Cluster, Value Network and Business Ecosystem: Knowledge and Innovation Approach

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Abstract

In this paper, three models, cluster, value network and business ecosystem, are assessed and their key features are compared. Conservative, imitative and absorptive innovation strategies are defined and their suitability to these three models is analyzed.

Keywords: cluster, value network, business ecosystem, innovation, knowledge creation, knowledge transfer

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1 Introduction

The way we perceive the business world around us is affected by various models originating from consulting, being developed in academic publications and finally finding their ways into wider acceptance. In this paper two well established models, cluster and value network, and an emerging model of business ecosystem are assessed. Especially, knowledge creation, knowledge transfer and innovation aspects in each model are discussed.

These three models have their own supporters, and they give insights to many different aspects of business life. Strict definitions are not available, and perhaps not even indispensable in practical use. However, while performing academic research concepts become tools of thought and much less latitude can be allowed. Such definitions are given in chapter 2 with assessment of different features of each model and comparison of these features.

Innovation has been a hot topic for years and quite a lot of research on how innovations happen and what should be done in order to enhance innovation has been conducted. Still, no magic formula has been found. Three innovation strategies are discussed and their suitability with preceding models is assessed in chapter 3.

Chapter 4 concludes and discusses future work.

2 Three models

Three models, cluster, value network and business ecosystem, have been chosen for analysis and comparison. There would have been also other possibilities, such as value chain (see e.g. Thompson & Strickland 2001, p. 129) or innovation network (see e.g. Küppers & Pyka 2002, p. 7). The choice has been made in order to highlight important and distinct features that these models posses.

2.1 Cluster

Cluster is a term introduced by Porter (1990). Clustering is a phenomenon linked to geographic concentrations of national industries which origin from vertical or horizontal relationships between companies. Firms in a cluster are often located in a single town or region within a nation (Porter 1990, p. 154). Other authors have also argued that regionality or locality is a major characteristic of a cluster (see e.g. Arboníes & Moso 2002, Scheel 2002, Tallman et al. 2004). According to Porter (1990) the power of a cluster lies in fierce competition within it, which obliges the firms to elevate their standards of performance. Aggressive rivalry is induced by the bargaining power of customers who may be in contact with several firms within the cluster. These connections also encourage the flow of information and diffusion of innovations. (Porter 1990, p. 151) These phenomena can also be termed spillovers. In addition to rivalry, Arboníes and Moso (2002, p. 347) claim that clusters prosper on the basis of their interaction.

According to Porter (1990, p. 152) developing clusters attract resources away from isolated firms and industries. This is because clusters can exploit these resources more efficiently. Physical proximity of world-class rivals of the same industry acts as the driving force. (Porter 1990, p. 156) The concept of industry is central in the cluster model. It is often taken as a self-evident fact that a cluster is a part or a representative of an industry (see e.g. Dayasindhu 2002, Tallman et al. 2004).

Within a cluster information about "needs, techniques, and technology" flows and is exchanged among buyers, suppliers, and related industries (Porter 1990, p. 152). At the same time, rivalry must be maintained. According to Porter (1990, p. 152), conflicts among buyers, suppliers, and rivals may prevent the flow of information, since each actor may want to keep their information proprietary. Information flow, however, is enhanced by informal ties between employers of different firms. In addition to contacts with other companies, Arboníes and Moso (2002, p. 351) state that universities are important source of knowledge for a cluster. Universities are on the supply side and firms in the demand side. This picture, however, does not take into account the importance of knowledge flow from firms to universities.

Bachtelt et al. (2004, p. 31) discuss spatial clustering of economic activity and its relation to the spatiality of knowledge creation. According to knowledge-based theory of spatial clustering, as they call it, innovation, knowledge creation and learning are results of interactive processes where actors with different types of knowledge come together to solve problems. When knowledge is codified, these processes are less space-sensitive. On the other hand, when the knowledge is tacit the interaction and exchange are dependent on the spatial proximity of the actors. Bachtelt et al. (2004, p. 31), however, criticize this reasoning since it does not take into account that interactions and transactions among firms within a cluster are often fairly limited. They (Bachtelt et al. 2004, p. 36) argue that members of a cluster benefit from their co-location because it allows them to be well informed about the characteristics of their competitors' products and about the quality and costs of their production mechanisms. According to this view, the advantages of proximity do not rise from interaction but from continuous monitoring and comparing.

2.2 Value network

According to Mariotti (2002), a value network is "an interactive combination of information machines, and people." Value networks are concentrated in creating value in each node. Fjeldstad and Haanæs (2001, p. 4) claim that value creation in a value network does not lie in transforming objects per se, but in their mediation. The strength of a value network originates from cooperation and interaction among participating companies. According to Haglind & Helander 1998) cooperation is motivated by increased revenue and reduced cost. The customer is the one in charge and other companies organize their activities around it. A company is chosen to be a member of the network because of its unique competencies. (Haglind & Helander 1998, pp. 350-351) There is an active function of choice. Value network is not seen as bound to certain region - it can even be global. The concept of industry is included in the discussion of value networks, but companies inside a value network can be parts of different industries.

Before value network we had value chain. As Turati and Ruta (2002) point out, chain refers to sequential flow while a network implies multidimensional connectedness. The connections stand for movement of products and services, but what is the role of knowledge within these connections? Does it run both ways? Where is knowledge created and does it transform within the network? Haglind and Helander (1998, p. 351) mention what kind of information they think is moving in a value network: economical figures, order quantities, transportation arrival times, quality measurements, and design specifications. In other words, it is operational information which does not have a lot to do with innovation. All information must be available to all its members (Haglind & Helander 1998, p. 351). If that happened, all resources would be tied up to communicating and receiving

information. What good would such a huge amount of information do, when there are not enough resources to analyze and exploit it?

2.3 Business ecosystem

Rotschild (1990, p. xi) states that "a capitalist economy can best be comprehended as a living ecosystem. Key phenomena observed in nature – competition, specialization, co-operation, exploitation, learning, growth, and several others – are also central to business life." The idea is to think in terms of whole systems, and appreciate your business as a part of an ecosystem.

According to Moore (1993, p. 76) members of a business ecosystem "work co-operatively and competitively to support new products, satisfy customer needs, and eventually incorporate the next round of innovations". Thus, business ecosystems base their success on both competition and cooperation. Business ecosystem rejects both regionality and the concept of industry. Moore (1996) claims that modern communication technology and global competition reduces the importance of geography. Moore (1996, p. 15) also wishes to abandon the concept of industry, since the fast-paced development of technology makes it difficult and fruitless to define such industries.

Moore (1996, p. 26) defines business ecosystem as "an economic community supported by a foundation of interacting organizations and individuals --. This economic community produces goods and services of value to customers, who are themselves members of the ecosystem. The member organisms also include suppliers, lead producers, competitors, and other stakeholders." The idea of business ecosystem is the same as of natural ecosystem. It is a system that can sustain itself without outside interventions. As time goes by it adapts to and evolves with the changes in its environment. Selection plays a major role. Business ecosystem is a complex system which exhibits complex behaviour. The concept of complexity is discussed in many papers (see e.g. Mitleton-Kelly 2003, Espejo 2003) and will not be reviewed in this one.

The idea of selection is an old one and has been developed under the title 'evolutionary economics'. The basic idea of evolutionary economics states that firm's capabilities and decision rules determine its fitness, or profitability, over which selection operates favouring the more profitable firms. Firm's capabilities and decision rules are modified by both deliberate problem-solving and random events. A firm does not maximize in its decision making as the orthodox theory suggests, but is satisfied with good enough solutions. Within this reasoning the concept of equilibrium loses its meaning. (Nelson & Winter 1982, p. 4, 12, 13) Potts (2000, p. 96) states that selection as a filtering mechanism does not favour the most profitable, but the sufficiently profitable. In order to have meaningful selection, variation must be present in the system. Tordjman (1998, p. 12) states that Darwinist competition has an evolutionary meaning only if there is variation in the population.

Selection is dependent other firms' actions and choices. Each firm's profitability is not compared to the best possible but to other firms' actual profitability. That brings co-evolution to the picture. According to Kauffman, co-evolution takes place within an ecosystem and cannot happen in isolation (in Mitleton-Kelly 2003, p. 28). Mitleton-Kelly (2003, p. 30) discusses social ecosystems and states that "in a social co-evolving ecosystem, each organization is a fully participating agent which both influences and is influenced by the social ecosystem made up of all related businesses, consumers, and suppliers, as well as economic, cultural, and legal institutions". In the context of social ecosystems Mitleton-Kelly (2003, p. 31) states that co-evolution is associated with learning and the transfer of information and knowledge. She also makes a difference between endogenous (individuals and groups within the organization) and exogenous (organizations within the ecosystem). However, it is also important to acknowledge co-evolution taking place between different ecosystems and the wider environment.

Nelson and Winter (1982, p. 277) quote Schumpeter's definition of economic

development. We should understand as "development only such changes in economic life as are not forced upon it from without but arise by its own initiative, from within". This definition of economic development is quite close to what complexity has to say about self-organization. For example, Mitleton-Kelly suggests that self-organization concerns spontaneity and new order. "This spontaneous movement is called self-organization and is one of the key characteristics of complex systems. -- It is this ability of complex systems to create new order and coherence." (Mitleton-Kelly 2004, pp. 10-11) Here self-organization is defined as a process in which novel structures or features arise in a system without the intervention of an outside actor or an inside controller. Self-organization is an ongoing process since it will never have completed its final outcome. Novelty is the contribution of self-organization and it can be specified in various ways in different systems. The lacking of an outside actor or an inside controller is the key to self-organization.

One of the features of business ecosystem is decentralized control. Each actor has only limited knowledge and limited power to effect change. Also, actors are not fully rational in their actions since it is impossible to predict future with absolute certainty. This is called bounded rationality which is discussed quite extensively in Sargent (1993) and termed as an aspect of complexity (Potts 2000, p. 186). Decentralized control also gives rise to robustness. The system is not dependent on any one of its members, but can adapt to sudden changes and recover.

Complexity applied in the analysis of economic systems shares many ideas with evolutionary economics. Potts (2000, p. 186) suggests that complexity should be defined as "the singular general principle of evolutionary framework".

2.4 Comparison of key features

These three models have a lot in common and also quite a lot of differing characteristics. Here five features have been chosen for comparison. First, we shall discuss the importance of geography. Then we analyze the role of competition and co-operation. Third, we will asses the significance of the concept of industry in each model. After that, we will discuss knowledge creation and knowledge transfer issues. Finally, we shall consider who has control or power in each model.

Depending on the author, the basic idea of cluster is either geographic concentration, locality, or regionality. This is only seldom questioned. For example, Arboníes and Moso (2002, p. 350) state that nowadays cluster benefits should arise more from cluster thinking than physical realities. Value network and business ecosystem are not based on geographic aspects. Texts about value networks place hardly any emphasis on the issue of locality versus globality. Value network can be global, but it can also be restricted to quite a limited area. Business ecosystem is deliberately rejecting the importance of geography. Because of deregulation and the development of information and communication technology, place has become a far less important determinant of success. Place has not lost its meaning, but its importance has been reduced. What a couple of decades ago would have been considered as 'international' can now be stated as 'local'. Steinbock (2003, p. 207) states that advantage should not be based on geographic but on strategic realities. Tallman et al. (2004, p. 259) are wondering whether geography even matters anymore.

The emphasis placed competition and co-operation differs in these three models. Cluster's success is based on fierce rivalry within the cluster. Value network, on the other hand, is quite strictly a co-operative structure. Each member has its tasks which are strictly defined and members are usually not competing with each other. However, there is competition when the members of a value network are chosen. Business ecosystem induces both competition and co-operation. In a capitalistic economy competition is always present, and possible methods of co-operation are strictly dictated by the law. Competition has its benefits in accelerating research and development, but it can also cause waste of resources. This can be prevented with co-operation.

The concept of industry has a significant role in texts about clusters. Porter (1990, p. 149) mentions clustering of industries as well as clustering of firms. Industry is a self-evident tool in analyzing clusters. Members of a value network can be seen as parts of different industries. The whole idea of value network arises from the notion that a single firm cannot produce the whole product by itself and needs other firms with different capabilities to complement the product. Business ecosystem rejects the concept of industry. Moore (1996, p. 13) argues that industry is no longer a useful concept in contemplating business. Moore even suggests that the term 'industry' should be replaced with the term 'business ecosystem'. Iansiti and Levien (2004), on the other hand, use the term 'industry' in their text about business ecosystem, but do not undertake a thorough analysis about it.

Knowledge creation and knowledge transfer issues are treated quite differently in these three models. Fierce rivalry within a cluster limits the willingness to share knowledge and create it co-operatively. However, 'local buzz' is quite often seen as a major benefit of co-location. Local buzz does not necessarily mean efficient knowledge transfer, but monitoring changes in the environment and answering to those aggressively. Bachtelt et al. (2004, p. 40) think that undirected, spontaneous local broadcasting may have its own benefits, but the role of intentional knowledge transfer through 'network pipelines' should not be underestimated. In value network shared knowledge can be limited to operative information, such as order quantities. Development of new products, however, requires co-operation and joint effort. Iansiti and Levien (2004, p. 18) stress that interconnectedness and shared fate are key elements of a business ecosystem. Interconnectedness can be seen as enabler and shared fate as motivator of knowledge sharing and co-operative knowledge creation.

The question 'Who has control?' can be answered in many ways. It depends on the power of negotiation that each member has. In a cluster there need not be any control at all, since the members are fairly independent of each other. In a case of joint technology development, for example, the control can be divided unevenly according to the market power that each member has. In a value network it is common that one actor is quite a lot larger than the others. Then, small suppliers that can be completely dependent on the dominant actor and must submit to its terms. In a business ecosystem control is decentralized. Although Moore (1996) claims that in each ecosystem there is a large dominant actor, so-called keystone species, it cannot dictate the terms to the extent that the leader of a value network can.

Also other features could have been analyzed. For example, whether a model is static or dynamic, modelled with agent-based simulations or differential equations are important issues. However, these features can not be included in the definitions of the models, since they are dependent on the analyzer's methodology and point of view.

3 Three strategies of innovation

It is common to refer to either innovation or imitation as means of producing new knowledge in a firm. Many authors have discussed the benefits and risks of first-movers and followers. Here, on the other hand, an approach introduced by Cantner et al. (1998, pp. 119-120) is utilized. Conservative, imitative and absorptive innovation strategies are introduced next. The concept of innovation is not analyzed here in great detail. It will suffice to note that all changes which introduce novelty to a firm are considered innovations.

3.1 Conservative innovation strategy

Conservative innovation strategy consists of exploitation of the existing technology (process innovations) and exploration of new technologies (product innovations) while relying solely on the firm's own research and development activities. All innovation efforts concentrate in creating new knowledge inside the firm. Technological developments outside the firm are neglected. Thus, knowledge is created in isolation. (Cantner 1998, p. 119)

This kind of strategy is best suited in a situation where development is to be

conducted in strict secrecy. Military technology can be an example of this. Also, in a situation where there are no other actors pursuing same kind of technology, conservative innovation strategy is valid. This is the case with a monopoly.

3.2 Imitative innovation strategy

Imitative innovation strategy is based on the exploitation of the most successful methods generated elsewhere. These firms do not take risks with unsure new technologies, but take on only those that competitors have already tried. They are satisfied with being technological followers and learning from other firms' failures. In order for this strategy to be feasible, the technology can not be subject to strict protection by patent or secrecy. (Cantner 1998, pp. 119-120)

According to Schewe (1996, p. 55), successful imitation strategy requires "strengths in the areas of technology, marketing and production, and the existence of suitable information gathering capabilities". In order to perform imitation successfully, the imitator must be able to overcome barriers established by the innovator. The imitator must also have adequate technological competencies, so-called intelligence potential, to be able to imitate a certain innovation. (Schewe 1996, p. 57, 70)

Imitation is not free, but the costs induced by imitation can be significantly lower than developing technology from scratch. Imitation can have great benefits while building a new kind of competences, but it has its limits. Building sustainable competitive advantage solely through imitation, however, can be extremely challenging.

3.3 Absorptive innovation strategy

Absorptive innovation strategy exploits external knowledge sources, but not to imitate but to achieve cross-fertilization effects in order to extend their opportunity space. The idea is to integrate the spillovers with the firm's existing knowledge stock. However, this can not be done without cost. New knowledge is not simply copied, but used for creating new opportunities with existing knowledge. Scanning the technological environment is not necessarily aimed at a specific research purpose, but to be prepared for future developments. (Cantner 1998, p. 120)

Leahy and Neary (2004, p. 3) discuss firm's "absorptive capacity", which they define as the ratio of usable to actual rival R&D. Absorptive capacity depends on the firm's own level of investment in R&D. In their analysis, Leahy and Neary (2004, p. 4) also define a parameter to represent the difficulty of absorbing rival R&D. They also emphasize that acquiring or increasing absorptive capacity is not costless, since it requires investment in own R&D.

Grünfeld (2003, p. 1092) remarks that in order to "understand, decodify and utilise" ideas and concepts of others, a firm must have certain capabilities. Also, to be able to monitor external knowledge and technology development, it is necessary to have rigorous understanding of the field.

3.4 Three models and innovation

In a cluster several firms produce same type of products or services with same type of technology. It is reasonable to think that imitation plays a major role within a cluster. Since the technology base that each firm has is quite similar, successful imitation will not be restricted by absence of adequate knowledge stock but by patent or secrecy. Conservative innovation strategy can be implemented towards firms, which are not members of the cluster. This means that members of a cluster do not take on ideas developed outside the cluster. Absorptive innovation strategy is more challenging, and must be implemented when firm in a cluster needs to create something new to the cluster.

In a value network each member has a strictly defined part or module of the whole to produce. This encourages obeying defined interfaces faithfully. In that kind of atmosphere conservative strategy among the members of the value network takes over. Each member concentrates in improving its own production processes in order to enhance quality or decrease cost. Towards firms, which are not members of the value network, imitative innovation strategy can be

implemented. In the case of co-operative product development, absorptive innovation strategy can have great benefits.

In a business ecosystem absorptive innovation strategy has great potential and can be stated as indispensable because it enhances co-evolutionary processes in a business ecosystem. If the implemented innovation strategy is either imitative or conservative, the system does not fulfil the definition of business ecosystem.

4 Conclusions and future work

Concepts cluster, value network and business ecosystem are just words and calling a system with a certain word does not change the features that the system possesses. However, concepts can be beneficial in analyzing systems and their features. In order to understand a system it must be described.

The analysis reported in this paper is a part of research about business ecosystems. Theoretical part, which will be conducted during the year 2004, will be followed by empirical research. It will include both case studies and quantitative analysis. Methodology will also involve agent-based modelling and simulation.

The contribution of the concept business ecosystem will be in providing a holistic or a system view of modern interconnected business. A wider conceptual analysis of business ecosystem is provided in Peltoniemi and Vuori (2004). According to Iansiti and Levien (2004, p. 8) a biological ecosystem offers a powerful analogy for understanding a business network. In the future, populations of companies will develop in the direction of ecosystems. According to Kelly (1994, p.189), the company of the future will and should be distributed, decentralized, collaborative, and adaptive. Moore (1996, p. 46) suggests that the key to managing such a system is in building an “ecological consciousness”. That means that managers should have a consciousness of the whole system.

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References

Arboníes, A.L. & Moso, M. 2002. Basque Country: the knowledge cluster. Journal of Knowledge Management. Vol. 6(4), pp. 347-355.

Bachtelt, H., Malmberg, A. & Maskell, P. 2004. Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. Progress of Human Geography. Vol. 28(1), pp. 31-56.

Cantner, U., Hanusch, H. & Pyka, A. 1998. Pushing technological progress forward: A comparison of firm strategies. In Lesourne, J. & Orléan, A. (eds.) Advances in Self-Organization & Evolutionary Economics. Economica. pp. 114-145.

Dayasindhu, N. 2002. Embeddedness, knowledge transfer, industry clusters and global competitiveness: a case study of the Indian software industry. Technovation. Vol. 22, pp. 551-560.

Espejo, R. Social systems and the embodiment of organizational learning. Ten principles of complexity and enabling infrastructures. In Mitleton-Kelly, E. (eds.) Complex Systems and

Evolutionary Perspectives on Organizations: The Application of Complexity Theory to Organizations. Pergamon. pp. 53-69.

Fjeldstad, Ø. & Haanæs, K. 2001. Strategy tradeoffs in the knowledge and network economy. Business Strategy Review. Vol. 12(1), pp. 1-10.

Grünfeld, L.A. 2003. Meet me halfway but don't rush: absorptive capacity and strategic R&D investment revisited. International Journal of Industrial Organization. Vol. 21(8), pp. 1091-1109.

Haglind, M. & Helander, J. 1998. Development of value networks – an empirical study of networking in Swedish manufacturing industries. IEEE International Engineering Management Conference. pp. 350-358.

Iansiti, M. & Levien, R. 2004. The Keystone Advantage: What the New Dynamics of Business Ecosystems Mean for Strategy, Innovation, and Sustainability. Harward Business School Press. 255p.

Kelly, K. 1994. Out of Control: The New Biology of Machines, Social Systems, and the Economic World. Cambridge, Perseus Books. 521p.

Küppers, G. & Pyka, A. 2002. The self-organization of innovation networks: Introductory remarks. In Pyka, A. & Küppers, G. (eds.) Innovation Networks: Theory and Practice. pp. 3-21.

Leahy, D. & Neary, J.P. 2004. Absorptive capacity, R&D spillovers, and public policy. CEPR Discussion Papers: 4171. 32p.

Mariotti, J.L. 2002. The Value Network. Executive Excellence. Vol. 19(7), p. 18.

Mitleton-Kelly, E. 2003. Ten principles of complexity and enabling infrastructures. In Mitleton-Kelly, E. (eds.) Complex Systems and Evolutionary Perspectives on Organizations: The Application of Complexity Theory to Organizations. Pergamon. pp. 23-50.

Moore, J.F. 1993. Predators and prey: the new ecology of competition. Harward Business Review. Vol. 71(3), pp. 75-83.

Moore, J.F. 1996. The Death of Competition: Leadership and Strategy in the Age of Business Ecosystems. HarperBusiness. 297p.

Nelson, R.R. & Winter, S.G. 1982. An Evolutionary Theory of Economic Change. The Belknap Press of Harvard University Press. 437p.

Peltoniemi, M. & Vuori, E. 2004. Business ecosystem as the new approach to complex adaptive business environments. To appear in the Proceedings of eBusiness Research Forum, Tampere 20.-22.9.2004.

Porter, M.E. 1990. Competitive Advantage of Nations. London, Macmillan. 855p.

Potts, J. 2000. The New Evolutionary Economics: Complexity, Competence and Adaptive Behaviour. New horizons in institutional and evolutionary economics. Edward Elgar. 239p.

Rotschild, M. 1990. Bionomics: Economy as Ecosystem. New York, Henry Holt and Company. 423p.

Sargent, T.J. 1993. Bounded Rationality in Macroeconomics. The Arne Ryde Memorial Lectures. Oxford University Press. 184p.

Scheel, C. 2002. Knowledge clusters of technological innovation systems. Journal of Knowledge Management. Vol. 6(4), pp. 356-367.

Schewe, G. 1996. Imitation as a strategic option for external acquisition of technology. Journal of Engineering Technology Management. Vol. 13(1), pp. 55-82.

Steinbock, D. 2003. Globalization of wireless value system: from geographic to strategic advantages. Telecommunications Policy. Vol. 27(3-4), pp. 207-235.

Tallman, S., Jenkins, M., Henry, N. & Pinch, S. 2004. Knowledge, clusters, and competitive advantage. Academy of Management Review. Vol. 29(2), pp. 258-271.

Thompson, A.A. & Strickland, A.J. 2001. Strategic Management: Concepts and Cases. Twelfth Edition. McGraw-Hill. 440p.

Tordjman, H. 1998. Evolution: history, change and progress. In Lesourne, J. & Orléan, A. (eds.) Advances in Self-Organization & Evolutionary Economics. Economica. pp.9-36.

Turati, C. & Ruta, C.D. 2002. Technology in knowledge based value chain. PICMET. p. 82.