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INFORMATION TRANSMISSION OF A POLICY PROGRAM: MODELS FOR THE OPTIMAL DETECTION OF KEY PLAYERS

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The underlying motivation for this work stems from the observation that there was weak participation in a policy program to modernize the commerce of a city center. This was due in part to a poor performance from the trade association board in the transmission of information. Using the tools of social network analysis and combinatorial optimization, we search for new sets of key players that are better positioned to disseminate information in the collective. We detect 2 new sets of key players and compare them with the trade association board. The comparison shows that social network analysis and combinatorial optimization can be useful tools in making policy implementation processes more effective.

Keywords: combinatorial optimization, commerce, information transmission, key players, policy, social networks

1. INTRODUCTION

The aim of this research is to explore alternative strategies to find sets of actors who may be best positioned for the implementation of policies, whose success depends on the massive mobilization of targets. The case under study concerns the implementation process of the policy program PROCOM¹ for the modernization of a historic city center of a midsize town in Portugal. Despite high financial incentives, it failed to mobilize traders. Only 25% participated, and, in consequence, there was no real modernization of the city center commerce. This level of participation was considered to be low by policy makers and traders alike.

A requisite for anyone who considers applying to a policy program is access to (quality) information. The task of transmitting information to potential participants pertains to program leaders, which in the case studied was the trade association

¹This specific program was called Urban Commercial Project and was part of a larger program called PROCOM. This case study took place from 1999 until 2001.

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board. A social network analysis (SNA) of the pattern of relations of the collective under study, that is, relations of discussion among the members of the trade association board and traders, has clearly shown the weak performance of this board in a simple task such as that of transmitting information concerning the program. This observation motivated our research, whose aim is to detect the actors best positioned to engage in tasks such as the transmission of information, the key players. Key players are those actors who are optimally positioned for the diffusion of information, attitudes, behaviors or goods. As such, they are crucial actors for the implementation of a policy program.

In this article we present methodologies for the detection of sets of key players that aim to facilitate the task of policy program leaders. These leaders must reach the maximum number of potential program participants in need of information to take a decision about participating. We start by characterizing the empirically observed trade association board and present its limitations in the information transmission task. Then we present integer linear programming models to find sets of key players: the first model is a formulation of the *key player problem positive*, defined in Borgatti (2006), which aims at maximum reachability. By taking into consideration the actors' attributes, we then build a second model to find a key player set with both high reachability and selectivity. The empirically observed trade association board and the two sets of key players obtained from the optimal solutions to the integer linear programming models are then evaluated and compared.

The value added of this research is threefold:

1. We formulate the *key player problem positive*, defined in Borgatti (2006), as an integer linear programming problem. We then present another integer linear programming problem that incorporates actors' attributes for the selection of the key players. The interest of incorporating attributes has been acknowledged by Borgatti (2006), but so far this problem has not raised the interest of social scientists.
2. We analyze a collective action that failed. Some authors, for instance, Strang and Soule (1998) and Ostrom (1998), have noted the strong bias in research toward successful cases of collective action. It is agreed that obtaining more information on failed attempts and why they failed will improve our capacity of preventing and/or overcoming such failures. As Bailey (1969) noted, "the man who correctly understands how a particular structure works can prevent it from working or make it work differently with much less effort than a man who does not know these things" (p.108). Elsewhere, Varanda (2005) has analyzed in detail the reasons behind traders' inability to coordinate efforts in order to profit fully from the project's advantages. Here we will focus instead on the reasons underlying such failure pertaining to program leaders and their ability to inform policy targets.
3. We use social network analysis in a nonmetaphoric way to do a systematic analysis of the pattern of interdependencies among the actors involved in a collective action, such as the participation in policy programs. The concept of network in policy research has been frequently used metaphorically and viewed as a specific form of governance structure and, as such, has so far produced insufficient explanatory research (Pappi & Henning, 1998; Carlsson, 2000; Thatcher, 1998), particularly concerning the collective action processes underlying the participation in policy programs.

2. THEORY

2.1. Policy Implementation, Participation, and Information Transmission

A common problem underlying policy implementation is policy makers' lack of quality information about the social system (e.g., communities, organizations, cities) or "concrete action system," in the expression of Crozier and Friedberg (1977). It is easily recognized by policy makers that good technical and economic information about problems is important, and they often invest considerable sums of money, time, and energy to study and analyze the economic and technical aspects of problems. But then it is forgotten that these problems can only be resolved through the "concrete action system" (Crozier & Friedberg, 1977). In modern society it is not that difficult to access theoretical knowledge about a social system, but there is little information on and little investment in obtaining information concerning social systems' capacities and resources, and concerning how they behave in practice. In consequence, it is frequent for policy interventions to be based on inadequate concrete knowledge about the social system over which they want to intervene, and that the impact of policy programs fall short of their initial goals (Pressman & Wildavsky, 1973) and may even lead to perverse effects (Palumbo, 1987).²

This awareness has led to a greater emphasis on participatory processes related to policy making, and also to issues of actor selection. The difficulty of selecting the most adequate actors to participate and/or lead a given policy process is often acknowledged. According to Sanderson (1999), the actors participating in any policy process are those who are part of already "known and established networks." This procedure results in the systematic exclusion of some sectors of society, and their exclusion will result in an impoverishment or failure of policy processes. In another line of research, adoption and diffusion of innovations, great attention has been paid to the issue of detection of those who influence opinions, attitudes, and behaviors of others, designated as "opinion leaders" (Rogers, 1995). An example is Valente and Pumpuang (2007) work, which identified 10 techniques used for the detection of opinion leaders in community health programs. However, of the 200 studies reviewed, none aimed at optimal solutions nor analyzed the effectiveness of these identified leaders.

Caution is needed with regard to the number of actors involved in policy processes, and especially policy leaders, as coordination problems may arise. For this reason their selection must be very careful, and must make use of the best information and of the most adequate methodologies available. One must make sure that a manageable number of actors have been selected, which lead us to the relevance of key players, a concept to be explained in detail in the next section.

Another challenge of policy making has to do with the information transmission capacity of those who lead the policy programs. Access to reliable information is important for anyone having to decide whether to participate in a policy program or not, and the more so if this decision is risky. Indeed, those better informed about the functioning of a program would be in a better position to make their decision. As a consequence, there are two necessary (but not sufficient) requirements for the

²This particular policy program, unlike most, even sponsored a diagnostic study prior to intervention, but its low quality impeded a good knowledge of the concrete social system of the collective studied.

success of any policy program: that those who lead the policy program possess information and that they should have good access to targets.

In short, successful policy implementation will be more probable if policy leaders are knowledgeable of the social system. In order to mobilize adherents to policy program, policy leaders must, at the very least, inform them. However, given scarcity of resources and coordination issues, the size of such a leadership team and the number of targeted participants must be relatively small. This entails an effort of selection of those leaders and targets alike in better condition to perform the information transmission tasks.

2.2. The Key Player Problem Positive

Key players are those actors optimally positioned for the diffusion of information, attitudes, behaviors, or goods. The relevance of detecting key players is obvious in any setting where the intention is to promote changes in attitudes and behaviors and in which information must be efficiently diffused.³ In our case, the detection of key players is seen as crucial for the transmission of information required for the participation in a policy program whose success depends on the massive participation of targets. The problem, according to Borgatti (2006), is that even if this is an old issue, it has been pursued in a methodologically erroneous manner. Indeed key players have been usually identified on the basis of measures of actors' centrality. (For an example in the environmental field see Prell, Hubacek, & Reed, 2009). Everett and Borgatti (1999) have pointed out that by following this strategy one may not reach the optimally located key players. Borgatti (2006) proposed two key player problems: the *key player problem negative* and the *key player problem positive*. Here we center our attention on the key player problem positive. The key player problem positive may be stated as follows: given a social network, represented as an undirected graph with node set V , and a fixed integer number k , find a set S of k nodes, called a kp-set, that can reach as many nodes as possible in its complementary set $V \setminus S$ via direct links or short paths. The approach adopted by Borgatti (2006) for the key player problem is a local search algorithm. The neighborhood of a kp-set is defined using the notion of swap. A neighbor of a node set S is a node set S' obtained by swapping a node in S with a node in $V \setminus S$. Starting from an initial kp-set S , all neighboring solutions of S are searched. If any neighboring solution improves on S the best neighbor of S is adopted and the neighborhood search proceeds from it. The local search algorithm for the key player problem is called using different starting randomly generated kp-sets. For local search algorithms in combinatorial optimization the reader is referred to Rothlauf (2011).

2.3. The Limitations of the Key Player Problem Positive: The Dilemma of Reachability/Selectivity

The optimal solution to the key player problem positive represents a group of actors that can reach the maximum number of remaining actors via direct links or

³We differentiate key players from opinion leaders as these are not necessarily optimally positioned.

short paths. Although this model maximizes reachability, it ignores the actors' attributes. In this work we present a new model to maximize reachability that takes into account the actors' attributes from the key player group as well as the attributes of the ones reached by key players, that is, a model that maximizes reachability taking into account selectivity.

The literature on processes of diffusion of innovations and on the mobilization for collective action has shown the relevance of considering actor attributes together with the relational contexts in which they are embedded. For instance, Marwell and Oliver (1993) have called attention to the role of the subgroup of those most interested and resourceful, who through their behavior influence others to participate in the production of collective action. In the literature pertaining to mobilization for social movements, some examples of relevant attributes are the actors' past participation in other movements, their current membership in other social movement organizations, the biographical circumstances of a person's life, and the expectation toward the movement's success (McAdam, McCarthy, & Zald, 1988). In addition, in the literature on innovation adoption and diffusion, Rogers (1995) has shown that leaders of innovative processes tend to be found among those who have higher formal education, own larger economic units (firms, lands, boats...) and are more cosmopolitan and better informed about the innovation. However, he notes that the relevant characteristics of leaders change according to the characteristics of the social system (Rogers, 1995).

Marwell and Oliver (1993) emphasized the idea of selectivity as the ability to communicate with those members of a network "who are most likely to contribute or who are likely to contribute the most" (p. 130). Obviously, selectivity requires information about the attributes of actors. In their study of collective action problems the relevant attributes are the interest of each person in the collective good, as well as his/her personal level of resources (as an indicator of how much each person is able or likely to give). Moreover, the ability to select is especially important in heterogeneous collectives where one person may be willing and able to contribute much more than another. When groups are homogeneous, there is no such need to select as everyone is interchangeable, and the collective outcome is a simple function of how many people participate (Marwell & Oliver, 1993). According to the same authors, the ideal strategy for organizers is one of "high reach and high selectivity"⁴ where everyone in the network is contacted; however, they recognize that the costs of this option are often prohibitive and, in result, trade-offs have to be made. The alternatives, according to them, would be the strategies of "high reach and low selectivity" or "low reach and high selectivity," the first implying an impersonal, mass-mediated approach to getting messages to network members, and the second a personalized, communication approach. In any case each strategy must be thought out in consonance with the context in question, as one strategy may be successful in one context and unsuccessful in another.

⁴Obviously, selectivity requires information about how interested each person is in the collective good, as well as their personal level of resources as an indicator of how much each is able or likely to give. This also suggests that the organizers need to know how to craft messages that focus on maximizing benefits for contributors while minimizing their costs (Marwell & Oliver, 1993).

3. CASE STUDY

3.1. The Policy Program

City center commerce in Portugal in general, and in this city center in particular, has suffered from the growing competition of large scale retail outlets (shopping centers and hypermarkets, mostly located on the peripheries). Policy makers contend that with no external incentives this type of commerce will tend to disappear. In this article we focus on PROCOM, a policy program whereby the Portuguese government, together with the European Union, offered traders a financial incentive of up to 66.6% of their investment to modernize their shops. All traders located in the city center—commerce, coffee shop, or restaurant owners—could apply. The general understanding was that the financial incentive was quite high in comparison with that of other programs. Moreover, this program was more attractive than most other programs because it accepted all applications, while other programs made a selection of applications. For those whose application was deemed average, rather than high quality, the incentive decreased from 66.6% to 50% of the investment.

Nonetheless, as remarked previously, a number of costs are attached to the participation, such as the inevitable share of traders' own capital investment, the low credibility of this kind of governmental program (e.g., delays in the payment of incentives) and the bureaucratic load attached. These obstacles consume a lot of time and energy of traders, who, for the most part, own small businesses which are very demanding of the owner's time. The main benefit of having a nice looking shop, besides the pride and the increase in the owner's status, is the expected increase in sales. But, unlike costs, this is more difficult to anticipate and quantify, because it is affected by external factors, such as the attractiveness of large scale retail outlets, the desertification of the city center and the competition from nearby cities.

3.2. Information Transmission Concerning the Policy Program

The ultimate entity responsible for the program's success was the state—the General Direction of Commerce. In order to inform traders and motivate their adhesion, it had promoted two public meetings, the first to launch the program and the second just before the application period started. This represents a strategy of "high reach and low selectivity," in Marwell and Oliver's (1993) terms. However, in order to participate in the program and invest in the remodeling of their shops, traders had to be informed about its specificities (e.g., administrative and legal procedures, deadlines, costs, benefits) and how they could be adapted to their individual case. This can only be achieved with a strategy of "high reach and high selectivity," which involves a component of interpersonal communication.

The task was delegated to the local trade association, which played the leadership role in this process. This trade association is a typical one in the Portuguese context: It had a small number of associates (1,600) and just three staff, two administrative and one technical, the latter of which was hired at the time of the program. Just prior to launching the program the trade association was undergoing a leadership crisis. At the time of the study there was no elected board, and, instead, two traders were in charge of administrative matters. We should note that traders are a group that traditionally resists associative strategies (Hosgood, 1992). According

to Bechhofer and Elliott (1981), they are “loners, not joiners” (p. 195). The role of leaders, which may be very attractive in large, prestigious, or professionally staffed associations, is not attractive in small, low prestige or volunteer associations that are unable to reward accordingly the extra effort of leaders. In the latter, leadership is voluntary work, has low status, and is subject to frequent attack by lower status members. For these reasons finding the best individuals (or just any individuals at all) to occupy leadership positions is not an easy task.

Nevertheless, one of these traders, who had been a member of past boards, viewed the program as a great opportunity to revive the city center commerce and took the initiative of inviting colleagues to form a board of directors. He played the role of the “organizer” in Marwell, Oliver, and Prael’s (1988) terms. In accordance with this particular trade association’s statutes, that stipulated a board of seven directors, he invited six other traders following the lines of friendship/acquaintanceship and perceived competence.

This board perceived the policy program as a historic moment for the modernization of the city center, and as an opportunity to recover the market share they had been losing to large scale retail outlets. It had indeed an agenda of modernization for the city center. For instance, they undertook an important initiative to extend opening hours on Saturday from morning only to morning and afternoon, a time schedule that was not practiced by the majority of traders in the city center, but was usual practice in large scale retail outlets. This initiative was considered controversial, especially among older traders who were used to having Saturday afternoons as rest periods.

3.3. City Center Traders

At first sight city center traders seem to be quite a homogeneous collective. What do they have in common? They are located in the same geographical area, they have a similar economic activity, and in consequence they face similar contextual problems, mainly the competition from large retail outlets and the decay of the city center. Most of them belong to the same trade association. Moreover, there is a relative homogeneity of the type of commerce practiced in the city center (Varanda, 2005), for instance, with regard to the small size of shops, the reduced number or inexistence of employees, the domination of family firms and of independent commerce (as opposed to franchises or chains), the decreasing performance of the last years, and even the local origin of most traders. But a more in depth analysis shows that this collective is quite heterogeneous as can be observed in Table 1.

Other important characteristics of this city center trade are the individualism, secrecy, and mistrust characterizing the relation among traders. This relational strategy can be explained by the long period of monopoly of city center trade in which every trader perceived himself as the competitor of every other trader (every euro spent in one shop was seen as a euro less to be spent in another shop). However, since the mid-1980s the competitors of city center trade have been located outside the city in the suburbs, shopping centers, and hypermarkets. Still, in the case studied, only a minority of traders who are proactive and ambitious understood that the real competition was located outside the city, and they adjusted their strategy accordingly, showing greater cooperation with their colleagues rather than treating them as competitors.

TABLE 1 Descriptive Statistics of the City Center Traders

	<i>N</i>	<i>M</i>	Max	Min	<i>SD</i>	Mode	Frequencies	Percentage
Age	192	47.7	89	20	13.2	50		
Number of employees	192	2.1	23	0	2.9	0		
Degree	192	3.2	26	0	3.4	2		
Gender	192							
Male							111	58
Female							81	42
Type of shop	192							
Commerce							162	84
Restaurant/Coffee shop							30	16
Business performance	163							
Increasing							37	23
Declining							73	44
Stable							53	33
Location	192							
Main street							148	77
Secondary street							44	23
Adhesion	192							
Yes							48	25
No							144	75

Note. In the item business performance we omit information from 29 shops because they had opened very recently, and their performance could not be evaluated.

The very low density of the traders' network (1.7%) and a low average degree of actors (3.2) are indicators of the fragmentation that characterizes the relational structure of this collective.

For the reasons mentioned previously, the information circulating among traders came up against the obstacle of suspicion and, in consequence, only information obtained through direct links was given credibility. The problem was that there were incentives to pass around erroneous information, so when the source was not well known, the information was not considered credible. Because of this we have only taken into consideration direct links, as indirect links are not conduits of reliable information.⁵

4. DATA AND METHODOLOGY

Data on the traders' attributes and relations were obtained through a questionnaire addressed to the universe of traders. Traders were questioned about discussion relations concerning the program, and discussion relations concerning the situation of the city's commerce in general. This questionnaire was applied 6 to 9 months prior to the adhesion application deadline, at a time when traders were making their minds up and gathering information about the program.

Discussion amongst colleagues about matters concerning the business may seem trivial in many occupations in which the interdependence among colleagues

⁵In the larger work (Varanda, 2005), of which this article is part, we show that relational measures built based on indirect links did not significantly explain behaviors like participation in the program, while measures using direct links, such as degree or cliques, did.

is well known and the exchange of resources is a necessary condition for good performance. However, in the context of commerce, in which independence and confidentiality are highly appreciated (they have a saying “secrecy is the soul of business”), discussing anything that relates to the profession is an important sign of openness to collective matters. This relational measure has limitations if we think that the coordination of efforts, which is necessary to obtain massive participation in a policy program, involves not only communication, but also influence and enforcement (Marwell & Oliver, 1993). We do not question this, but statistical results presented in previous work show a positive and significant effect of *embeddedness* in discussion networks—measured through degree centrality—on program participation. Given these results we are led to think that in contexts where actors are competitors who value the secrecy of their strategies, having a discussion relation with someone is more meaningful than it would be in a context where individuals openly discuss among themselves. But such discussions are unusual as the very low density of the traders’ network seems to indicate.

Based on the sociometric data, we have obtained the following structure for the traders’ network:

- Main component:
 - Composed of 159 nodes and 304 edges
- Other components:
 - 1 component composed of 2 nodes
 - 31 isolated nodes

Each node of the traders’ network represents a potential participant for the program as well as a potential traders’ association member. Given a pair of nodes, an edge exists linking them if the corresponding traders share information.

From now on we will restrict our analysis to the main component with 159 nodes since the other components represent traders with only one or no ties within the community.

4.1. Models for the Detection of Key Players

4.1.1. The Key Player Problem Positive Model. We consider the following version of the key player problem positive (Borgatti, 2006): given a social network, represented as an undirected graph with node set V , and a fixed integer number k , find a set S of k nodes, called a kp-set, that can reach as many nodes as possible in its complementary set $V \setminus S$ via direct links.

We will denote by G_T the undirected graph that represents the main component of the trader’s network, by V_T the set of nodes of G_T , and by $|V_T|$ the cardinality of V_T .

Let x_j be equal to 1 if node j is in the kp- set and 0 otherwise. Let v_i be equal to 1 if node i is not in the kp-set and is linked to at least one node in the kp-set, and 0

otherwise. The key player problem positive may now be formulated as:

$$\text{(KPP) Max } Z = \sum_{i \in V_T} v_i \quad (1)$$

$$\text{s.t. } v_i \leq \sum_{j \in V_T} a_{ij} x_j \quad i \in V_T \quad (2)$$

$$\sum_{j \in V_T} x_j = k \quad (3)$$

$$x_j + v_j \leq 1 \quad j \in V_T \quad (4)$$

$$x_j \in \{0, 1\} \quad j \in V_T \quad (5)$$

$$v_i \in \{0, 1\} \quad i \in V_T, \quad (6)$$

where a_{ij} is equal to 1 if there is an edge linking nodes i and j in G_T , and 0 otherwise.

The objective function maximizes the number of nodes linked by an edge to at least one node in the kp-set. Constraints (2) state that a node i cannot be reached unless at least one node adjacent to i is selected to be included in the kp-set. Constraint (3) gives the number of selected key players. Constraints (4) guarantee that v_j is equal to zero if node j is selected to be included in the kp-set. Conditions (5) and (6) define the decision variables as binary.

4.1.2. The Attributes Key Player Model. In this section we present an integer linear programming model for finding a set of key players, based on both reachability and the attributes of the collective.

The attributes to consider in such models are those that based on theory and context specificities are found to potentially influence participation in collective action. In our case, we have selected only one attribute: attitude towards participation in the program. Through the questionnaire addressed to the universe of traders, we have observed four different attitudes towards participation: traders who have decided to participate, traders who have decided not to participate, undecided traders, and reluctant traders.

It is our supposition that a show of interest in adhering to the program is a necessary condition to qualify as a potential program leader, who has to commit to the task of transmitting information about the program. When building a team to mobilize others to a policy program, the members must themselves be adherents of that initiative. So, in the *attributes key player* model only traders who have decided to participate in the program will be considered candidates to be part of the set of program leaders.

In addition, assuming that no set composed of k traders is able to reach all other traders in one link—targets of the program—traders who have already made a decision will not be considered as targets for information transmission. This is so because those who have already decided to participate do not need extra information, and those that have already decided not to participate would constitute too great an effort given the shortage of human resources for the task. Therefore, in the attributes

key player model, the targets are the undecided traders and the reluctant ones. However, the potential for a positive return on the information transmission effort made on a reluctant trader is likely to be inferior to the return on the information transmission effort made on an undecided one. In the attributes key player model, the goal is to maximize the number of undecided traders linked to at least one key player. If there are alternative kp-sets that maximize this goal, the kp-set that reaches the maximum number of reluctant traders will be selected.

Let D be the set of nodes that represent traders who have decided to adhere to the program, U the set of nodes that represent the undecided traders, and R the set of nodes that represent traders who are reluctant to participate.

With the decision variables x_j and v_i defined previously, the attributes key player set is the optimal solution to the following integer linear programming problem:

$$(AKP) \quad \text{Max} \quad Z = |V_T| \sum_{i \in U} v_i + \sum_{i \in R} v_i \quad (7)$$

$$\text{s.t.} \quad v_i \leq \sum_{j \in V_T} a_{ij} x_j \quad i \in V_T \quad (2)$$

$$\sum_{j \in V_T} x_j = k \quad (3)$$

$$x_j + v_j \leq 1 \quad j \in V_T \quad (4)$$

$$\sum_{j \in V_T \setminus D} x_j = 0 \quad (8)$$

$$x_j \in \{0, 1\} \quad j \in V_T \quad (5)$$

$$v_i \in \{0, 1\} \quad i \in V_T, \quad (6)$$

where a_{ij} is equal to 1 if there is an edge linking nodes i and j in G_T , and 0 otherwise.

The objective function maximizes the number of nodes in U adjacent to at least one node in the kp-set. If there are alternative sets of key players that maximize this number, the model will select the one that maximizes the number of nodes in R adjacent to at least one key player. Constraints (8) state that no node other than nodes in D can belong to the kp-set. The remaining constraints are the same as in formulation KPP.

5. RESULTS

The integer linear programming models KPP and AKP are formulations of the maximum covering problem (Daskin 1995). The maximum covering problem is NP-complete on a general network (Garey & Johnson, 1979).

In the integer linear programming models the value of k was set to 7 because, as already mentioned, the trade association's statutes limited the board of directors to 7. The models were solved by the integer linear programming optimizer of the

commercial package ILOG/Cplex 11.1. Due to their small dimensions, Cplex was able to find optimal solutions to both models KPP and AKP in just a few seconds. The optimal kp-sets found by models KPP and AKP will be denoted by KPP-set and AKP-set, respectively.

5.1. Characterization of the Trade Association Board: Attributes and Reachability

With regard to the composition of the trade association board, the first aspect to be mentioned is that of its seven members only five are eligible for the program, and among them there is one isolated.⁶ Other relevant characteristics of the elements of the group of five eligible traders are: They are all male, the average age is 50 (only one of them is aged under 40), and they are all commerce owners; that is, no one owns a coffee shop or restaurant. Their business' performance either has been going up or is stable and their shops are all concentrated in just two of the city center streets (over a total of 30 streets/alleys/squares). Moreover, they are all planning to adhere to the policy program (even if one changes his mind later on). This board is homogenous, which is to be expected according to homophily theories. The typical formation method of a board in a voluntary association is often contingent on the existence of a highly interested individual or a few people who plan a campaign and seek to draw others into it (Marwell et al., 1988). This individual or small number of individuals recruits others among a pool of friends/acquaintances, and in consequence these groups end up being very homophilous⁷ as individuals preferentially interact with people similar to themselves (Hinds, Carley, Krackhardt, & Wholey, 2000). For this reason, leadership teams in general, and associations' boards of directors in particular, are often very homogeneous (Middleton, 1987).

Recall that the formation of this board, after a period of administrative management of the trade association due to an absence of an elected board, was possible thanks to the effort of one trader. Not surprisingly, this trader is a man, 50 years old, owner of a successful commerce located in a main street. It is also consistent with the literature that the constitution of these boards have an elite bias, as the members are significantly more likely to have better business performances and businesses of greater dimension, and to be older and more educated than the communities they represent (Weare, Musso, & Jun, 2009). In consequence their interests and priorities also reflect this elite bias; that is, they are not representative of the heterogeneity that characterizes their communities (see Table 2).

In the measurement of reachability, we considered only the four eligible members of the trade association board who have representation in the main

⁶These two board members were not eligible for the program because in one case the board member's business was located outside the city center and in the other case the member's field of business was not allowed in this specific program. These two members were not included in the sociomatrix, which was not considered problematic as they were not cited by any of the eligible traders.

⁷For more information on the homophily tendency, see Lazarsfeld and Merton (1954). For a more recent approach and literature review concerning this concept, see for instance Mcpherson, Smith-Lovin, and Cook (2001).

TABLE 2 Descriptive Statistics of the Trade Association Board

	<i>M</i>	Max	Min	Frequencies
Age	50.4	62	38	
Number of employees	4.8	8	2	
Degree	11.8	26	0	
Gender				
Male				5
Female				0
Type of shop				
Commerce				5
Restaurant/Coffee shop				0
Location				
Main street				5
Secondary street				0
Business performance ^a				
Increasing				3
Declining				0
Stable				1

Note: Here, we consider only the five board members eligible for the program.

^aSince one shop had opened very recently, there are no data for the evolution of performance.

component (node set V), which naturally excludes the isolated board⁸ member. Hence, with regard to reachability, we found that these four board members have direct links to 45 other traders. This means that 110 traders are not directly reached by the board. For a leadership group whose main mission is to develop the program in the city center, low reachability can be considered a poor performance in the task of transmission of information.

5.2. Characterization of the KPP-Set

The KPP-set is composed of five men and two women. The average age is 41, and four elements are aged below 40. The set has six commerce owners and one coffee shop owner. Their businesses are located in main and secondary streets, spread over six different locations of the city center (in a total of 30 streets/alleys/squares). Most of them run a successful business, although one had a business which was not doing well, and three of them are planning to adhere to the policy program. We should also note that this key player set has two members in common with the trade association board: the president of the board and the trader who had been in charge administratively of the association prior to election and who took the initiative to form the new board. These are the two actors with the highest centrality degree in the network. It is clear that this set of key players is more heterogeneous than the trade association board, and a better representation of city center traders as a whole. We will discuss these matters further below.

⁸Through field work we found out that he was not involved in the city's commerce and his participation on the board was also diminishing. For instance, he was frequently absent from meetings.

TABLE 3 Descriptive Statistics of the KPP-Set

	<i>M</i>	Max	Min	Frequencies
Age	41.4	65	29	
Number of employees	3.1	6	0	
Degree	12.7	26	5	
Gender				
Male				5
Female				2
Type of shop				
Commerce				6
Restaurant/Coffee shop				1
Location				
Main street				5
Secondary street				2
Business performance ^a				
Increasing				3
Declining				1
Stable				2

^aSince one shop had opened very recently, there are no data for the evolution of performance.

With regard to reachability the key player team has direct links to 72 other traders. In total there are 79 traders with first hand or one link away information. This means that the board is unable to reach 80 traders in a single link (see Table 3).

5.3. Characterization of the AKP-Set

The AKP-set set comprises five men and two women. The average age is 50, and there is only one member aged below 40. There are two coffee shop owners in the group. Within the group, three traders recognize that the business is not going well. Their businesses are spread over five different locations. Like the KPP-set this one is also quite heterogeneous in its composition. It shares three members with the trader association board and reaches 59 traders, 23 of whom are undecided traders (see Table 4).

5.4. The Trade Association Board, the KPP-Set, and the AKP-Set Compared: Composition, Eligibility of Members and Selective Reachability

Performance limitations, such as those in the transmission of information, of groups similar to the board of this trade association, which are formed based on acquaintanceship/friendship ties, can be better evaluated if compared to groups whose membership is selected for their optimal location in the network and for the relevance of their attributes to the task at hand.

With regard to the eligibility of the board members (a necessary condition for participation in the policy program), two members are not eligible and one is an isolate. As for the KPP-set, all seven members are eligible for the program, but three members are unwilling to adhere to it. With regard to the AKP-set, only

TABLE 4 Descriptive Statistics of the AKP-Set

	<i>M</i>	Max	Min	Frequencies
Age	50.6	62	31	
Number of employees	2.9	6	0	
Degree	10.9	26	4	
Gender				
Male				4
Female				3
Type of shop				
Commerce				5
Restaurant/Coffee shop				2
Location				
Main street				6
Secondary street				1
Business performance ^a				
Increasing				1
Declining				3
Stable				2

^aSince one shop had opened very recently, there are no data for the evolution of performance.

traders willing to adhere to the program are included. Since both key player sets are constructed based on previous knowledge about the social network and the rules of the program, we ensured that only eligible traders were taken into consideration.

As far as reachability is concerned the trade association board reaches 45 traders, the KPP-set reaches 72, and the AKP-set reaches 59 traders. In the set of traders reached by the trade association board only 12 are undecided. The numbers of undecided traders reached by the KPP- and the AKP-sets are, respectively, 18 and 23. Since the total number of undecided traders in the network is 47, the trade association board, the KPP-set, and the AKP-set reach 26%, 38%, and 49% of the undecided traders, respectively (Tables 5 and 6).

The results presented show that the optimal solution to the key player problem positive represents an improvement compared to the trade association board. However the blindness of the model to attributes leads to a choice of key players who are not the most competent at transmitting information to those most in need of it. An improvement is achieved by considering actors' attributes, which leads to a better solution in terms of reachability and selectivity. We have shown that restricting the key player set to just those who are willing to adhere to the program, and considering those that have not decided about participation as priority targets can be a step towards increasing mobilization as more undecided traders can have access to direct information by key players.

An interesting result of the sets produced by both optimization models KPP and AKP is their heterogeneous character in contrast with that of the trade association board. For instance, there were no female members in the board while the KPP-set and the AKP-set were comprised of both men and women. Both the KPP-set and the AKP-set have members in different types of businesses and are placed in more locations than the actual board. The heterogeneous character of both key player sets, as compared to the homogenous character of the trade association

TABLE 5 Descriptive Statistics of the Trade Association Board and the Two New Sets of Key Players

	Whole population	Trade association	KPP-set	AKP-set
Gender				
Male	58%	7	5	4
Female	42%	0	2	3
Age (<i>M</i>)	47.7	50.4	41.4	50.6
Type of shop				
Commerce	84%	7	6	5
Restaurant/Coffee shop	16%	0	1	2
Number of employees (<i>M</i>)	2.1	4.8	3.1	2.9
Location				
Main street	79%	5	6	6
Secondary street	21%	0 ^b	1	1
Business performance				
Increasing	23%	3	3	1
Declining	44%	0	1	3
Stable	33%	1 ^c	2 ^a	2 ^a
Willingness to adhere				
Yes	34%	4	4	7
No/Undecided/Reluctant	66%	1 ^b	3	0

^aSince one shop had opened very recently, there are no data for the evolution of performance.

^bTwo board members have their shops outside the program intervention area.

^cInformation not available for three board members.

board is easily explained by the approach used in their constitution recruitment through friendship and acquaintanceship ties versus maximum reachability and selectivity criteria.

In the same way, but also due to the functioning of the homophily principle, we should expect that the key player sets found by solving the optimization models are as heterogeneous as the collective from which such sets were produced. As a result, all subgroups of the city center commerce should be represented: men and women, commerce and coffee-shops, young and old, traders from main and secondary streets, those who are successful as well as those whose business is declining. In this sense, optimally found actors are much more representative of the city center traders.

The discussion on the outcomes of homogeneity vs. heterogeneity in groups goes beyond the scope of this article. These issues have been widely debated in the literature and there is still no clear cut answer regarding their effects in group performance (e.g., Oh, Chung, & Labianca, 2004; Pelled, 1996; Reagans & Zuckerman, 2001; Weare et al., 2009). For instance, in homogeneous groups cohesion is more

TABLE 6 The Trade Association Board and the Two New Sets of Key Players Compared: Total Reachability + Selective Reachability

Reachability	Trade association	KPP-set	AKP-set
Total (<i>N</i> = 192)	45 (23%)	72 (38%)	59 (31%)
Undecided (<i>N</i> = 47)	12 (26%)	18 (38%)	23 (49%)
Reluctant (<i>N</i> = 8)	3 (38%)	4 (50%)	4 (50%)

easily reached, but that is not a warrant of good performance. In the case of the board of the trade association studied, even if recruitment was carried out on the basis of personal friendship and was thus homogeneous, cohesion could not be taken as given; through observation we noted that the level of cohesiveness declined as time went by. This was perceptible in the low participation of some members in board meetings, in the general activity of the trade association, and even in their disrespect of board decisions. On the other hand, heterogeneous groups, which tend to be less cohesive, can have a better performance due to their increased capacity to transmit and receive information from a wider and more diverse audience. But again, this does not necessarily translate into more effective group action. In short, the effectiveness of group action cannot be reduced to an issue of homogeneity versus heterogeneity. It can be argued that, if the right context is achieved, one in which cooperation is valued, both heterogeneous and homogeneous groups can perform well. The organizers and the resources they can mobilize play a crucial role in this process (Marwell et al., 1988).

6. CONCLUSION

The aim of this article was to reinforce the idea that social network analysis together with combinatorial optimization can be useful in the identification of key players in a collective, especially when their attributes are taken into consideration. Since key players are considered to be those best positioned to influence other actors' attitudes and behaviors, they have a crucial role in the success of any policy implementation. In our case we are just concerned about the key players' ability to transmit information to their targets, a necessary first step to obtain their participation in any kind of collective action, such as the implementation of a policy program. We have formulated as an integer linear programming problem the key player problem positive, proposed by Borgatti (2006), which seeks maximum reachability. We have also proposed another integer linear programming model to find a key player set with both high reachability and selectivity.

Given some relevant characteristics of our case study, such as the complexity of the message to be diffused, the heterogeneity of targets (e.g., who belong to different age groups and have firms of different dimensions, with different levels of performance) and the context of competition and low trust among traders (Varanda, 2005), as well as the specificities of the policy program whose success was contingent on massive participation, only a message of "high reach and high selectivity" is appropriate. Marwell and Oliver (1993) have concluded that this kind of message is optimal but has often "prohibitive costs." The solution obtained to the attributes key player model has led us to think that it is possible to reduce such costs.

Taking an empirically observed leadership team as our baseline, we have also shown the limitations related to the information transmission process of a group formed following the homophily principle, that is, on the basis of friendship/acquaintanceship criteria, compared with a group formed based on optimization criteria. We showed that when the collective is heterogeneous, the optimal leadership will necessarily be heterogeneous, and thus more representative. Thus, if we are concerned with policies that envisage change in behaviors or the adoption of innovative behaviors by policy targets, the group of actors leading the process

has to be carefully chosen. The trend toward homogeneity must be avoided for such a trend will necessarily lead to low reachability and, in consequence, a smaller number than desired of individuals changing behavior.

Based on the network structure of this collective, we have also shown that the reach of the information transmitted would always be insufficient if this task was to be undertaken solely by the trade association board. Prior to intervention, the state as the promoter and ultimate entity responsible for the program's success should have procured additional human resources. Ignoring this step led to a waste of energy and resources. In markets composed of small independent firms that are competitors, the board of directors of the trade association by itself may be incapable of extensive reachability. Policy makers should invest additional resources in devising and implementing new forms of transmitting information, rather than focusing solely on the attribution of financial incentives, which do not seem to have a strong effect on participation. In the case studied simple and cheap measures related to information transmission could have been taken to increase participation. An example would be the use of local newspapers during the period of application procedures to inform traders about who was adhering to the program. This knowledge would motivate those still reluctant to adhere.

The limitations and problems of this work can only be fully apprehended after replication in similar cases, where the participation in policy programs is envisaged. The application in our case study is only an illustration. The data set used, due to its low density, may not be ideal for methodological illustrative purposes. However, if we wish to study a collective where information exchange is rare and where mistrust abounds, one would not expect a very different network structure.

Another limitation has to do with the choice of just one attribute for board members and target actors. Other attributes could be added if considered meaningful for the selection of board members and target actors. But again, given the low density of this network, the choice of more attributes would not improve the explanatory objective of this article.

In short, the objective of this article was to serve as an illustration of how knowledge of the "concrete action system" and its actors' attributes may facilitate the task of the actors leading the implementation of a policy program, reducing the complexity of the task and the time and energy wasted, and consequently improving the efficiency and effectiveness. With the tools of social network analysis and combinatorial optimization, policy implementation processes could be made easier and more effective by helping with the choice of key actors and with the selection of the most relevant targets. This methodology requires detailed knowledge of the collective and its social organization and composition, which may entail high costs for the organizers of collective action, but this knowledge, is a necessary condition for the success of policy implementation.

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