

Multidimensional quantitative methods for improving world-system analysis:

Examining mobility across periphery-semi periphery-core structure

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Abstract

Even though during the last five decades world-system framework has experienced an enormous development, as it has provided a wide range of analytical categories for spatiotemporal processes from historical sociology gaze, it might not have deepened enough into its empirical dimension beyond historiographic resources. Regarding this fact, one of its main axes as three tier structure of core-semi periphery-periphery and its features have been well described and discussed from the beginning. However, empirical quantitative methodology for determining reshaping and mobility along this structure has been barely treated in comparison with the employment of qualitative and observational techniques.

To fill this relative absence is fundamental not only to study mechanisms for upgrade or downgrade mobility during long wave periods but also because of the importance of providing tools for researching systemic transformations in a controversial region such as the semi periphery. This last one is especially important in relation with this sort of methodology because of the ambiguity that this category sometimes have showed in different analysis as well as the structural relevance that it has for (dis)stabilizing world-system.

In this sense, this paper seeks two main goals. Firstly, to collect all the previously described quantitative methodologies for world-system mobility analysis. Secondly using primary sources and data, to put them into practice and to combine their different tools in order to boost the future outcomes from world-system theory.

Key words:

world systems, semi periphery, mobility, methodology, comparison

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Introduction

The well-known tripartite structure of the capitalist world-economy, based on the development of the dialectic between the core and the periphery, having as a synthetic result the historical-spatial conformation of the semi-periphery; has been shown as a category of analytical and explanatory potential for long processes from the sphere of historical sociology in general (Wallerstein 1974, 1976; Hopkins and Wallerstein 1977; Radice 2009; Karataşlı 2017) and in an accessory way offering multiple tools and background for other disciplines such as international relations, geopolitics and political economy. Within this framework, despite initial criticism of the issue of ambiguity surrounding the ontological delimitation of the semi periphery category (Aymard 1985), subsequent and more recent works have been able to provide a series of definitions (Arrighi and Drangel 1986; Chase-Dunn 1988; Terlouw 1992; Radice 2009) provide more detailed and solid basis on the role of the semi-periphery, as well as everything related to upward and downward mobility within this social structure. However, precisely within this epistemological plurality, a methodological plurality has also developed when it comes to specifying the hierarchy, antagonisms and the variables that govern them within the world-economy. In short, proposals have been made by different authors who, beyond the diversity in the modification of algorithms or quantitative techniques to obtain results with good statistical quality, do not coincide at all in the inclusion criteria of variables that simply have to do with the differential spatial distribution of income in the world system, with the international division of labor throughout the core and the periphery, with the inclusion of social dimensions that characterize local labor forces and with the capacity of national states to develop coercive power and legal-administrative influence on a global scale to maintain or improve their position within the tripartite structure (Babones 2005).

Taking this background into consideration, the possibility of determining to what extent this relationship between the use of a certain methodology based on the formulated epistemology influences the determination of a particular configuration of the world system, appears relevant. Although the main methodologies both at a qualitative level (Wallerstein 1974, Braudel 1992, Frank 2011) and the previously mentioned quantitative ones are well known and have been largely compiled (Babones 2005; Clark and Beckfield 2009; Barbones and Chase-Dunn 2012). This compilation has not been accompanied by a comparison that makes it possible to analyze the differential results when reflecting changes in mobility within the structure. Considering

this fact, this article precisely aims to be able to concretely assess the precision and sensitivity of the main methodologies developed under the systemic theoretical framework. Under a total sample of 105 States, from the period from 1972 to 2022, which makes it possible to obtain all the necessary data and variables according to each methodology, it is proposed to apply four of the main most used techniques at the same time through which a relationship of the upward and downward mobilities that occurred during the last long wave of expansion and contraction of the capitalist world-economy is obtained. To achieve this objective, the article will be organized through the following structure. Firstly, the main axioms and premises will be briefly explained, both those previously tested at an empirical level and those that are purely theoretical, about the mobility that has occurred since the rise of the world-economy until today to understand and explain the mechanisms of mobility in the results obtained in the analysis. After this, the next section details the more purely methodological aspects and discussions to make understandable the previous works that have discussed the inclusion criteria for the variables, the different foundations of the algorithms, the limitations when establishing the size sample, the methods to compare the mobility data obtained, etc. Subsequently, the results obtained with each of the four methodologies will be presented, their comparison will be made, and the potential and limitations will be discussed based on the analyzed sample itself. Finally, in the conclusions, it will be fully established how the main methodologies present today within the world systems perspective make it possible to obtain a complete scheme of the transformations in long-term global power relations, as well as the possible developments, from this, in future academic works.

Hypotheses and foundations of mobility within the capitalist world-economy

Although mobility within the capitalist world-economy can largely be conceived as the rise from the periphery to the core or vice versa, passing through the semi-periphery, it must be taken into consideration that other jobs that have precisely focused on production of multivariate quantitative methodologies (Nemeth and Smith 1985; Van Rossem 1996; Mahutga and Smith 2011; Jacinto 2023) have established new divisions within each of the parts with different degrees of integration in each of them. In any case, these new tones also appear to be relevant when analyzing the mobility of nation-states. Once we have taken this clarification into account, we must go to the

basic root that explains the transformations in the core-periphery dialectic. This means understanding the Marxist expression of capital accumulation (M-C-M') not simply as a social relationship, but as a historical-spatial process in which the production of mercantile equivalents corresponds to systemic material expansion (M-C) and contraction has to do with obtaining surplus value as profit (C-M') (Arrighi 1994). It is precisely after these cycles that the reorganization of the role that capital and States acquire, with their agency capacities, in the international division of labor occurs. Although the ultimate foundation of the system, unequal exchange, is maintained and therefore direct mobility between periphery and core in a single cycle is very complicated, the semi-peripheries are presented as the regions with the most upward and downward mobility for different reasons. Even despite this general characterization, there is no consensus on the unique particularities of semi-peripheries. Since there are no specific productive activities that differentiate the semi-peripheries because these will always be relational to the development of historical capitalism (Morales-Ruvalcaba 2013). However, attempts have been made to conceptualize them through other peculiarities such as the mix of core and periphery activities, with an intermediate geographical position between the core and periphery and the value chains between them (Arrighi and Drangel 1986) and with sufficient balances. in these nodes to avoid falling towards the periphery (Radice 2009, Mahutga 2012); the difference in the ways of organizing production, the diversity of public policies and strategies by institutions to maintain stability in contraction cycles, the intermediate levels of intensive capital (Chase-Dunn 1988), the strong control of the political structures of the national elites compared to those of the peripheries, the character of the core but with an internal periphery that is capable of exploiting (Babones 2013), etc. They do roughly compose the characteristics of the semi-peripheries according to most of the authors, unlike others, such as the level of income distribution or the destabilizing or stabilizing nature between cycle transitions, which is subjected to further questioning (Terlouw 1992).

Beyond the innovative base on which the semi-peripheries are based to achieve upward mobility, the maintenance of their role or even the dispute for hegemony at the core; the strategies they can follow to achieve this are very diverse, being able to distinguish mainly three (Chase-Dunn 1988): those of evolutionary potential, maintaining adaptation and adaptability between the innovation of economic, political and cultural practices; that of the “advantage of backwardness”, through which a given, although with less intensive technologies and capital, can exceed the rate of profit of a given core activity

through higher rates of exploitation of the labor force combined with organizations more effective productive structures and, finally, the strategy of uneven and combined development, through the incorporation of new processes and practices brought from the core, while maintaining structures typical of peripheral underdevelopment. However, if we look at the strategy of the semi-peripheries not with respect to their interior, but rather based on their relationship with the core and the hegemon, we could differentiate two possible results and, therefore, two types of semi-peripheries results. of this mobility (Arrighi 1990; Bornschier and Trezzini 1997). On the one hand, those that fight against exclusion, seeking their integration through the transfer of core activities and their subordination to it; and on the other hand, those that fight against exploitation through partial disconnection, seeking a direct dispute of hegemony (Bradshaw and Lynn 1994). Both can result in the opposite effect and produce downward mobility since they can either increase dependence on the core and reduce the decision-making capacity for future new strategies and innovations or hinder access to fixed capital and technology to be able to compete at the same time. even with the core. These semi-peripheral processes are usually determined in turn by the historical dependence on the export income of raw materials, fostering interclass conflicts that hinder upward mobility, unlike others where this social composition does not occur and the process of substitution by import is shorter (Bornschier and Trezzini 1997).

Regarding the most recent mobility processes, these have been characterized by the capacity to attract medium-value manufacturing activities (Arrighi and Drangel 1986). Although this process would have led to significant mobility during the 1970s and 1980s through dependent development with rapid economic growth, such as in Southeast Asia, today it would have been much more limited (Clark, 2010), due to the great stabilization in the unequal exchange that the current composition of the semi-periphery would have achieved (Mielants 2012) despite the greater capacity that exists between the three levels to transfer capital, technology and labor force (Mahutga and Smith 2011). Other authors, on the contrary, affirm that precisely the great territorial conflicts and wars at the end of the 20th century are examples of this reconfiguration, of new mobility processes during the contraction cycle (Bergesen 1992).

Methods for determining hierarchy and mobility

Babones (2005) fundamentally distinguishes three main quantitative methodological trends when analyzing hierarchies in the world-economy: those that establish network analysis, with multiple types of dimensions, to determine the level of connection between the different States to from there infer its position; those that carry out a conceptualization of the structure in a non-compartmentalized manner in a non-discrete manner, but rather as a continuous whole through indexing and normalization of multiple variables; and finally, the third and one of the first to be developed (Arrighi and Drangel 1986), which establishes a discrete distribution based on the income distribution as an indirect measure, not to infer with great precision, but to determine changes in mobility and power. incorporate a voluminous sample due to the ease in obtaining data. Applying each of them, we will carry out the comparative analysis. Furthermore, we will add a fourth considering one more element of an epistemological and methodological nature. This consists of carrying out another analysis from the continuous perspective but without including variables that have to do with the coercive capacity, diplomatic and military influence of the States (Terlouw 1992; Van Rossem 1996; Kentor 2014) and without applying indexation but rather factorization. and blockmodeling based on the position in global commodity chains.

For the first type, network analysis, after discrete analysis by income, is one of the methods that has been most used (Nemeth and Smith 1985; Kick 1987; Smith and White 1992; Clark and Beckfield 2009, Boyd et al 2010, Hyacinth 2023). The main foundation of these methodologies is the establishment of connections between States based on international trade data, regarding imports and exports. It is based on the premise that the States closest to the core will have a greater number of connections while the more peripheral ones will be more disconnected. Through different network analysis algorithms that factor and simplify the matrix obtained, a range of scores between 0 and 1 is generated to determine the position. In this case, we will apply the SVD/MINRES algorithm, based on the State-by-State import data matrix, which has been shown to be effective in establishing these hierarchies (Boyd et al 2010, Jacinto 2023). The statistics, in this case, have been obtained from trade data from the International Monetary Fund.

Regarding the second method, based mainly on the proposal of Kentor (2014), an index will be established that will serve as continuous stratification based on three dimensions: economic power, coercive power and global dependence. The dimension of economic power will be determined from four

variables: capital intensity (indirectly through GDP per capita), the size of production based on GDP, the volume of trade through the size of exports and finally, control over global capital through a ratio between the investment of national capital outside the country and foreign direct investment. For the dimension of military power, military spending, arms exports and global military control will be included through a ratio between the volume of arms exports and imports. Thirdly, regarding global dependence, the degree of diversification of the type of exports will be considered, the dependence on foreign capital through the volume of debt with respect to GDP and military dependence as a ratio between arms imports with respect to GDP. All these variables, obtained through the World Bank database, will be standardized through a normal distribution to obtain Z scores that can be grouped to form the index.

For the third case, the distribution of income in relation to the population (Arrighi and Drangel 1986; Babones 2005), data on the total populations of the States and their GDP per capita will also be collected. These, to facilitate graphical distribution, will be converted into decimal logarithms so that the set of accumulated populations will be represented as dependent variables with respect to it. The relative positions of the concavities will group each of the structural parts of the world-economy. To better interpret the distribution in the histogram, the function will be transformed using the Kernel Gaussian method, smoothing the lines. Furthermore, to determine the limits of each region between the minimum and maximum of the concavities, the method of Korzeniewicz and Martin (1994) will be applied. Both variables, in this method, will also be compiled from the World Bank databases.

Lastly, for continuous clustering, the methodology proposed by Mahutga and Smith (2011) is used. This is based on the premise of the definition of global commodity chains within the world system (Gereffi and Korzeniewicz 1993; Bunker and Ciccanetll, 2005; Fernández-Stark and Gereffi 2019), which understands that the differential spatialization of commercial productive nodes is fundamental to understanding how exchange is generated. unequal based on competitive advantages and innovations, leading to the rise or fall within the structure. Within this hypothesis, five sets of chains are taken as representative: high-tech and heavy industry, sophisticated extraction goods, simple extraction, low value/light industry, and animal products and bioproducts. Based on these data, obtained from the UN COMATRADE Database, a hierarchical clustering is developed along two extracted factors

through Principal Component Analysis (PCA) employing hierarchical algorithm.

The total sample of 105 States in a distributed manner is applied to the period from 1972 to 2022. This long wave period allows for finding a balance between including a time frame that includes two economic crises to be able to assess mobility or absence of it. Furthermore, methodologically, data from this large sample is available within it for all the variables necessary in each of the four methods to be applied.

Results and discussion

Firstly, in order to evaluate the compositions in the three dimensions of the structure, we will apply to the set of distributions of each methodology, based on their normality, the T test for the means of the three parts of the structure established from deciles, although in the case of clustering of commercial chains (Chart 3.1 and Chart 3.2) they are grouped into three despite obtaining six groups as the optimal distribution (Mahutga and Smith 2011). Observing the results, given the total statistical significance obtained in each case, the analysis of commercial networks using the SVD/MINRES algorithm (Chart 1.1 and Chart 1.2), appears to be the most sensitive when it comes to establishing significant changes in the total of the composition of each part, highlighting above all the change appreciated only by this between the periphery and the semi-periphery between 1997 and 2022 and the greater significance that it gives to those that occurred between the semi-periphery and the core for the same period. Next, partly unexpected, is that the clustering method (Chart 3.1 and 3.2) and the discrete income/population distribution (Chart 2) show practically the same sensitivity and results. The only difference between these is in the periphery-semi periphery changes from 1972 to 1997 and the intra semi periphery mobility between 1997 and 2022. Finally, the least sensitive, although like the latter two, is the continuous analysis of economic and coercive power (Table 2), which does not reach the highest level of statistical significance $p < 0.01$ in any period and for any part of the world economy.

	1972-1997			1997-2022		
Trade network analysis	PS*	H.H**	SC*	PS*	H.H**	SC**
Economic and coercive continuum	P.S.	H.H*	S.C.	P.S.	H.H*	SC*
Income/population discrete distribution	PS*	H.H**	SC*	P.S.	H.H*	SC*
Continuum Clustering Commodity Chains	P.S.	H.H*	S.C.	P.S.	H.H**	SC*

Table 1. Statistical significance for changes in parts from Student's T test (: $p < 0.05$; **: $p < 0.01$).
Source: author.*

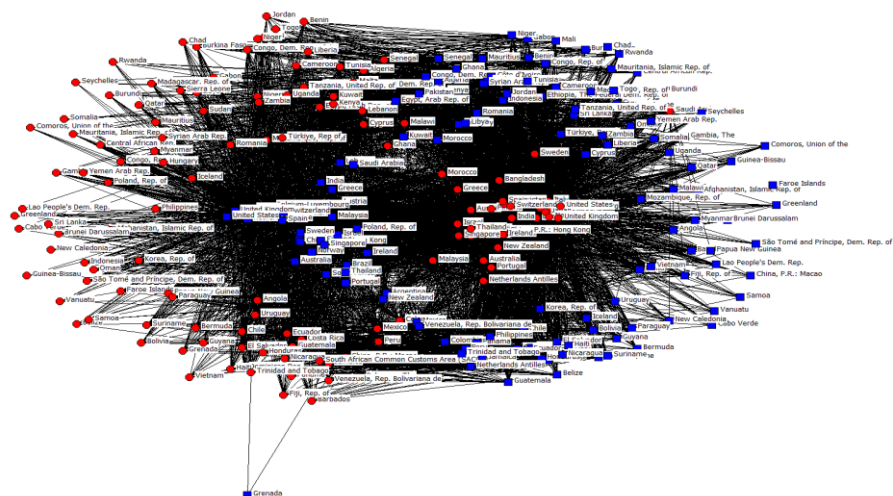


Chart 1.1. Trade network after SVD/MINRES analysis for import/export coreness in 1972.
Source: own elaboration based on IMF data

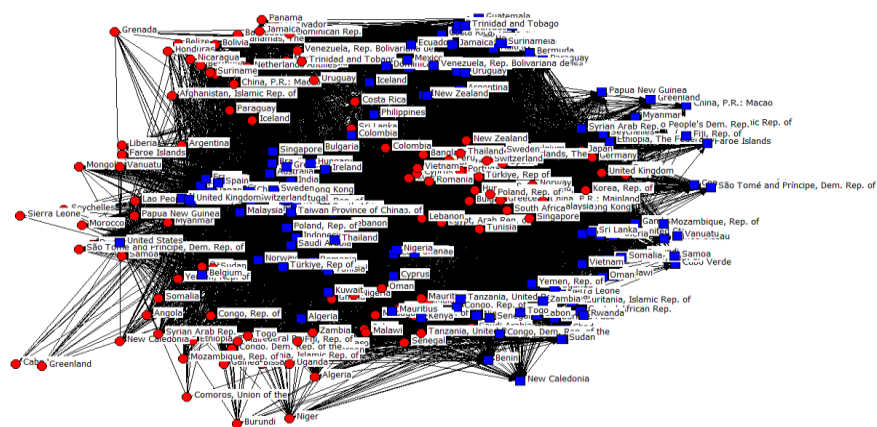


Chart 1.2. Trade network after SVD/MINRES analysis for import/export coreness in 2022.
Source: elaboration

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	1972	1997	2022
1	United States (5.71; 5.12; 0.88)	United States (5.11; 4.79; 0.92)	United States (5.98; 4.8; 0.07)
2	United Kingdom (6.41; 0.27; 0.55)	Japan (3.18; -0.33; 1.29)	China (3.15; 0.62; 0.33)
3	France (2.26; 0.23; 0.24)	Germany (2.44; -0.12; 0.72)	Germany (2.93; -0.32; 0.48)
4	Germany (1.77; -0.17; 0.70)	United Kingdom (2.14; -0.08; 0.69)	United Kingdom (2.47; -0.28; 0.25)
5	Italy (1.26; -0.46; -0.22)	France (1.82; 0.10; 0.49)	France (2.14; -0.08; 0.07)
6	Japan (1.08; -0.50; 1.44)	Netherlands (1.62; -0.67; 0.21)	Japan (2.13; -0.60; 0.80)
7	Belgium (1.03; -0.51; -0.25)	Italy (1.45; -0.44; -0.06)	Netherlands (1.91; -0.76; -1.91)
8	Australia (0.99; -0.59; -1.54)	China (1.43; -0.05; -0.40)	Italy (1.78; -0.35; -0.30)
9	Sweden (0.88; -0.61; -0.14)	Canada (1.11; -0.33; -0.12)	South Korea (1.77; -0.57; 0.63)
10	China (0.55; -0.55; -1.33)	Australia (0.83; -0.65; 0.25)	Spain (1.59; -0.54; -0.28)
...			
50	Suriname (-0.94; -1.11; -0.89)	Costa Rica (-0.78; -0.73; 0.74)	Thailand (0.49; -0.75; 0.95)
51	South Korea (-0.95; -0.55; -0.22)	Jamaica (-0.80; -0.73; -1.71)	Indonesia (0.47; -0.74; -0.72)
52	Türkiye (-0.96; -0.44; -1.44)	Thailand (-0.83; -0.70; 1.56)	South Africa (0.41; -0.75; 0.28)

53	Malaysia (-0.97; -0.69; -1.12)	Botswana (-0.84; -0.75; -2.06)	Colombia (0.38; -0.74; 0.46)
54	Costa Rica (-0.98; -0.71; -1.88)	Dominican Republic (-0.85; -1.05; -0.8)	Peru (0.38; -0.76; -1.53)
55	Fiji (-0.98; -0.99; -1.44)	India (-0.88; -0.60; -1.24)	Vietnam (0.37; -0.77; 0.71)
56	Algeria (-0.99; -0.59; -1.00)	Tunisia (-0.89; -0.82; -1.24)	Suriname (0.36; -0.77; 1.67)
57	Colombia (-0.99; -0.51; -0.88)	Ecuador (-0.90; -0.88; -0.52)	Botswana (0.35; -0.77; -2.21)
58	Iraq (-1.01; -0.78; -2.12)	Suriname (-0.91; -0.73; -2.25)	Ecuador (0.33; -0.76; -1.12)
59	Tunisia (-1.02; -0.88; -0.81)	Morocco (-0.92; -0.71; -0.70)	Algeria (0.32; -0.74; -2.23)
...			
96	Mauritania (-1.11; -0.62; -1.33)	Central African Republic (-1.04; -0.73; -0.48)	Malawi (0.14; -0.75; -0.85)
97	Senegal (-1.12; -0.63; -1.72)	Niger (-1.04; -0.73; -0.55)	Mozambique (0.13; -0.72; 2.14)
98	Solomon Islands (-1.17; -0.59; -1.55)	Malawi (-1.04; -0.68; -1.22)	Gambia (0.13; -0.77; -0.80)
99	Indonesia (-1.18; -0.68; 0.8)	Rwanda (-1.05; -0.68; -0.83)	Chad (0.12; -0.69; -1.98)
100	Niger (-1.21; -0.68; -2.28)	Cambodia (-1.05; -0.69; -0.94)	Guinea Bissau (0.12; -0.79; -1.24)
101	Chad (1.22; -0.60; -1.51)	Nepal (-1.05; -0.70; -1.36)	Niger (0.11; -0.77; -1.43)

102	Gambia (-1.23; -0.63; 0.21)	Chad (-1.06; -0.73; 1.51)	Somalia (0.11; -0.81; -0.83)
103	Central African Republic (-1.23; -0.67; 0.51)	Myanmar (-1.06; -0.67; -0.95)	Sierra Leone (0.10; -0.77; -1.52)
104	Cambodia (-1.24; -0.67; -2.1)	Sierra Leone (-1.07; -0.91; 0.71)	Burundi (0.09; -0.77; -1.66)
105	Haiti (-1.25; -0.68; -1.99)	Ethiopia (-1.07; -0.92; -0.33)	Central African Republic (0.09; -0.79; 1.02)

Table 2. Z scores result for continuum multivariate analysis [State (economic power; military power; global dependence)]. Source: Author

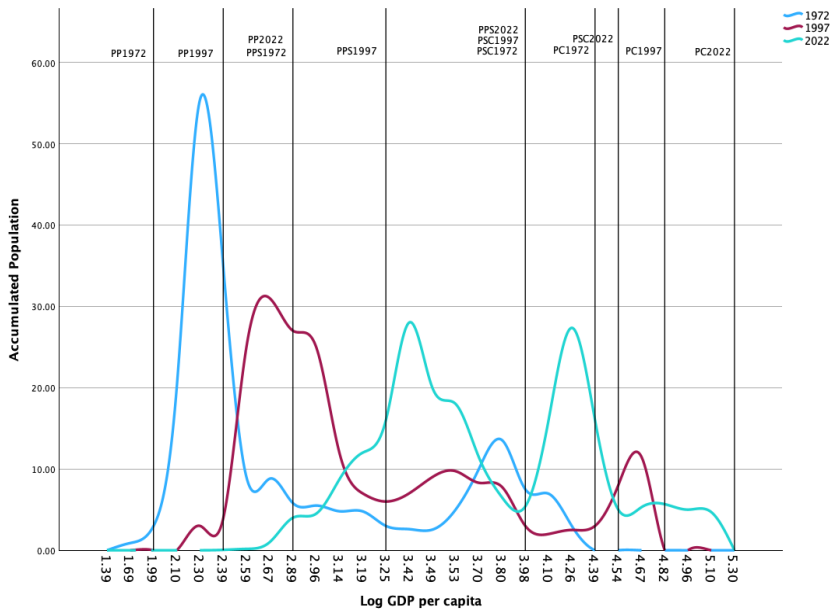


Chart 2. Income/Accumulated population distribution for 1972, 1997 and 2022. Source: own elaboration

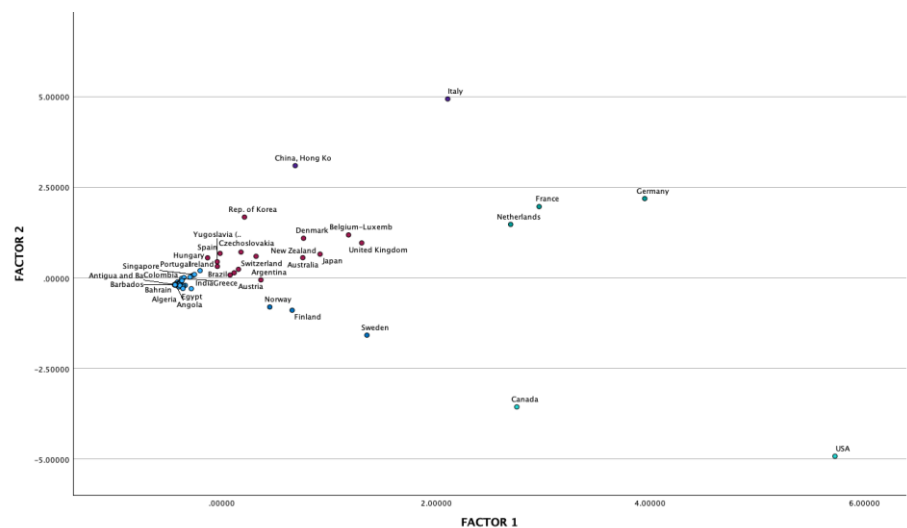


Chart 3.1. Continuum Clustering Plot by Commodity Chains for 1972. Source: Own elaboration

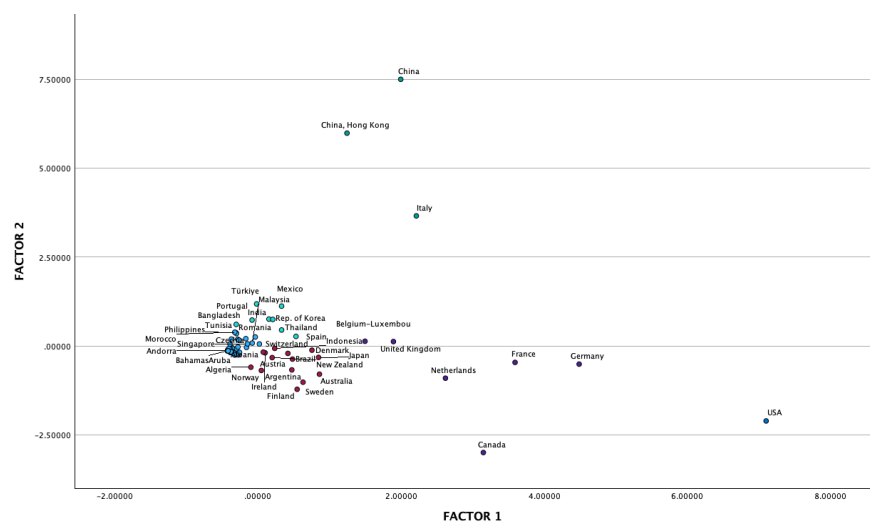


Chart 3.2. Continuum Clustering Plot by Commodity Chains Plot for 2022. Source: Own elaboration

Secondly, to compare upward mobility and downward mobility between the different models, a Student's T test has also been applied to compare those States that had experienced mobility of more than 10 positions in each corresponding period. If we look at Table 3 where these results are collected.

Once again, for the specific cases of States, the trade network analysis methodology appears to be the most sensitive, especially to determine mobility between the periphery and the semi-periphery, compared to the rest. The other three, although highlighting different cases, show very similar results. A problem to highlight in the distribution of accumulated income/population is the special and oversized mobility that it gives to oil-exporting countries. This, for example, is an advantage in the value chain methodology, since it completely excludes all goods linked to fossil fuels, giving a much more realistic image of the position in the international division of labor.

	1972-1997	1997-2022
Trade network analysis	Brazil (U, 19) China (U, 13), India (U, 14), Indonesia (U, 25) South Korea (U, 12), Spain (U, 13), Thailand (U, 24) Vietnam (U, 18), Botswana (U, 11)	Argentina (D, 15) Australia (D, 10), Brazil (U, 12), India (U, 21), Indonesia (U, 10), DPR Laos (U, 14), Lesotho (D, 20), Libya (D, 12) Nepal (D, 23), Sierra Leone (D, 22), South Africa (U, 13) South Korea (U, 13), Thailand (U, 11), Turkey (U, 15) Venezuela (D, 13), Vietnam (U, 20), Zambia (D, 14)
Economic and coercive continuum	Brazil (U, 15) China (U, 10), Vietnam (U, 19), India (U, 26), Indonesia (U, 24), Malawi (U, 20)	Brazil (U, 13), India (U, 24) South Africa (U, 15) Venezuela (D, 12), South Korea (U, 13) Vietnam (U, 20), Zambia (D, 16)
Profit/population discrete distribution	China (U, 12), Indonesia (U, 22), Nepal (D, 20), Vietnam (U, 18), Zambia (D, 21)	Brazil (U, 11), China (U, 17), India (U, 21), United Arab Emirates (U, 25), Guinea Bissau (D, 10), Nigeria (U, 14), Sierra Leone (D, 12), Thailand (U, 15) Vietnam (U, 14), Qatar (U, 22)

Continuum	Clustering	China (U, 11), India (U, 15),	Australia (D, 10), Argentina
Commodity Chains		Nepal (D, 21) Spain (U, 13),	(U, 12) Brazil (U, 10), China
		Singapore (U, 17)	Hong Kong (U, 15)Norway
			(D, 10), Venezuela (D, 10)

Table 3. Statistically significant mobility between periods in the different methodologies [State (D: Downward mobility, U: Upward mobility, No. of positions)]. Source: Author.

Conclusions

In addition to evaluating the specific cases of States that have experienced mobility in the last long wave cycle, being able to corroborate that, although limited in comparison to other previous cycles within the world economy, relevant mobility continues to occur, especially within the semi-periphery; We have been able to achieve both objectives: apply the main methodologies developed through the same sample for a period of 50 years in which significant changes could be observed and compare results to evaluate the quality and sensitivity of each one. With this, in short, it could be said that the method that presents the best prospects today is network analysis based on trade data. After it, we find that, despite the simplicity in data collection and analysis, the discrete distribution of income/accumulated population presents very good sensitivity for determining the composition of the parts. Although, in terms of mobility, it may overestimate some cases such as countries that export raw materials with variable prices, it finds a very good balance between time spent and results. The clustering of commercial chains, although it requires greater data processing and analysis, is not far from the quality of results of the latter and allows greater precision in the classification by establishing 6 groups in the structure (one for the core, two for the semi-periphery and three for the periphery). For its part, the continuous analysis, although it shows greater detail in variables that, although questioned by authors from the world systems tradition, the other analyzes do not include, finds a worse balance between the time necessary for its application and the less sensitivity shown.

Based on this, with a view to future methodological perspectives from a systemic prism, it would be very interesting to explore the continuation of the development of the network methodology applied to new variables, beyond trade data, which would make it possible to extend the analysis periods and

would provide, if possible, within the quality already obtained, greater statistical significance.

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