theoretical perspectives is beyond the scope of our paper, although such a review can be found in Austin et al. (2012) and in So (1999). Our primary goal is instead to offer a rather complete test of CH from several points of view and over a significantly long time series. The extension of our tests allows another main objective to be reached: to show the problems that underline the statistical and network analyses of world trade, especially when considering the absolute values of exchanges and dealing with patterns and not with aggregate country values. This aspect makes our paper methodologically rich and at the same time explains the unusual length of its methodological section, which introduces some network analysis methods that we have employed to measure CD. In fact, after some pioneering work in the seventies and nineties (Snyder and Kick 1979), international trade has been a frequent object of network analysis over the last 20 years: see Maoz (2011), Kick et al. (2011), De Bendictis and Tajoli (2011), De Bendictis et al. (2013), Fagiolo et al. (2010, 2014), and, more recently, Cepeda-López et al. (2018). Among the various acronyms used so far in this specialized literature, we have chosen WTW (World Trade Web), which was introduced by Serrano and Boguñá in 2003. We have not reviewed the aforementioned studies here, because they do not offer useful information to help explain or confirm/reject CH. Some explanatory models have been developed over the last 10 years, most of which are based on gravity models (Almog et al. 2017; Dueñas and Fagiolo 2013; García-Pérez et a., 2016; Serrano et al. 2010). These models could suggest an explanation of CD at the country group level, even though Dueñas and Fagiolo argued that their model did not work well for higher-order statistics, and CD belongs to this category. We will come back to this issue in Discussion and conclusion section.

Previous studies have provided a great deal of descriptive knowledge, and some of them have underlined the need to run both a binary analysis (pure structural, topological) and a weighted one (involving link weights, that is, economic values), because they could give rather different results (Fagiolo et al. 2010), as also confirmed by our findings. We have followed this approach; thus, we distinguish economic globalization (weighted) from structural (binary) globalization and the corresponding effects on CD measured in economic (weighted) and structural (binary) terms. In other words, the economic dimension in our analysis also includes the structural dimension, because only the weight of the links changes, while the analysis is the same in terms of trade *patterns*. This is why the economic analysis run here should be more appropriately referred to as weighted—or, even better, integrated—as we have sometimes done hereafter. Therefore, the binary (purely structural) analysis allows us to distinguish that part of the results that is only due to the structural dimension and is separated from the role of trade values. Conversely, except for the work of Berry et al. (2014), who cannot be classified in either of the two aforementioned categories, the analysis conducted by convergentists and divergentists only deals with the economic dimension and overlooks not only the structural aspect, but also the true sense of the structure, that is, it overlooks the patterns of trade. In other words, it does not disaggregate world trade into a network of exchanges. In short, structural globalization should be considered as an aspect of economic (integrated) globalization.

We test four (groups of) hypotheses, which are introduced in the next section together with a short literature review on CH in international trade. We then present the dataset and methodology which contribute to a great extent to the network analysis of international trade, since we introduce and discuss not only the methodological choices that are implemented therein, but also those that we experimented with but then abandoned because they resulted to be distortive, ineffective, or not explicative. In section four, we show the main results, from which a complex relationship between globalization and convergence emerges, and which is rather differentiated in terms of time segments, import and export and groups of countries. Therefore, although all these results are discussed in the concluding sections, we here summarize the most important ones: i) the pure structural CD, at the overall WTW level, is high and growing, while the hybrid (structural–economic) CD is low and declining; ii) the structural CD of the 20 most connected countries grew remarkably and constantly over the considered 37 years and reached an almost perfect convergence (0.96) in 2016; iii); iv) both the structural and economic measures of globalization are able to clearly explain both the structural and hybrid measures of CD, albeit through a negative effect. Discussion and conclusion sections insert these and other findings into the debate on CH and business cycle synchronization, with further implications on the evolutionary economic geography and world-systems theory approaches.

2 A short literature review

Over time, the thesis on income convergence (Williamson 1996) has progressively been extended to technological and/or structural convergence (Mancusi 2001; Stehrer and Wörz 2003). Such an argument claims that one of the effects of globalization is the progressive stabilization and complementarity of trade patterns (Brecher and Choudhri 1993; Gagnon and Rose 1995). In this perspective, Crespo and Fontoura (2007) examined the structural change and convergence of CEEC (Central and Eastern European Countries) trade within the integrated EU market for the 1995–2003 period. As is well known, their integration occurred through a dramatic process of production structure transformation, and the question raised by Crespo and Fontoura just concerned whether such a process was converging toward a similar structure. They answered positively, because their results showed that CEEC trade specialization was evolving quickly toward Western partners. Carter and Xianghong (2004) studied the trade patterns of four different groups of goods: bulk agricultural ones, high-value agricultural ones, other primary and manufactured goods. The analysis concentrated on the period from 1980 to 1997 and considered five OECD (Organization for Economic Co-operation and Development) economic regions: the USA, the EU, Canada, Australia and Japan. Their results revealed changing trade patterns, especially for the EU and Japan, and to a lesser extent also for the USA, while there emerged uniformity for Canada and Australia. In terms of goods, the manufactured products resulted to be the most dynamic and variable, while the most stable were the bulk agriculture goods and those of the other primary sector. These results confirm that trade pattern stability depends on both physical and socio-geo-political stability.

However, as Carter and Xianghong (2004) pointed out, those empirical results cannot be considered conclusive, since other authors found the opposite (see Berry et al. 2014; Carolan et al. 1998; Cotsomitis et al. 1991; Lutz and Kihl 1990). Among the ones who found opposite results, Berry et al. (2014) conducted one of the most recent and most extensive studies that dealt with demographic, knowledge, financial and political aspects, apart from economic ones. They analyzed the latter aspects in terms of three variables for the 1960–2009 period: GDP (gross domestic product) per capita, export % and import % of the GDP. They found a divergence in the economic dimension at the world level, which was also confirmed when distinguishing between the core, periphery and semi-periphery countries. However, their work is of limited relevance for our analysis because, apart from some methodological aspects,[1] they considered exports and imports in aggregate and in the percentage of GDP, thus ruling out the possibility of conducting an analysis in terms of trade *patterns* and their absolute values.

Analogously, in the business cycle synchronization debate, Kose et al. (2008) showed that, at least for developing countries, globalization, intended as total trade and financial capital growth rate, does not produce GDP synchronization. Hence, even when restricting the question to only international trade, it still needs a clear and definitive explanation. We argue that these contradicting and inconclusive results are due to four main reasons. The first one concerns the time series, because, as we will show, CD can change considerably over time. The second one refers to the level of aggregation of the analysis, because CD may vary across industries, and thus, the level of the whole world's trade necessarily hides combination and compensation effects between countries. The third reason lies in the choice of either considering the aggregate value of a country's international trade, perhaps in GDP percentage, or of unraveling it into a country's trade patterns. In fact, the absolute value or the percentage of trade for various countries could converge, while the corresponding patterns could diverge. Finally, the last reason concerns CD measures, in terms of a purely structural or mixed economic–structural dimension. In fact, as a result of the variance of bilateral exchange values over 6 magnitudes—from thousands to billions of dollars—these CD measures can give very different results.

In our work, we fill some of these gaps by testing the CH of international trade *patterns* through both CD measures of all the aggregated sectors during the 1980–2016 period by conducting the analysis in three ways: at aggregate world level, separating imports from exports, and finally dividing the world into four groups of countries. For our purpose, we check for associations and explanations between two globalization indicators—trade values and density (i.e., the number of exchanges)—as independent

[1] We refer to the fact that: i) the number of countries considered for the GDP per capita is higher (193) than the number of countries considered for exports and imports (179), ii) the result of the former is not separated from the two latter variables, and iii) we have no indications concerning how the time series was built, especially in consideration of the disintegration of the USSR, the unification of Germany, and other major events (see Appendix for our choices in this regard).

variables and CD measures as the dependent variables to measure the CD level and dynamics and to test the more accredited hypotheses on the causes of convergence. We employ two types of structural equivalence indexes to measure CD. These indexes are among the most interesting social network analysis methods and are particularly appropriate when the purpose is comparing the relative similarity of the patterns of relations among nodes in a network and international trade is a network to all extent and purposes.

According to the world-system approach (Babones and Chase-Dunn 2012; Chase-Dunn et al. 2000; Smith and White 1992; Van Rossem 1996), far more important than the previous list of factors preventing convergence, is the fact that world trade reflects a hierarchy between dominant/exploiting core countries and dominated/exploited peripheral countries, and that the former—strategically—act in such a way to maintain a dominant position. A true convergence would mean reducing their hierarchical distance, which would thus be hindered by core countries. The recent political success of anti-globalization policies in Europe and the USA appears to confirm the claims raised by world-system scholars, because, apart from the purpose of "defending" national economies, such a success can be interpreted as an explicit reaction to the progressive erosion of the advantages of core countries by semi-peripheral countries and especially by BRICS (five major emerging countries—Brazil, Russia, India, China and South Africa).

Furthermore, the world-systems theory also distinguishes between the intermediate group of semi-peripheral countries, which are believed to play a relevant role in the dynamics of world politics, society and economy, and thus, also in world trade (Austin et al. 2012). We have followed this approach and further divided this group into strong and weak semi-periphery countries, according to the number of trade partners: that is, strong semi-periphery countries if the considered country is just below that of the core countries, and weak if it is much closer to the peripheral countries.[2] This way, our work also functions as a test of the world-systems theory itself, because it implies that core and peripheral countries must have very different CDs and that they did not reduce significantly over time.

3 Hypothesis formulation

We propose four sets of hypotheses formulated around two lines of reasoning: the first one concerns the expectations regarding the CD of the whole WTW or its parts, while the second one concerns globalization as the possible explanatory factor of the CD of single countries. The two lines of reasoning are logically independent, because whatever the confirmations or rejections in the former are, the latter looks for the causes and not the expected level of CD. In other words, the CD level of a group of countries may be determined by several different causes and it is referred to as the average CD (ACD). Conversely, according to the second line of reasoning, we employ a regression model to check whether two specific globalization variables can explain the CD of a single country. As mentioned above, our analysis differentiates between pure structural and integrated (structural–economic) variables, but the numerous hypotheses have not

[2] All these methodological choices are discussed in detail in the next section.

distinguished between the two aspects, so as to avoid making them too numerous. The clear difference between the pure structural results and the integrated ones is underlined in results section and in more detail in Discussion section.

The hypotheses based on the former line of reasoning are easy to define, because it is sufficient to test whether the ACD has increased or not. Conversely, the other hypotheses need to have previously chosen an (independent) variable to measure globalization and then to use it to explain and test the CD of single countries. Among the various features of globalization—namely, transportation costs, lower tariff barriers, more political integration, etc. —two of them have been considered to play a crucial role to confirm or reject CH: trade values and the number of partner countries. These features are CT (Country Trade) and LD (Local Density).[3]

The datasets on which the four sets of hypotheses are applied are the following: (1) the whole WTW; (2) the WTW distinguished into the three periods that constitute the whole time series; (3) exports and imports taken separately; and finally, (4) four groups of countries, which correspond to core, strong and weak semi-periphery and periphery countries, whose analysis is also dealt with in depth across the three periods. Here, we adopt a distinction, in terms of connectivity, by ranking countries into four groups (see the next section for further details): Early 20 (E20), Strong Peripheral Countries (SPC) from the 21st to 60th position, Weak Peripheral Countries (WPC) from the 61st to 100th position, and the Remaining Countries[4] (RC).

Before considering the formulation of our hypotheses, it is worth looking at the purely structural and integrated measures, because they can produce very different results. Although convergentists and divergentists never explicitly distinguish between the two aspects, it can be assumed that they implicitly refer to the latter, because their theories deal with economic analysis. Indeed, as mentioned before, neither of the two groups have dealt with trade patterns, except for a few contributions that are not connected with CH, and thus, they have not delved into the analytical level in which we are interested. In order to justify our hypotheses, we employ either arguments raised by convergentists and divergentists, or even by ourselves, in which the line of reasoning is mostly topological. The small size of the WTW allows a straight reasoning process to be made, while the lack of previous integrated data on convergence does not allow such a process to be made. Nevertheless, we do not distinguish the hypotheses built upon structural measures from those built upon integrated measures, because we test a great number of hypotheses, even without such a distinction, but we indicate such a distinction when presenting the results.

The first set of hypotheses concerns the highest level of WTW aggregation. As suggested by convergentists, ACD is believed to have grown over the 37 years between 1980 and 2016, and CT and LD are considered to clearly explain CD at a single country level. Hence, at the whole WTW level, we hypothesize that:

H1a ACD grew over the 37 years, and especially in the last period.

[3] Intuitively, it can be understood that CT corresponds to weighted Dc. We make this clearer in methodological section.

[4] The size of the latter group varies over the three periods, according to the growing size of WTW. We used the size and features of the WTW to know the criteria and to build groups, see the methodological section. See Appendix for details on the exact composition of each group in each period.

H1b The variance explained by CT varies over the time periods and clearly explains CD.

H1c The variance explained by LD varies over the time periods and clearly explains CD.

In principle, there is no reason to believe that CD is similar for exports and imports, because they can be influenced in different ways by LD and CT. Moreover, the sectoral differential specializations addressed by the new economic geography theory (Fujita et al. 1999; Fujita and Thisse 2002; Krugman 1991; Krugman and Venables 1995) and supported by the evolutionary economic geography theory (Boschma and Martin 2010; Martin and Sunley 1998) would seem to suggest that export and import trade patterns could be distributed in very different ways. However, because we conduct the analysis at the highest level of aggregation, and CD is averaged across countries, such sectoral differences could mutually compensate for and/or reduce (or even elide) any export–import differences. Therefore, we expect that such differences, if any, will be small, and thus, we formulate the following three hypotheses:

H2a The export ACD and import ACD grew over the whole period.

H2b The export ACD and import ACD are correlated.

H2c The export ACD and import ACD are very close to one another.

Despite the sectoral compensative forces, according to the new economic geography and evolutionary economic geography theories, the export CD and import CD may be uncorrelated at the single country level, because of country specificities. Furthermore, the export CD and import CD may be influenced to significantly different degrees by our two globalization variables. Therefore, we add the following two hypotheses to the previous set:

H2d The export CD and import CDs are uncorrelated at the single country level.

H2e The export CD and import CDs are influenced by significantly different intensities of CT and LD.

Given the high economic variety of countries, what holds at the global level might not hold at the group level. However, according to convergentists, globalization and economic development produce a "leveling effect," which is reinforced by the synchronization of economic cycles. Since "highly developed" largely corresponds to high-trade and high-connectivity countries, we should expect that the countries with the highest connectivity to also show the highest CD. In fact, as the WTW is very small, it is easy for highly connected countries to do trade with almost all the other countries, and thus, their CD will be high and very similar between countries. The same argument can be extended to the SPC group, which is expected to move closer to E20. In short, slight ACD differences follow the group degree centrality: from E20 to RC. This reasoning seems particularly sound when calculating CD in purely structural terms, that is, without considering trade values.

However, at a closer inspection, the expectations concerning WPC (Weak Peripheral Countries) and RC (Remaining Countries) are more complicated, because the reasoning behind them is not symmetric: the relatively few links could in fact be distributed in very different ways. Furthermore, there could be another aspect that influences their trade patterns: the geographical location. In fact, WPC and RC trade patterns are generally composed of two parts: one is made up of connections with highly connected countries (the E20 group in particular), and the other part is made up of local connections, that is, connections with geographically proximate countries. Many peripheral countries are spatial neighbors, because some large regions (and even continents, such as Asia and Africa) are full of countries that can be considered peripheral from the international trade connectivity viewpoint. Therefore, we can expect the WPC and RC of such countries to be similar in two parts of their trade patterns: the part connected with E20, with which all of them are likely to be connected, and the part for which they are geographical neighbors. A recent paper by Abate et al. (2018), in which it is demonstrated that trade patterns are influenced by the local geographical distance, seems to support these expectations. This argument runs parallel to the gravity model, and it could be further sustained by arguing that a country's early partners are generally[5] the spatially closest ones, because they are more similar in terms of culture and are the ones with the lowest transportation costs. Therefore, on average, peripheral countries should record the lowest ACD, but the reciprocally closest ones have a relatively higher ACD. A further complication is that although the group of the most connected countries is small in size (20), the group of the remaining countries is about 3–4 times larger, and the regions where WPC and RC lie are so large that the geographical proximity is not so noticeable.

In conclusion, the following aspects push the ACD of the four groups of countries in different directions: (i) the small WTW size suggests that, at least when measured in purely structural terms, ACD varies proportionately with LD, and thus, moving from the core countries to the periphery ones, ACD decreases; (ii) geographical proximity suggests that the most peripheral countries are highly connected to the core countries and to their geographically proximate countries, and thus, their CD may not be so low; (iii) the two groups of peripheral countries—and especially the RC—are much larger than E20, and thus, this "size effect" changes to keep its CD at a low level. All in all, we can expect the ACD of WPC and RC to be much lower than those of E20 and SPC, though with a moderate conviction.

When looking at ACD growth, it is possible to hypothesize that the higher the potential of new partners is, the greater the benefits from globalization. In fact, since the range of CD potential growth of poorly connected countries is believed to be higher than that of closely connected countries (Table 3), globalization is expected to push the CD of such countries more than that of closely connected countries. Therefore, ACD growth should follow the inverse order of group degree centrality.

The reasoning behind legitimating the current and the previous sets of hypotheses is based on a mix of "technical" (topological) and empirical (recent studies) considerations. However, such sets seem fully consistent with divergentists but only partially with convergentists. In fact, according to the world-systems theory and dependence theory, core countries behave and are structured in a similar way, and their trade patterns should therefore behave and be structured in a similar way. Conversely, peripheral countries are more heterogeneous and not likely to reach the same degree of connectivity as the core countries, because the latter need to keep them in that situation and to exploit their weaknesses. As far as the SPC and the WPC are quickly concerned, the former is more like core countries and the latter like peripheral countries. Such differences are mirrored in the hypotheses that we have formulated independently of the divergentists' theories. Therefore, the coincidence of our hypotheses with the divergentists' theories also makes our tests a simultaneous test of them. Convergentists' theories seem to match our hypotheses, albeit when limitedly to E20 and, to a certain extent, to SPC, because CD is considered to be high for both and growing quickly or the latter.

Therefore, by considering the different reasoning and the whole time series, we can expect that:

H3a The CDs of the four groups of countries do not differ substantially.

H3b Slight ACD differences follow group degree centrality: from E20 to RC.

H3c ACD growth follows the inverse order of group degree centrality.

So far, we have formulated hypotheses regarding the level and growth of ACD for the four groups of countries, regardless of the explanatory power of the globalization variables on the CD of the single countries. To explain such a power, it is important to understand that the two explaining variables—CT and LD—play different roles in the four groups, because CT can grow ad infinitum, while LD is limited by the small size of WTW. Therefore, assuming that a certain resilience decreases for all the variables, LD can give a relatively low "impulse" to the CD of countries that are already very closely connected, such as, for example, the E20 group, while CT has no upper limit even for such countries.[5] Therefore, it is likely that E20 countries are particularly insensitive to LD variations, for the simple reason that almost all of them are almost completely connected to one another and to all the other countries. Therefore, from a purely structural point of view, these countries are all structurally equivalent, and thus, because CD is measured precisely in our analysis, in terms of structural equivalence, their CDs are almost always very high for all of these countries, with only small differences, if any. This is supposed to hold for the purely structural CD measures. A further influence of globalization could be expected, in principle, when considering it in integrated (economic) terms, which refers the CT independent variable, on the integrated measure of CD as a dependent variable. However, there are reasons to believe that such an influence might be not so important as could be expected, because all E20 countries have very high CT values, and their GNP and trade values do not vary so much yearly as a whole. Furthermore, most of them are impacted by the economic cycle in the same way, because of their synchronization of economic fluctuations, which seems to meet wide consensus (Backus et al. 1992; Kose et al. 2003a, b; Lopes et al. 2018). Therefore, an increase in world trade is considered to impact these countries in a similar way and, likely, to maintain their trade patterns invariant, in economic terms. Therefore, if the composition of their trade patterns

[5] However, as we discuss in methodological section, there is a remarkable difference between BDc and LD, because the former grows linearly, while the latter grows squarely, according to the number of neighbors.

does not vary significantly, then, consistently with hypotheses H1, the corresponding integrated CD measure would result to be very high and stable.

Furthermore, even a decrease in world trade would have a weak impact on purely structural CD measures because the high connectivity of such countries dates back to a long time ago, and trades, once established, tend to be very stable over time, although eventually perhaps having different values. Consequently, even in this case, if an impact can be exerted on CD by CT decreases, such an impact could be on the countries' differences, in terms of trade values, and not in terms of trade patterns. In short, although globalization variables are hypothesized to matter for all countries, E20 and SPC are believed to be more resilient (less sensitive) to globalization changes and vice versa for peripheral countries. Hence, we can propose the following two hypotheses:

H4a Globalization variables are significant for each group of countries.

H4b LD and CT are less significant for E20 and SPC than for the other two groups.

The situation can change over the three periods, because the BDc distribution changes considerably in relation to the WPC and RC groups (Tables 1 and 2). Since E20 and SPC are rapidly approaching full connectivity (Table 3), a progressively less relevant LD can be expected to explain CD with a positive coefficient. If structural globalization is expected to reduce its influence on the structural CD of E20 and SPC overtime, economic globalization can be expected to maintain or even increase its explanatory power, because CT and the weighted convergence can grow ad infinitum. Conversely, the structural globalization of WPC and RC can be very important to explain CD, although perhaps with a negative coefficient, because, as discussed for the previous set of hypotheses, the large size of those two groups and the volatility of their trade partners, an increase in LD can produce a reduction and not an increase in CD. Furthermore, since the trade patterns of WPC and RC contain a much higher share of zeros (missing exchanges) than the other two groups (Table 3), LD must influence structural CD to a great extent. Conversely, such an influence is not expected to be significant for E20 and SPC. Finally, since the ACD of the four groups is expected to be different for the three periods (see hypotheses 4 and 5), it is reasonable to suppose that the explanatory power of the three globalization variables also differs. Hence, we advance the following (last) set of hypotheses, according to which, *over time*:

H4c The explanatory power of LD decreases on E20 and SPC.

H4d The explanatory power of CT increases on E20 and SPC.

H4e LD always maintains a relevant and growing explanatory power on WPC and RC.

4 Dataset and methodology

Dataset. This work involves two main methodological issues: the rationale behind segmenting the 1980–2016 timespan, and the choice of the indexes to measure globalization and CD. As far as the first issue is concerned, we used the IMF cross-country

Table 1 Max and min % of TT and the total connectivity per groups of countries

Year	Groups of countries	E20		SPC		WPC		RC	
	Variables	Max	Min	Max	Min	Max	Min	Max	Min
1980	IMP + EXP % world trade	12.22	1.08	1.07	0.15	0.14	0.02	0.02	1E-6
	Normalized (%) Tot-Dc bin	90	67	66	36	36	24	23	4
1992	IMP + EXP % world trade	12.17	1.25	1.16	1.1	0.08	0.02	0.02	1E-6
	Normalized (%) Tot-Dc bin	99	85	84	48	48	35	34	12
1993	IMP + EXP % world trade	13.22	1.19	1.18	0.1	0.09	0.03	0.03	1E-6
	Normalized (%) Tot-Dc bin	98	84	83	49	49	35	35	9
2007	IMP + EXP % world trade	9.87	1.26	1.23	0.19	0.18	0.03	0.03	1E-6
	Normalized (%) Tot-Dc bin	100	96	95	72	72	57	56	22
2008	IMP + EXP % world trade	9.33	1.25	1.19	0.21	0.02	0.03	0.03	1E-6
	Normalized (%) Tot-Dc bin	100	95	95	74	74	56	56	19
2016	IMP + EXP % world trade	13.53	1.26	1.18	0.2	0.19	0.06	0.06	1E-6
	Normalized (%) Tot-Dc bin	99	95	95	80	80	65	65	29

Table 2 TD, TT and ACD coefficients of variation

	1980–2016	1980–1992	1993–2007	2008–2016
TD	0.27	0.09	0.11	0.03
TT	0.75	0.30	0.44	0.12
WED	0.68	0.32	0.39	0.12
JM	0.18	0.09	0.10	0.03

export dataset (called DOTS), which provides inter-country trade data in current US$. The matrices were constructed using aggregate exports and dividing the entire period into three segments: 1980–1992, 1993–2007 and 2008–2016. As a result of the many geopolitical changes that occurred over the 37-year period, the trade network corresponding to each segment has a different number of countries and, to a certain extent, even different countries, because some new nations were created and some

Table 3 Share of zeros as the % of the total possible exchanges

	1980–1992	1993–2007	2008–2016	All
E20	0.86	0.21	0.23	0.44
SPC	8.70	3.94	2.20	4.95
WPC	15.00	9.42	6.28	10.23
RC	30.45	28.90	22.68	27.34
All	14.53	11.14	8.48	11.38

others ceased to exist. The first period is made up of 164 countries, the second of 179 and the third of 183 countries.[6] The yearly word trade network is expressed by a squared countries x countries matrix, whose size corresponds to the set of countries that remained constant during each period. Each matrix corresponds to a digraph, whose nodes (vertexes) are the countries and whose links (arcs) are the (unilateral) exchanged values. We used three software packages: UCINET (Borgatti et al. 2013; Hanneman and Riddle 2005), NEDDI[7] for social network analysis and STATA for statistical analyses (StataCorp. 2019. Stata Statistical Software: Release 16. College Station, TX: StataCorp LLC).

4.1 Measuring the globalization variables

Globalization is expressed by two variables: country trade (CT) and local density (LD), which correspond to economic (integrated) and structural globalization, respectively. The former is a typical economic measure which corresponds to a typical network analysis centrality index: a country's WDc (Weighted Degree centrality),[8] while the latter represents a structural variable which, in Social Network Analysis, corresponds to the density of an ego-network. Instead, in WTW, it represents the number of exchanges that occur between a country's neighbors (trade partners), normalized by the number of possible exchanges among such countries.[9] Initially, we employed and tested another structural globalization variable: binary degree centrality, that is, the number of partners of a country. In strict mathematical terms, the difference between this index and LD is that the former varies according to the number of neighbors of a country, which is a linear function, while the latter varies according to the number of trades between them, which is a squared function. Furthermore, the economic difference is that, in the former case, we make a country's globalization depend on the number of its trade

[6] The countries of each segment are listed in Tables 8, 9 and 10 of Appendix, and some of the many geo-political changes are mentioned.

[7] NEDDI (Network-Based Euclidean Distance) is a software that was made in Python by one of our group members to calculate the relative ED of weighted networks. UCINET in fact only calculates it in absolute terms, and this prevents inter-period and inter-group comparisons. The normalization of weighted ED is anything but simple, and it is not "light" in computational terms.

[8] In the mathematical jargon of network analysis, WDc is called the strength of a node and corresponds to the sum of the weights in the links adjacent to it.

[9] If we indicate the number of neighbors with m, the normalized term is the usual m(m-1) expression.

partners, that is, on its ability to establish connections, while in the latter case, globalization is expressed in terms of the number of trades between its partners. Therefore, in the latter case, a country's globalization index depends on the trade capacities of its partners instead of those the focal country itself. The choice of LD instead of binary Dc was made since, in light of the statistical analysis, it emerged that binary Dc had a very low (if any) explanatory power and often also a low R^2 for all the dependent variables. Thus, for the sake of simplicity, we decided to avoid using it, but we will come back to this point in discussion section, because this choice seems to lead to an interesting result.

In the present case, since CH is tested at an aggregate and disaggregate (country-specific) level, the variables are a little different: we use the total density (TD), total world trade (TT) and average convergence degree (ACD) at the aggregate level. In the latter case, the values of the three convergence indexes are intended as averaged across countries. TD is the absolute number of exchanges, distinguished (and summed) per in-edges (imports) and out-edges (exports), for the whole WTW or for some of its partitions: single periods, only imports or exports and/or groups of countries. Analogously, TT is the value of exports and imports of WTW or some of its partitions. We use LD and CT at the disaggregated level, which is also the only level used to run the statistical analyses.

4.2 Measuring the convergence degree

We measure CD as the intra-network structural equivalence, that is, the degree of similarity between node (exchange) patterns, because the trade patterns of two countries "converge" to the extent that they are similar. Wasserman and Faust (1994) pointed out that Pearson's Correlation, the Euclidean Distance (ED) and Simple Matching are the most frequently used and most useful measures of structural equivalence. Hanneman and Riddle (2005) extended the set of measures to include JM (Jaccard Matching), a variant of Simple Matching. We tested all of these possibilities, and, in the end, we decided to use ED and JM because of the reasons that we are going to explain hereafter. We decided to offer this methodological discussion to help other researchers working on the field of international trade networks and to others not involved in this field, because it shows many interesting elements that are valid for the analysis of any network whose link and node values spread over several magnitudes and are distributed in a heavy-tail shape. Inter-firm ownership networks, for instance, show the same properties (Biggiero and Magnuszewski 2021). We found that Pearson's Correlation was not a good measure for our data, because it checks for linear relationships, while there were no reasons to expect that our variables would be linearly related. Moreover, our data are nonlinearly distributed, especially in the economic dimension (Fig. 1), and it is widely agreed that Pearson's Correlation is not appropriate for either of these cases. In other words, the distribution of CT and WDc are shaped in a rather pure scale-free form, while that of the weighted ED (hereafter WED) is heavy-tailed, but not so scale-free.

On the other hand, ED, which does not suffer from any of these flaws, seemed to be the most appropriate measure, and it is available in both a binary and a weighted

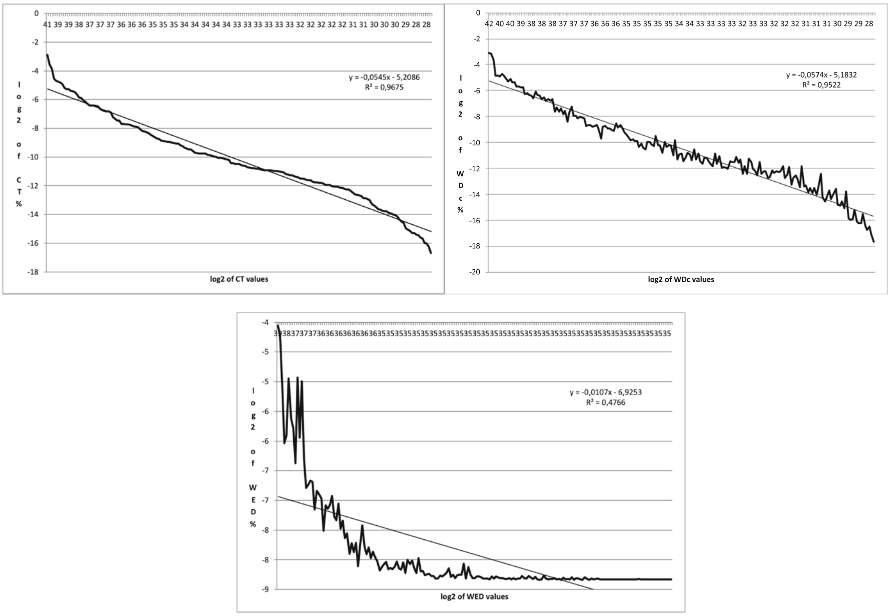

Fig. 1 Heavy-tail distribution of the three main economic variables: CT, WDc and WED

version, thus allowing a strict methodological consistency to be obtained to compare the two types of CD. ED is usually employed in statistics to compare two (or more) objects concerning several attributes (variables). Thus, ED between two countries, in terms of, for instance, *x* exports and *y* imports, with the coordinates (x_1, y_1) and (x_2, y_2), is calculated as:

$$\mathrm{ED} = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} \tag{1}$$

This formula is based on the Cartesian coordinate system when only two variables are compared. If there were *z*, then the distance would need to be calculated for the corresponding *z* dimensional space. The algorithm becomes slightly more complicated when ED is applied to relational phenomena and to digraphs. In the present case, the attributes are the outgoing and incoming links that each country has with the other *n-1* countries, and ED is thus equal to the number of neighbors that differ between two countries. If two countries had the same trade patterns, then the values in the respective rows (exports) and columns (imports) would be equal: therefore, since ED measures the dissimilarity (distance, divergence), when two countries have the same trade partners, then Ed would be "0" and its CD would be 100%. Once the ED has been calculated for each country of a given year, it is possible to average it for the whole network or keep it for each country, depending on the specific purposes of the analysis. Hence, we used binary ED in the first stage of our work to measure pure structural CD. However, for reasons that we discuss below, we decided not to use this measure, because it showed a low response, in terms of regression coefficient or

R^2. We therefore employed WED, whose calculation does not differ from the binary version: instead of measuring binary distances, we measure weighted distances, that is, a very high number that arises from links, weights and distances. It is worth noting that the difference between the binary calculation and the weighted calculation of ED is that two countries with the same trade partners have binary ED equal to zero, but they could have a high weighted ED if the values of such exchanges are very different. This is what happens with E20 countries and makes structural globalization very different from economic (integrated) globalization.

4.3 Problems of the normalization and standardization of CT and WED

WTW shares, with many other economic networks, the property of being a heavy-tail (and mostly scale-free) structure (Barabási 2016; Biggiero and Angelini 2015; Caldarelli 2007; Newman 2010), sometimes in binary or weighted form or in both versions. WTW has two further particular features: the first one is that many of its properties take on the opposite value, depending on whether they are calculated in terms of the binary or the weighted dimension. For instance, connectivity is not scale-free in topological terms, but it is in economic terms, and it is assortative in economic terms and disassortative in topological terms (De Bendictis and Tajoli 2011; Fagiolo et al. 2010, 2014; Kali and Reyes 2007; Kick et al. 2011). The second particular feature concerns the huge scale on which the main WTW variables are distributed, not only concerning link weights, but also node values (CT in our case) and even WED, as we have already mentioned in the previous section. The combination of a high range of values and a strongly skewed distribution is a fundamental aspect, which should not be bypassed through the use of some mathematical manipulation, for example, by standardizing the values, as is sometimes done to make the analysis easier. In fact, the extremely high skewness of these distributions is an ontological aspect of international trade and, as such, it should be not hidden by using a method that makes the statistical treatment easier. This problem is rather subtle and, when faced with the analysis of convergence applied to the weighted version of WTW, we initially normalized the corresponding ED values, in order to give them an a-dimensional measure that varied between 0 and 1, and to make them comparable across the three periods of our time series. A further advantage would have been to include the weighted convergence in a single regression model, together with the other two topological indexes of CD, which are all employed as dependent variables (see below). To this aim, we also proceeded to standardize CT—our independent, economic, globalization variable. The normalization of WED is much more complicated than that of binary ED, because, apart from the "final" normalization of the whole distance—which does not change with respect to the binary case—it is necessary to normalize each single export and import pattern for each country. These values change for each country for exports and imports because they depend on the extreme (min and max) values. This operation, which is usually called "scale normalization,"[10] on close inspection results to be a

[10] It would be too long to present details of the algorithm, which implies a somewhat heavy computational load. This aspect and its complexity are perhaps because the software packages with which we are familiar – Ucinet, ORA, R – only provide ED in absolute values. However, we needed to express ED in relative

true standardization and not just a simple normalization. The outcome was rather discomforting, because the effect of standardization-normalization made WED almost 0 for each country, even after a scale reduction in log2. Therefore, we decided not to normalize WED and thus to keep it in absolute values. Hence, we applied WED to measure ACD for the whole WTW and for any of its partitions (periods and groups of countries), and we analyzed its basic statistical aspects (mean, standard deviation and coefficient of variation) and the differences between countries, but the comparison across periods became less homogeneous, because the number of countries varied. A further consequence, as discussed below, is that we were not able to put all the dependent and independent variables into a single regression model.

We close this discussion on the weighted dimension of WTW and its implications on CH by highlighting that the weighted measure also *includes* the binary dimension, and that, especially in such networks as WTW, which are not large and have link weights ranging over several magnitudes, we should pay particular attention to the weighted dimension. In fact, as our results show, CD tends to increase—or at least, may tend to increase—because the ease of communication, the relaxation of geopolitical tensions and the reduction of transport costs facilitate the starting and settlement of exchanges, at least for a minimum trade value. This explains the extremely high normalized density of WTW, which rounds at about 0.6, compared with other economic networks, which are usually at less than 0.05. Almost all countries will eventually be connected to one another, so that WTW will approximate a quasi-clique. What will continue to be very different are the corresponding trade values, which will indicate the true difference in CD across countries, and whose trend is uncertain. In other words, as a result of the small size of WTW and trade resilience—that is, the propensity to maintain a partner country once trade has become established (at least for some years), if CD is measured in binary terms, then convergentists will be right in the long term. We will come back to this issue in concluding section, when discussing the implications of our results on the debate on CH between "convergentists" and "anti-convergentists."

4.4 The pure structural (binary) measure of CD

As mentioned above, apart from Pearson's Correlation and ED, there is another measure of structural equivalence for binary networks: Simple Matching. This measure is related to binary ED through a mathematical relation,[11] and we therefore did not choose it, because it would have not added any more information and, at the same time, we would have lost the perfect homogeneity with the weighted measure of ED. However, the Simple Matching method has a very interesting variant: JM (Jaccard Matching). This is a more restrictive form of Simple Matching, because it "cleans"

Footnote 10 continued
(weighted) terms to express convergence in terms of degree, and to allow its comparisons across the three-time series and different indexes. It should be pointed out that, to achieve such a goal, we set up a dedicated software, NEDDI (Network-Based Euclidean Distance). However, as we explain in the text, after all this work, we discovered that the double operation of standardization and normalization, as well as the high skewness and high range of variance of values made the weighted ED useless.

[11] To be completely sure, we also applied the mathematical relation, and the trends and regression results coincided with those of the binary ED.

the calculation from the overlapping of zeros. In other words, similarities that derive from the overlapping of missing links (trades) are excluded from the calculation. Since many (perhaps most) economic networks have an extremely low density, with a much lower rounding than 0.05, when referring to binary normalized values, for example concerning inter-firm networks, in terms of ownership, board interlock, RandD collaboration or innovation (Biggiero and Angelini 2015; Sammarra and Biggiero 2008), this property has an important implication for the measurement of structural equivalence, which would be dramatically overestimated by including the overlapping of zeros (absent links). Since WTW is a particularly abnormal case of extremely high binary density (about 0.65), we did not initially use JM. However, we applied it later on and compared the results with ED, and it emerged that the differences were very relevant, especially when the whole WTW was disaggregated into groups of countries, some of which—namely, the most peripheral ones—have a much lower density than the core countries (Table 3). Therefore, if we had measured the binary CD with binary ED, we would have overestimated the CD of WPC and RC. Furthermore, we discovered that, in the regression analysis, JM responded well for both the coefficient and for R^2. Therefore, we calculated CD in two ways: we used WED for the weighted version[12] and JM for the binary version, whose formula is:

$$\mathrm{JM} = \frac{x_{11}}{x_{11} + x_{10} + x_{01}} \tag{2}$$

4.5 The statistical model

We used LD and CT as independent variables at a country level to measure structural and economic globalization, while we used JM and WED as dependent variables to measure either the structural or the economic CD.[13] When the level was aggregate, the latter indexes were averaged over the countries. The results (Table 30 in Appendix) led to a dataset composed of 6.464 observations, when we used the 4 sub-groups (introduced hereafter) as control variables. After many experiments, we decided not to put both independent variables into a single regression model, but rather to separate the regression of CT on WED from the regression of LD on JM. The reason for this pertains to the extremely different scales and shapes of these distributions, as discussed above. In fact, keeping all these variables in a single multiple regression model would have implied employing one of the two following adaptations: standardizing the CT regression coefficient or standardizing CT and WED before the calculation. The former alternative does not work because of the extremely high CT standard deviation, while the latter, although recommended in most handbooks and in spite of being very practiced, is disputable from both a methodological and an epistemological point of view. In fact, being shaped in heavy-tail forms, the standardization of CT and WED would imply a great amount of manipulation and consequent annihilation of a precise

[12] Unfortunately, the algorithm for the weighted version of JM is not available.

[13] We used our variables as dependent and independent variables because of the possibility of transforming ? such variables? into panels via the tsset STATA command https://www.stata.com/manuals13/tstsset.pdf.

and fundamental property of WTW. Therefore, we preferred to renounce the advantage of obtaining only a single multiple regression model that included all the variables, and we split the statistical analyses into two parts, while preserving the scale-free ontological property of WTW. In short, we employed two regression models[14]: one in which we measured the economic effect of globalization by applying CT to WED, both of which were in absolute values, and the other in which we measured the structural effects of globalization by applying LD to JM, both of which were normalized, because structural globalization and convergence are not shaped in a heavy-tail form in their binary dimensions.

4.6 The analysis in terms of groups of countries

As mentioned in the previous section on the formulation of the hypotheses, CD may change considerably in relation to the centrality of a country. We therefore ordered countries according to their total binary Dc (in decreasing order): the Early 20 (E20), the 40 countries from the 21st to the 60th (SPC), the 40 countries from the 61st to the 100th (WPC), and the group of remaining countries (RC). It should be pointed out that, since this ordering can change each year, especially for non-leader countries, we recalculated it for each year. To check whether our results concerning subgroups were consistent with those of other authors, we compared the composition of our four groups with the ones in the classifications made by Snyder and Kick (1979), Mahutga (2006) and Kick (2011) concerning core, strong and weak semi-periphery, and periphery countries. We show, in Appendix,[15] that these categorizations are very similar, but ours has the advantage of being free from certain methodological problems that the core-periphery categorization raises when conducted with block-modeling methods. Though the comparison is rather articulated, because the Dc rank of a country can change yearly, we found a generally high degree of similarity, especially for the core countries, which coincided for more than 80% with our E20 group. The main differences between the two categorizations depend strictly on the fact that the core-periphery analyses systematically used 30% fewer countries than what we did, and that such missing countries all fall between the weak and strong semi-periphery, and the periphery group borders. Therefore, the differences between these and our three groups (SPC, WPC and RC) reduce to a minimum of 30% and a maximum of 60%. An important implication is that the marked differences in our findings from those of Berry et al. (2014), pertaining to convergence, do not depend on the *composition* of the three less connected groups, but rather on the major *number* of less connected countries included in our dataset. We will come back to this point in the final (discussion) section.

[14] We also tried the alternative approaches by standardizing CT and WED, and the results were very different from the absolute value case. It is extremely rare to face a problem that is well-known to other researchers who worked on WTW with variables that scale 13 orders of magnitude.

[15] We only show the comparison for one year, but we also conducted such a comparison for the two other possible years, according to the analyses made by the authors, adopting the core-periphery categorization.

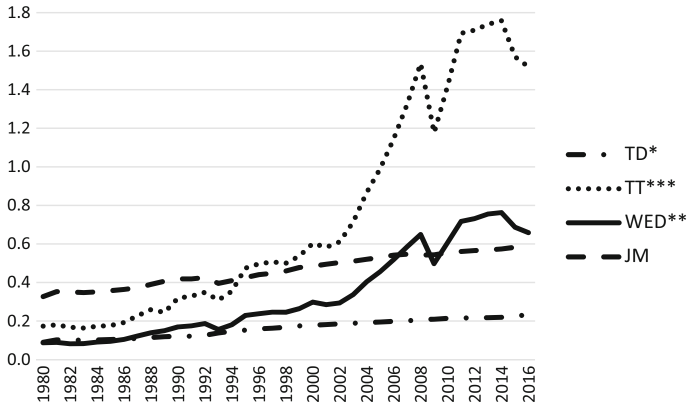

Fig. 2 The trends of TT (the figure representing the trend of TT could lead to some confusion, and we therefore specify that it is an absolute value in scale), TD, JM and WED over the 37 years Legend: * values in 10^5; ** values in 10^{11}; *** values in 10^{13}

4.7 The influence of different selection criteria for the group formation of CD

In order to check whether the different group formation criteria influenced CD, we explored what happens when using three other centrality indexes to identify the four groups at the initial and final year of each period. Hence, we calculated the orderings that are generated by four centrality indexes: binary and weighted degree centrality (BDc and WDc, respectively), and binary and weighted eigenvector centrality. We chose an eigenvector as an indirect centrality index because an eigenvector is widely considered the most complete centrality index to capture the role played by the number of a node neighbor and Dc, and to repeat this operation on all the nodes. After calculating the ordering generated by each of these four centrality indexes, we compared their outcomes by counting how many differences occurred between the four orderings.[16] We used a procedure which measures the overlapping degree between the six pairs of orderings, that is, different combinations of the four indexes. The result of confronting the outcomes of these four criteria is rather impressive: although the differences in the country orderings are somewhat relevant, because the overlapping degree sometimes falls to only 0.3, ACD is not affected by such differences for any year or for any group of countries (Tables 12 and 13 in Appendix). This is because JM and WED are rather homogeneous within each dataset—the whole WTW, export and import, and the four groups—and between adjacent groups (see Tables 12 and 13 in Appendix). The only relevant difference (almost 30% of ACD) is, albeit only for 1993, between the binary and weighted orderings of the E20 group.

16 This is binary counting: we obtain 1 if a given country of a given group is present in both orderings, otherwise 0. The result was then normalized according to the class size.

Table 4 Correlations between CD and the globalization measures

	1980–2016				1980–1992			
	WEC	JM	CT	LD	WEC	JM	CT	LD
WEC	1.00				1.00			
JM	−0.43***	1.00			−0.26***	1.00		
CT	−0.91***	0.33***	1.00		−0.91***	0.24***	1.00	
LD	0.18**	−0.31***	−0.26***	1.00	0.43***	−0.57***	−0.49***	1.00
	1993–2007				2008–2016			
	WEC	JM	CT	LD	WEC	JM	CT	LD
WEC	1.00				1.00			
JM	−0.33***	1.00			−0.31***	1.00		
CT	−0.91***	0.31***	1.00		−0.92***	0.34***	1.00	
LD	0.33***	−0.53***	−0.41***	1.00	0.37***	−0.82***	−0.42***	1.00

WED = Weighted Euclidean convergence; JM = Jaccard matching; CT = Country trade; LD = Local density
*$p < 0.05$, **$p < 0.01$, ***$p < 0.0011$

Table 5 Regression analysis for the whole period and for all the countries

	1980–2016	
	JM	WEC
LD	−0.26***	
CT		−0.38***
_cons	0.66***	1.82e + 10***
N	6464	6464
R^2	0.11	0.83
	1980–1992	
	JM	WEC
LD	−0.27***	
CT		−0.37***
_cons	0.57***	6.75e + 09***
N	2132	2132
R^2	0.33	0.83
	1993–2007	
	JM	WEC
LD	−0.38***	
CT		−0.39***
_cons	0.76***	1.67e + 10***
N	2685	2685
R^2	0.28	0.83
	2008–2016	
	JM	WEC
LD	−0.79***	
CT		−0.35***
_cons	1.18***	3.71e + 10***
N	1647	1647
R^2	0.67	0.86

$^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.0011$

5 Results

5.1 At the whole network level

TT grew exponentially and TD grew linearly over the 37 years (1980–2016—Fig. 2): from 174 trillion US$ in 1980 to 1,519 trillion US$ in 2016, and from 9,000 to 23,100 exchanges, respectively. Thus, TT increased almost 8 times and TD 1.5 times, but TT varied much more than TD, as is shown by the coefficients of variation (Table 2): 0.75 and 0.25, respectively. However, the variation was rather differentiated across the three periods: it was much more accentuated during the golden age of globalization—0.44 and 0.11, respectively—and, despite the two contractions in 2009 and in the 2015–2016 period, the lowest variation occurred after the important financial crisis. The economic (integrated) *divergence* of trade patterns (the WED line) dramatically increased during the first two periods and remained constant in the third one (Fig. 2 and Table 14 in Appendix). Interestingly, it followed the same trend as TT, which means that, in aggregate, the economic CD varied in the opposite direction to that of the trade volume. This is confirmed by the extremely high (> 0.90) inverse correlation (Table 4) between CT and WED across the whole time series and over its three periods. Therefore, the *economic CD dramatically decreased across the whole time series, while it remained constant in the third series*. Conversely, CD almost doubled, in pure structural terms, as it increased from 0.33 in 1980 to 0.59 in 2016, with the major increment being observed in the first two periods. Since Hypotheses H1a states that CD should grow over the 37 years and especially in the third period, this hypothesis should be rejected for the integrated measure of CD and partially confirmed for the structural measure of CD. Hence, *CH, in its broadest formulation, is basically rejected*. Let us now check hypotheses H1c and H1d, which concern the possible explanatory power of globalization. The former is confirmed for the whole time series and for each sub-period to a certain extent (Table 5): its regression coefficient is always higher than −0.35 and $R^2 > 0.83$. As for the structural aspect, LD showed a mild explanatory power over the whole time series, but it grew over time and it became extremely significant in the last period: the regression coefficient was −0.79 and $R^2 = 0.67$. Therefore, the CH is clearly confirmed regarding the hypothesis that, when considering WTW as a whole, globalization influences convergence, although it acts negatively for both the structural and integrated dimensions. Hence, when a country's trade partners intensify their exchanges or when a country's total trade increases, convergence decreases. Thus, CH is confirmed in its more precise formulation, but in a reverse way: *globalization negatively influences a country's convergence*. As far as hypotheses H1b and H1c are concerned, the variance explained by the two independent variables varies to a great extent for each dependent variable in each period, and thus, the two hypotheses are confirmed. Hence, *the influence of globalization on convergence is constant for the WTW as a whole*.

5.2 At the export and import level

Interestingly, the situation changes a little if we consider the export CD and import CD separately (Fig. 3 and Table 15). Let us first examine the structure of CD index. We should first notice, unlike the aggregate variable that the export CD and import CD oscillate significantly over the 37 years. JM grew from 1980 to 2016 for both exports and for imports: from 0.22 to 0.61 and from 0.41 to 0.56, respectively. A remarkable increase can be observed: about threefold for the export CD and by one-third for the import CD. Such results are of the same magnitude as the TD growth and, albeit to a

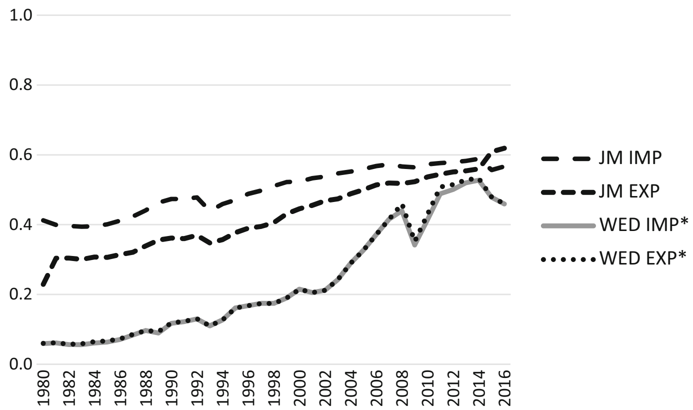

Fig. 3 JM and WED of the imports and exports over the 37 years Legend: *values in 10^{11}

lesser extent, in the same direction as TT growth. It is possible to conclude that H2a is confirmed when imports and exports are considered separately, although only for the structural form of CD, and especially for exports.[17] Conversely, as for the whole aggregate, both the import WED and the export WED grew more than 7 times over the 37 years and especially in the second period. Therefore, hypothesis H2a must be rejected when considering the economic CD, because the *divergence increased about 8 times*.

H2b hypothesized that the CD of exports and that of imports are correlated. We performed a more detailed analysis to test this hypothesis by disaggregating CD measures in the exports (JM EXP, WED EXP) and imports (JM IMP, WED IMP) for the 37 years and then distinguishing between each single period. It is possible to conclude that hypothesis H2b is confirmed. Hypothesis H2c suggests that the import CD and export CD are close to one another. Table 15 and Fig. 3 show that this is true and that, over time, the binary CD becomes closer. Therefore, H2c is also confirmed.

Examining the correlation at an aggregate country level (Table 16), we find that JM imports and exports are positively correlated (0.79). They are highly negatively correlated (−0.72 and −0.84, respectively) with LD, and hence the same result (Table 4) emerges when we analyze the relationship using JM not divided between imports and exports. The result is negative (−0.43) for the association with the economic CD, which means similar trade patterns in imports provide dissimilar export patterns.

However, when we check the correlation at a single country level (Table 16b), it is possible to see that JM imports and exports are perhaps very highly positively correlated (0.79). Interestingly, they are moderately positively correlated (0.25 and 0.39, respectively) for LD. Thus, what we have seen in Table 4, when overlooking the distinction between imports and exports, is confirmed. The same holds for all the other associations considered in that table. The correlation becomes extreme but negative

[17] It is not surprising that the combination of CD, disaggregated per exports and imports – which means by rows and columns – is rather different than that calculated separately, because the matrix is not symmetrical to the diagonal. Moreover, rows and columns can move in different ways: they can be poorly associated. This is what has happened in our case, as the correlation analysis below shows.

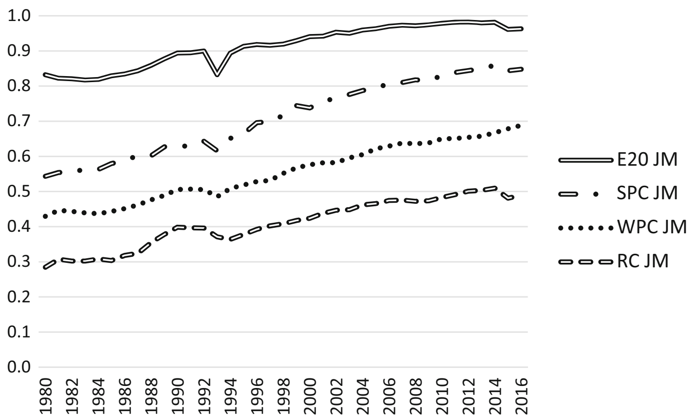

Fig. 4 JM for groups of countries over the 37 years

(-0.94) when considering the economic CD, which means that *when trade patterns are very similar for imports, they are very dissimilar for exports*. This likely means that, in economic terms, *there is a huge asymmetry in the weight of bilateral exchanges*. Therefore, although the exchanges are reciprocated—and thus, symmetric—they are very unbalanced in binary terms—and thus, asymmetric—in exchanged volume terms. Is it possible to conclude that hypothesis H2d should be rejected, because the export CD and import CD are correlated, although with different signs between the binary and the economic dimensions, and this does not change over the time periods. We also ran a regression analysis to understand whether the two independent variables were good predictors of exports and imports. The results (Table 17 in Appendix) show that, with respect to its sum, CT has a lower explanatory power for the economic CD of exports and imports: -0.26 vs. -0.38. As for the structural variable, exports are better explained than imports. Hence, hypothesis H2e, which states that the export CD and import CD are influenced, at significantly different intensities, by CT and LD, is confirmed.

5.3 For groups of countries

Hypothesis H3a states that the CD of the four groups of countries does not differ substantially. In structural terms, the average CD of E20 is 30% more than that of SPC, 67% more than WPC and 1.28% more than RC (Table 27), while, in economic terms, the level of divergence of E20 is 3.3, 5.2 and 5.3 times more than that of the other three groups of countries (Table 24). It should be noted that, even when considering the median WED values, such divergence ratios are only about one point lower, and these results are therefore rather robust, because they concern most of the countries in each group.[18] Therefore, the structural CD is *substantially* different for the four groups of countries for the whole time series and the economic CD is *extremely* different. Hence, it is possible to conclude that hypothesis H3a should be rejected. Hypothesis

[18] Interestingly, the greatest distances between E20 and the other groups are observed during the second period, which is considered the golden age of globalization.

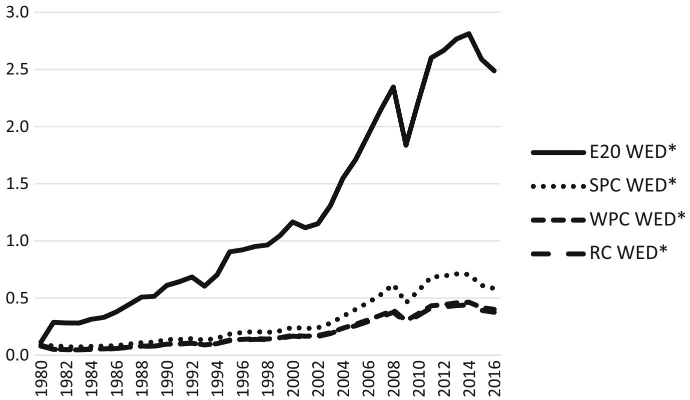

Fig. 5 WED for groups of countries over the 37 years Legend: *values in 10^{11}

H3b advances that the ACD differences follow the group degree centrality: from E20 to RC. This hypothesis is confirmed (Fig. 4, Tables 24, 26) for the binary measure of convergence, while it should be rejected for economic convergence. If we compare Fig. 5 with Fig. 2, we can see that WED closely follows the trend of TT, and since E20 always shows more than 71% of the TT share (see Table 29 in Appendix), its distance follows the global TT trend.

Hypothesis H3c advances that ACD growth follows the inverse order of group degree centrality. Table 27 shows that this is true in structural terms: RC has a 0.72 yearly grow rate of structural CD, which then declines to 0.16 for E20. Conversely, E20 records a 21 yearly grow rate of economic divergence, which declines to 3.6 for RC (Table 25). It should be highlighted that the differences almost disappear in median growth rate terms. Therefore, is it possible to conclude that hypothesis H3b is only confirmed for structural convergence.

When looking at the fourth hypotheses, H4a states that the globalization variables are significant for each group of countries. This hypothesis is only partially confirmed (Table 7), because LD is irrelevant for JM for the two intermediate groups. Interestingly, the coefficient of regression of LD for JM is rather relevant for E20 and RC (0.68 and –0.49, respectively), but the signs are inverted. In other words, structural globalization leads to an increase in the convergence of industrialized countries and a decrease for the poorest countries but has no clear effect on intermediate peripheral countries. It is worth noting that economic globalization negatively influences the economic convergence of all the groups of countries, with a progressive increase from the core counties toward the peripheral countries. This means that, although E20 shows the highest economic divergence, the economic impact of globalization is higher, in relative terms, for the peripheral countries, although it increases their trade patterns dissimilarity. The effect on E20 seems to be particularly high because the relative average trade values of such countries are much higher than those of the peripheral countries. Consequently, hypothesis H4b, which states that LD and CT are less significant for E20 and SPC than for the other two groups, should be rejected, especially

Table 6 Correlations between CD and globalization measures of the whole period divided by groups

	E20				SPC			
	WEC	JM	CT	LD	WEC	JM	CT	LD
WEC	1.00				1.00			
JM	−0.58***	1.00			−0.79***	1.00		
CT	−0.89***	0.56***	1.00		−0.93***	0.67***	1.00	
LD	−0.47***	0.74***	0.38***	1.00	−0.21***	0.08***	0.09***	1.00
	WPC				RC			
	WEC	JM	CT	LD	WEC	JM	CT	LD
WEC	1.00				1.00			
JM	−0.82***	1.00			−0.66***	1.00		
CT	−0.83***	0.74***	1.00		−0.55***	0.57***	1.00	
LD	−0.19***	−0.09***	0.01	1.00	−0.04***	−0.34***	−0.21***	1.00

*$p < 0.05$, **p 0.01, ***$p < 0.001$

for the economic dimension, because the regression coefficient of CT for WEC is −0.37 for E20 and −0.49 for SPC, with R^2 equal to 0.79 and 0.87, respectively.

However, the correlation analysis (Table 6) gives interesting results that confirm a high (always significant) association among almost all the variables for all the groups of countries, though they often have a negative sign. Both of the independent variables are positively correlated with JM and negatively correlated with WEC for E20. Approximately the same correlation pattern is observed for SPC, but with two interesting differences: the correlation between LD and CT is irrelevant, and LD is not correlated with JM, while it is highly correlated in E20. WPC has the same correlation pattern as SPC. The correlation pattern of RC is even more interesting: despite being at the extreme periphery, it is closer to E20, the core countries, than to the two intermediate groups. The major difference from E20 is that LD is not correlated with WEC.

The last three hypotheses enhance the group correlation and regression analysis across the three periods. Hypothesis H4c advances that the explanatory power of LD declines for E20 and SPC: this hypothesis should be rejected, because it instead increased (see Tables 19, 21, 23 in Appendix). Hypothesis H4d suggests that the economic globalization variable increased the explanatory power of E20 and SPC. This hypothesis should also be rejected, because the corresponding regression coefficient declines from −0.37 and −0.41 in the first period to -0.32 in the third period. Furthermore, hypothesis H4e states that LD maintains an always relevant and growing explanatory power of WPC and RC. This hypothesis is fully confirmed, because the regression coefficient grows from 0.11 to −0.65 for WPC and from −0.27 to −0.84 for RC. A final remark concerns the explanatory power of the economic dimension of globalization on the CD of WPC and RC, about which we have been unable to make

Table 7 Regression analysis of the whole period divided by groups

	E20	
	JM	WEC
LD	0.68***	
CT		−0.37***
_cons	0.14***	2.22e + 10***
N	740	740
R^2	0.55	0.79
	SPC	
	JM	WEC
LD	0.07**	
CT		−0.49***
_cons	0.47***	9.84e + 09***
N	1480	1480
R^2	0.00	0.87
	WPC	
	JM	WEC
LD	−0.09***	
CT		−1.79***
_cons	0.56***	1.01e + 10***
N	1480	1480
R^2	0.00	0.69
	RC	
	JM	WEC
LD	−0.49***	
CT		−5.59***
_cons	0.82***	1.57e + 10***
N	2764	2764
R^2	0.11	0.31

*$p < 0.05$, **$p < 0.01$, ***$p < 0.0011$

any hypothesis. An opposite trend can be observed, because it declines from −0.82 and −1.66, respectively, in the first segment to −0.35 and −0.28 in the third segment. Hence, it seems that the international trade of the peripheral countries influences their economic CD negatively to a great extent, but this effect is dramatically reduced over time.[19] Hence, the CD of the most peripheral countries grows positively and is influenced by the structural dimension of globalization, and it diminishes negatively and is influenced by the economic dimension of globalization.

6 Discussion

We here distinguish our findings into the methodological ones and the conceptual ones. For the former, we have found, through several analytical experiments, whose design and results are discussed in the methodological section, that:

- The integrated (economic) measure of CD is very different from and a much better measure than that of (only) structural convergence.
- Such a measure cannot be standardized-normalized without severely distorting its particular heavy-tail distribution.
- The number of partners of a country is not a good measure of structural globalization, at least as far as CD is concerned.
- The number of zeros (missing trades) matters to a great extent when measuring pure structural CD, despite the extremely high density of WTW (compared with other economic networks).

As far as the conceptual findings are concerned, we first summarize those related to economic convergence, which are the ones that matter the most in the debate on CH:

(a) Economic convergence dramatically decreased over the 37 years, and during the 2008–2016 period, that is, after the globalization of the golden age, and peaked twice in correspondence to the important crises in 2008 and 2015.
(b) Economic globalization is able to explain convergence, but only in a stable reverse relationship in economic convergence terms.
(c) The negative effect of economic globalization, which is extremely strong for peripheral countries and weak for semi-peripheral countries, is less important for strong semi-peripheral and core countries: the sparser a country's partners' trades are and the more backward the country is, the more divergent its trade patterns.
(d) The economic convergence of export and import trade patterns are very asymmetric.
(e) The economic convergence of the core countries is much lower than that of all the other groups, and especially of very peripheral countries.
(f) The economic divergence of the four groups of countries increased and at approximately the same growth rate.

We now summarize the very different results of the structural dimension of globalization and convergence, but we should bear in mind that such results are much less salient, because i) the small size of WTW exerts a leveling effect on the aggregate outcomes; ii) the extremely different degrees of connectivity across the groups of countries influence the outcomes to a great extent; iii) what really matters, in economic development terms, and when deciding between convergentists and divergentists, is economic convergence. In short:

19 It should be noted that R^2 is very low in all cases.

- Structural convergence grew considerably from 0.33 to 0.59 in 2016 but was systematically lower for imports and exports.
- It was almost maximal for the core countries, very high for the semi-peripheral ones and moderate for the peripheral countries.
- Structural globalization negatively influenced structural convergence, with a strength that was inverse to a country's density of trade between neighbors, while its influence grew over time.
- The influence of structural globalization was only strongly positive for the core countries, almost irrelevant for the semi-peripheral countries and highly negative for the peripheral countries, which, being much more numerous than the core countries, made the aggregate relation negative.
- The structural globalization variable showed a good explanatory power, which declined over time for the core countries, while it increased for the peripheral countries.

Testing the convergence hypothesis at a local level is of particular interest as a result of the recent discovery that WTW is disassortative at a long distance and assortative at a short distance (Abbate et al. 2018). This finding could confirm the triadic closure principle[20] at a country level, which would be rather interesting and unexpected, because this principle is based on the homophily principle, which is considered very specific for single individuals, but is doubtful at the organizational level and, even more so, at the country level. On the other hand, the expression of homophily as proximity is widely accepted and has been studied extensively in the field of inter-firm networks (Boschma 2005; Biggiero 2016), and it could hence be extended to inter-country networks. In other words, social, organizational, technological and geographical proximity concepts may find a corresponding analogue in international trade, in terms of industrial specialization, degree of openness, the occurrence of common agreements, etc. The salience of the local level could provide a possible explanation of why the high explanatory power of structural globalization is made by LD and not by binary Dc, which means that it is the trades that occur between a country's partners that matter, and not those that occur between that country and its partners.

Furthermore, in a geographical perspective that zooms in at the local level, it is also possible to re-define convergence in terms of the *local* CD, because the CD of each group in our analyses was obtained by extracting the corresponding CD from the matrix of all the countries, while a pure local CD would only refer to the sub-network of each group. In other words, our group CD, in spite of being a group CD, is not local, that is, it is a local zoom of a CD calculated on the whole WTW, while, in the case of the local CD, it would be calculated as CD in a similar way between group members. Thus, it is possible to distinguish convergence inside each group from that between the group and the rest of the countries. The world-system (Hopkins and Wallerstein 2016; Van Hamme, and Pion 2012) and the network perspective (Austin et al. 2012; Kick et al. 2011; Mahutga 2006; Maoz 2011) seem to be particularly suitable for these types of research developments.

[20] For a recent and broad introduction and discussion on the triadic closure principle, homophily and its implications on social and economic networks, see Easley & Kleinberg (2010).

The variety of all these results, in relation to the different aggregate periods, and the ways of measuring the independent and dependent variables discussed in methodological section, explains why all the studies conducted so far have been inconclusive. In fact, the claims of trade convergence come from empirical studies on sets of highly connected countries, mostly those that, in our analysis, are grouped together as core countries and sometimes also include some countries that belong to the strong semi-periphery group. Moreover, such studies usually considered the golden age of globalization: our second period. For instance, to mention just a few of the most recent papers: Crespo and Fontoura (2007) examined the structural change and convergence of CEEC trade within the integrated EU market between 1995 and 2003; Carter and Xianghong (2004) studied the trade patterns of the USA, the EU, Canada, Australia and Japan from 1980 to 1997; Alcidi (2019) and Monfort (2008) dealt with economic integration and convergence in the EU. The same happened in the business cycle synchronization literature: see Guerini et al. (2019), Koopman and Azevedo (2008) and Stanistic (2013). Indeed, in both fields—trade convergence and business cycle synchronization—those who enlarged the scope of the empirical investigation to a large number of countries and a long time series were not able to confirm CH, because they found contradictory results (Berry et al. 2014; Kose et al. 2008, 2012; Lopes et al. 2018; Sengupta 2011). Even our analysis has shown that, if restricted to core countries or strongly connected countries during the golden age of globalization, there is a remarkable increase in structural convergence.

However, the findings of convergentists do not concern structural convergence, but rather economic convergence, which instead has been shown to diverge to a great extent in our analyses. Therefore, how is it possible to obtain such opposite results? The explanation lies in the fact that the analyses of the previously mentioned authors considered a scalar variable, a country's volume of trade, while ours has considered the overall patterns of trade. Therefore, although the distance between trade volumes can progressively reduce, it is possible that the distance between its patterns increases. A further factor that can help to explain the opposite results is because above discussed of the local as part of an overall and local itself. In our analyses, the core countries or other groups of countries were treated in the former way, while those groups were considered as a whole in the other studies. These two factors concur to explain why it is easy to find confirmation of CH in the form of conditional convergence (the so-called β–convergence) in modern economic growth theories (Barro and Sala-i-Martin 1992, 2004) and in the new economic geography theory (Krugman 1995), which allow some kind of country specificity—namely, technological and institutional differences to be acknowledged (Boschma and Lambooy 1999; Boschma and Frenken 2006; Martin, and Sunley 1998).

7 Conclusions

Purely structural measures are not very meaningful for measuring convergence in WTW, because they largely depend on network density: as such a density grows above half level, convergence, from necessity, also grows. Since WTW is a very small in size and it is already way beyond 50%, it is no surprise that structural convergence, apart from showing small oscillations, and for specific groups of countries, is destined to grow with the growth of structural globalization, here intended as the density of exchanges. This expectation would be reinforced if the reasonable supposition that trade links, once established, tend to be stable, were confirmed in future studies. However, if purely structural convergence were still credited to be of relevance—and thus, if future studies were to show that there is a high volatility of links, in strictly topological terms—then the most appropriate measure would certainly be that cleaned of zeros, especially when the focus of an analysis is not on the leading countries. In fact, peripheral countries have a much lower density than core countries, and thus the missing trade could hide the true degree of convergence.

In short, the convergence hypothesis seems to be confirmed when the pure structural aspect and core countries are considered, albeit with a few flaws. Hence, from this analytical perspective, convergentists seem to be right when they claim that, under the pressure of globalization, world trade becomes more homogeneous. This conclusion would also support the idea of a progressive synchronization of business cycles, because the similarity of world trade is clearly one of the main synchronization forces. Moreover, if international trade volatility—which is supposedly one of the features of globalization—decreases, then the convergence hypothesis will also be confirmed in the future. However, such a confirmation only concerns structural convergence, which is *not* what modernization theories deal with.

The picture changes radically when convergence is measured in economic terms. In our work, when we used an integrated measure of convergence, the diversity between countries again emerged: countries have very different trade patterns, and such a diversity increased sharply, instead of decreasing, over the 37 years. Furthermore, divergence is distributed in a heavy-tail shape, so that the few rich and highly connected countries produce the greatest distance, while many peripheral countries show the lowest distance. In other words, even for the core or strong semi-peripheral countries, the very high structural convergence degree is compensated for much more by the magnitude of the economic exchanges, which then generate a high degree of "divergence." Moreover, our analysis shows that economic globalization influences convergence, but in a strongly negative way. Therefore, our findings support divergentists, because they show that economic globalization does not increase the homogeneity of world trade, but on the contrary it maintains and reinforces a large diversity which, at first seems to confirm the polarization between core and periphery countries, but also suggests that both core and periphery countries are rather "divergent" from each other.

This picture supports the world-systems theory and addresses its compatibility with the evolutionary economic geography theory that was introduced in the first two sections. In fact, the persistence of core-periphery polarization, even in terms of dissimilarity in trade patterns, demonstrates that economic development is unable to reduce inequalities, while the marked differences, even between core and peripheral countries, suggests that country specificity, in terms of industry specialization and place in the global value chains, is an important factor. Future studies will deepen the analysis of the four groups examined here and move toward a disaggregate industry level, in order to evidence the role of industry specificity and reduce inter-industry compensative effects on the convergence degree. The two perspectives are in fact compatible, at least regarding the doubts about the convergence hypothesis.

Two further implications of our work concern the debate on trade convergence and business cycle synchronization. An implication that is common to both aspects regards the sample size selection for applied analysis. As we demonstrated, through the analysis of groups of countries, E20 is a very particular sample, and the other three groups have very different characteristics from it. What holds for E20 cannot in fact be generalized to the remaining countries. This concept is particularly important because, as we have shown in the introduction and in the discussion sections, most works on trade convergence or business cycle synchronization have so far only considered subsets of E20—often the Euro Zone, the EU, or Eastern European countries or just the US. The results obtained from such particular samples can be very misleading for orienting general convictions and, even worse, for international economic policy making purposes. The other concept regards longitudinal analysis. Our work has in fact shown that many results changed considerably over the three periods. However, most studies only look at the third period, which is of course the most interesting, but it can hide long-term trends. We have shown that when employing an integrated measure, which is able to capture the economic and the structural dimensions together, WTW appears far less ordered than in purely structural terms.

7.1 Limitations and further developments

A first issue concerns the level of aggregation of all the considered goods and services, which can mask compensation effects among the sectors. It is reasonable to expect that the situation could change even more when disaggregating WTW into the 20 main sectors (with the 2-digit NACE code) and even more so when combining the 20 sectors with the four groups of countries. When considering sectoral or microsectoral levels, some sectors might be very convergent and others not. Furthermore, in order to understand how relevant a purely structural analysis can continue to be, it is important to understand the degree of resilience of trade and financial links. Moreover, the future agenda should also move in another three directions: (i) repeating the analysis for groups of countries by building such groups according to a geographical criterion; (ii) measuring which part of convergence arises from exchanges within the same group and which arises from other groups; (iii) ordering the groups of countries according to their degree of convergence and then checking whether their business cycle synchronization varies over time according to such a degree. These studies could give a reliable answer to the question about whether what matters is trade pattern similarity, that is, convergence, or trade pattern integration, that is, dissimilarity due to complementarity.

Appendix

See Tables See Tables 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29 and 30.

Table 8 Countries of the first period 1980–1992 (164 countries)

Afghanistan	Djibouti	Kuwait	Rwanda
Albania	Dominica	Lao People's Dem. Rep	Sacca
Algeria	Dominican Republic	Lebanon	Samoa
Angola	Ecuador	Liberia	São Tomé and Príncipe
Argentina	Egypt	Libya	Saudi Arabia
Australia	El Salvador	Madagascar	Senegal
Austria	Equatorial Guinea	Malawi	Seychelles
Bahamas, The	Ethiopia	Malaysia	Sierra Leone
Bahrain, Kingdom of	Faroe Islands	Maldives	Singapore
Bangladesh	Fiji	Mali	Solomon Islands
Barbados	Finland	Malta	Somalia
Belgium-Luxembourg	France	Martinique	Spain
Belize	Gabon	Mauritania	Sri Lanka
Benin	Gambia, The	Mauritius	St. Kitts and Nevis
Bermuda	Germany	Mexico	St. Lucia
Bolivia	Ghana	Mongolia	St. Vincent and the Grenad
Brazil	Greece	Morocco	Sudan
Brunei Darussalam	Greenland	Mozambique	Suriname
Bulgaria	Grenada	Myanmar	Sweden
Burkina Faso	Guadeloupe	Nepal	Switzerland
Burundi	Guatemala	Netherlands	Syrian Arab Republic
Cabo Verde	Guiana, French	Netherlands Antilles	Tanzania
Cambodia	Guinea	New Caledonia	Thailand
Cameroon	Guinea-Bissau	New Zealand	Togo
Canada	Guyana	Nicaragua	Tonga
Central African Republic	Haiti	Niger	Trinidad and Tobago
Chad	Honduras	Nigeria	Tunisia
Chile	Hungary	North Korea	Turkey
China, P.R.: Hong Kong	Iceland	Norway	U.S.S.R
China, P.R.: Macao	India	Oman	Uganda
China, P.R.: Mainland	Indonesia	Pakistan	United Arab Emirates
Colombia	Iran	Panama	UK
Comoros	Iraq	Papua New Guinea	USA
Congo, Dem. Rep. of	Ireland	Paraguay	Uruguay
Congo, Republic of	Israel	Peru	Vanuatu
Costa Rica	Italy	Philippines	Venezuela, Rep. Bol. de

Table 8 (continued)

Côte d'Ivoire	Jamaica	Poland	Vietnam
Cuba	Japan	Portugal	Yemen, Republic of
Cyprus	Jordan	Qatar	Yugoslavia, SFR
Czechoslovakia	Kenya	Réunion	Zambia
Denmark	Korea, Republic of	Romania	Zimbabwe

Table 9 Countries of the second period 1993–2007 (179 countries)

Afghanistan	Czech Republic	Kyrgyz Republic	Sacca
Albania	Denmark	Lao People's Dem. Rep	Samoa
Algeria	Djibouti	Latvia	São Tomé and Príncipe
Angola	Dominica	Lebanon	Saudi Arabia
Argentina	Dominican Republic	Liberia	Senegal
Armenia, Republic of	Ecuador	Libya	Serbia and Montenegro
Australia	Egypt	Lithuania	Seychelles
Austria	El Salvador	Macedonia, FYR	Sierra Leone
Azerbaijan, Republic of	Equatorial Guinea	Madagascar	Singapore
Bahamas, The	Estonia	Malawi	Slovak Republic
Bahrain, Kingdom of	Ethiopia	Malaysia	Slovenia
Bangladesh	Faroe Islands	Maldives	Solomon Islands
Barbados	Fiji	Mali	Somalia
Belarus	Finland	Malta	Spain
Belgium	France	Mauritania	Sri Lanka
Belize	Gabon	Mauritius	St. Kitts and Nevis
Benin	Gambia, The	Mexico	St. Lucia
Bermuda	Georgia	Moldova	St. Vincent and the Grenad
Bolivia	Germany	Mongolia	Sudan
Bosnia and Herzegovina	Ghana	Morocco	Suriname
Brazil	Greece	Mozambique	Sweden
Brunei Darussalam	Greenland	Myanmar	Switzerland
Bulgaria	Grenada	Nepal	Syrian Arab Republic
Burkina Faso	Guatemala	Netherlands	Tajikistan
Burundi	Guinea	Netherlands Antilles	Tanzania

Table 9 (continued)

Cabo Verde	Guinea-Bissau	New Caledonia	Thailand
Cambodia	Guyana	New Zealand	Togo
Cameroon	Haiti	Nicaragua	Tonga
Canada	Honduras	Niger	Trinidad and Tobago
Central African Republic	Hungary	Nigeria	Tunisia
Chad	Iceland	North Korea	Turkey
Chile	India	Norway	Turkmenistan
China, P.R.: Hong Kong	Indonesia	Oman	Uganda
China, P.R.: Macao	Iran	Pakistan	Ukraine
China, P.R.: Mainland	Iraq	Panama	United Arab Emirates
Colombia	Ireland	Papua New Guinea	UK
Comoros	Israel	Paraguay	US
Congo, Dem. Rep. of	Italy	Peru	Uruguay
Congo, Republic of	Jamaica	Philippines	Uzbekistan
Costa Rica	Japan	Poland	Vanuatu
Côte d'Ivoire	Jordan	Portugal	Venezuela, Rep. Bol. de
Croatia	Kazakhstan	Qatar	Vietnam
Cuba	Kenya	Romania	Yemen, Republic of
Cyprus	Korea, Republic of	Russian Federation	Zambia
	Kuwait	Rwanda	Zimbabwe

Table 10 Countries of the third period 2008–2016 (184 countries)

Afghanistan	Czech Republic	Lao People's Dem. Rep	SACCA exc South Africa
Albania	Denmark	Latvia	Samoa
Algeria	Djibouti	Lebanon	São Tomé and Príncipe
Angola	Dominica	Liberia	Saudi Arabia
Argentina	Dominican Rep	Libya	Senegal
Armenia, Republic of	Ecuador	Lithuania	Serbia, Republic of
Aruba	Egypt	Luxembourg	Seychelles
Australia	El Salvador	Macedonia, FYR	Sierra Leone
Austria	Equatorial Guinea	Madagascar	Singapore
Azerbaijan, Republic of	Estonia	Malawi	Slovak Republic

Table 10 (continued)

Bahamas, The	Ethiopia	Malaysia	Slovenia
Bahrain, Kingdom of	Faroe Islands	Maldives	Solomon Islands
Bangladesh	Fiji	Mali	Somalia
Barbados	Finland	Malta	South Africa
Belarus	France	Mauritania	Spain
Belgium	Gabon	Mauritius	Sri Lanka
Belize	Gambia, The	Mexico	St. Kitts and Nevis
Benin	Georgia	Moldova	St. Lucia
Bermuda	Germany	Mongolia	St. Vinc. and the Grenad
Bolivia	Ghana	Montenegro	Sudan
Bosnia and Herzegovina	Greece	Morocco	Suriname
Brazil	Greenland	Mozambique	Sweden
Brunei Darussalam	Grenada	Myanmar	Switzerland
Bulgaria	Guatemala	Nepal	Syrian Arab Republic
Burkina Faso	Guinea	Netherlands	Tajikistan
Burundi	Guinea-Bissau	Netherlands Antilles	Tanzania
Cabo Verde	Guyana	New Caledonia	Thailand
Cambodia	Haiti	New Zealand	Togo
Cameroon	Honduras	Nicaragua	Tonga
Canada	Hungary	Niger	Trinidad and Tobago
Central African Republic	Iceland	Nigeria	Tunisia
Chad	India	North Korea	Turkey
Chile	Indonesia	Norway	Turkmenistan
China, P.R.: Hong Kong	Iran	Oman	Uganda
China, P.R.: Macao	Iraq	Pakistan	Ukraine
China, P.R.: Mainland	Ireland	Panama	United Arab Emirates
Colombia	Israel	Papua New Guinea	UK
Comoros	Italy	Paraguay	USA
Congo, Dem. Rep. of	Jamaica	Peru	Uruguay
Congo, Republic of	Japan	Philippines	Uzbekistan
Costa Rica	Jordan	Poland	Vanuatu
Côte d'Ivoire	Kazakhstan	Portugal	Venezuela, Rep. Bol. de
Croatia	Kenya	Qatar	Vietnam
Cuba	Korea, Republic of	Romania	Yemen, Republic of
Cyprus	Kuwait	Russian Federation	Zambia
	Kyrgyz Republic	Rwanda	Zimbabwe

Table 11 Overlapping in 1980 between Dc-based groups and Kick's groups (2011)

Nations	(binary) Dc-based groups	Kick's groups
UK	E20	Core
DEU**		Core
NLD		Core
ITA		Core
FRA		Core
JPN		Core
BEL-LUX		Core
USA		Core
DNK		Core
CHE		Core
ESP		Core
SWE		Core
CAN		Core
NOR		Core
AUS		Core
PRT		Core
IND		Semi-periphery weak
FIN		Semi-periphery weak
BRA		Periphery

Nations	(binary) Dc-based groups	Kick's groups
AUT	SPC	Core
GRC		Core
YUG		Core
IRL		Semi-periphery strong
KEN		Semi-periphery strong
ISR		Semi-periphery strong
ROU		Semi-periphery strong
TUR		Semi-periphery strong
CYP		Semi-periphery strong
MYS		Semi-periphery weak
KOR		Semi-periphery weak
ARG		Semi-periphery weak
PAK		Semi-periphery weak
PHL		Semi-periphery weak
SAU		Semi-periphery weak
PER		Semi-periphery weak
VEN		Semi-periphery weak
URY		Semi-periphery weak

Table 11 (continued)

Nations	(binary) Dc-based groups	Kick's groups
CHN		Periphery
MEX		Periphery
NZL		Periphery
COL		Periphery
MAR		Periphery
TUN		Periphery
JAM		Periphery
CRI		Periphery
IDN		Periphery
MLT		Periphery
GHA		Periphery
DZA		Periphery
POL		Periphery
TTO		Periphery
SEN		Periphery
CMR		Periphery
CIV		Periphery
THA		Periphery

Nations	(binary) Dc-based groups	Kick's groups
HUN	WPC	Semi-periphery strong
JOR		Semi-periphery strong
U.S.S.R		Semi-periphery strong
SDN		Periphery
ISL		Periphery
LBR		Periphery
ARE		Periphery
PAN		Periphery
CSK		Periphery
SLV		Periphery
NGA		Periphery
SOM		Periphery
DOM		Periphery
GTM		Periphery
HTI		Periphery
SYR		Periphery
CHL		Periphery
LBY		Periphery
ECU		Periphery

Table 11 (continued)

Nations	(binary) Dc-based groups	Kick's groups
HND		Periphery
ETH		Periphery
COG		Periphery
YEM*		Periphery
Nations	(binary) Dc-based groups	Kick's groups
CUB	RC	Semi-periphery strong
LBN		Semi-periphery strong
IRN		Semi-periphery strong
IRQ		Semi-periphery strong
BGR		Semi-periphery strong
MNG		Periphery
TCD		Periphery
BOL		Periphery
MLI		Periphery
NER		Periphery
PRY		Periphery
TGO		Periphery
NIC		Periphery
GAB		Periphery
UGA		Periphery
CAF		Periphery
BDI		Periphery
SLE		Periphery
AFG		Periphery
RWA		Periphery
PRK		Periphery
MRT		Periphery
VNM		Periphery
NPL		Periphery
ALB		Periphery
KHM		Periphery

Criteria to segment time series

Considering that our time series starts in 1980 and finishes in 2016, the rationales that led us to distinguish three periods are the following:

- USSR disaggregation, from which 15 new nations (additional nodes for our network) are born: Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyz,

Table 12 Similarity of CD for sub-groups based on the ordering generated by the centrality indices

	1980											
	BDc/WDc		WDc/BEig		WDc/BEig		WEig/BDc		BDc/BEig		WDc/WEig	
	WED	JM	WED	JM	WED	JM	WED	JM	WED	JM	WED	JM
E20	0.86	1.00	1.16	1.00	0.84	1.00	1.19	1.00	1.00	1.00	0.98	1.00
SPC	1.09	1.02	0.91	0.98	1.13	1.02	0.88	0.98	1.00	1.00	1.04	1.00
WPC	1.23	0.99	0.81	1.01	1.23	0.98	0.82	1.01	1.00	1.01	0.99	1.00
RC	1.01	0.98	0.99	1.01	1.01	0.99	0.99	1.01	1.00	1.00	1.00	1.00
	1992											
	BDc/WDc		WDc/BEig		WDc/BEig		WEig/BDc		BDc/BEig		WDc/WEig	
	WED	JM	WED	JM	WED	JM	WED	JM	WED	JM	WED	JM
E20	0.89	1.01	1.12	0.99	0.89	1.00	1.13	1.00	0.99	1.00	1.00	0.99
SPC	1.12	1.01	0.91	0.99	1.11	1.02	0.88	0.98	1.02	1.00	1.01	1.01

Table 12 (continued)

	1992											
	BDc/WDc		WDc/BEig		WDc/BEig		WEig/BDc		BDc/BEig		WDc/WEig	
	WED	JM	WED	JM	WED	JM	WED	JM	WED	JM	WED	JM
WPC	1.18	1.01	0.85	0.99	1.16	1.02	0.86	0.99	1.00	1.00	0.99	1.00
RC	1.01	0.98	0.99	1.02	1.02	0.97	0.98	1.03	1.00	1.00	1.00	1.00
	1993											
	BDc/WDc		WDc/BEig		WDc/BEig		WEig/BDc		BDc/BEig		WDc/WEig	
	WED	JM	WED	JM	WED	JM	WED	JM	WED	JM	WED	JM
E20	0.78	1.00	1.29	1.00	0.78	1.00	1.29	1.00	1.00	1.00	1.00	1.00
SPC	1.33	1.02	0.75	0.98	1.34	1.01	0.75	0.99	1.00	1.00	1.00	0.99
WPC	1.23	1.03	0.81	0.96	1.21	1.04	0.82	0.96	1.00	1.00	0.99	1.00
RC	1.01	0.97	0.99	1.04	1.02	0.97	0.98	1.03	1.00	1.00	1.01	1.00

BDc = Binary Dc; WDc = Weighted Dc; BEig = Binary Eigenvector centrality; WEig = Weighted Eigenvector centrality

Table 13 Similarity of CD for sub-groups based on the ordering generated by the centrality indices

	2007											
	BDc/WDc		WDc/BEig		WDc/BEig		WEig/BDc		BDc/BEig		WDc/WEig	
	WED	JM	WED	JM	WED	JM	WED	JM	WED	JM	WED	JM
E20	0.87	1.01	1.14	0.99	0.87	1.01	1.16	0.99	0.99	1.00	0.99	1.00
SPC	1.06	1.02	0.97	0.98	1.06	1.03	0.92	0.97	1.03	1.00	1.02	1.01
WPC	1.12	1.02	0.89	0.98	1.11	1.02	0.90	0.98	1.00	1.00	0.99	1.00
RC	1.10	0.97	0.90	1.03	1.10	0.97	0.91	1.03	1.00	1.00	1.00	1.00
	2008											
	BDc/WDc		WDc/BEig		WDc/BEig		WEig/BDc		BDc/BEig		WDc/WEig	
	WED	JM	WED	JM	WED	JM	WED	JM	WED	JM	WED	JM
E20	0.88	1.01	1.15	0.99	0.87	1.01	1.14	0.99	1.01	1.00	1.00	1.00
SPC	1.01	1.03	0.96	0.97	1.05	1.03	0.98	0.98	0.97	1.00	1.01	1.00
WPC	1.10	1.01	0.93	0.99	1.07	1.02	0.91	0.98	1.02	1.00	1.00	1.00
RC	1.12	0.97	0.89	1.03	1.12	0.97	0.89	1.03	1.00	1.00	1.00	1.00
	2016											
	BDc/WDc		WDc/BEig		WDc/BEig		WEig/BDc		BDc/BEig		WDc/WEig	
	WED	JM	WED	JM	WED	JM	WED	JM	WED	JM	WED	JM
E20	0.94	1.01	1.07	0.99	0.93	1.01	1.07	0.99	1.00	1.00	1.00	1.00

Table 13 (continued)

	2016											
	BDc/WDc		WDc/BEig		WDc/BEig		WEig/BDc		BDc/BEig		WDc/WEig	
	WED	JM	WED	JM	WED	JM	WED	JM	WED	JM	WED	JM
SPC	1.11	1.01	0.90	0.99	1.11	1.01	0.91	0.99	0.99	1.00	1.00	1.00
WPC	1.02	1.00	0.98	1.00	1.03	1.01	0.98	0.99	1.00	1.00	1.00	1.01
RC	1.01	0.99	0.99	1.01	1.01	0.98	0.99	1.02	1.00	1.00	1.00	0.99

Legend: BDc = Binary Dc; WDc = Weighted Dc; BEig = Binary Eigenvector centrality; WEig = Weighted Eigenvector centrality
E20 = Early 20; SPC = Strong peripheral countries from 21st to 60th position; WPC = Weak peripheral countries from 61st to 100th position; RC = Remaining countries; WED = Weighted Euclidean convergence; JM = Jaccard matching

Table 14 Dependent and independent variables during the 37 years

1st period	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992		
TD*	0.09	0.10	0.10	0.10	0.10	0.11	0.11	0.11	0.11	0.12	0.12	0.12	0.13		
TT***	0.17	0.18	0.17	0.16	0.17	0.18	0.19	0.23	0.26	0.25	0.32	0.33	0.35		
WED**	0.09	0.09	0.08	0.08	0.09	0.09	0.10	0.12	0.14	0.15	0.17	0.18	0.19		
JM	0.33	0.35	0.35	0.35	0.35	0.36	0.36	0.37	0.39	0.41	0.42	0.42	0.43		
2nd period	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
TD*	0.14	0.15	0.15	0.16	0.16	0.17	0.18	0.18	0.18	0.19	0.19	0.19	0.20	0.20	0.20
TT***	0.31	0.35	0.48	0.50	0.51	0.50	0.54	0.60	0.58	0.61	0.72	0.87	0.99	1.14	1.33
WED**	0.16	0.18	0.23	0.24	0.25	0.25	0.26	0.30	0.28	0.29	0.34	0.40	0.46	0.52	0.59
JM	0.40	0.41	0.43	0.44	0.45	0.46	0.48	0.49	0.49	0.50	0.51	0.52	0.53	0.54	0.55
3rd period	2008	2009	2010	2011	2012	2013	2014	2015	2016						
TD*	0.21	0.21	0.21	0.22	0.22	0.22	0.22	0.23	0.23						
TT***	1.54	1.18	1.42	1.69	1.71	1.74	1.76	1.57	1.52						
WED**	0.65	0.50	0.61	0.72	0.73	0.76	0.76	0.69	0.66						
JM	0.54	0.54	0.56	0.56	0.57	0.57	0.57	0.58	0.59						

*Values in 10^5; ** values in 10^{11}; *** values in 10^{13}

Table 15 Dependent variables divided into Import and Export during the 37 years

1st period	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992		
WED IMP**	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.08	0.10	0.09	0.12	0.12	0.13		
WED EXP**	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.09	0.10	0.09	0.12	0.12	0.13		
JM IMP	0.59	0.60	0.60	0.61	0.60	0.60	0.59	0.58	0.56	0.54	0.53	0.53	0.52		
JM EXP	0.77	0.70	0.70	0.70	0.69	0.69	0.69	0.68	0.66	0.64	0.64	0.64	0.63		
2nd period	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
WED IMP**	0.11	0.13	0.16	0.17	0.17	0.17	0.19	0.22	0.21	0.21	0.24	0.29	0.33	0.37	0.42
WED EXP**	0.11	0.13	0.16	0.17	0.17	0.17	0.19	0.22	0.21	0.21	0.24	0.29	0.33	0.37	0.42
JM IMP	0.56	0.54	0.53	0.51	0.50	0.49	0.48	0.48	0.47	0.46	0.45	0.45	0.44	0.43	0.43
JM EXP	0.65	0.64	0.62	0.61	0.61	0.59	0.57	0.55	0.54	0.53	0.53	0.51	0.50	0.49	0.48
3rd period	2008	2009	2010	2011	2012	2013	2014	2015	2016						
WED IMP**	0.44	0.34	0.41	0.49	0.50	0.52	0.53	0.48	0.46						
WED EXP**	0.46	0.35	0.43	0.51	0.52	0.53	0.53	0.48	0.46						
JM IMP	0.43	0.44	0.43	0.42	0.42	0.42	0.41	0.44	0.43						
JM EXP	0.48	0.48	0.46	0.46	0.45	0.45	0.44	0.39	0.38						

**Values in 10^{11}

Table 16 Correlations between aggregated CD measures divided into import and export, and globalization variables

	1980–2016						1980–1992					
	WEC IMP	WEC EXP	JM IMP	JM EXP	CT	LD	WEC IMP	WEC EXP	JM IMP	JM EXP	CT	LD
WEC IMP	1.00						1.00					
WEC EXP	−0.43***	1.00					−0.47***	1.00				
JM IMP	0.09***	0.09***	1.00				0.03	0.10***	1.00			
JM EXP	0.06***	0.04***	0.79***	1.00			−0.03	−0.04*	0.61***	1.00		
CT	0.08***	0.11***	−0.29***	−0.34***	1.00		0.19***	0.18***	−0.08***	−0.33***	1.00	
LD	0.02	0.06***	−0.72***	−0.84***	0.46***	1.00	0.12***	0.13***	−0.49***	−0.80***	0.59***	1.00
	1993–2007						2008–2016					
	WEC IMP	WEC EXP	JM IMP	JM EXP	CT	LD	WEC IMP	WEC EXP	JM IMP	JM EXP	CT	LD
WEC IMP	1.00						1.00					
WEC EXP	−0.33***	1.00					−0.46***	1.00				
JM IMP	−0.04***	−0.06***	1.00				−0.06***	−0.07***	1.00			
JM EXP	−0.08***	−0.11***	0.76***	1.00			−0.08***	−0.06***	0.69***	1.00		
CT	0.12***	0.19***	−0.26***	−0.35***	1.00		0.15***	0.15***	−0.30***	−0.32***	1.00	

Table 16 (continued)

	1993–2007						2008–2016					
	WEC IMP	WEC EXP	JM IMP	JM EXP	CT	LD	WEC IMP	WEC EXP	JM IMP	JM EXP	CT	LD
LD	0.07***	0.15***	−0.72***	−0.86***	0.52***	1.00	0.10***	0.14***	0.81***	−0.88***	0.48***	1.00
	1980–2016						1980–1992					
	WEC IMP	WEC EXP	JM IMP	JM EXP	CT	LD	WEC IMP	WEC EXP	JM IMP	JM EXP	CT	LD
WEC IMP	1.00						1.00					
WEC EXP	−0.94***	1.00					−0.92***	1.00				
JM IMP	0.36***	0.37***	1.00				0.12***	0.12***	1.00			
JM EXP	0.42***	0.43***	0.79***	1.00			0.33***	0.34***	0.61***	1.00		
CT	−0.88***	−0.91***	−0.29***	−0.34***	1.00		−0.91***	−0.92***	−0.08***	−0.33***	1.00	
LD	0.18***	0.18***	0.25***	0.39***	−0.26***	1.00	0.44***	0.44***	0.33***	0.68***	−0.49***	1.00
	1993–2007						2008–2016					
	WEC IMP	WEC EXP	JM IMP	JM EXP	CT	LD	WEC IMP	WEC EXP	JM IMP	JM EXP	CT	LD
WEC IMP	1.00						1.00					
WEC EXP	−0.93***	1.00					−0.93***	1.00				
JM IMP	0.26***	0.29***	1.00				0.26***	0.27***	1.00			
JM EXP	0.33***	0.36***	0.76***	1.00			0.28***	0.28***	0.69***	1.00		
CT	−0.89***	−0.91***	−0.26***	−0.35***	1.00		−0.88***	−0.93***	−0.31***	−0.32***	1.00	
LD	0.32***	0.33***	0.46***	0.66***	−0.41***	1.00	0.36***	0.36***	0.69***	0.81***	−0.42***	1.00

WEC = Weighted Euclidean Convergence; LD = Local Density

*$p < 0.05$, **$p < 0.01$, ***$p < 0.0011$

Table 17 Regression analysis by import and export

	1980–2016			
	JM IMP	JM EXP	WEC IMP	WEC EXP
LD	0.19***	0.41***	.	.
CT	.	.	- 0.26***	- 0.26***
_cons	0.35***	0.26***	1.23e+10***	1.28e+10***
N	6464	6464	6464	6464
R^2	0.06	0.15	0.78	0.84
	1980–1992			
	JM IMP	JM EXP	WEC IMP	WEC EXP
LD	0.170***	0.416***	.	.
CT	.	.	- 0.26***	- 0.26***
_cons	0.45***	0.38***	4.48e+09***	
N	2132	2132	2132	2132
R^2	0.11	0.47	0.82	0.84
	1993–2007			
	JM IMP	JM EXP	WEC IMP	WEC EXP
LD	0.28***	0.62***	.	.
CT	.	.	- 0.27***	- 0.27***
_cons	0.27***	0.09***	1.09e+10***	1.22e+10***
	2008–2016			
	JM IMP	JM EXP	WEC IMP	WEC EXP
LD	0.69***	0.91***		
CT	.	.	- 0.24***	- 0.25***
_cons	- 0.11***	- 0.25***	2.57e+10***	2.58e+10***

*$p < 0.05$, **$p < 0.01$, ***$p < 0.0011$

Latvia, Lithuania, Moldova, Tajikistan, Turkmenistan, Ukraine, Uzbekistan, plus Russian Federation. It resulted in a 10% size growth of WTW, with a consequent impact also on its trade patterns. These geopolitical changes played an important role in economic growth in the first period because they prepared the ground for the great growth of the golden age of globalization. Further, the signing of free trade agreements between the great world powers such as the 1992 NAFTA between the USA, Canada and Mexico played an important role. Even in the European continent, free trade agreements played a key role as a result of the fall of the USSR. One is the CEFTA (Central European Free Trade Agreement) stipulated in 1992, one year after the official disaggregation of the USSR among many of the countries that

Table 18 Correlations between CD measures and globalization variables of 1st period divided by groups

	E20				SPC			
	WEC	JM	CT	LD	WEC	JM	CT	LD
WEC	1.00				1.00			
JM	−0.28***	1.00			−0.43***	1.00		
CT	−0.87***	0.12*	1.00		−0.66***	0.29***	1.00	
LD	0.15*	0.35***	−0.26***	1.00	0.23***	−0.36***	−0.38***	1.00
	WPC				RC			
	WEC	JM	CT	LD	WEC	JM	CT	LD
WEC	1.00				1.00			
JM	−0.28***	1.00			−0.26***	1.00		
CT	−0.14***	0.31***	1.00		−0.07*	0.64***	1.00	
LD	−0.00	−0.26***	−0.01	1.00	−0.03	−0.29***	−0.35***	1.00

*$p < 0.05$, **$p < 0.01$, ***$p < 0.0011$

Table 19 Regression analysis of 1st period divided by groups

	E20	
	JM	WEC
LD	0.13***	
CT		−0.37***
_cons	0.36***	7.53e + 09***
N	260	260
R^2	0.12	0.76
SPC		
	JM	WEC
LD	−0.14***	
CT		−0.41***
_cons	0.51***	5.64e + 09***
N	520	520

were previously part of it. For Western Europe the most important agreement is undoubtedly the TUE (Treaty of Maastricht) signed in 1992 and recognized as the founding treaty of the European Union together with the Treaty of Rome of 1957. The TEU set the political rules and parameters economic and social needs for the entry of the various member states in the European Union. Therefore, the first period ends the year after USSR dissolution;

Table 19 (continued)

SPC		
	JM	WEC
R^2	0.135	0.44

	WPC	
	JM	WEC
LD	−0.11***	
CT		−0.82***
_cons	0.48***	6.32e + 09***
N	520	520
R^2	0.07	0.02

	RC	
	JM	WEC
LD	−0.27***	
CT		−1.66*
_cons	0.54***	6.84e + 09***
N	832	832
R^2	0.08	0.00

Table 20 Correlations between CD measures and globalization variables of 2nd period divided by groups

	E20				SPC			
	WEC	JM	CT	LD	WEC	JM	CT	LD
WEC	1.00				1.00			
JM	−0.33***	1.00			−0.64***	1.00		
CT	−0.84***	0.36***	1.00		−0.91***	0.52***	1.00	
LD	−0.19***	0.45***	0.09	1.00	−0.05	−0.03	−0.13	1.00

	WPC				RC			
	WEC	JM	CT	LD	WEC	JM	CT	LD
WEC	1.00				1.00			
JM	−0.61***	1.00			−0.43***	1.00		
CT	−0.73***	0.54***	1.00		−0.43***	0.55***	1.00	
LD	−0.11**	−0.37***	−0.14***	1.00	−0.06*	−0.49***	−0.34***	1.00

*$p < 0.05$, **$p < 0.01$, ***$p < 0.0011$

Table 21 Regression analysis of 2nd period divided by groups

	E20	
	JM	WEC
LD	0.38***	
CT		−0.38***
_cons	2.20e + 10***	2.20e + 10***
N	300	300
R^2	0.71	0.71
	SPC	
	JM	WEC
LD	−0.02	
CT		−0.41***
_cons	0.54***	1.27e + 10***
N	600	600
R^2	0.00	0.81
	WPC	
	JM	WEC
LD	−0.30***	
CT		−1.61***
_cons	0.72***	1.17e + 10***
N	600	600
R^2	0.13	0.54
	RC	
	JM	WEC
LD	−0.54***	
CT		−4.87***
_cons	0.87***	1.50e + 10***
N	1185	1185
R^2	0.24	0.19

- 2007/2008 crisis, which was caused by the mortgage default caused by mortgages passed to history as "subprime" and "near-prime" mortgages. All the sectors of the economy, including the real one, were affected by the financial shock. The relationship between trade in goods and GDP fell sharply in 2009 after the economic crisis, an equally strong rise was in 2010–2011 but already from 2012 began a new gradual decrease until 2014, and then plunged back into significant way in 2015. Also, in 2009 there was a sharp decline in world commodity prices. This had a

Table 22 Correlations between CD measures and globalization variables of 3rd period divided by groups

	E20				SPC			
	WEC	JM	CT	LD	WEC	JM	CT	LD
WEC	1.00				1.00			
JM	0.03	1.00			−0.27***	1.00		
CT	−0.83***	0.13	1.00		−0.91***	0.29***	1.00	
LD	−0.04	−0.41***	−0.16*	1.00	0.25***	−0.74***	−0.33***	1.00
	WPC				RC			
	WEC	JM	CT	LD	WEC	JM	CT	LD
WEC	1.00				1.00			
JM	−0.23***	1.00			−0.12***	1.00		
CT	−0.48***	0.49***	1.00		−0.11**	0.49***	1.00	
LD	0.05	−0.82***	−0.45***	1.00	−0.04	−0.66***	−0.39***	1.00

a$p < 0.05$, **$p < 0.01$, ***$p < 0.0011$

significant impact on the value of global trade in goods and then rebounded in the opposite direction already in the following year in 2010, at the end of which a decrease began and finally a new significant decline in 2015, a new negative record, arrived at half of the negative value reached in 2009. Another significant indicator that shows the non-stability of world trade in this period is the value of trade in goods and services, this also collapsed in 2009 and then slowly rise above pre-crisis levels in the 2014 and undergo a new crash in 2015 (WTO World Trade Statistical Review, 2016).

The effects of applying these criteria are the segmentation of the 37 years into the following three periods:

- 1st period 1980–1992, which is composed by 164 nations by aggregating the values of the ones that formed the USSR up to 1991, keeping Yemen united instead of separating and Germany united with GDR;
- 2nd period 1993–2007, which is made of 179 nations, obtained by keeping united Serbia and Montenegro, South Africa Custom Union (SACCA) and South Africa, France with Guadeloupe, Martinique, French Guiana and Réunion and the Netherlands Antilles with Aruba;
- 3rd period 2008–2016, where there are 183 countries and it was not necessary to make separations or unions of countries. This is, in fact, the less "manipulated" set of countries among the three under study.

Table 23 Regression analysis of 3rd period divided by groups

	E20	
	JM	WEC
LD	−0.27***	
CT		−0.32***
_cons	0.83***	6.67e + 10***
N	180	180
R^2	0.17	0.69
	SPC	
	JM	WEC
LD	−0.45***	
CT		−0.32***
_cons	0.95***	3.21e + 10***
N	360	360
R^2	0.54	0.83
	WPC	
	JM	WEC
LD	−0.65***	
CT		−0.35***
_cons	1.09***	3.58e + 10***
N	360	360
R^2	0.67	0.23
	RC	
	JM	WEC
LD	−0.84***	
CT		−0.28**
_cons	1.21***	3.82e + 10***
N	747	747
R^2	0.43	0.01

Table 24 WED divided by sub-groups during the 37 years

1st period	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992		
E20 WED	0.11	0.29	0.28	0.28	0.31	0.33	0.38	0.44	0.51	0.51	0.61	0.64	0.68		
SPC WED	0.08	0.09	0.07	0.07	0.08	0.08	0.08	0.10	0.11	0.11	0.14	0.14	0.15		
WPC WED	0.09	0.05	0.05	0.05	0.05	0.06	0.06	0.07	0.08	0.08	0.10	0.10	0.11		
RC WED	0.08	0.05	0.05	0.05	0.05	0.05	0.06	0.07	0.08	0.08	0.10	0.10	0.11		
2nd period	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
E20 WED	0.60	0.70	0.90	0.92	0.95	0.96	1.05	1.17	1.12	1.15	1.31	1.55	1.71	1.93	2.15
SPC WED	0.13	0.15	0.19	0.20	0.21	0.20	0.21	0.25	0.23	0.24	0.28	0.34	0.40	0.46	0.53
WPC WED	0.09	0.10	0.13	0.14	0.14	0.14	0.15	0.17	0.17	0.17	0.20	0.24	0.27	0.31	0.35
RC WED	0.09	0.10	0.13	0.13	0.14	0.14	0.15	0.17	0.16	0.17	0.19	0.23	0.26	0.30	0.34
3rd period	2008	2009	2010	2011	2012	2013	2014	2015	2016						
E20 WED	2.35	1.84	2.23	2.60	2.67	2.77	2.81	2.59	2.49						
SPC WED	0.62	0.46	0.57	0.68	0.69	0.71	0.71	0.61	0.58						
WPC WED	0.40	0.30	0.37	0.43	0.44	0.46	0.46	0.42	0.40						
RC WED	0.38	0.29	0.35	0.41	0.42	0.43	0.44	0.39	0.38						

Values in 10^{11}

Table 25 WED increasing and yearly growth rate

	1980–2016	1980–2016	1980–1992	1993–2007	2008–2016
E20	20.65	0.089	0.160	0.095	0.007
SPC	6.32	0.057	0.052	0.104	- 0.007
WPC	3.54	0.043	0.017	0.102	0.002
RC	3.62	0.043	0.022	0.100	0.000

Table 26 JM divided by sub-groups during the 37 years

1st period	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992		
E20 JM	0.83	0.82	0.82	0.82	0.82	0.83	0.83	0.84	0.86	0.88	0.89	0.89	0.90		
SPC JM	0.54	0.55	0.56	0.56	0.56	0.58	0.59	0.60	0.60	0.63	0.63	0.63	0.64		
WPC JM	0.43	0.45	0.44	0.44	0.44	0.44	0.45	0.46	0.48	0.49	0.51	0.51	0.51		
RC JM	0.28	0.31	0.30	0.30	0.31	0.30	0.32	0.32	0.35	0.38	0.40	0.40	0.40		
2nd period	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
E20 JM	0.83	0.89	0.91	0.92	0.92	0.92	0.93	0.94	0.94	0.95	0.95	0.96	0.96	0.97	0.97
SPC JM	0.62	0.65	0.66	0.70	0.70	0.72	0.74	0.74	0.76	0.77	0.78	0.79	0.79	0.81	0.81
WPC JM	0.49	0.51	0.52	0.53	0.53	0.55	0.57	0.58	0.58	0.58	0.60	0.61	0.62	0.63	0.64
RC JM	0.37	0.36	0.38	0.39	0.40	0.41	0.42	0.42	0.44	0.45	0.45	0.46	0.47	0.47	0.48
3rd period	2008	2009	2010	2011	2012	2013	2014	2015	2016						
E20 JM	0.97	0.97	0.98	0.98	0.98	0.98	0.98	0.96	0.96						
SPC JM	0.82	0.82	0.83	0.84	0.84	0.85	0.86	0.84	0.85						
WPC JM	0.64	0.64	0.65	0.65	0.65	0.66	0.67	0.68	0.69						
RC JM	0.47	0.47	0.48	0.49	0.50	0.50	0.51	0.48	0.49						

Table 27 JM increasing and yearly growth rate

	1980–2016	1980–2016	1980–1992	1993–2007	2008–2016
E20	0.16	0.004	0.007	0.011	−0.001
SPC	0.56	0.012	0.014	0.020	0.005
WPC	0.60	0.013	0.014	0.020	0.010
RC	0.72	0.015	0.028	0.018	0.004

Table 28 Standard Deviation and Coefficient of Variation for WED and JM

1st period	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992		
SD WED*	0.14	0.15	0.14	0.15	0.18	0.19	0.21	0.24	0.27	0.29	0.32	0.33	0.35		
coeff. var WED	1.70	1.70	1.73	1.83	1.98	2.01	2.05	1.99	1.98	2.06	1.92	1.90	1.90		
2nd period	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
SD WED*	0.33	0.38	0.45	0.46	0.49	0.51	0.55	0.62	0.59	0.59	0.65	0.76	0.85	0.95	1.04
coeff. var WED	2.14	2.13	1.98	1.97	2.02	2.08	2.11	2.11	2.09	2.04	1.95	1.89	1.87	1.84	1.78
3rd period	2008	2009	2010	2011	2012	2013	2014	2015	2016						
SD WED*	1.11	0.88	1.07	1.24	1.29	1.36	1.39	1.32	1.26						
coeff. var WED	1.71	1.77	1.78	1.74	1.77	1.80	1.83	1.94	1.92						

1st period	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992		
SD JM	0.17	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.15	0.15	0.15	0.15	0.15		
coeff. var JM	0.51	0.45	0.45	0.45	0.44	0.45	0.43	0.43	0.39	0.38	0.37	0.37	0.36		
2nd period	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
SD JM	0.15	0.15	0.15	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
coeff. var JM	0.38	0.38	0.36	0.36	0.35	0.34	0.34	0.32	0.31	0.31	0.31	0.30	0.30	0.29	0.29
3rd period	2008	2009	2010	2011	2012	2013	2014	2015	2016						
SD JM	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.15	0.15						
coeff. var JM	0.30	0.29	0.29	0.28	0.28	0.28	0.28	0.26	0.26						

*Values in 10^{11}

Table 29 World trade share (WTS) divided by groups

1st period	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992		
Early 20 WTS	0.77	0.75	0.75	0.75	0.75	0.76	0.80	0.80	0.81	0.80	0.80	0.81	0.81		
SPC WTS	0.21	0.22	0.22	0.22	0.21	0.21	0.18	0.18	0.17	0.17	0.17	0.17	0.17		
WPC WTS	0.02	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02		
RC WTS	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00		
2nd period	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Early 20 WTS	0.80	0.80	0.80	0.79	0.78	0.79	0.79	0.78	0.78	0.78	0.77	0.76	0.75	0.74	0.73
SPC WTS	0.18	0.18	0.17	0.18	0.19	0.18	0.18	0.19	0.19	0.19	0.20	0.21	0.22	0.22	0.23
WPC WTS	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
RC WTS	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3rd period	2008	2009	2010	2011	2012	2013	2014	2015	2016						
Early 20 WTS	0.71	0.72	0.72	0.71	0.71	0.72	0.72	0.72	0.72						
SPC WTS	0.25	0.24	0.24	0.25	0.25	0.24	0.23	0.22	0.22						
WPC WTS	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04						
RC WTS	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02						

Table 30 Descriptive statistics of country-year dataset for regression

Variable	Obs	Mean	SD	Min	Max
Year	6464	–	–	1980	2016
WED	6464	3,426E + 13	5,736E + 13	4,135E + 12	7,843E + 14
JM	6464	0.467	0.113	0.062	0.697
CT	6464	4,205E + 13	1,376E + 14	0	2,293E + 15
LD	6464	0.742	0.135	0.331	1
WED IMP	6464	2,341E + 13	4,077E + 13	3,211E + 12	6,516E + 14
WED EXP	6464	2,422E + 13	4,045E + 13	94,263,242	6,331E + 14
JM IMP	6464	0.497	0.1	0.304	1
JM EXP	6464	0.57	0.141	0.299	1
E20	740	–	–	–	–
SPC	1480	–	–	–	–
WPC	1480	–	–	–	–
RC	2764	–	–	–	–

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