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Social e-business as support for construction e-procurement: e-procurement network dynamics

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1. Introduction

If correctly designed and implemented, construction e-procurement platforms may increase performance-based competition, stimulate suppliers' noncontractible investments, encourage trust development and promote project quality [9,17]. Therefore, e-procurement networks, which are constituted by buyers and suppliers, will be able to grow and consolidate, which is beneficial to buyers and suppliers [1] but also to e-procurement service providers, who will be able to increase profits. However, it is pertinent to ask if the e-procurement networks generated will tend to grow indefinitely, as it seems to happen in the well-known social networks [24], and what management approaches service providers should implement in order to encourage growth and obtain maximum benefits. It is also pertinent to discuss if Social e-business [10], which is an e-business approach that integrates several social networking tools, having in mind that social networking approaches should focus on collaborative processes, win–win relationships and supply chain integration instead of competition-based situations, may potentiate this growth. As stated by Grilo [14] an atmosphere of co-operation between firms, where they may have mutual expectation of long-term commercial interaction, is very important to the emergence and sophistication of innovative systems. Furthermore, the frequency and volume of information and financial exchanges and social contacts also largely influence the adoption of e-procurement instruments, providing the adequate environment for a growing growth rate.

In this sense, two models to support deeper analysis of social and e-procurement network dynamics are proposed, which were developed using game theory [19]. Based on the models developed, two theorems were deduced and discussed and three computer simulations were developed to support in-depth network dynamics analysis. Afterwards, a new vision for e-procurement platforms is discussed considering the results of network dynamics analysis.

2. On the dynamics of e-procurement networks

The developments of e-procurement networks based on electronic platforms are generating a wide range of benefits to improve supply chains and, therefore, are gaining popularity and their respective benefits have been largely discussed [4,12,18,22,23,27,29]. Among the reasons for such debate is the fact that e-procurement systems emerge promoting a more integrated, efficient and performance-based vision of procurement [7,8,11,20,25], facing a wider range of challenges coping with the strategic procurement issues and giving a central role to contract and its evaluation [6,26].

However, e-procurement platforms must be carefully designed in order to be successful. The informed buyer environment promoted by e-procurement platforms [2] may lead suppliers to a competitive price-taking equilibrium, underlying the Bertrand's zero-profit equilibrium in oligopolistic settings, improving buyers' benefits but reducing sellers' power [2,21,28]. This situation may instigate strong price competition among suppliers, and, in some cases, may degrade supply quality (delays, less client support, etc.), especially in situations in which noncontractible factors are relevant. In these cases, and as Mithas et al. [17] argue, buyers face a considerable dilemma when switching from their existing supply chain relationships to electronic platforms, as this change may harm existing social connections, and prejudice future purchasing. It has also been observed that, in some cases, buyers tend to rely on fewer suppliers [3,5,16], as smaller and tighter networks of suppliers incentivize the suppliers' investment in noncontractible, such as innovation, new technology use, quality improvement, trust improvement and responsiveness.

However, by creating restricted groups of suppliers, buyers may be more vulnerable to collusion or may have less competitive bids, unless

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they continue monitoring the whole market. So, reducing the size of e-procurement network may not necessarily be the best option; it should be more appropriate to implement effective evaluation mechanisms capable of valuing the various dimensions of proposals (cost, quality, deadlines, etc.), such as preliminary classification phases, which allow classifying suppliers according to their skills and experience, and multicriteria models for tenders' evaluation, which allow ranking the proposals according to several relevant criteria involving various dimensions of tenders. The implementation of these instruments will allow incentivizing suppliers to invest in noncontractibles and will stimulate the development of qualified e-procurement networks, in which both procurers and suppliers will benefit on participating [9].

So, if correctly designed and implemented, e-procurement platforms may promote easy and transparent full sourcing information to any procurer, increase competition between suppliers, and stimulate noncontractible investments and better performances. Though, quite challenging questions about e-procurement network dynamics still can be raised, such as how far the network size will increase? Another pertinent question has to do with the emergent social network phenomenon, which may open new perspectives also for e-procurement platforms. The considerable success of several social network platforms, such as Facebook and LinkedIn, showing significant growth and considerable gains [1,13], raises the following question: is it possible to have an e-procurement platform with a similar behavior to social network platforms, i.e., showing the network effect [24]?

These questions open new perspectives on e-procurement networks, which are crucial for development of more valuable and efficient platforms. However, no results have been published modeling social and e-procurement network dynamics and comparing their behavior, which makes this paper pertinent.

3. Modeling e-procurement and social networks

3.1. Methodology

In the present study, theoretical models for social and e-procurement networks will be proposed using the formulation developed by game theory. E-procurement network (PN) and social network (SN) are defined as sets of members exchanging services and open to deny and accept new members at each time, and so modeling their dynamics implies:

- modeling benefits and costs for its existing members;
- modeling the decision process of each member to stay or to leave the network;
- modeling the decision process of each potential new member to join or not the network.

It is relevant referring that the proposed models consider that benefits are generated by interaction between members and a cost is due to the participation in the network (time, effort, opportunity costs, etc.) and to any eventual membership fee. Moreover, the benefits generated for sellers (procurers) in an e-procurement network are proportional to the selling (buying) opportunities offered by procurers (sellers), but in a social network the benefit generated for any member is assumed proportional to the value of interactions to be established with all the other members.

The proposed formulation considers the existence of intermediary service providers, usually represented by the management of the adopted electronic platform, who are responsible for managing the network services (website operation, communication and data handling, security protections, hazard recovery, data storage, etc.), as well as for defining and implementing the membership rules. Moreover, it is the manager who decides about the pricing model and the acceptance or rejection of membership applications for new members. Finally, it is considered that any existing member can leave the network, although, in reality, some fidelity rules may apply for specific periods (e.g., 1 year).

3.2. A model of social networks

Let be $N_{SN}(t)$ the number of members of a Social Network (SN) at time t, and k a new potential member, who considers two alternatives:

$D1$ joining the network;
$D2$ not joining the network.

Obviously, SN can also consider two alternatives:

$D_1{}'$ accepting k;
$D_2{}'$ rejecting k.

The benefit of k derived from being a member of SN at time t is assumed to be proportional to $N_{SN}(t)$ and so can be modeled by:

$$B_k(t) = \alpha \cdot [N_{SN}(t) + 1],$$

adopting a homogeneous assumption about the potential benefit of k being able to interact with any member of SN and where α is a positive parameter. This assumption does not imply to have every member directly connected to each other but rather that the selection of those to be connected can be based on wider choices more appropriate to each member.

Thus, each existing member of SN will have an additional benefit equal to α if k joins SN and so the average benefit for each existing member of SN due to $D1$ will be given by:

$$B_{SN}(t) = \alpha \cdot [N_{SN}(t) + 1].$$

The existence and operation of the e-network imply several types of cost (information and communication technologies, security, management, etc.) which can be covered by advertisements and by a fee to be supported by the new member which will be denoted by C.

Most well-known social networks with a general scope (Facebook, Twitter, Linkedin, etc.) are adopting $C = 0$ but this variable can play a key role to manage the evolution of any network as it is shown in this paper.

Therefore, the decision of joining or not the network by k can be formulated in terms of the usual payoff matrix of a two-player game:

$$\begin{array}{c} \boldsymbol{SN} \\ k \begin{array}{c} D1 \\ D2 \end{array} \begin{bmatrix} \overset{D'}{\{\alpha \cdot [N_{SN}(t)+1] - C\}; \{\alpha \cdot [N_{SN}(t)+1]\}} & \overset{D_2'}{0;0} \\ 0;0 & 0;0 \end{bmatrix}. \end{array} \quad (1)$$

The usual notation is adopted (left → payoff for k; right → payoff for SN).

Obviously, $[D_1; D_1{}']$ is the stable solution for this cooperative game providing that $\alpha \cdot [N_{SN}(t) + 1] > C$ and so the SN manager should accept k.

3.3. A model of e-procurement networks

The advantage generated to procurers by belonging to PN stems from obtaining better buying opportunities offered by suppliers. The additional value of such opportunities is due to increasing competition between sellers as they are all invited to tender for each specific procurement request according to their capacity to cope with the type of the contract and the additional advantages offered by suppliers. Therefore, the total benefit for procurers is proportional to the advantages offered by each seller (in average, expressed by a positive parameter, β_p) and to its number, $N_s(t)$, and so it will be given by $[\beta_p \cdot N_s(t)]$.

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