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Interconnections between Minister Cabinets in Greece. A Bicentennial Study with Implications on Economy

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Abstract: In this paper we deal with a network analysis of interconnected cabinets in Greece for an extended time period. In parallel, we present a small review of the economic crises that have occurred in Greece over this period. More particularly, we used historical sources to locate all different Greek governments and all economic crises starting from the 1821 Greek revolution to the present days. We also formed a two-mode (also known as affiliation) network of ministers and cabinets and subsequently created a network of interconnected cabinets. We used dedicated software to visualize this network and used Social Network Analytical procedures in order to calculate its properties. Finally, in an attempt to investigate possible relations between network metrics and economic crises, we note and discuss an interesting observation between a specific metrics and such major economic events. In our paper, we firstly introduce the context and present our research questions. We then present the relevant literature, mainly discussing the extent to which Social Network Analysis has been used to investigate patterns of behaviors in politics. We then proceed to presenting and applying our methodology on network creation, visualization and metrics computations. The following section discusses the longitudinal evolution of our network and the relation between its clustering coefficient and the emergence of economic crises. We then finalize our paper with some conclusions.

Keywords: social network analysis; governments in Greece; economic crises; clustering coefficient; political networks; longitudinal networks; macroeconomics; Kondratieff waves.

JEL classification: D72; D73; D85.

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1. INTRODUCTION

In 2021, Greece celebrated its bicentennial liberation from the Ottoman Empire, after the Greek War of Independence (1821). During these last two centuries, the Greek state has matured politically (after passing through a series of different political periods) and expanded geographically (with the latest expansion taking place in 1912-1913). It has also suffered a series of dramatic Historical events (local and global wars) and also a number of (major and minor) economic crises, the latest one starting from 2008. Actually, about eight to ten major economic events have been recorded during this period (Tsoulfidis & Zouboulakis, 2016), including four (or five including the 2nd World War) defaults (see Table no. 1). Notably, in two hundred years of Greek independence, for almost 50% of the time Greece is under a type of financial control imposed by creditors.

Table no. 1 – Major economic incidents in Greece

Time	Type	Default
1827	Loans not paid	Yes
1843	Temporary stop of paying loans	Yes
1860	Temporary rest of paying loans	
1893	Major default	Yes
1921 - 1930	Partly stop paying loans	
1932	Temporary stop in paying loans	Yes
1942-1943	Stop of paying loans (war)	Yes
1953	Major drachma devaluation	
1973 - 1978	Oil crisis	
1985	Close to default	
2009 -	Close to default, salvation (!) by the Troika	

Viewing this period from a different perspective, that is, the political – parliament – government one, Greece exhibits a very rich modern political history. Ever since 1821, a number of 386 different formations of ministerial cabinets have been formed and served, almost two for every year of independence passed (Kydros, 2021). This large number of different cabinets does not actually mean a similar number of general elections; rather, in one parliament period, different formations (restructuring or reformation) of cabinets is common. However, as seen in the relevant literature (Sotiropoulos & Bourikos, 2002), the actual absolute number of different ministers is rather small, being 1955 different persons. This means that during the whole modern political government history, ministers are selected from a rather small ‘ministerial elite’. This fact in turn means that in many cabinets, ministers are interconnected, in the sense that they serve together in different government formations.

Having the above two observations in mind, in this paper we venture to investigate possible relations between ministerial elites and their participation in different cabinets with major economic events (crises) in the Greek modern state. A relevant literature discussion is held in Section 2. In Section 3, we first create a network of interconnected cabinets (i.e., cabinets that share the same ministers) and discuss its structural properties, using different views (local and global ones). In Section 4, we place this network on a longitudinal scale and discuss some important relations between network metrics and relevant economic incidents. This paper concludes with some final remarks in Section 5. Overall, we try to cope with the following Research Questions (RQs):

RQ1*: What is the structure of the cabinets' network in Greece? Does it belong to any categories of networks found elsewhere in real-life networks?*

RQ2*: Is there any relation between the cabinets' network and important economic events (such as crises)?*

RQ3*: If RQ2 has a positive answer, what type of phenomenon actually triggers this relation? Is it the economic crisis or the structure of the network at this particular time-frame?*

As a final point in this introduction, it must be noted that in this paper we do not actually deal with typical economic theories on crises. We rather try to locate patterns from the view of social network analysis in politics, since economy and politics are closely interconnected.

2. RELEVANT LITERATURE

Network Analysis (or Social Network Analysis – SNA or even Network Science) investigates the relations between individual actors. These actors may represent actual living and interacting persons (we then talk about social networks) or other entities, such as countries, computers, animals, companies, etc. According to Wellman (1988), network analysis is not statistics in the traditional way of thinking, where one investigates attributes of individuals. It is the structure of relations among these individuals that matter. Hence, in network theory one elaborates on the attributes of pairs of individuals (Borgatti & Everett, 1997). This paradigm has its roots on Graph Theory, firstly introduced be Euler (in the famous Konigsberg bridges problem). Graph Theory is being extensively studied since the 1950's, with many important results in many different aspects of research (Hage & Harary, 1983). During the last 30 to 40 years, major breakthroughs were made in Social Network Analysis (Watts & Strogatz, 1998; Barabási & Albert, 1999; Newman *et al.*, 2006). It is important to note that social networks actual play a very important role in today's life: Twitter, Facebook, LinkedIn, Google search are all implementations of social network analytic ideas and methods. A number of software tools that can be used to create, manipulate and study networks is also available such as PAJEK (Batagelj & Mrvar, 2002), NodeXL (Smith *et al.*, 2010), Gephi (Bastian *et al.*, 2009), NetworkX (Hagberg *et al.*, 2008), etc.

Social Network structure has an important trace on Economics (see the excellent reviews by Benhabib *et al.* (2011) and Jackson *et al.* (2017). Regular or sparser interaction between people has a major impact on the way people decide or form opinions in an extensive list of economic life, such as spreading information about new markets, new products, jobs, technologies and others. The structure of our social networks has an important impact on education, career, financing, business decisions and a large number of similar economic situations. According to Jackson *et al.* (2017), the above-mentioned situations are only a partial list of economic behavior of individuals affected by network structure. Furthermore, when we turn our view on organizations rather than individuals (countries and trade, alliances of corporations etc.) more insights can be gained when dealing with relationships rather than individual characteristics.

Economic behaviors are influenced by the underlying network structure and vice-versa. As an example, one can consider the famous interlocking board of directors (Mizruchi, 1996), a social network comprised of persons that serve simultaneously in directorates in large corporations: a bunch of well interconnected people affect economic decisions of a disproportionally large number of economic organizations in the USA. Important economic decisions are also severely affected when networks are polarized or communities of actors are present: one can consider the current situation that has been emerged after the Russian imperialistic invasion in Ukraine (March 2022): the community of EU nations is collectively taking economic measures against Russia that would never have been taken if the structure of "community" was not present in the European states network. Even if some EU member states feel that some aspects of the sanctions (especially the natural gas payments) are not in favor of their narrow interests, the actual structure of the network is imposing a special, common direction.

SNA has been also used in investigating crises in general and particularly economic crises. Social systems are hard to understand because of their inherit complexity. SNA can enlighten important information that could be missed, since it can show subgroups, elements that can greatly alter a network an also pursues the longitudinal change of networks (Güreşci & Arpat, 2016). Social Networks may hinder the economic uncertainty spillover network, especially strong during the COVID-19 pandemic. Furthermore, developed provinces are more prone to create new links in spillover networks (Ma *et al.*, 2022). Morales *et al.* (2014) attempted to estimate bank financial strength during the 2008 economic crisis, by using SNA methods. Wang and Yang (2022), in a very important paper, developed a dynamic industry network model to evaluate critical industries in China. They also used SNA methods and metrics to assess industries quality. Iglič *et al.* (2021), again investigated the impact of economic crisis on the European social capital. They prove that changes in social trust and formal networks can especially be explained by the impact of the political factors, while variations in informal networks are mainly due to the changing economy. Moreover, the analyses show that while the economic crisis generally lowered social capital, some mechanisms such as a sense of togetherness and left-wing political activism, enhanced social capital.

In Macroeconomics, again, a number of researches have produced important literature. Bögenhold (2013) discusses the concept of Social Embeddedness and he conclude that SNA may provide with tools to foster the understanding of social dynamics. In turn, he argues that this enhances the debate on micro-macro gap and on limitations of the potential of economics. Acemoglu *et al.* (2016), provided an empirical exploration on Networks and the Macroeconomy. They argue that small shocks in small enterprises may quickly travel through the networks in which this enterprise is present. Such networks may be global, so the potential problems could lead to macroeconomic events. The cascading phenomenon, especially connected with the network topology, was investigated regarding risk propagation along supply chains in the U.K. (Spatareanu *et al.*, 2023). Economic policies and the impact of networks on them are discussed by Elliott *et al.* (2019). The authors focus on six policy domains, discuss the impact of network economics on them and argue that not only this type of analysis depends our knowledge on the inner construction of economic policies, but can also help in producing and applying new ideas and policies.

Network Science has also been used in Political research in a number of different ways, although with a slower acceptance (Żukiewicz *et al.*, 2018) and mostly by researchers in the USA rather than then more traditional European ones (Heaney & MacClurg, 2009; Ward *et al.*, 2011). According to *The Oxford Handbook of Political Networks* (2017), Social Network methods have been used to research on political parties and campaigns, international relations, vote choice, etc. Furthermore, during the last 10 years, much research is done regarding Social Media applications (such as Facebook or Twitter) and their impact on political life (Jungherr, 2016; Confessore, 2018). Content and sentiment analysis on political discourse is also present

(Chase Dunn, 2019; Keller & Klinger, 2019). Similar research is present in the Greek sphere (Kydros & Anastasiadis, 2017).

An attempt to investigate Greek political history, in the level of parliament members, through Networks Analysis was done by Kydros *et al.* (2012), resulting in a severely congested (highly knotted) network. In a recent paper, Kydros (2021) used a methodology similar to our study in order to create a network of ministers and mainly investigate the emerging relations of nepotism over the Greek ministerial elite. In this paper we use the same original dataset (with a difference in preprocessing) but we produce a different network view, together with a discussion on the relation to economy.

At this point, it must be noted that, to the authors' knowledge, similar to the present paper research has not been found in the literature. Hence, it is our hope that a new area of study might be emerged.

3. METHODOLOGY, NETWORK CREATION, VISUALIZATION AND METRICS

As already stated in the previous section, in this paper we will use an already formed data set containing all persons that have served as ministers and all corresponding cabinets over a period of 200 years. One can access the paper by Kydros (2021) in order to clarify the data-collection procedures from various sources. The original dataset is formed as a simple spreadsheet, where persons are stored in each row label and cabinets are stored as column labels. The entries of this two-way matrix are 1's and 0's: an entry (row, column) equals 1 if the person in (row) has served in the cabinet in (column). This matrix has 1955 rows and 386 columns.

A necessary preprocessing has to be held here, since these 386 original columns correspond to different formations of cabinets and not actual government period (as already noted, it is common in Greece to reshuffle cabinets during one government period). Hence all columns that belong to the same government period were merged in one column (a binary OR function was used). After this preprocessing the new 'clean' matrix contains 1955 rows and 205 columns.

Such matrices correspond to two-mode (or bipartite) networks (Borgatti & Everett, 1997). A bipartite network has two disjoined sets of nodes with cardinalities of N and M. All links connect nodes belonging to different sets and there is no link joining two nodes of the same set. A pictorial example, containing a small such matrix and the corresponding bipartite network is shown in Figure no. 1a and no. 1b respectively.

At this point, a simple linear algebra function, the dot (•) product of matrix A by AT (A transposed) yields two different matrices as follows: A•AT results in a square matrix N X N, which corresponds to a network of ministers that have served in the same cabinets, while AT•A results in a M X M square matrix that corresponds to the network of cabinets that have common ministers. The whole procedure is shown in Figures no. 1c and no. 1d, where we produce the network of cabinets.

	Cabinet1	*Cabinet2*	*Cabinet3*	*Cabinet4*	*Cabinet5*	*Cabinet6*
Minister1	1	0	1	0	0	0
Minister2	1	0	1	0	0	0
Minister3	0	1	0	0	1	1
Minister4	0	0	0	1	0	1
Minister5	0	0	1	0	0	0

Figure no. 1a – Original two-mode matrix A. Minister1 has served in Cabinets1 and 2, together with Minister2, Minister3 has served in three cabinets, etc.

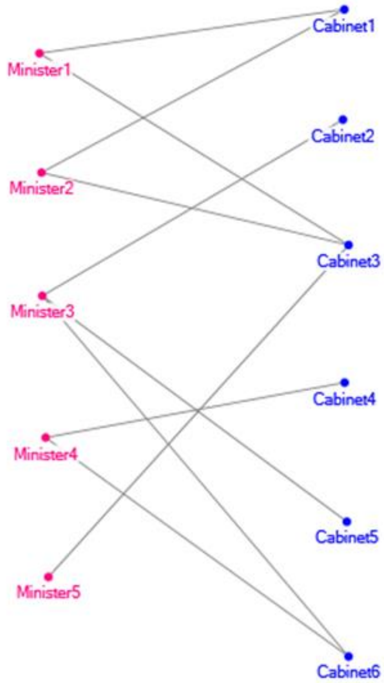

Figure no. 1b – Bipartite network corresponding to matrix A

	Cabinet1	*Cabinet2*	*Cabinet3*	*Cabinet4*	*Cabinet5*	*Cabinet6*
Cabinet1	2	0	2	0	0	0
Cabinet2	0	1	0	0	1	1
Cabinet3	2	0	3	0	0	0
Cabinet4	0	0	0	1	0	1
Cabinet5	0	1	0	0	1	1
Cabinet6	0	1	0	1	1	2

Figure no. 1c – The result of AT•A. By setting diagonal element to 0 and reducing all positive values to 1, an adjacency matrix is created

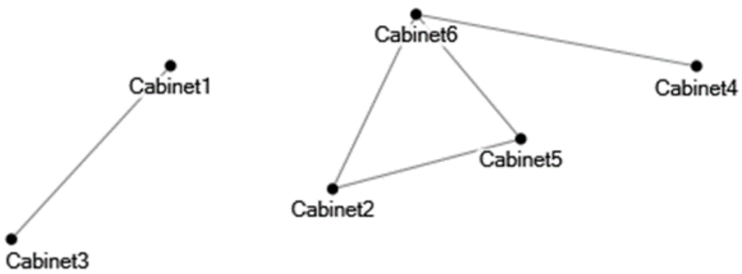

Figure no. 1d – The network of cabinets. Links correspond to cabinets that have common ministers

In our paper, all preprocessing was held in a spreadsheet and all network creation, visualizations and metrics calculations were held through the use of NodeXLPRO (Smith *et al.*, 2010), with some minor calculations performed in NetworkX (Hagberg *et al.*, 2008).

In Figure no. 2 we present a visualization of the cabinets' network. Figure no. 2 was prepared in high resolution and can be zoomed in. All cabinets are shown as nodes (points). A line between two nodes corresponds to ministers that served in both cabinets. Color is used to represent constitutional period (there have been thirteen such constitutional periods in Greece, with the latest been 'Metapolitefsi' from 1974 to present, shown in yellow). All nodes are labeled by the prime-minister's (or the head of the cabinet) names.

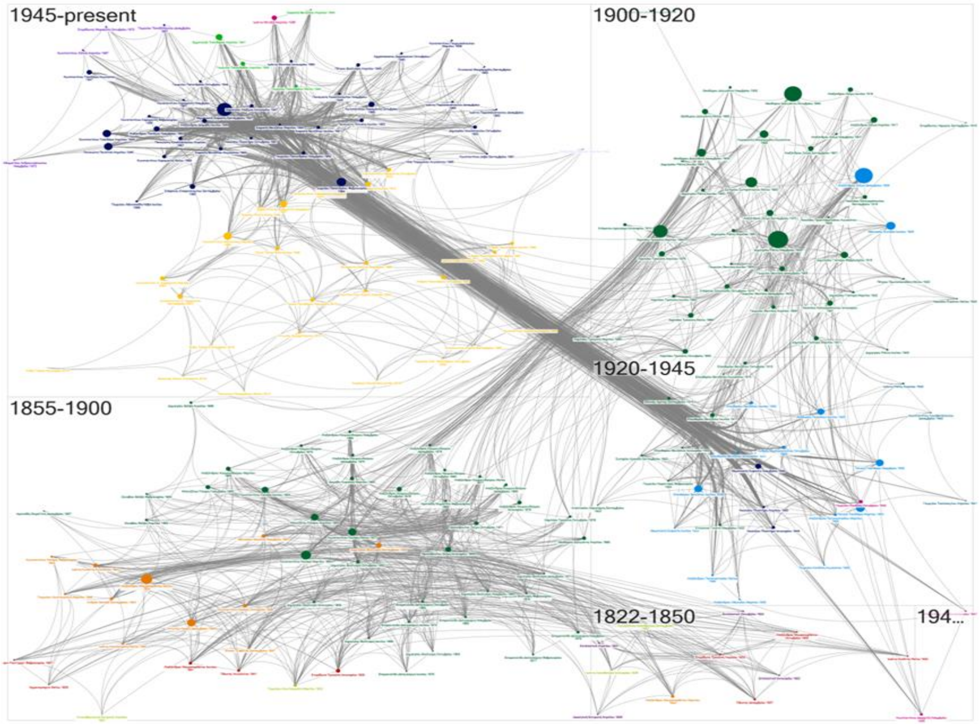

Figure no. 2 – The Greek cabinets network

In Figure no. 2, the size of nodes proportionally corresponds to betweenness centrality, a very important metric calculated as the proportion of actual shortest paths between all pairs of nodes passing through the specific node, divided by the total number of shortest paths. This metric actually corresponds to the degree of mediation of a node between other nodes. In our case, since we are actually interested in information shared between cabinets with the same ministers, betweenness centrality actually corresponds to the importance of a cabinet as a mediator (or broker) for the sharing of common ideas between cabinets.

Finally, Figure no. 2 depicts some segregation between cabinets, calculated as communities (Newman *et al.*, 2006). A community is a group of nodes where more links can be found between nodes within this group than nodes outside the community. Thus, a community serves as a (rather loose but still present) group of nodes that seem to interact more between them. This is type of grouping that made obsolete some older grouping ideas (such as cliques, clans, etc.) which may rely on structure but have quite strict definitions. In Figure no. 2, communities are shown within rectangles. Links between communities are also present but 'bundled'. Communities do overlap with constitutional periods but nor in a strict manner and labeled accordingly.

Table no. 2 – Basic Metrics

Metric	Number	Explanation
Nodes	205	The number of cabinets
Links	2352	The number of connections (common ministers) between cabinets
Connected components	2, Number of nodes in the major component: 204	All cabinets (but one) are connected
Maximum Distance	8	The diameter of the network (the most distant pair)
Average Shortest Path	3.13	The average distance between two cabinets
Density	0.11	The proportion of actual links over the maximum possible number of links
Modularity	0.5	A measurement that shoes high clusterability.
Average Degree	22.9	The degree of a node is the number of its neighbors. In average, every cabinet is connected to about 30 others.
Average Clustering Coefficient	0.575	The clustering coefficient varies from 0 to 1 and represents the ability of a node to create dense neighborhoods around it.
Sigma coefficient	2.143	For sigma>1, a network is a small-world

In Table no. 2 we show a number of metrics calculated over the network. Most metrics are self-explanatory, perhaps except from sigma coefficient. Positive values over 1, mean that this specific network lies in the family of small worlds (Humphries & Gurney, 2008). Small worlds are characterized with small average path lengths and large clustering coefficient. This topology has been said to be common in many real-life networks (from social networks to the network of neurons in the human brain). It is characterized by tolerance to perturbations (Watts & Strogatz, 1998). In an attempt to check whether this network is also a scale-free network (Barabási & Albert, 1999) after fitting the nodes degree distribution, we came up with the results in Figure no. 3. Obviously, the cabinets network possesses a degree distribution closer to chi2 or gamma distributions, but not in the power-law one. This discussion fully answers our RQ1.

At this point, a normal study on the structure of our network would switch on a more microscopic view, studying the importance metrics and relevant rankings of individual nodes. However, in this paper we are mostly interested in the relationship between the network structure and major economic events, so we proceed to the relevant discussion in the next section.

distribution	sumsquare_error	aic
chi2	0.035523	956.478
gamma	0.035523	956.478
lognorm	0.035600	957.058
rayleigh	0.035679	952.581
norm	0.037477	1013.72

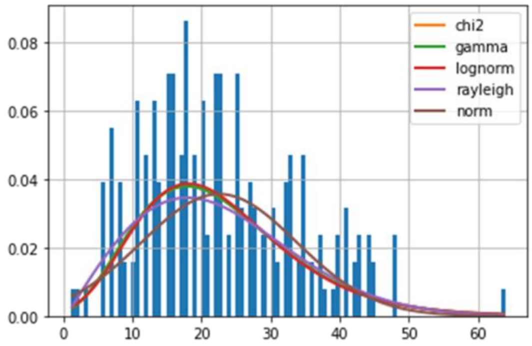

Figure no. 3 – Degree distribution and fitting to common distributions

4. NETWORK LONGITUDINAL STRUCTURE AND ECONOMIC CRISES

The evolution of networks over time is an important thread on research. A number of theories, varying from randomly created (Erdos-Renyi) networks to small-worlds, scale-free networks have - and is being - studied (Newman *et al.*, 2006). The simplest way to investigate this evolution is to visualize a network on an appropriate time-scale. In our dataset, we also recorded the date of cabinet creation, together with its duration in days. In Figure no. 4, we present this network over time, where each node is drawn at the time of the corresponding cabinet formation. In Figure no. 4, the size of nodes still corresponds to their betweenness centrality score while Y-axis represents their clustering coefficient score.

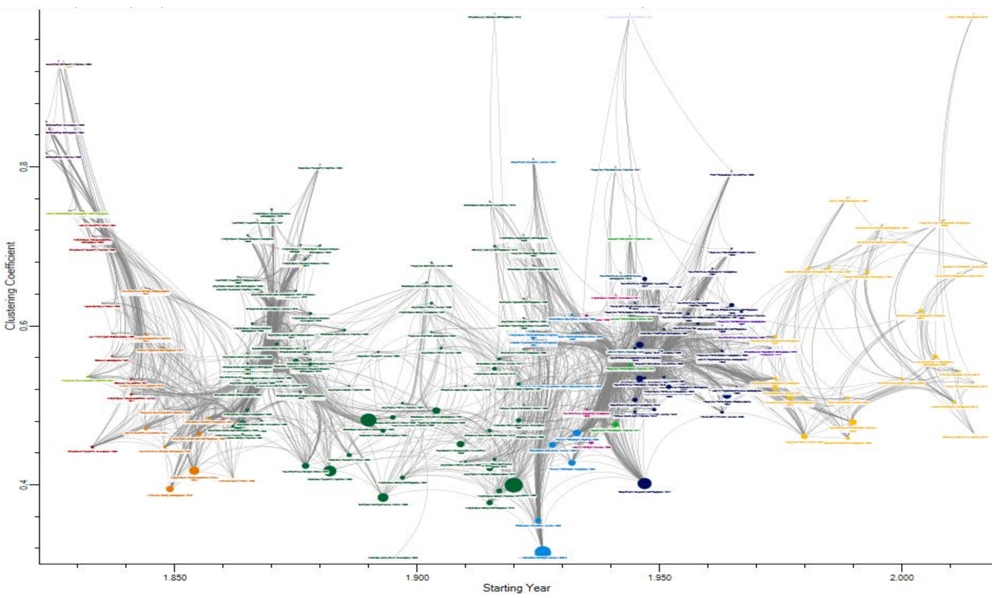

Figure no. 4 – The evolution of the network over time

We now produce Figure no. 5, where we use a dotted line to represent clustering coefficient and its rolling average (over 2 periods), after the removal of outliers. It is reminded that those nodes with high clustering coefficient operate as hubs in the overall network structure, since they seem to create highly interconnected nodes in their neighborhood. In our case, a cabinet with high clustering coefficient is one that exhibits many cooccurrences of ministers over this node and its immediate neighbors, which in turn implies a restricted 'ministerial pool' with fewer newcomers and many long-lasting ministers (even if cabinets change).

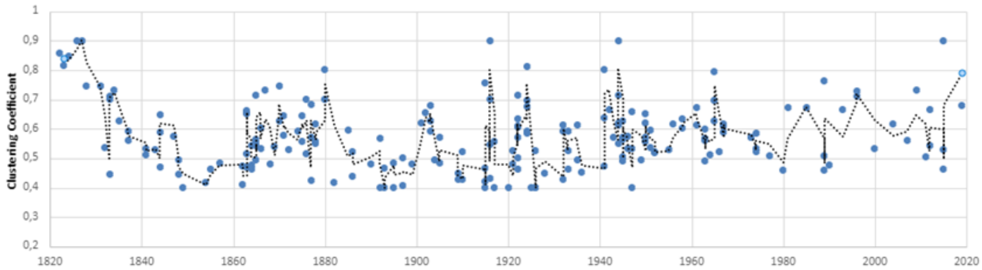

Figure no. 5 – Rolling Average of Clustering Coefficient over time

An interesting pictorial result of Figure no. 5 is that a type of periodical pattern, somehow similar to a sinus wave, seems to exist. This sinusoidal curve oscillates around a value of 0.6 in clustering coefficient. The curve seems to have denser and sparser periods, a fact that is natural since each value corresponds to a different cabinet formation: there have been extraordinary turbulent political periods in Greece when cabinets lasted for a few months or even a few days. However, it is tempting to point out that sinusoidal curves (waves) have been proposed in macroeconomics, ever since the early decades of the previous century, mainly by Kondratiev (the Kondratiev long waves of the economic cycles). This is a way of thought that has influenced a number of important economists or even historians/philosophists, such as Schumpeter or Hobsbawm. One could argue at this point that political life in the level of executive authority (at least in Greece) does follow this waving pattern, despite the lack of normality in frequency.

A possible explanation for this waving pattern is that over the years some political (or economic) situations yield cabinets that do not share too many common ministers. A lasting economic crisis, for example, might trigger a major shift in government formation, resulting not only in new political parties taking over the chair but also in a kind of 'sending the old personnel home': failed ministers should somehow pay for their faults. A major change in the personnel happens and clustering coefficient drops. However, it should be noted that in the Greek case low values of clustering coefficient (lower than 0.2) rarely happens, meaning that even with major changes, some ministers do keep on participating in cabinets.

We now turn our attention in our RQ2 and RQ3, namely the possible relation between the network structure and economic crises in Greece. As already stated, in Table no. 1 we listed the main economic disturbances over the years, some of them resulting to defaults. Of course, in some cases local economic crises happened for reasons outside the responsibility of the local political situations. Hence, in the following discussion we will not take under consideration the economic crises of 1827 (revolution period), 1921-1925 (Minor Asia war), 1942-43 (Nazi occupation), 1953 (not a real crisis) and 1973-1978 (global oil crisis). In our final Figure no. 6, we reproduce Figure no. 5 with the addition of red vertical lines that correspond to the remaining crises of Table no. 1.

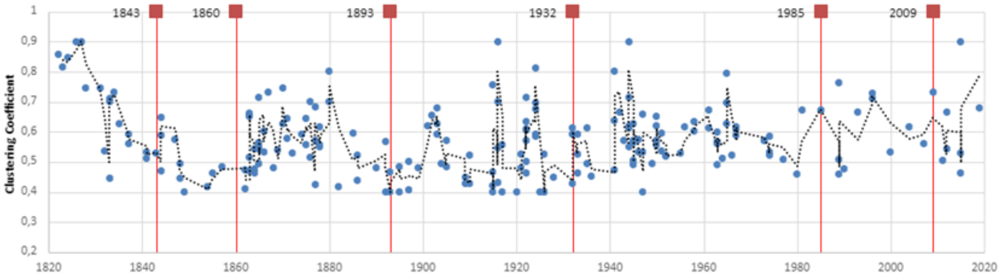

Figure no. 6 – Clustering coefficient and economic crises

Some first observations, relevant to our RQ1, are self-evident: economic crises seem to start on years with high clustering coefficient (all cases except 1860). Actually, the incidents happen on local maximum values or just before them, but not on absolute maxima. Hence, it is obvious that the answer to our RQ2 is positive: a relation seems to exist between the network structure and major economic crises. The interconnection of cabinets through common ministers do seem to play a role in the emergence of a crisis.

Regarding our RQ3, perhaps most importantly one should examine the time periods before and after the beginning of a crisis, since such major events do not happen spontaneously. In all our cases it seems that a period of five to ten years of absolute minima in clustering coefficients of the cabinets network is present right before the incidents. Also, since the events are found on local maxima, right after each event (and again for a period of 5 to ten years) a steep drop on clustering coefficient is also present.

An interpretation of this phenomenon might rely on the following thread of thinking: when a new cabinet is formed and this cabinet has a low clustering coefficient, this means that a large number of newcomers enter, probably because of a quite strong political polarization. This in turn means that older ministers, perhaps with much bigger experience and cautions are sent out. Newcomers cannot rely on trusted policies or try to implement new policies in a rather abrupt - a 'sorcerer's apprentice'- manner. Such a shift in policies triggers problems in economy which in turn and after a period of 5 to 10 years do lead to major economic incidents. Political polarization and major changes in economic policies are not always to the best of the economy.

It is interesting to note that in almost all cases the beginning of the crisis is found on local clustering coefficient maxima. The political personnel foresee that 'things are not going well' and tries to react by forming new cabinets, bearing more experienced (thus more interconnected) ministers, but it seems that these reactions come 'too late and too little'. The economic crisis is here and almost nothing can be done to reverse it. Hence, a new period of low clustering coefficient follows, with newly formed cabinets with many newcomers trying to cope with the situation.

The above discussion answers RQ2 and RQ3 in our context. We should point out that we do not prove that low clustering coefficients in the interconnected cabinets' network will eventually lead to crisis. In Figure no. 6 we can see such periods (after all we have already seen this as a wave) that did not lead to such a major event. Furthermore, as already stated, major economic crises usually have multiple causes, especially in today's highly interconnected world. However, our research can be seen a complimentary way of predicting (or at least warn) for possible such outcomes.

5. CONCLUSIONS

In this paper we used historical data from the Greek political – government history over a long period of 200 years in order to create a network of interconnected cabinets (cabinets that share the same persons as their ministers-members). We recorded relevant data in a two-way matrix and by proper linear algebra functions we produced the adjacency matrix of these cabinets.

Next, we used software to create and visualize the corresponding network and calculate important structural metrics on it. After a discussion on these results, together with an attempt to categorize this network, we continued by exhibiting the value of clustering coefficient of the nodes over time, where we noticed a sinusoidal (but not with a stable frequency) long wave.

We then overlapped this wave with time-stamps where an economic crisis was declared (but not a crisis created by exogenous reasons). We pointed out that economic crises were declared after a 5-10 period of low clustering coefficient values, followed by a local peak of clustering coefficient on the (almost) exact year and in turn followed again by a 5-10 period of reduced clustering coefficient.

Finally, we discussed probable interpretations of this phenomenon that could be used as a warning for forthcoming major economic crisis, in a complimentary fashion. Stability and experience in the decision-making level seem to be an important factor here.

This research was based on data from Greece, but can be easily extended to other countries that may share common characteristics in their political life, that is, countries where 'ministerial elites' are present, in the sense that despite changes in political parties taking over administration, a pool of persons is used to form the executive authority (cabinets) over and over again. It is our suspicion that this is a common situation, at least in countries where a stagnation in political personnel is present.

In an attempt to speculate on the possibility of yet another forthcoming major economic event in nowadays Greece, one should carefully inspect the far-right time period shown in Figure 6. The clustering coefficient seems to grow up after a local minimum in the year 2019, when a change in the ruling political party happened. During the last three and a half years the new Government has been quite stable, without many changes in its cabinet. If this situation continues after the following elections, and the new cabinet exhibits higher clustering coefficient (i.e. uses the same persons as ministers), then a major economic event might occur after about 4-5 years. However, again, we must insist that this is a speculation that will be verified in the not-so-close future. *Time will show!*

Still, as a final but important notice, one should point out that the interrelationships between politics and economy are extremely complicated. Our network paradigm is just one view of the study of this relationship but can be used to explore different aspects of it.

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