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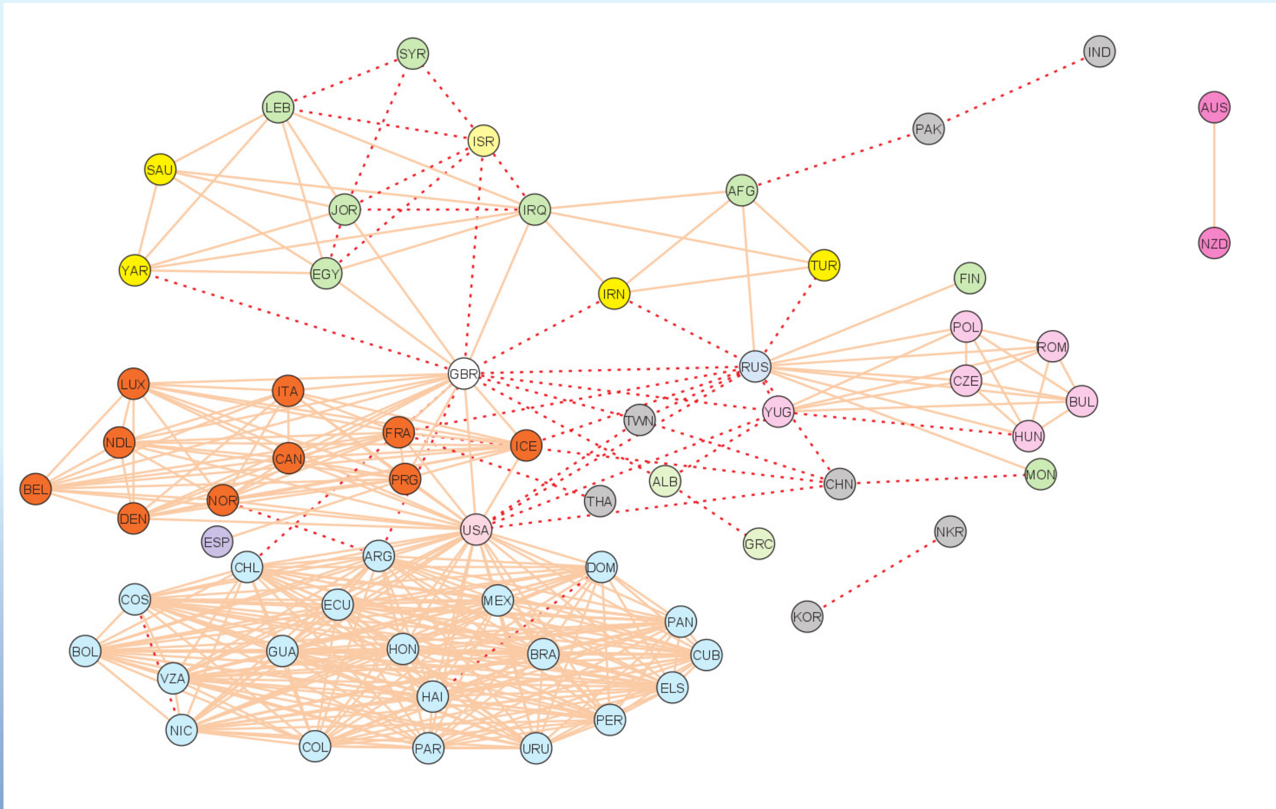

Official Journal of the International Network for Social Network Analysis

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Cover image: Doreian, this issue pg. 14

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From the Editor

I am proud to introduce a new issue of Connections. In this issue you can find articles on: structural balance in signed networks (Doreian and Mrvar); operationalising oligarchic networks as rich clubs (Ansell, Bichir, Zhou); the use of experiments in social exchange networks (Neuhofer, Reindl and Kittel); Tom Valente's keynote on network influences on behaviour (Dyal); description of a dataset from a network exchange experiment (Skvoretz); and the description of a dataset from a health promotion study (Gesell and Tesdahl).

In the last few years we have introduced a section on datasets, codebooks and data collection methods (DEN); state of the art reviews; and the professionalization of the production process with the assignment of DOI numbers and copyright agreements with authors. Beyond our regular call for original research articles, I would like to invite submissions on network research design as a new section to the journal. Of particular interest are studies where the use of novel research designs reflect on the choice between alternative models.

The journal is moving towards distributed editorship, emulating the model adopted by Network Science as most pertinent for an interdisciplinary audience. We will shortly circulate the list of area specific editors.

We are looking forward to your suggestions and feedback at Sunbelt and via email. We are organising a short reception on Wednesday the 6th of April at 8pm at the Presidential Suite of the Marriot Hotel (i.e. the Hospitality Suite) and we would like to invite all authors, potential authors and friends of the journal to come and meet the Editorial Board.

Dimitris Christopoulos
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Who Says Networks, Says Oligarchy? Oligarchies as "Rich Club" Networks

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Abstract
Departing from Roberto Michels's classic analysis of oligarchy, we provide a structural analysis of the concept based on social network analysis. We define oligarchy as a social network that exhibits three structural properties: tight interconnections among a small group of prominent actors who form an "inner circle"; the organization of other actors in the network through the intermediation of this inner circle; and weak direct connections among the actors outside the inner circle. We treat oligarchy as a global property of social networks and offer an approach for measuring the oligarchical tendencies of any social network. Our main contribution is to operationalize this idea using a "rich club" approach. We demonstrate the efficacy of this approach by analyzing and comparing several urban networks: Sao Paulo urban infrastructure networks and Los Angeles and Chicago transportation policy networks.

Keywords: *oligarchy, rich clubs, policy networks, urban networks*

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We would like to thank Margaret Weir and Eduardo Marques for allowing us to use relational data they collected on, respectively, Chicago and Los Angeles transportation networks and Sao Paulo urban infrastructure networks.

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1. Introduction

The concept of oligarchy has a long history in the social sciences and in the popular imagination, from Aristotle's description of oligarchy as rule by the few, to Roberto Michel's "Iron Law of Oligarchy," to the colloquial description of post-Soviet capitalist grandees as "oligarchs." The term has various connotations in the social sciences, from the "bureaucratic conservatism" of social movements (Voss and Sherman 2000), to the control of the economy by "industrial tycoons" (Guriev and Rachinsky 2005), to the domination of politics by "major producers" (Acemoglu 2008). Most of these references, however, share the idea that an oligarchy is a regime controlled by cooperation or collusion among a small group of powerful elites.

Given the long history and ubiquitous use of the idea of oligarchy and the potential importance of oligarchical control over social movements, economies, and political systems, it is surprising that there is so little theoretical and empirical attention paid to the concept of oligarchy. Many authors make reference, of course, to Roberto Michels's work, *Political Parties*, which provides the classic theoretical treatment of the concept. But since the publication of this important work in 1910, there has been limited theoretical analysis of the concept of oligarchy. Taking Michels's claim that oligarchies were inevitable seriously, subsequent scholarship has mostly sought to identify the conditions under which organizations and social movements do *not* become oligarchical (Lipset, Trow, and Coleman 1977; Voss and Sherman 2000). In this paper we build on, but go beyond Michels's classic treatment by analyzing the structural bases of oligarchy, which we operationalize using social network analysis. We treat oligarchy as a global property of social networks and offer an approach for measuring the oligarchical tendencies of any social network.

We begin by briefly reviewing Roberto Michels's classic analysis of oligarchy, pointing to how it provides the basis for our own structural analysis. A protégé of Max Weber's, Michels analyzed the development of oligarchy in complex bureaucratic organizations. His central insight was a synthesis of the "elite theory" of fellow Italians Gaetano Mosca and Vilfredo Pareto with Weber's expectation that modern bureaucracy could become an "iron cage." He argued that organizational differentiation and stratification produced a distinctive, self-perpetuating elite ("Who says organization, says oligarchy"). Though formally sovereign, the "masses" were unable to organize themselves and as a result become dependent on the elite group to direct them. While the elite group is composed of a stable "inner circle" that monopolizes control over organizational offices, the average member has a narrow and unstable relationship with the organization. Consequently, the elite's advantages allow them to transform their "inner circle" into a "closed caste." This closure is essential if elites are to prevent a challenge to their position by the rank-and-file. In sum, an oligarchy has three aspects: the elite are tightly interconnected among themselves, forming an "inner circle"; the masses are organized through the intermediation of this inner circle; and the masses are poorly interconnected among themselves.

Literature in the Michelsian tradition has focused on the organizational aspects of oligarchy.[1] By contrast, we focus on the relational character of oligarchy, as it might develop within a social network. A social network perspective has two important advantages for the study of oligarchy. First, it frees us from the confines of a single organization and allows us to examine how relationships might structure the organization of elites spanning organizational or institutional boundaries (see Marques (2000, 2003, 2008, and 2012) on the permeability of the "State fabric"[2]). Second, a social network perspective may be used to capture the informal relational basis of oligarchy—the proverbial 'old boys network.'

An earlier generation of scholars made much the same argument and closely dissected the structure of relationships among "ruling elites" (Hunter 1953, Mills 1956, Dumhoff 1967). But this scholarship got bogged down in debates between "elite theorists" and "pluralists" (Polsby 1960, Dahl 1961). Although this debate generated new insights, it tended to be structured in dichotomous terms as an issue of whether or not a ruling elite existed. In the 1970s, work in this tradition shifted its attention to one specific type of network—"interlocks" between the boards of corporations. As this corporate interlock literature developed, it increasingly focused on how links

1 See Leach (2005) for a review and critique. He defines oligarchy as the "concentration of entrenched illegitimate authority and/or influence in the hands of a minority..." (2005, 329).

2 This concept refers to the relational patterns formed by both institutional and personal relationships that structure state organizations. According to Marques: "The state fabric is created and changed by networks among people and organizations, both inside the state and in the larger environment of policy communities. The contacts are both personal and institutional and are based in old and new ties, constantly re-created. These midlevel structures control several resources and affect preferences, restrict choices and strategies, and change political results" (2012, 33).

between corporate boards shaped the flow of influence and resources between them (Mizruchi 1996). These studies usefully widened the discussion of the role of corporate interlocks, but also gradually shifted attention away from the regime-like characteristics of interlocking directorates.

We have no interest in resurrecting the old elite-pluralist debate. Our relational approach to oligarchy suggests that the structure of social networks is likely to affect the flow of information, the distribution of resources, patterns of decision-making and influence. But to be clear, a structural analysis of networks alone does not provide sufficient behavioral evidence that a ruling elite monopolizes power and influence; it can only demonstrate that the relational basis for such control or influence exists. In addition, as our analysis will show, we depart from the more dichotomous inclinations of the elite-pluralist debate, focusing instead on how to measure oligarchical tendencies in networks.

Why is a relational concept of oligarchy useful? One way to approach this question is through the idea of brokerage. Brokerage is a form of intermediation where a focal actor, the broker, mediates the relationship between some other set of actors. Social network analysis has a well-established tradition examining this brokerage role (Simmel 1950; Gould and Fernandez 1989; Burt 2005; Obstfeld 2005; Stovel and Staw 2012). The focus of this tradition has been to understand the position and power of individual brokers, and the advantages that accrue to them or those they connect. However, in many cases, it is also interesting or valuable to understand the collective pattern of mediation in a network. The concept of oligarchy, we suggest, *points to the collective mediation of a network by a small but cohesive subgroup*. To explain this point, recall the three aspects of oligarchy that we drew from Michels: the elite are tightly interconnected among themselves, forming an “inner circle”; the “masses” are organized through the intermediation of this inner circle; and the masses are poorly interconnected among themselves. An oligarchy describes a network where a cohesive subgroup monopolizes the intermediation of relationships in the network as a whole. As in the work on individual brokerage, Michels suggests that advantages accrue to the inner circle. But the concept of oligarchy is about the collective, rather than individual intermediation of the network.

Pure oligarchies may rarely exist. Nevertheless, many kinds of social networks may have oligarchical tendencies. It is well established in the social network literature that some nodes are often much more central than others and that these central nodes may play an important brokerage role, often by spanning “structural holes” in the network. We also know that subgroups form within networks, often among well-connected actors, and that networks often exhibit center-periphery patterns. Work on “small world” networks has also found that a small group of “hubs” can link a sparsely connected network together (Watts 1999). When taken together, these findings suggest the possibility for cohesive subgroups to dominate or monopolize the intermediation of the network as a whole. It is more useful, however, to understand the degree to which a social network is collectively intermediated than to become fixated on whether or not a network has a ruling elite.

In the following section, we develop a strategy for measuring the oligarchical tendencies of a network using a “distribution of degree” approach. In later sections of the paper, we demonstrate the value of this approach by analyzing several social networks.

2. Three Network Metrics

How should we identify the tendency of a social network to be oligarchical? The tool kit of social network analysis offers several possibilities. In this paper, we introduce a method based on work in physics and computer science that focuses on how ties are distributed across the network. We use the concept of “rich clubs” (Zhou and Mondragón 2004; Zhou and Mondragón 2007, Mondragón and Zhou 2009) as our basic measure of the oligarchical tendencies of a network, and supplement it with an analysis of the “mixing properties” of networks (Newman 2002) and the degree distribution of ties (Barabasi and Albert 1999). Taken together, these measures identify the tendency of social networks to exhibit the key features of oligarchy that we have identified: the existence of a small, cohesive group that monopolizes the intermediation of the rest of the network.

2.1 Power-Law Degree Distribution

Many real networks – especially large and complex ones – may display a skewed degree distribution known as the “power law,” or $P(k) \sim k^{-\gamma}$, where degree k is defined as the number of links a node has (Barabási and Albert, 1999; Xu, Zhang and Small, 2010). A power-law network is called ‘scale-free’ because it is not the average degree, but the exponent of the power-law distribution, that characterizes the network’s connectivity.[3]

In a power-law network, most nodes have only a few links, and the network is guaranteed to have a small set of nodes with very high degrees, order(s) of magnitude higher than the average degree expected from a random process. Thus, for power-law networks, it is particularly important to examine the role of the high-degree nodes in organizing the network’s global structure.

2.2 Network Mixing Patterns

Newman (2002) identified different mixing patterns in networks. A network is *assortative* if nodes of similar degrees tend to be connected to one another and *disassortative* if nodes tend to be connected to nodes of different degrees. To measure these different mixing patterns, Newman proposed the assortative coefficient r, which ranges from -1 to 1. When r = 1, there is perfect assortative mixing in the network, i.e., every link connects two nodes with the same degree; when r = -1, there is a perfect disassortative network, i.e., every link connects two nodes with different degrees; when r = 0, there is a neutral mixing network.

2.3 Rich-Club Coefficient

The “rich club” concept proposed by Zhou and Mondragon (2004, 2007 and 2009) complements this discussion of network mixing patterns. In doing so, it addresses the following ambiguities. For example, if a network displays assortative mixing where high-degree nodes tend to link with other high-degree nodes, does this mean the high-degree nodes are tightly (or fully) interconnected with each other? Or, if a network is disassortative and high-degree nodes (on average) tend to link with low-degree nodes, does this mean the high-degree nodes do not link with themselves at all?

“Rich” nodes are defined as a group of nodes with the highest degrees in a network, specified either as the top **n** best-connected nodes or as the nodes with degrees larger than or equal to a given degree **k**. For a given group of rich nodes, any member of the group has a degree higher than or equal to any node outside the group. More nodes with lower degrees are included when the size of the group increases.

The rich-club coefficient Ø is defined as the ratio of the actual number of links to the maximum possible number of links among a group of rich nodes (Zhou and Mondragon 2004, 2007).[4] It is a quantitative measure of the density of connectivity among a given group of rich nodes. When Ø=1, the rich nodes are fully interconnected, forming a clique. When Ø=0, the rich nodes have no direct link among themselves (although each of them may have a large number of links with nodes outside the group).

For simplicity, a network is said to contain a *rich club* if the richest nodes (e.g. the top 5% best-connected nodes) have a high value rich-club coefficient (say, Ø > 0.5). No a priori definition exists to determine which nodes are in the rich club. The rich-club coefficient is usually calculated for all groups of rich nodes so that this structural property can be examined across all levels of network hierarchy.[5] The rich-club coefficient has been found to be critically relevant to the redundancy and robustness of a network (Zhou and Mondragón 2004b) and to its routing efficiency in terms of shortest paths between nodes (Zhou 2009).

Zhou and Mondragon (2007) shows that a network’s rich-club coefficient is not trivially related with the network’s degree distribution or mixing pattern. For example, networks having exactly the same degree distribution can have a vastly different rich-club coefficient; and high-degree nodes in an assortative network are not necessarily more interconnected than those in a disassortative network.

2.4 Debate on the Rich-Club Phenomenon

There has been a debate on the rich-club phenomenon with respect to how to determine whether the rich nodes in a network show a tendency to form a tightly interconnected club. Colizza et al. (2006) propose to compare the rich-club coefficient of a real network against a null model defined as the average of a maximally randomized version of the real network. The logic here is analogous to the difficulty of determining whether a person is “tall” or “short” without comparing their height to the average height of the group of people that the person belongs to. One “surprising” result is that the Internet (AS graph), which is considered to exemplify a strong rich-club phenomenon, would have a slightly lower rich-club

3 This property derives from two main mechanisms of the power-law networks identified by Barabási and Albert (1999, p.509): (i) networks expand continuously by the addition of new vertices, and (ii) new vertices attach preferentially to sites that are already well connected. In other words, the authors showed that large networks self-organize into a scale-free state, a feature unpredicted by previous random network models.

4 The maximum possible number of links among n nodes is n(n-1)/2.

5 When the group of rich nodes is given by the node rank n, the most exclusive group contains only the top 2 best-connected nodes (n=2), and the largest group is the whole network (n=N). When the group is given by degree k, the smallest group has nodes with k=kmax where kmax is the largest degree in the network, and the largest group contains all nodes with k >= 1.

coefficient when the network is randomly rewired (while preserving the original degree distribution). However, this method cannot be used to compare between different real networks – because a “short” person on a basketball team may be taller than a “tall” person in a primary school class.

Amaral and Guimera (2006) relate the rich-club phenomenon to a monotonic increase of the rich-club coefficient as a function of degree. They conjecture that the monotonic increase may be “a natural consequence of a stochastic process” and comment that “… an oligarchy will always appear to be present, even if the network is random.” However, it is widely known that the rich-club coefficient is not a monotonic function in most real networks (McAuley et al 2007; Opsahl et al 2008). The rich-club coefficient can even be a bell-shaped function in some networks (Zhou and Mondragon 2007).

Mondragon and Zhou (2007) argue that the rich-club coefficient is an absolute measure of the density of interconnectivity among a group of rich nodes. It is calculated without any assumption and judgment about the rich-club phenomenon. In other words, it is measuring a person’s height without judging whether a person is tall or not. In this paper we use the rich-club coefficient as a network metric and avoid referring to the rich-club phenomenon.

3. Oligarchy as a Global Property of Networks

Assortative mixing is common in social networks, but is not associated with “oligarchical” networks. An oligarchy is a rich club with disassortative mixing. In other words, the “rich” nodes are interconnected, but they are also connected to the “poor” nodes who are not strongly interconnected among themselves.

The idea that the power of well-connected people is derived from their connections to other well-connected people is well established in social network analysis, and typically measured using eigenvector centrality (Bonacich 1972) or, in a form that allows you to vary the relative importance of indirect ties, “power centrality” (Bonacich 1987). One difficulty with the later measure, however, is that it requires an arbitrary decision on the part of the analyst about whether people gain more power by being tied to other “rich” nodes or by being tied to more “impoverished” nodes. Following this tradition of measuring centrality and power in networks, some authors have recently developed new measures for identifying “leadership insularity” (Abersman & Christakis, 2010) or “organizational influentials” (Cole and Weiss, 2009).[6] Similarly, classic strategies of detecting cohesive subgroups (Wasserman and Faust 1994), such as clique analysis and its variants, or newer methods of “community detection,” such as the Girvan-Newman method (Newman 2004) may be quite useful for identifying the “inner circles” of oligarchies.

The rich-club approach has a different focus and purpose than these techniques. First, it expands the analytical focus beyond identifying well-connected leaders or important subgroups. “Rich” nodes form a cohesive group among themselves, but they also maintain ties to more “impoverished” nodes—e.g., their clients. It is these ties with non-rich nodes that makes rich nodes “rich.” Second, the rich-club approach aims to characterize the oligarchical tendency of entire networks as opposed to identifying the oligarchs themselves.

The rich-club approach uses the “mixing properties” of the network to evaluate whether rich nodes merely affiliate among themselves, or whether they also affiliate with non-rich nodes. If a network is “assortative,” rich nodes affiliate primarily with other rich nodes, while non-rich nodes affiliate primarily with other non-rich nodes (in an assortative network, nodes of similar degree associate with each other). If a network is “dissassortative,” by contrast, nodes of dissimilar degree associate together. While the “rich club” measure captures the way a core group monopolizes ties, the disassortative measure guarantees that this core is not segmented off from the rest of the network.

In addition to knowing that there is a group of rich nodes who are tied together, but also linked to a wider network of clients, the concept of oligarchy also presumes that the “rich club” at the core of the network is small relative to the network as a whole. One way to evaluate whether the “rich club” is small is to examine the degree distribution of the network. If the rich-club is small, we should expect the degree distribution to resemble a power law.

To summarize, an oligarchical network can be characterized as having a “rich club” (a group of well-connected nodes who are connected to one another), but the overall network exhibits mixing properties that are disassortative (where each rich node is strongly connected to the poor nodes) and a power-law degree distribution (few well-connected nodes and many poorly-connected nodes). Taken together, these three properties capture the degree to which a small group dominates the collective intermediation of the network as a whole. In

6 Looking for the most influential individuals in school networks, Cole and Weiss (2009, 4) propose four methods: 1) absolute cut score (in-degree score); 2) fixed percentage of population is defined as influential; 3) degree standard deviation; 4) random permutation.

Michels’ terms, the rich club is a cohesive “inner circle” that organizes the weakly organized “masses.”

One alternative way to identify an oligarchical network regime is to develop a core-periphery analysis. Much like the concept of an oligarchy, a core-periphery structure is a “core” of people who are tied together and a “periphery” of less well connected actors (Laumann and Pappi 1976). Breiger describes a core-periphery network as follows: “a coherent set of active members (or a “leading crowd”) is surrounded by isolated individuals who have interchange both to and from them” (1979, 29). Consistent with this definition, Borgatti and Everett (1999) developed a partitioning algorithm for analyzing core-periphery structure that assigns those who are closely connected to each other (1-block) to the “core” and those who are not connected to each other (0-block) to a “periphery.” They then develop a “fitness measure” to evaluate how closely the derived assignment corresponds with an idealized core-periphery structure. However, there are several limitations of using a core-periphery analysis as measure of oligarchy:

1. The core-periphery algorithm partitions a network into a core that is tightly interconnected (1-block), but this measure does not directly capture the degree to which this core is a “rich-club” (as measured by the rich-club coefficient);
2. The core-periphery measure says that the core is tightly interconnected and the periphery is weakly interconnected; it says less about the link between core and periphery (only that it expects an imperfect 1-block). The rich club approach directly measures how rich nodes are tied to non-rich nodes (assortative and disassortative mixing).
3. The “core” of a core-periphery structure might be very large, while we are assuming that the “rich club” is a small group (as measured by the power law distribution).

Thus, while core-periphery measures may also provide an approximate measure of oligarchical structure, the rich-club approach offers a more direct and discriminating measure of oligarchy. In the next section, we will analyze several social networks using this rich-club approach: urban infrastructure policy networks in São Paulo, Brazil over six mayoral administrations and transportation policy networks in two U.S. cities, Chicago and Los Angeles. These networks allow us to compare urban policy regimes across time in the same city (São Paulo) and across city for the same kind of policy domain (Chicago and Los Angeles), and across urban regimes in two countries (Brazil and the U.S.).

4. Description of the Networks

4.1 São Paulo Urban Infrastructure Networks

São Paulo is the largest and most important metropolis in Brazil and South America, with roughly 11.9 million municipal inhabitants and 20 million in the metropolitan region. Besides shaping the urban space in São Paulo, urban-infrastructure policy is at the core of municipal politics and policies, and receives a large share of the municipal budget – 13% on average during the period 1975-2000 (Bichir, 2005). Thus, it is an influential and important policy domain.

Policy network data was collected by Eduardo Marques and Renata Bichir in order to investigate the policy dynamics of the Secretariat of Public Roads (“Secretaria de Vias Públicas” – SVP), the São Paulo municipal agency responsible for urban infrastructure policy (Marques, 2003).[7] Based on an examination of contract notices published in the official press, this research analyzed spatial, relational, and political dynamics of urban-infrastructure policy in the city of São Paulo from 1975 to 2000.[8]

7 Urban infrastructure policy is a part of a broader “urban engineering” community that encompasses several policy domains, including infrastructure, maintenance of the built environment and services, urban transportation, and cleaning (Marques, 2003). The municipal agency responsible for urban infrastructure policy depends on the municipal budget, does not have strong institutional boundaries or civil service career patterns, and experiences strong migrations from and to other parts of the government and the private sector (Marques, 2003). These institutional features affect the policy network and the way policy is formulated and implemented.

8 In Brazil, all government contracts have to be published in official daily publications called “Diários Oficiais.” To obtain information on the patterns of investment in urban infrastructure, the data set includes information on almost 5500 urban public works project contracts (road and drainage work, river canalization, bridges and tunnel construction etc.) from 1975 to 2000.

To recreate the policy network from 1975 to 2000, the researchers conducted 26 in-depth interviews with career officials, technicians, and members of the community of engineers associated with SVP. These interviews sought to characterize the policy and political dynamics in the city over time, as well as to investigate the continuity of the networks.[9] The interviews used a name generator – based on official data of all incumbents of the main institutional positions of the Secretariat over time – and snowballing techniques, to identify the complete network. The network data analyzed in this paper is the data set produced by the Marques team using this data collection process.

This policy network was constructed with the aim of analyzing the power dynamics inside this bureaucracy under different mayors with different political inclinations. The study focused on the differences between right-wing and left wing parties, since this is a policy area traditionally associated with the right in the city of São Paulo.[10] The relations among different groups of the Secretariat, the broader political environment (political parties, other public agencies), and private companies responsible for public works were investigated. The analysis found that this policy community is characterized by the importance of personal ties among state actors and between state and private sector actors (Marques, 2003, 2012). The infrastructure policy network in São Paulo became more dense and complex over time, from approximately 75 interconnected people prior to 1975 to more than 250 people in the administration of Celso Pitta (1997-2000). Marques (2003) found a hegemonic group in control of policy across this period, which was stable even during the two left-wing administrations (Covas and Erundina) despite their attempts to change the power dynamics in this policy domain by introducing new players into the policy network. These new actors, however, failed to displace or break the hold of the hegemonic group.

Chicago and Los Angeles Transportation Policy Networks

Weir et al. (2009) collected data on the transportation policy networks of the second and third largest U.S. metropolitan regions — Los Angeles (13 million people) and Chicago (9 million people). The purpose of the study was to investigate whether the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) had created conditions for collaboration on transportation policy issues among groups operating on an urban and regional scale. ISTEA also sought to encourage the participation of new groups typically excluded from previous planning regimes. In addition to their size, L.A. and Chicago were selected because they represent contrasting urban political dynamics. L.A. is traditionally regarded as having a very fragmented urban and regional politics, while Chicago’s active business and civic community and centralized political regime make it an example of more organized and cohesive policy-making.

Semi-structured interviews were conducted in 2003 with 41 groups active in transportation issues in the Los Angeles region and in 2005 with 35 groups active in the Chicago region. During these interviews, groups were shown a list of organizations involved in transportation issues and asked to “check every name on the list that your organization has worked with as part of its transportation work.” A follow-up question then asked respondents to indicate which of these groups they had worked with “closely.” The questions were intended to capture the difference between “weak” and “strong” network ties.

The study found that ISTEA had encouraged the creation of new groups and that these groups brought new perspectives to the urban and regional transportation policy process. It was also found that these groups were engaged in active networking within their regions. The interviews, however, also indicated that the groups

9 Since this is a relatively stable and close community-many of the technicians studied together in the same universities, have common business associations outside the public sector and are co-members of professional associations-the research team assumed that most people would know each other, forming a one-mode network. Information on all types of contacts inside the policy community was considered, and not only information on ties associated with some specific policy issues or contracts. In this sense, the relationship between two nodes may represent several types of ties, including work ties, friendship ties, business ties, etc. The researchers did not exclude people from the network due to retirement, only when someone died or went to a completely different sector. The interviews revealed that the retired public servants usually went to the private sector and stayed as formal and informal consultants for the public sector. Additional interviews were then conducted in order to separate contacts into different periods and to differentiate the types and strength of ties (indicated by the frequency of citation of each dyad). These interviews allowed the construction of the network of relationships between individuals, entities and private companies in each mayoral administration from 1975 to 2000.

10 The study characterized “right-wing” politicians as belonging to the party that supported the military regime (Arena) and the parties that were created after it (PPB and PDS), including a party aligned with them at the municipal level (PTB). Thus, Olavo Setúbal (in charge of the municipality from 16/04/1975 to 12/07/1979), Reynaldo de Barros (12/07/1979 to 13/05/1982), Salim Curiati (13/05 / 1982 to 13/05/1983), Jânio Quadros (1986 to 1988), Paulo Maluf (1993 to 1996) and Celso Pitta (1997 to 1999) were classified as “right-wing.” “Left-wing” mayors were those belonging to the opposition to the military regime – the MDB – and their descendants after the political opening: Mario Covas (13/05/1983 to 31/12/1985) and Luiza Erundina (1989 to 1992), who belonged to the PMDB and the PT, respectively.

felt that they were still not fully included in a planning process now dominated by the Metropolitan Planning Organizations (MPOs) also created by ISTEA. Of the two cities, Chicago groups were more successful in getting their MPO to be responsive to their input.

5. Comparison of the Networks

As indicated in Table 1, the policy networks vary significantly across the three cities. The São Paulo networks are much larger than the U.S. networks, but also much sparser (e.g., less dense). Since density often declines as networks become larger, this is not surprising. As the comparison of the "strong" and "weak" tie networks in Chicago and L.A. suggests, density is also a reflection of the kinds of social relations elicited by interviews and surveys. If you ask people to specify only the people they work with closely ("strong ties") then you will generate a sparser network than if you ask them whom they have worked with ("weak ties"). The differences between the networks indicate that it is important to exercise caution when making comparisons, since many network measures are sensitive to the size and density of the network. In the analysis that follows, we attempt to normalize our measures where possible.

5.1 The Rich-Club Coefficient

When we look at the distribution of the rich-club coefficient as a function of degree (Figures 1 and 2), we can see that all the policy networks show a rich-club pattern. According to Zhou and Mondragón's (2004) definition, rich nodes are those with the highest degrees (much larger than the average degree). The figures show that the people with the highest degree are also interconnected with each other--the higher the degree, the greater the rich club coefficient.[11]

Table 1: Degree, Clustering and Mixing Properties

Dataset	Density	Number of Nodes	Number of Ties	Average Degree	Maximal Degree	Shortest Path Length Between Nodes	Clustering Coefficient	Assortative Coefficient
São Paulo								
Reynaldo	0.030	162	429	5.3	42	3.18	0.279	-0.23
Covas	0.028	198	562	5.67	47	3.23	0.299	-0.196
Janio	0.024	236	686	5.81	51	3.32	0.286	-0.169
Erundina	0.026	209	584	5.59	49	3.37	0.312	-0.179
Maluf	0.028	196	551	5.62	49	3.24	0.321	-0.191
Pitta	0.028	204	586	5.75	49	3.25	0.305	-0.175
Chicago								
Chicago – Weak	0.403	35	240	13.71	29	1.62	0.62	-0.16
Chicago – Strong	0.106	33	63	3.82	9	2.91	0.413	-0.013
Los Angeles								
LA – Weak	0.359	37	239	12.92	29	1.69	0.519	-0.114
LA – Strong	0.156	38	103	5.42	12	2.49	0.274	0.006

11 MISSING FOOTNOTE

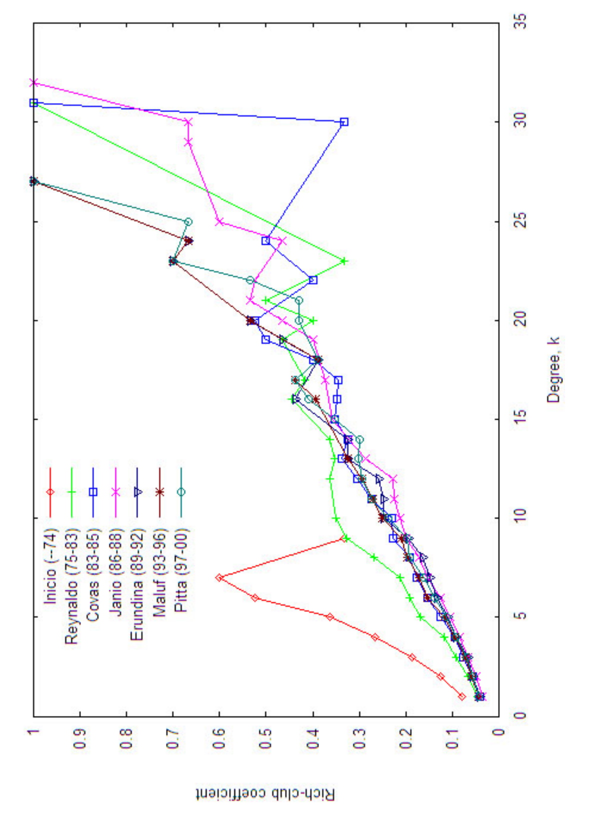

Figure 1: Rich Club Coefficient as a Function of Degree: São Paolo

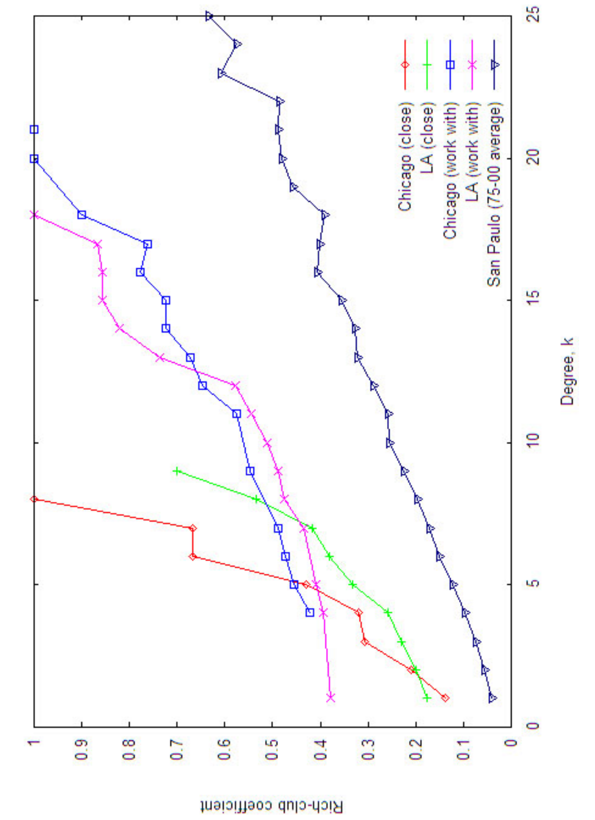

Figure 2: Rich Club Coefficient as a Function of Degree: Chicago and LA

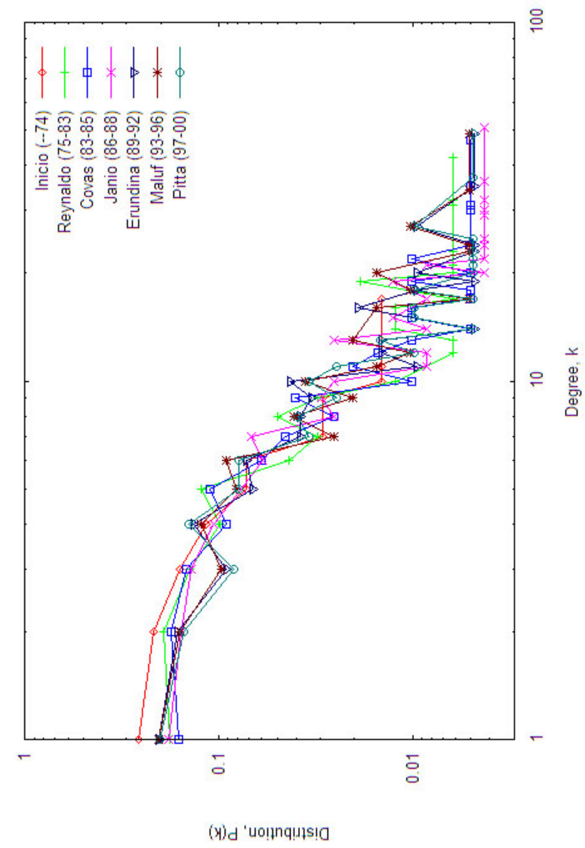

Figure 3: Degree distribution: São Paolo networks

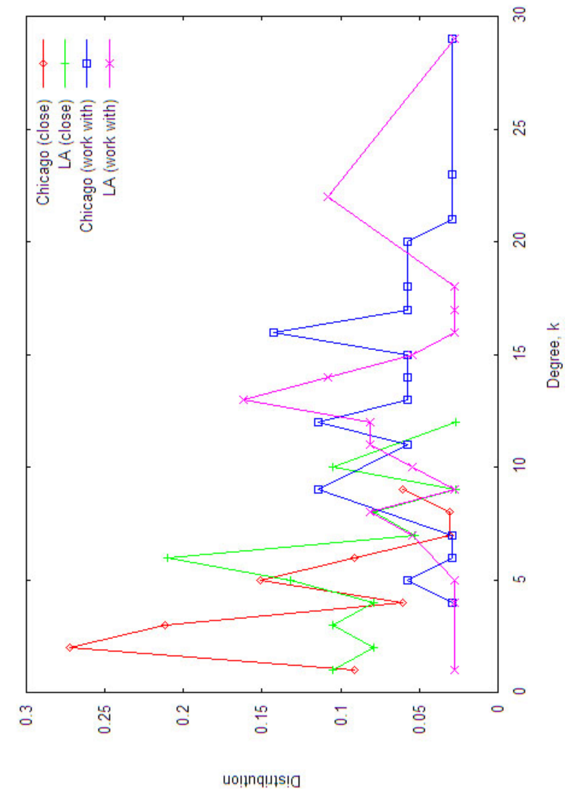

Figure 4: Degree distribution: Chicago and LA networks

5.2 Mixing Properties

Table 1 also shows the findings for the assortative coefficient and several other related measures.[12] With the exception of the Los Angeles strong tie network, all the networks are disassortative (r < 0). This means that nodes with dissimilar degree tend to be connected to each other, i.e. well-connected nodes tend to be connected to poorly-connected nodes and vice-versa (Zhou and Mondragón, 2007; Colizza et al, 2006). In the case of São Paulo, it is interesting to note that the Reynaldo regime is the most disassortative (r = -0.230), which is consistent with Marques's finding that a hegemonic group is first established during this administration. The disassortative coefficients, however, are quite similar across the different administrations in São Paulo, regardless of their ideological inclination. This finding is consistent with the argument that the hegemonic group, once established, is quite stable (Marques 2003).

5.3 Degree Distribution

We can also contrast the São Paulo networks with the US networks by looking at degree distribution in these networks. The degree distribution is indicative of a network's global connectivity, although different properties/mixing patterns may be found in networks sharing the same degree distribution (Zhou and Mondragón, 2007). One important type of degree distribution is a "power law" distribution, in which many nodes have only a few links and a small number of nodes have a very large number of links (Zhou and Mondragón, 2007).

When we look at Figures 3, we see the degree distributions approximate a power law, where there are few nodes with a large number of connections, but most nodes have few connections. Compared with the Chicago and LA networks (Figure 4), the São Paulo networks more closely resemble a power law distribution.

6. Analysis

Four bases of comparison are presented by our three urban policy networks. The São Paulo data allows us to examine regime-level properties over time — across different municipal administrations. The Chicago and Los Angeles data allow us to compare policy network regimes in two different American cities, while holding policy sector constant. The Chicago and Los Angeles data also allows us to compare weak and strong tie networks within each city (and, to some degree, to draw generalizations about the character of weak and strong ties in both cities). Finally, we can cautiously contrast a Brazilian urban policy network against U.S. urban policy networks.

All three policy networks show some tendencies towards oligarchical organization. All of them demonstrate a "rich-club" organization, where the best-connected individuals or organizations are connected to other well-connected people and groups. With the exception of the Los Angeles strong tie network, however, all the networks are disassortative, meaning that the well-connected are also connected to the less well-connected. This is to be expected in an oligarchic network, where the inner elite collectively intermediate the social network as a whole. While all these networks may have oligarchical tendencies, the São Paulo networks are more clearly oligarchical than either of the American networks. The São Paulo networks are more disassortative than the American networks, particularly the strong tie networks. This means that the São Paulo elite has strong links to the entire policy network, while elites in the American networks are less broad-based. To some degree, this makes us reflect upon the concept of oligarchy we have embraced. Is a regime more oligarchical if the elite (e.g., the well-connected) organize the broader network or ignore it? In the Michelsian tradition, the former qualifies, but we might consider whether the latter case also represents a form of oligarchy. The fact that the strong tie networks in the American cities are less disassortative than the weak tie networks suggest that when it comes to the closest ties, the American networks are more clubbish.

There is another more important reason, however, to question the oligarchical qualities of the American networks. The well-structured power law distribution of the São Paulo networks indicates that there is a small "inner circle" that monopolizes most of the network. By contrast, in the American cities, this "inner circle" is not well differentiated. In the weak tie networks, in particular, a rather large group of institutions are well-connected, suggesting more of a pluralist than an oligarchical regime. In other words, there are well-connected organizations but no small group of elite that monopolize ties. The strong tie networks appear closer to power law distributions, suggesting a more distinct elite. But even these networks do not differentiate between a small well-connected elite

12 Each of the São Paulo networks contains multiple components. In the rich club analysis, we only considered the giant component, which is the largest component in a network. The giant component contains more than 90% of the nodes in these networks. All other analyses consider entire networks.

and a less well-connected periphery.

Our analysis concludes that the São Paulo networks come much closer to being oligarchies than do the American networks. While the American networks have some oligarchical tendencies, they ultimately appear more pluralistic. Well-connected organizations in the American networks are clubbish, but the analysis does not suggest that this elite is very well differentiated. Without studying other Brazilian cities, it is difficult to confidently conclude that these contrasts represent national differences in urban policy networks. But the contrast suggests that this is a distinct possibility. One thing that is clear from the data, however, is that the Brazilian oligarchy appears to be stable across municipal administrations, a point that reinforces the argument made by Marques (2003) about these networks. Different political parties were in charge during these different administrations, so it is striking to find this stability. There is a sharp disjuncture in the distribution of the rich-club coefficient at higher degrees during the first left-wing administration (Covas) that probably reflects an attempt to destabilize the oligarchy. But the distribution returns to the prior pattern under the next left-wing administration (Erundina).

The contrast between Chicago and Los Angeles was less striking than we anticipated, though in the expected direction. As mentioned, Los Angeles is reputed to be a civically fragmented city, while Chicago has a reputation for more civic cohesion. The distribution of the rich-club coefficient by degree (Figure 2) is very similar: in both cities, the well-connected are strongly linked to one another. The Los Angeles networks are less disassociative than the Chicago networks, suggesting that that the well-connected organizations in Los Angeles are less well-connected to the wider network. This could be one indicator of greater fragmentation in the Los Angeles networks. For the strong tie networks, Chicago also appears somewhat closer to a power law distribution (many organizations with few ties; a few organizations with many ties) than the Los Angeles network; in Los Angeles, many organizations have a medium range of ties. Our conclusion is that there is a less distinctive elite in Los Angeles. For the weak tie networks, however, this contrast is less clear.

7. Conclusion

The concept of oligarchy has an illustrious history in the social sciences, but is only weakly developed as an analytical concept. Though it is not uncommon to hear the word used to describe political and economic regimes in organizations, social movements, and nations, the precise meaning of the concept is often suggestive rather than precise. In this paper, we provide a structural analysis of the concept based on social network analysis. Building on the classic treatment of oligarchy by Michels, we begin with a conception of oligarchy as a social structure organized and dominated by a small inner circle of prominent actors tightly interconnected among themselves. These "oligarchs" are linked to less prominent actors in the network, who are only weakly interconnected among themselves. The power of an oligarchy lies in the cohesion of the oligarchs, their ability to organize less prominent actors, and the weakness of these less prominent actors to organize themselves.

Our main contribution is to operationalize this idea using a "rich club" approach. The social network concept of a "rich club" captures the idea that well-connected actors (high degree) are also connected among themselves. The "mixing properties" of a rich-club network indicate whether well-connected actors are only connected to each other (assortative) or to less well-connected actors (disassortative). Finally, by evaluating whether the network fits a power law distribution (few actors of high degree; many actors of low degree), we can determine whether the inner-circle is a small or large group relative to the size of the network.

We demonstrate the efficacy of this approach by analyzing and comparing several urban networks. Our analysis of São Paulo, Chicago, and Los Angeles suggests that policy networks have oligarchical tendencies, in the sense that well-connected actors in all three cities tend to be connected to other well-connected actors. The São Paulo networks, the weak tie networks in Chicago and Los Angeles, and the Chicago strong tie network are also disassortative, meaning that the well-connected actors are connected to less well-connected actors. However, only the São Paulo networks demonstrate a clear power law distribution, indicating a small coterie of well-connected actors. We conclude that the São Paulo networks come closest to being oligarchical regimes, while the Chicago and Los Angeles networks are more pluralist. Remarkably, the oligarchical structure of the São Paulo networks is stable across several municipal administrations, suggesting that oligarchy, once formed, may be a robust form of political organization.

References

Arbesman, S. and Christakis, N. (2010). Leadership Insularity: a New Measure of Connectivity between Central Nodes Networks. *Connections*, 30 (1), 4-10.

Acemoglu, D. (2008). Oligarchic Versus Democratic Societies. *Journal of the European Economic Association*, 6, 1, 1-44.

Amaral, L. A. N., & Guimera, R. (2006). Complex networks: Lies, damned lies and statistics. *Nature Physics*, 2(2), 75-76.

Barbasi, A. L. and Reka A. (1999). The Emergence of Scaling in Random Networks. *Science*, 286, 509-512.

Bichir, R. (2005). Investimentos viários de pequeno porte no município de São Paulo: 1975-2000. In: Marques, E. and H. Torres (eds.). *São Paulo: segregação, pobreza e desigualdade sociais*. São Paulo: Editora Senac.

Borgatti, S. and Everett, M. (1999). Models of Core-Periphery Structures. *Social Networks*, 21, 375-395.

Borgatti, S.P., Everett, M.G. and Freeman, L.C. (2002). *Ucinet for Windows: Software for Social Network Analysis*. Harvard, MA: Analytic Technologies.

Breiger, R. L. (1979). Toward an Operational Theory of Community Elite Structures. *Quality & Quantity* 13(1), 21-57.

Burt, R. S. (2005). *Brokerage and closure: An introduction to social capital*. Oxford University Press.

Cole, R., & Weiss, M. (2009). Identifying organizational influentials: Methods and application using social network data. *Connections*, 29(2), 45-61.

Colizza, V., Flammini, A., Serrano, M.A. and Vespignani, A. (2006). Detecting Rich-Club Ordering in Complex Networks. *Nature Physics*, 2: 110-115.

Dahl, Robert. 1961. *Who Governs: Democracy and Power in an American City*. New Haven: Yale University

Domhoff, G. W. (1967). Who Rules America? Englewood Cliffs, N. J.: Prentice-Hall.

Everett, M. G. and Borgatti, S.P. (1999). Peripheries of Cohesive Subsets. *Social Networks*, 21, 397-407.

Everett, M. G. and Borgatti, S.P. (1998). Analyzing Clique Overlap, *Connections*, 21(1), 49-61.

Gould, R. V., & Fernandez, R. M. (1989). Structures of mediation: A formal approach to brokerage in transaction networks. *Sociological methodology*, 89-126.

Guriev, S. and Rachinsky, A. (2005). The Role of Oligarchs in Russian Capitalism. *Journal of Economic Perspectives*, 19(1), 131-150.

Hunter, Floyd. 1953. *Community Power Structure: A Study of Decision Makers*.

Leach, D. K. (2005). The Iron Law of What Again? Conceptualizing Oligarchy Across Organizational Forms. *Sociological Theory*, 23(3), 312-337.

Lipset, S. M., Trow, M. and Coleman, J.S. (1956). *Union Democracy: The Internal Politics of the International Typographical Union*. New York: The Free Press.

Luo, F., Li, B., Wan, X-F. and Schuermann, R.H. (2000). Core and Periphery Structures in Protein Interaction Networks. *BMC Bioinformatics*, 10(Suppl 4), S8, 1-11.

Marques, E. and Bichir, R. (2001).Investimentos públicos, infra-estrutura urbana e produção da periferia em São Paulo. In: *Espaço & Debates,* Ano XVII, 2001, nº 42.

Marques, E. (2000). *Estado e redes sociais: permeabilidade e coesão nas políticas urbanas no Rio de Janeiro*. Rio de Janeiro: Revan/Fapesp.

Marques, E. (2003). *Redes Sociais, instituições e atores políticos no governo da cidade de São Paulo*. São Paulo: Ed. Annablume.

Marques, E. (2008). "Social Networks and Power in the Brazilian State: Learning from Urban Policies." *Revista Brasileira de Ciências Sociais*. Vol. 3, Special Edition, 14-41. Also available at: http://www.centrodametropole.org.br/t_bb_art.html#nome

Marques, E. (2012). Public policies, power and social networks in Brazilian urban policies. *Latin American Research Review,* Vol. 47 (2).

McAuley, J. J., da Fortoura Costa, L. and Caetano, T.S. (2007). The Rich-Club Phenomenon across Complex Network Hierarchies. *Applied Physics* Letters 91, 084103.

Mills, C. Wright. 1956. *The Power Elite*. Oxford: Oxford University Press.

Mizruchi, M. S. (1996). What do Interlocks Do? An Analysis, Critique, and Assessment of Research on Interlocking Directorates. *Annual Review of Sociology*, 22, 271-298.

Newman, M. E. (2004). Detecting community structure in networks. *The European Physical Journal B-Condensed Matter and Complex Systems,* 38(2), 321-330.

Newman, M.E.J. (2002). Assortative Mixing in Networks. *Physical Review Letters*, 89(20), 1-4.

Mondragón, R. and S. Zhou. (2012). Random networks with given rich-club coefficient. *European Physical Journal B: Condensed Matter and Complex Systems*, 85(328), 1-6.

Obstfeld, D. (2005). Social networks, the tertius iungens orientation, and involvement in innovation. *Administrative science quarterly*, 50(1), 100-130.

Opsahl, T., V. Colizza, P. Panzarassa and J. J. Ramasco.

(2008). Prominence and Control: The Weighted Rich-Club Effect. *Physical Review Letters*, 101, 168702.

Polsby, N.W. (1960). How to Study Community Power: The Pluralist Alternative. *The Journal of Politics*, 22(3), 474-484.

Simmel, G. 1950. *The Sociology of Georg Simmel*. Simon and Schuster.

Stovel, K., & Shaw, L. (2012). Brokerage. *Annual Review of Sociology,* 38, 139-158.

Voss, K. and Sherman, R. (2000). Breaking the Iron Law of Oligarchy: Union Revitalization in the American Labor Movement. *The American Journal of Sociology*, 106(2), 303-349.

Wasserman, S. and Faust, K. (1994). *Social Network Analysis: Methods and Application*. Cambridge: Cambridge University Press.

Watts, Duncan. 1999. *Small Worlds: The Dynamics of Networks Between Order and Randomness.* Princeton: Princeton University Press.

Weir, M., Rongerude, J. and Ansell, C. (2009). Collaboration is not enough: Virtuous Cycles of Reform in Transportation Policy. *Urban Affairs Review*, 44(4), 455-489.

Zhou, S. and Mondragón, R. (2004). The Rich-Club Phenomenon in the Internet Topology. *IEEE Communications Letters*, 8(3), 180-182.

Zhou, S. and Mondragón, R. (2004b). Redundancy and robustness of the AS-level Internet topology and its models. *IEE Electronic Letters*, 40(2), 151-152.

Zhou, S. and Mondragón, R. (2007). Structural constraints in complex networks. *New Journal of Physics*, 9(173), 1-11.

Zhou, S. (2009). Why the Internet is so ‘small’? *LNICST*, 16, 4-12.