# e-Sourcing Clusters in Network Economy

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**Abstract.** Acquiring resources has always played an important role in doing business. Initially companies gathered them within their own capacity until different sorts of business clusters started to appear. They began to purchase products and services needed to do business by their individual members in order to obtain preferential prices and other trade conditions. Thanks to geographical proximity as well as close and stable cooperation, companies are able to gain a lot of benefits that they would not reach if they worked on their own. The information and communication technologies (ICT) has given a possibility to go beyond traditional cluster concept and has allowed various geographically spread companies to form electronic clusters (e-clusters). Agent technology seems especially promising in this respect. Software agents are able to support inefficient traditional e-marketplaces, including partners who offer one another the best cooperation possibilities and conditions at a given time. The main contributions of this book chapter is the presentation of new resources acquisition method and the e-sourcing cluster concept. Additionally authors have built and verified simulation model of four e-sourcing cluster strategies.

**Keywords:**, e-sourcing, network economy, clusters, logistics, electronic supply chains, agent based simulation, NetLogo.

## 1 Introduction

The information and communication technology revolution that has been observed for the last 40 years, and especially the development of the Internet, has initiated a transition of well-developed and developing economies in the direction of an information society. On the basis of this information "order", a new economy called informational, global or network-ized has grown.

The new economy has caused changes in the logic of enterprise organization. Knowledge, unique resources and key competences are being brought to the foreground. Increasing competitiveness is forcing a new organizational model characterized by newer and faster alliances created more frequently. These are formed on an international as well as local scale, between different industries, markets, spheres of activity, or individual enterprises and lead to a network-ized organization model. All functions of an organization which are not part of its basic activity and which may be fulfilled more process and cost-effective by other parties are assigned outside.

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The move of the global-economy-functioning axis towards knowledge, unique resources and key competences has caused a selection of new organizational models. They are based on networks and virtuality and constitute a response to the changes brought about by the era of the information society.

Virtuality, with reference to enterprises, is understood as the use of the network character of business connections in reply to the opportunities emerging on the markets. An enterprise in the course of virtualization oversteps its limits in the search of potential partners to enter into cooperation with in order to achieve a specific benefit. These partners do not simply play a traditional role of suppliers but together build a value chain (virtual organization), which creates a product consistent with the needs of the final client.

An electronic cluster, which is used to acquire resources on e-marketplaces, is an example of such new organizational models presented in this article.

This chapter is a continuation of the author's work presented at the KES-AMSTA[1] 2009 and 2010 conferences, regarding resource acquisition by e-sourcing clusters. Its structure is as follows: the evolution of resource acquisition is discussed in Sec. 2, then, Sec. 3 describes the strategic role of sourcing and Sec. 4 presents e-sourcing. In Sec. 5 the idea of clusters is explained and in Sec. 6 the e-sourcing cluster is described. Four e-sourcing cluster strategies proposed by the authors are presented in Sec. 7. Next, Sec. 8 depicts the simulation experiment background, variables, constants and constraints, while Sec. 9 contains the results of the simulation experiments. The conclusions and directions for future research are outlined in Sec. 10.

## 2 Evolution of Resource Acquisition in Enterprises

Nowadays, the activity of almost every enterprise relies on resources to a large extent; it may even be stated that an enterprise would not be able to function without resources. Resource can be defined as (1) an available source of wealth, (2) a new or reserve supply that can be drawn upon when needed.[1] The above formulation shows that enterprise resources may be very broadly understood. The classification of resources most frequently encountered in literature divides them into: material ones (e.g. buildings, machines, raw materials, products), immaterial ones (e.g. knowledge, information, competence) and human resources (employees). The subject matter of this article concerns material and immaterial resources that may be acquired on electronic markets. Human resources, in turn, are a very specific type of enterprise resources subject to completely different management methods than the other two; therefore, they have been omitted for the sake of cohesion.

Resource acquisition understood as commerce traces back to the beginning of human civilization. The first finds proving commercial exchange date back to Pleistocene. The beginning of commerce may also be related to the emergence of surplus production of the prehistoric human. Awareness of the possibility that the products may be exchanged initiated commerce which was taking the form of barter exchange throughout most of human history.

[1] International KES Symposium on Agents and Multi-agent Systems – Technologies and Applications.

In ancient times merchants travelled to distant countries to purchase resources and find new markets. Mesopotamia imported wood, stone, metal ores and precious stones. Egypt provided itself with long wooden beams used in construction. Many cities located at the Mediterranean Sea, on the other hand, needed food and raw materials for craft production. Luxurious goods, such as silk imported from China, were also objects of trade. The Silk Road linking Europe with Asia attracted thousands of merchants avid for the precious fabric and soon became the place where European goods were exchanged for Asian ones. The trade towards the Mediterranean Sea mainly involved silk, paper and iron, whereas gold, cultivated plants and aromatic oils were exported to China.

Sourcing has been subject to numerous alterations since that time. The interest in purchasing started to increase among many scientists in the second half of the 20th century. The influence of resource acquisition on the activity of enterprises began to be investigated thoroughly. In his article, published in Harvard Business Review [2], D.S. Ammer, after having examined 750 enterprises, stressed that high-level management considered purchases to be of passive significance to the enterprise activity. Such an attitude resulted from ignorance and lack of knowledge and understanding what a purchasing process really was and what elements it consisted of. The difference in understanding the process of resource acquisition as well as the lack of directives related to purchasing on the strategic level led to poor effects of the purchasing process. The crisis on the oil market of the 1970s did not change the attitude towards resource acquisition in enterprises, either.[3]

H.I. Ansoff also emphasized that purchases in enterprises (in the 1960s and 1970s) had an administrative, not strategic, character.[4] J.R. Caddick and B.G. Dale noticed that enterprises did not conduct analysis and planning processes correctly, which translated into insufficient strategy preparation and implementation, especially in the sphere of purchase functions.[5]

## 3 Strategic Attitude towards Resource Acquisition

A closer look at M.E. Porter's work [6] and his five forces influencing competitiveness makes the key role of the purchasing process in enterprise activity, and ipso facto in its strategy, become obvious. It mainly results from two out of Porter's five forces, the bargaining power of suppliers and the bargaining power of customers, that is. Porter considers the choice of an appropriate group of suppliers and customers to be a key strategic decision. Enterprises can improve their strategic position by selecting suppliers and customers characterized by the least force of being influenced negatively.[6] Porter's three remaining forces may also be treated as those exerting influence on the purchasing function of an enterprise. Their influence is not so obvious, yet a strategic approach to resources may greatly contribute to a better competitive position in a given industry (the intensity of competitive rivalry), protection against new entrants (the threat of the entry of new competitors) or a better product / service adjustment to the customers' needs (the threat of substitute products or services). It clearly shows that the concept, so basic for shaping enterprise competitiveness, has become one of the mainstays of the strategic meaning of resource acquisition.

The collective analysis of the research on the strategic role of the purchasing function (see table 1) conducted by L.M. Ellram and A. Carr [7] confirmed the

continuously increasing interest of analysts, researchers and enterprises in the problems related to the purchasing function in the enterprise strategy. Growing competition as well as a need to reduce costs and, simultaneously, maintain, or even improve, the quality of products stimulated enterprises to look at resource acquisition in a more strategic way.

**Table 1.** The role of resource acquisition in supporting an enterprise strategy

| Author/Authors | Research methodology | Main conclusions |
|---|---|---|
| **Spekman** | Conceptual | The purchasing function must be included in the enterprise strategy. Resource acquisition must reflect the way of thinking and the strategic development of the company. |
| **Browning et al.** | Conceptual | The purchasing function is connected with the enterprise strategy as it supports the monitoring and interpretation of the purchasing trends, the identification of the ways of supporting the company strategy and the development of possible resource acquisition. |
| **Burt and Soukup** | Conceptual | If the purchasing function is included in the development of new products soon enough, it may significantly influence the success of their launch. |
| **Caddic and Dale** | empirical – case studiem | Resource acquisition must develop strategies and be connected with the overall enterprise strategy. |
| **Landeros and Monczka** | empirical – interviews | The purchasing function may support the company's strategic position thanks to the cooperative relations between the buyer and the seller. |
| **Carlson** | empirical – case studiem | The purchasing strategy is important from the perspective of product development and the company's long-term objectives. |
| **Reid** | Conceptual | Resource acquisition should be included in the early stage of the enterprise strategy development in order to achieve cohesion with the company's strategic plans. |
| **St. John and Young** | empirical – survey | Managers responsible for purchases, production and production planning are unanimous as far as the significance of a long-term strategy is concerned. However, their every-day tasks are inconsistent with strategic, long-term plans of the enterprise. |

Source: Ellram L. M., Carr A., Strategic purchasing: A history and review of the literature, International Journal of Purchasing and Materials Management, Vol. 30, Issue 2, 1994, pp. 14.

The strategic importance of resource acquisition was also confirmed by European researchers. L. Gadde and H. Hakanson identified three strategic issues related to resource acquisition [8]:

1. An increase in the significance of "buy" over "make". A decrease in vertical integration and greater complexity of the problems related to make-or-buy caused a necessity of a strategic attitude to these issues.
2. Systematic attempts at structuring the supplier base, including their reduction and an improvement of coordination.
3. Closer cooperation with key suppliers in order to improve technological development.

The most important implication of the above issues was a considerably increasing interest of high-level management in the purchasing process and, what follows, growing strategic significance of resource acquisition. Managing relations with key suppliers, designing products together or planning technological investments required strategic decisions from the point of view of the entire enterprise.

Another consequence was purchase decentralization, resulting from two trends in enterprises [8]: 1) decisions should be made by people being closest to the problems in question; 2) creating the so-called independent profit-generating centers which were closely related to the decentralization of the decision-making process. The tendency to outsource was mainly connected to a high level of purchasing costs in the total costs of the enterprise (over 50% [8]). The decision decentralization facilitated entering into closer contacts with suppliers, which entailed better supply conditions and, at the same time, reduced costs of the entire enterprise activity.

Changes in the organizational structures of enterprises took place, too. They were caused by an increase of the strategic aspect of resource acquisition. The dominant selling function was resigned from in favor of functions oriented more towards integrated problem-solving. Thus, logistics and enterprise technological development gained more significance.

The change in the perception of the purchasing function was also reflected on a more global level of enterprise activity. The increased importance of the relations with suppliers resulted in the emergence of a network of connections which expanded the specialization potential of the given enterprise as well as the whole supply chain.

## 4 e-Sourcing

Strategic sourcing on a global scale, though, requires integration and co-ordination of the supply needs of the enterprise's all economic units from the perspective of the common products, processes, technologies and suppliers.[9] It would not be possible without ICT, especially the Internet, whose dynamic development in the 1990s initiated the idea of e-sourcing.

E-sourcing is defined "*as the use of Web-based applications, decision-support tools, and associated services to identify, evaluate, negotiate, and configure purchases and supplier relationships that will effectively support supply chain and other business operations*".[10]

At the beginning of the e-sourcing evolution, enterprises built electronic product catalogues, ordered goods via an internet browser and made payments on-line. Now e-sourcing manifests itself in establishing close co-operation between recipients and suppliers as well as in better information and knowledge management.[10]

The benefits of e-sourcing can be divided into operational and strategic ones. The former include purchase costs reduction (discounts resulting from aggregation of purchase, greater competition among suppliers, more possibilities in the field of negotiation and offer analysis, etc.) and process improvement (faster, simpler and more flexible product ordering, continuous accessibility of supply markets, etc.) while the latter are related to increasing the innovative potential of the enterprise (identification of new buying sources and evaluation of the previous ones, incorporating suppliers into innovative processes, etc.).[11]

The accomplishment of the e-sourcing process assumes making use of the transaction-negotiation solutions. These may be: on-line auctions, on-line catalogues, electronic RFx queries and electronic marketplaces (e-markeplaces).

The first of the above methods presumes competition between selected participants who want to conclude a purchase or sale transaction on pre-set conditions. The winner of the auction is the one who has offered the best conditions. The following may be distinguished among on-line auctions: reverse auction, dutch auction, first-price sealed-bid auction, vickrey auction.[12]

On-line catalogues, on the other hand, can be used in two ways: via a website or an electronic purchase system (in this case it is possible for the buyer to combine catalogues of different suppliers, which definitely makes comparing offers easier). Suppliers can establish custom catalogues for buyers who can, in turn, work with pre-established supplier catalogues and prices to procure material and services. There are three different types of electronic catalogue options: static product catalogue, static configurable product catalogue (content is static and has to be updated on regular basis by the vendor), and dynamic product catalogue (content is generated the moment the user accesses the catalogue). When describing on-line catalogues one cannot forget about the most technologically advanced dynamic catalogue which collects data directly from the catalogues on the suppliers' websites.[11]

The third transaction-negotiation solution is electronic RFx queries. These can be divided into: RFI – Request For Information, RFQ – Request For Quotation and RFP – Request For Proposal. RFI is one of the most general ones as it is supposed to initiate receiving information about the supplier and the estimated purchase costs. The next two, RFQ and RFP, are followed by notification about a possibility to make an offer. RFx queries include all requirements related to the supplier, a detailed description of the needed product and the criteria for the choice of the best offer.[13]

The fourth method is e-marketplace which, similarly to on-line catalogues, enable standard goods (usually raw materials) trade. These are internet platforms joining buyers, sellers and brokers in order to increase the competition between suppliers and to obtain access to a greater number of purchasers. E-marketplaces offer dynamic price establishment, aggregation of orders, making offers to numerous suppliers, individual suppliers' price openness, negotiation mechanisms and co-operation possibilities. E-marketplaces are the most sophisticated form of e-sourcing used today and their popularity is still rising. eMarket Services currently has about 640 e-marketplaces in its database.[14] One of the most important advantages of

e-marketplaces is that they do help companies find the almost ideal suppliers.[15] E-marketplaces can reduce the potential partner searching costs, as well as the administration costs, on both buyer and seller sides.[16]

Although they offer a lot of facilities and have many strengths, there are some limitations of these solutions supporting e-sourcing. Firstly, today it is very easy to establish a marketplace on the Internet. Thus, there are hundreds of globally operating e-marketplaces. It is very difficult to sort all the information about potential suppliers from so many e-marketplaces and to compare it in order to make a final decision. Moreover, the environment of e-marketplaces is constantly changing – some e-marketplaces occasionally give much better offers than others.[17]

Electronic markets are very important element of modern network-ized economy. Though their adjustment to customers' needs, integration with broad spectrum of other IT systems, or implementation of sophisticated inner negotiation algorithms will among other things determine the future development of e-marektplaces. Some other insights about e-marketplaces in relation to presented in this chapter e-sourcing model are presented in section 6.

## 5 Cluster

In order to solve the problems presented in the previous section we are suggesting to use the e-sourcing cluster concept to acquire resources needed by companies. Before this concept is presented, however, let us explain what the cluster is, according to the traditional approach.

Generally, a cluster can be described as a group or bunch of objects. Merriam-Webster Online Dictionary defines a cluster as a number of similar things that occur together.[1]

Cluster applications are multiple. The concept may be found in astrophysics (star cluster), biology and health sciences (cancer cluster), computing (computer cluster), music (tone cluster), economics (business cluster), the military (cluster bomb), etc. This paper focuses on the business cluster. Intuitively the business cluster can be specified as a group of companies which cooperate in order to achieve some advantages.

The term, business cluster, also known as an industry cluster, competitive cluster, or Porterian cluster, was introduced and popularized by M.E. Porter in his work, *The Competitive Advantage of Nations*.[18] He defines a cluster as *''…a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementariness''*.[19]

The best example of a business cluster is The Silicon Valley (in the field of computer technology), Hollywood (U.S. movie production site), and Detroit (U.S. automobile production plants concentration).

Clusters are formed by enterprises linked through vertical (enterprises connected with others in the relation "supplier-buyer") and horizontal (e.g. competitors creating an alliance to achieve the strategic goal) relationships with the main players located in the same place. The geographical proximity is seen as a way of facilitating the transmission of knowledge, supplies and the development of institutions, which in turn may enhance cluster effectiveness.[20] According to M. Porter, it creates competitive

advantages for small and medium enterprises (SMEs) which cooperate and compete closely, since a host of linkages among cluster members results in a whole greater than the sum of its parts.[19] So, all the companies can benefit directly from being part of a cluster.

Unfortunately, clusters understood in this way have some limitations. The definition presented above and many other existing in the professional literature and papers [18][20][21][22][23], suggest that the characteristic feature of the business cluster is the geographical proximity. This vicinity as well as the informal communication and face-to-face contacts connected with it still matter and create the competitive advantage.[24] However, not every enterprise (especially SMEs) can be a member of the business cluster due to high entry costs. Moreover, it is impossible to physically locate all enterprises in one place. Further, clusters are formed for years, that is why there is a high exit cost.

## 6 E-sourcing Cluster

As mentioned above, the problems of resource acquisition on e-marketplaces can be solved by the e-Sourcing Cluster (eSoC) concept. The e-sourcing cluster (a type of a business cluster) is a group of enterprises which are looking for the same type of resource (e.g. steel, plastic, packaging, transportation, etc.), so they cooperate in order to acquire it more quickly and more effectively.

They communicate and exchange information automatically using software agents. In such clusters the geographical proximity does not matter at all. Enterprises do not have to be located in one place because they cooperate using the Internet. The eSoC consists of net of enterprises from the same or similar branch, which are characterized by the capability of quick and dynamic adaptation to the changing market and other requirements. The eSoC concept can be very attractive to SMEs, because it refutes high entry/exit costs barrier from the traditional cluster theory.[25] Another distinctive feature of such clusters is decentralization and the lack of one central point around which enterprises are concentrated.

As e-sourcing clusters have highly distributed, decentralized character, so there is also no centralized information storage. There are many interconnected nodes (software agents) that individually interchange information and form e-sourcing clusters. This idea complies with Digital Business Ecosystems (DBE) paradigm assuming highly network-ized social and business reality. Companies acting within DBE, regardless of their size, have equal access to resources, competencies and knowledge indispensable for their goals and tasks realization. This interconnected, decentralized characteristics of DBE derive from:[26][29]

- resource limitations,
- necessity to avoid having a single point of failure,
- need to more efficient use of distributed information and resources,
- need to increase the performance and stability of the system.

As eSoC model is very closed to DBE or even it can be stated that eSoC can be a part of DBE, so other features of eSoC model corresponds with ones that define DBE. Table 2 shows these characteristics divided into three science domains: social, computer and natural science.

**Table 2.** DBE characteristics [27]

| Social Science | Computer Science | Natural Science |
|---|---|---|
| • A community of users<br>• A shared set of languages<br>• A set of regulatory norms and guidelines to foster trust<br>• A population of services<br>• An open-source service-oriented infrastructure | • Several categories of users<br>• A set of formal languages<br>• A security and identity infrastructure<br>• A service-oriented architecture<br>• A service development environment<br>• A distributed P2P run-time environment<br>• A distributed persistent storage layer | • A population of interacting agents/ apps<br>• A distributed evolutionary environment<br>• A dynamic, adaptive, learning, and scale-free network infrastructure |

Clustering within DBE can be described as extended, dynamic and knowledge-oriented (type D at figure 1). This perfectly corresponds with eSoC cluster characteristics presented in this section. Within eSoC model all business interconnections can be very dynamic and created even for one transaction. Additionally agents (companies electronic representatives) can participate in multiple virtual clusters. This type of relations in highly virtualized environment can led to global network of cooperation, one correlative economic ecosystem – Digital Business Ecosystem.

Open-source, service oriented character of DBE infrastructure require standardized, interoperable information exchange protocols. When we refer to all types of information exchange (websites, rss, social networks, emails, business messages, etc.) via computer networks, mainly internet, this desired state (combination of protocols) is called semantic web. The access to the semantic web does not require application of any specialized IT systems. Information can be process in format that is readable and understandable simultaneously for computers and humans. This sounds a little bit futuristic but if we take only business information as a subject of exchange we can refer to electronic data exchange standards as desired equivalent for eSoC model information interchange protocols.

Nowadays business information exchange standards originated from combination of EDI (Electronic Data Interchange) standards and XML (eXtensible Markup Language). Combination and extension of above-mentioned led us to multiple information exchange standards: ebXML, RosettaNet, EPCglobal Network, GDSN, BizTalk. Unfortunately there are some interoperability problems between those standards. However it is most likely that one of those standards will occur as leading one and others will have to evolve to interoperate with it or just simply will vanish from e-business reality.

In authors opinion combination of EPCglobal Network and GDSN (both supported by GS1 consortia) are the most promising background for eSoC model information

exchange. Main reason for our approach is complementarity of both standards. Global Data Synchronization Network (GDSN) corresponds for static data exchange: localization of company's facilities, product categorization and description, customers basic segmentation, etc. Whereas Electronic Product Code Global Network (EPCglobal Network) stands for dynamic data exchange: serial number of individual product, production date, product status change (shipment, warehousing, placement on store shelf), etc. Proper combination of these two standards enables efficient, unified and transparent information exchange between enterprises.

GDSN is global, internet based, network of independent data pools with central registry managed by GS1. Information within GDSN is stored locally in data pools which are highly distracted over the internet and central registry is only a map of those data pools.

On the contrary EPCglobal Network is responsible for monitoring of dynamic flows in supply chains. It is based on automatic identification technologies (e.g. Radio Frequency Identification) and allows companies to track and trace information about product flows in supply chains. The infrastructure of this Network are EPCISs – Electronic Product Code Information Services – stand alone databases with all company's dynamic data and reference for data pool with static data.

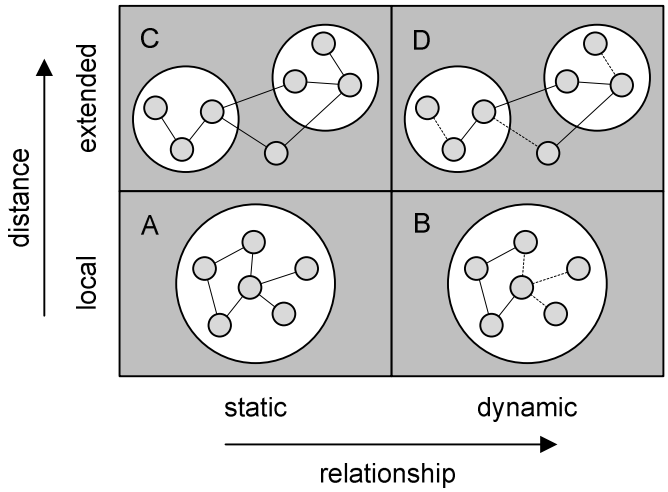


**Fig. 1.** Clustering typology [30]

This new network-ized business ecosystem can be very promising for SMEs, which can on its basis develop new competitive advantages and new competencies. Within the e-sourcing cluster SMEs can coopete[2] with big enterprises which use their size and purchasing power to get cheaper supplies and offer inexpensive goods. The

[2] Coopetition is a neologism which joins cooperation and competition. Examples of coopetition include Apple and Microsoft building closer ties on software development and the cooperation between Peugeot and Toyota on a new city car for Europe in 2005.

entities joined in eSoC share useful information and knowledge with other members in order to achieve better reciprocal understanding, acquire a wider offer range and develop a base for mutual trust that may eventually lead to collaboration in achieving the members' individual as well as collective goals.[25] Thanks to that, it is easiest to reconfigure elements of sourcing processes according to changing output requirements and the rise of a new market.[26]

Obviously, it must be remembered that in the case of eSoC some transaction costs are higher (e.g. the transportation costs are boosted due to the longer distances), but can be compensated by a lower cost of searching and choosing suppliers, contracts management, data interchange, effects of synergy, and, what is most important, lower prices of resources.

Following paragraphs will describe how companies with support of various types of software agents can utilize eSoC model for resource acquisition. Authors assume that companies within eSoC model are familiar with agent and other background technologies that must be utilized to tap eSoC potential.

First of all company must unify its processes according to GS1 standards (GDSN and EPCglobal Network). As eSoC model covers only buy-sell transactions standardization process applies just to small part of company's processes. Secondly company implements on its local server or other personal computer with static IP and internet access eSoC module (extension of EPCIS) with group of software agents, GS1 standards based database for sell and purchases transaction storage, validation mechanisms and other features responsible for data integrity and automatization of e-sourcing processes (Fig. 2).

If configuration of eSoC module and information about company (company's profile) are validated a delegated agents look for e-sourcing cluster/s (eSoC/s). If they do not find one, they create one. In the next step *leader agents* (type of software agents) of each company assigned to the e-sourcing cluster delegate other, subordinate to them, *scout agents* (another type of software agents) to search for resource with defined conditions (quantity, quality, price, shipping terms, etc.) and with proper eSoC strategy (cf. section 7). After that, *scout agents* visit all potential EPCISs (equivalent of individual e-marketplaces) and look for resources (sell offers) that meet the predefined conditions.

If *scout agent* finds proper resource, it compares resource supply (*VRs*) with it company's demand (*Dm*). Than it reserves *Rv* units of the resource, where *Rv* value depends on:

1) $Dm >= VRs => Rv = VRs$
2) $Dm < VRs => Rv = Dm$.

In first scenario only one company acquires the resource. Its demand can by partially ($Dm > VRs$) or fully satisfied ($Dm = VRs$). If $Dm > VRs$ *scout agents* keep looking for next resource offers and its *leader agents* monitor eSoCs' database for findings of other agents.

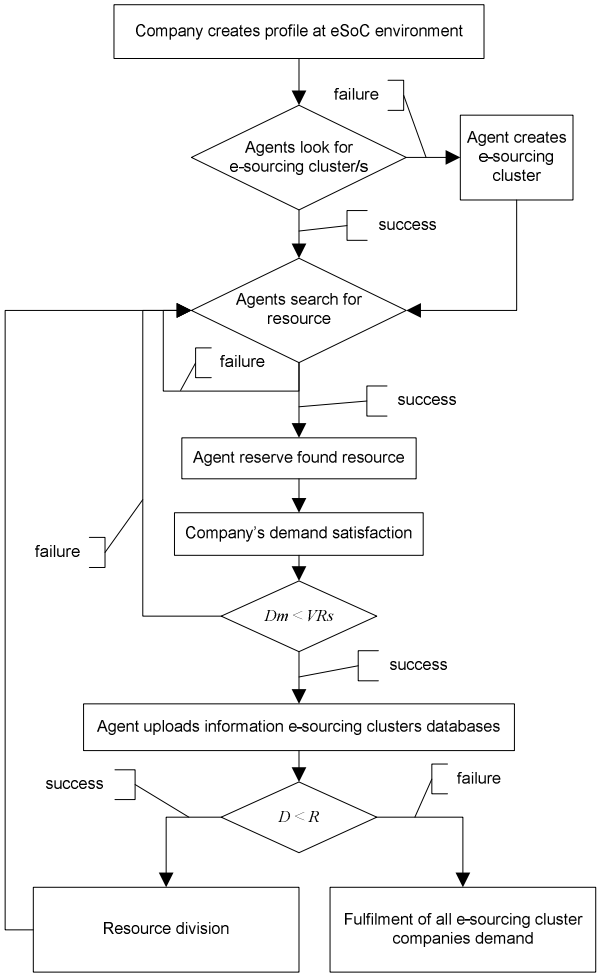


**Fig. 2.** eSoC model algotrithm

When supply of the resource exceeds demand of *scout agent*, that company satisfies whole demand. Next, *scout agent* comes back to the eSoC from which it originate and uploads information about resource into eSoC database. Than it passes the information to other eSoCs in which it participates. Notifying other agents from all of its clusters about resource results in two main advantages. On the one hand, found resource is almost always used. On the other hand the possibility of resource acquisition increase, if the company is a member of greater number of e-sourcing clusters.[17][28]

In the next step *leader agents* sum individual demands of all, interested in resource, companies in its eSoCs and set cluster demand ($D$) for found resource. Than $D$ is compared with left resource supply ($R = Vrs - Dm$). Found resources can be divided in two ways. If total demand of the eSoCs for the resource is lower than or

equal to left supply of the resource ($D <= R$), all *foraging agents* (third type of software agent presented) can migrate to the specified EPCIS and start the resource acquisition process of needed resource. In this case they fulfill all their demands. In the contrary situation, if $D > R$, authors distinguished two types of resource division methods: *First-come, First-buy* and *Proportionally*.

After that *scout agents* visit again potential EPCIS and look for the resource that meets the predefined condition. They repeat this process as long as their demands are satisfied.

## 7 e-Sourcing Cluster Strategies

As stated in section 2 and 3 sourcing should be the strategic aspect of modern enterprises. The way of resources acquisition mainly depends on supply/demand relation, resource scarcity, size of suppliers base, technological advancement of the product, resource substitutes, or cooperation level with key suppliers. On the basis of those and other market conditions company defines its sourcing strategy. Last twenty years have shown that sourcing is no longer locally oriented (sourcing from the nearest supplier is time and cost effective) and it should additionally take into account global trends in business management. Development of internet technologies supporting business, outsourcing of processes and competencies are, in authors opinion, the two most important trends that have redefined modern sourcing strategies.

When eSoC strategies ware conceptualized two main assumption ware taken into consideration. First one relates to cooperation between companies. Authors claim that orientation to collective value generation and knowledge acquisition is fundamental for companies competitive advantage and effectiveness increase. This statement is supported by works of Marshall [31], Porter [32], Prahalad [33], Williamson [34], Powell [35] to name just a few. European Commission report [36], inner alia, led authors to form second assumption about eSoC strategies: efficient, supported by information and communication technologies, information flow is crucial in the network economy.

On the basis of this two pillars – information and cooperation – authors have distinguished four eSoC strategies which refer to the level of the scout agent's empathy and the method of resource distribution. Agent's empathy is defined as *willingness to search for resources that meet the requirements of other firms (agents) from the agent's eSoCs*. Each resource has three kinds of fitness: price (*price*), place (*place*) and shipping time (*shipTime*). As eSoCs are established on location basis, the agent's empathy refers to the two extant finesses of the resource [17]: price and shipping time. Thus, the condition that found resource must meet, when the agent is empathic, can be described as:

$$price_i = \max\left(price_{1,\dots,j}\right) \tag{1}$$

$$shipTime_i = \max\left(shipTime_{1,\dots,j}\right) \tag{2}$$

The above equations show that the empathic agent seeks for resources that suit at least one firm from its eSoCs. The $price_i$ and $shipTime_i$ variables are new conditions of the empathic agent and $price_{1,\ldots,j}$ and $shipTime_{1,\ldots,j}$ are conditions of agents concentrated in the empathic agent's eSoCs. The methods of resource distribution that are enclosed in eSoC strategies on one hand correspond to the proportional share with resource acquisition, and on the other hand reflect the tough market law: first-come, first-buy. The four selected eSoC strategies are presented in table 3.

**Table 3.** eSoC strategy matrix

| | | Resource distribution | |
|---|---|---|---|
| | | first-come, first-buy | proportional |
| Empathy | no | ***egoistic*** (strategy A) | ***social*** (strategy D) |
| | yes | ***helpful*** (strategy B) | ***empathic*** (strategy C) |

## 8 Simulation Assumptions

Evaluation of each e-sourcing cluster strategy was simulated in the NetLogo environment. NetLogo is a programmable agent based modeling environment for simulating natural and social phenomena. Full description of environment and its capabilities and features can be found at [37]. Worth mentioning is fact that NetLogo works on time basis, so changeability of the simulated model over time can be observed and analyzed. Implicitly time in *Netlogo* is measured in *tick* units. *Tick* can represent any possible real time unit (second, hour, day, year, specific time period, etc.).

As in antecedent experiments [17][28] two kinds of *breeds* were distinguished: resources (*ress*) and companies (*coms*). Thanks to that we could define different behaviors and *agentsets* of both breeds.

The fitness of sought after resource was compared with the fitness of found one according to the rules:

1) *price* of found resource cannot exceed *price* declared by the company or set by empathy mechanism (1).
2) *place* of found resource must be the same as region of company.
3) *shipTime* of found resource cannot exceed *ship-time* declared by the company or set by empathy mechanism (2).

The basic number of potential e-marketplaces was assumed to be 9000. Other parameters, which were constant, are as follows:

- *cnum = 1000* – initial number of companies.
- *rnum = 1000* – initial number of resources.
- *maxResLife = 100* – maximum resource life.
- *maxShipWeeks = 1* – maximum randomization of number of shipping weeks.
- *maxCluNum* = 5 – maximum clusters number.

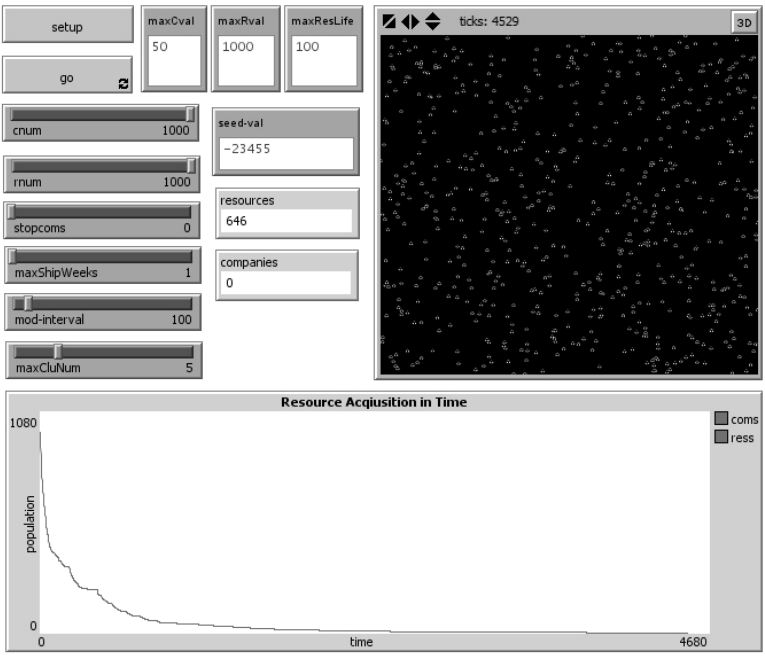


**Fig. 3.** Netlogo GUI of sample eSoC model simulation

Each strategy was simulated for various values of *maxCval* (maximum individual demand) and *maxRval* (maximum individual supply). Each variable was assumed to take the value between 50 and 1000. Its influence on strategy performance and further on whole population demand satisfaction is the main experiment measurement. Additional important assumptions, for this experiment, describing resources life cycle are:

- Method of new resources generation: every 100 ticks random *rnum* resources are generated – from 0 to 1000 resources.
- Resources are available for random *maxResLife* ticks, evaluated for each resource independently.

The simulation was run 100 times for each case (changing *max-cval* and *max-rval* by 50 and choose one of four eSoC strategies), that gives 160000 simulation experiments.

Analysis of this amount of data needed statistical methods of average values estimation based on distribution of simulation output. Below section refers to average data of eSoC simulation experiment.

## 9 Results of Simulation Experiments

Analysis of estimated average values showed that the most common is empathic strategy. Being empathic is the best choice in three situations: 1) when maximal individual

demand (*maxCval*) is relatively high (above 53% of maximum) and maximal individual supply (*maxRval*) is relatively low (below 53% of maximum) and $maxCval/maxRval \in \langle 0{,}05; 1)$. 2) when *maxCval* is relatively low (below 53% of maximum) and *maxRval* is relatively high (above 53% of maximum) and $maxCval/maxRval \in (1; 4\rangle$. 3) both variables are relatively high ($maxCval \geq 53\%$ and $maxRval \geq 53\%$ of maximal values).

Average values visualization (Fig. 3 – two middle areas) also revealed that there are conditions where the best strategy can't be selected. We distinguish two possible states of this situation. At the first area the most common strategies are B (helpful) and C (empathic), but neither is prevailing. Both strategies are empathy positive (cf. table 3) so we called this state *modern empathy*. In the second situation all four eSoC strategies are equally probable. This proves that other variables than maximal individual supply and demand have bigger influence on strategy selection in this area. It might be initial number of companies and resources, maximum clusters number, maximum resource life or even variables not included in the simulation model. In authors opinion it can be interesting direction of future research which may lead multidimensional analysis and verification of the eSoC model.

Last region at presented in this section phase diagram pertain to egoistic strategy (D). This situation can be described with three conditions: 1) both variables has relatively low values ($maxCval \leq 25\%$ and $maxRval \leq 25\%$ of maximal values). 2) $maxCval/maxRval \in (0; 1)$, $maxCval < 25\%$ of maximal values and $maxRval \in (25\%; 30\%\rangle$ of maximal values. 3) $maxCval/maxRval \in (0; 1)$, $maxRval < 25\%$ of maximal values and $maxCval \in (25\%; 30\%\rangle$ of maximal values.

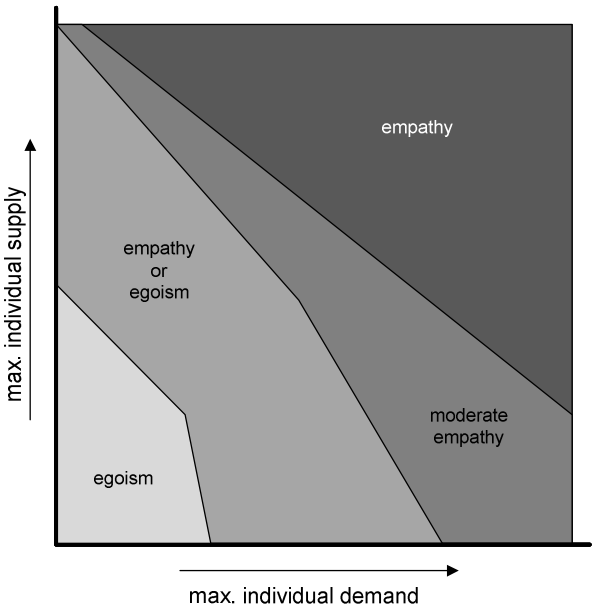


**Fig. 4.** Phase diagram of averaged simulation output data

## 10 Conclusions and Future Work

Automatic resource acquisition by enterprises is gaining more and more importance. Companies noticed long ago that cooperation with other parties is better than relying on themselves only. By merging into clusters which base on electronic business and agent technology, companies may get easier and faster access to more attractive sources. The concept of an e-sourcing cluster presented in this paper is a perfect solution for SMEs which, being its member, can respond to the increased pressures of the globalization process and cost reduction, transform themselves and boost their individual competitiveness. Also, they may take advantage of the synergy effects created by entering into cooperative relations with other SMEs and related partner institutions.

The proposed eSoC model can significantly improve the company's resource acquisition process. Additionally, Porterian cluster entry/exit costs lower than traditional ones can indirectly result in a lower risk factor of investing into a new business model. This can, in turn, lead to better cooperation, cross-companies relations and collaboration in achieving the eSoC's members' individual as well as collective goals.

The type of strategy that the cooperating companies choose is, however, of utmost importance. The authors of this paper have suggested four kinds of strategies (i.e. egoistic, helpful, social, and empathic) which depend on the level of agent empathy and the distribution methods. The choice of the best strategy is influenced by the size of resource supply on the market and the size of the demand of the enterprises belonging to the clusters. Certain tendencies have been noticed as a result of the numerous simulation experiments. For example, if the cluster demand is relatively low and the supply – high, the egoistic and social (non-empathic) strategies are more beneficial. Conversely, in the case of high demand and low supply companies benefit most from the helpful and empathic strategies.

Further work on the development of the eSoC model is planned. One of the research directions will be the bundle buying and selling possibilities implementation. Additional work will be conducted in regard to proposing practical insights into the Electronic Product Code Global Network standards as well as the Global Data Synchronization Networks standards.

Another interesting research direction will be to elaborate on the concept of highly decentralized, dispersed individual e-marketplaces. Every enterprise will be able to create such e-marketplaces even for single transactions as well as for longer periods of time.

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