DOI: 10.20472/BMC.2017.005.014

MANTAS VALUZIS
Vilnius College of Technologies and Design, Lithuania

LAURA GUDELYTE
Vilnius College of Technologies and Design, Lithuania

ON THE EVALUATION OF SYNERGY AND SYSTEMIC RISK IN INNOVATION CREATING BUSINESS CLUSTERS

Abstract:

It is necessary to be able to evaluate the synergistic effect, which is one of the key incentives for businesses to develop clusters and cooperate with each other in order to determine the efficiency of innovation creating business cluster. The synergistic effect of business clusters is one of the key factors supporting cooperation, boosting innovative operational efficiency. However, despite synergy is one of the main determinants of the business cluster establishment its evaluation is insufficiently investigated since the scientific literature has not yet offered a reliable method for determining the value of a business cluster synergy and influence the further development and commercialization of innovation in the business activities of the clusters. On the other hand, there are some fundamental prpblems to quantify the synergistic effects and to identify the factors that have a significant impact on the additional outcomes cluster activitiy. In the literature, there are many attempts to describe the synergistic effects and classify it, but this knowledge is still quite fragmented. This article aims to review the evaluation approaches of synergistic effect of business cluster activity and the structure of synergistic effect and the relationship between synergistic effect, complementarities and systemic risk in business cluster. This article identifies the major problems associated with cluster assessment modeling, and analyzed the possibilities to generalize the applicable models.

Keywords:

business cluster, synergy, structure of synergy

Introduction

Synergies of business cluster creating innovations can be achieved by sharing resources (tangible assets, know-how) between business entities if production based on utilization of these resources is subject to reducing average business entity costs, i.e. if economies of scale can be generated or if commercialization of innovative products is successful. Synergies can appear in innovation creating business cluster and can be determinated as the output of following processes (see, e.g., Iversen, 1997): sharing of indivisible resources whose acquisition costs are reduced over multiple uses; optimization of the fit among sequentially performed activities; combination of the outputs of mutually adjusted activities to achieve superior functionality of the combined output. Synergy is closely related to the optimal common utilization of resources held and, on the other hand, strongly depends on complementarity that means the ability and opportunity to compensate the fragmentation of resources and generally help to increase the overall efficiency. On the other hand, synergies are also related to business risk that in business cluster case is composed at mos due to uncertainty of innovation and due to systemic risk (i.e., relevance of each entity in networked structure). Risk of innovation and commercialization is essentially common to all cluster members, but its distribution between them is not known and also partially reflects the fraction of cluster synergies generated by the interaction between the same entities. Therefore business cluster members interested in innovative activities must understand what is necessary to control in networked collaboration.

In the literature investigating synergistic effect the main evaluation methods mentioned are the level (degree) of synergy, synergy coupling degree, entropy equation method, interval value judgment and gray correlation. Despite the attempts to assess adequately the synergistic effect, the modelling of its financial amount is still nors very vell developed. The existing assessment tools are not yet very well developed to evaluate adequately the general efficiency of business cluster performance in the context of creation of innovations. However, from the side of investors, the evaluation of the risk of innovation creation and commercialization is crucially important since this is related to the high uncertainty due to the unique, unclear, idiosyncratic and complicated activity. The expert assessment of performance parameters is not reliable and very exhaustive and in often cases does not provide the sufficient information about the state of business cluster and innovation creation and commercialization.

Complementarity and conditions for synergy

Complementarity in business cluster is distinct variable from synergy because it does not require interaction between several entities or business processes. Complementarity assumes distinct operations or areas of interests and responsibility, non-contradiction of outcomes of individual business entities becoming to cluster, and also a common objective to which all efforts of business cluster are directed and therefore it can be treated as a value of asset of business entity and is additive over whole busi-

ness cluster activity. In addition, combination of different functional strengths, e.g. when a company with strong marketing skills cooperates with a company providing advanced technologies, means the complementarity of resources and also pose a need to evaluate the relationship between the synergistic effect and the level of compementarity. Reduction of operating costs and increased efficiency of resource utilization due to interaction create the conditions for raising competitiveness and profit margins of business entities. It is an obvious necessity to coordinate further activities aimed at increasing synergies, with a view to avoid duplication and to become more effective (Graves et al., 2008). In addition, complementarity and harmonized collaboration helps to create negotiating power in negotiations with potential investors and in competition with potential competitors. In general, it is necessary condition for rational business entities from distinct business sectors to consolidate resources and collaborate in innovation creating. Typically more common sets of complementary resources are complementary product lines, technologies, created knowledge, geographical markets and potential customer groups (for more details, see also Teece, 1983).

In the case of innovation creation, the complementarities are essentially based in creating technology and its transfer from R&D institutions and business infrastructure of investors and other business entities. In addition, these categories of complementary resources typically aim for the enhancement of revenues of business entities rather than cost reductions. On the other hand, complementary reflects the systemic relevance of each busines cluster member and can also be estimated by applying the measures of systemic risk.

The focus on synergies and complementarities is treated as a way to ensure better collaboration between R&D institutions and business entities through the optimal use of available resources (for more details, see, e.g., Boekholt et al., 2013). For example, the association on different technological networks for innovative products or services and marketing is one of the efficient tools for synergistic effects utilization on performance of organization with networked structure (also see, e.g., Radeva, 2013). On the other hand, the synergistis effect anf its advantages can only be sustainable if imitation of the synergistic activities is deterred by observable commitments or impaired by isolating mechanisms such as time compression diseconomies (for more details, see Iversen, 1997). Necessary conditions for the synergistic effect in the enterprise scale are the same as conditions for profitable performace of every business company (effective internal procedures, the ability to quickly and flexibly adapt to the needs of the market, etc.). The appearance of incentives or even protectionist government policies also creates the positive impact on synergies. On the other hand, because the positive synergies are additional value to the financial result of business entity activity, it should come under even more rigorous conditions: ability to cooperate and reach an agreement with business partners for joint activities, the ability to effectively collaborate and identify opportunities when they are not seen by other partners (sharing of collective intelligence and creation of high level social capital). Usually synergies in innovation creating clusters occur due to expectations, cocordinati and potential to achieve desirable results concerning following main reasons: creating of new prod-

ucts, technologies and their development, resources, risk reduction and risk diversification, developing technical standards, reduction of costs and achieving competitive advantage, cooperation of potential rivals, or pre-emptying competitors, complementarity of goods and services to markets, co-specialization and avoidance of operations duplication in the value chain (see, e.g., Todeva, Knoke, 2005).

The main problem of the assessment of complementarity is that qualitative characteristics have a significant impact on this parameter and constitute the necessary conditions for synergies to occur, rather than added value.

Similar combinations of resources sharing and coordinating of processes can be applied to wide variety of collaborations in networaked structure of business entities since functional strengths can be transferable across businesses (see also, e.g., Damodoran, 2005). Also, this includes technology transfer from R&D institutions and sharing of know-how that can be estimated using collective intelligence measures.

Synergies evaluation approaches are based on the assumption that the efficiency of business cluster performance is directly related to the complementarity level of cluster members' activities. So synergies with complementarities related directly and arso, are inversely proportional to the whole risk that business cluster faces with. At least two different business units are necessary for a positive synergies to occur, but it is not sufficient condition, and tsufficiency criteria does not depend on the number of business units, but depend on the quality of intercooction, mutual complementarity and the level of favourable external conditions (demand for innovation etc.).

However, it is possible to achieve synergies only when the interests of business cluster members are harmonized, i.e. harmonization of expectations and interests are essential preconditions for a synergy of innovation creation process. On the other hand, besides the positive values of synergistic effect there exist some negative factors since the activity of business entity in innovation creating cluster means restricted behaviour in market. As a result, it means that the competitveness of companies acting in innovation creating business clusters, may tend to converge with companies that are not clustered, due to restricted collective behaviour of cluster members during time as they define their own field of competition from within, resulting in competitive blind spots which limit their innovation, strategic positioning to the extent of reducing their ability to react to industry-wide shock like governmental policy changes (for more details, see Kuah, 2002). Such casess mean that the harmonization of collaboration inside cluster is not sufficient condoition for positive synergy. Also, it depends on external conditions. In addition, non-clustered business entities tend to be less constrained and more adaptable to sudden industrial sectory-wide changes.

Evaluation of the synergy: non-additivity and other problems

Evaluation of synergistic effect should focus on interactivity costs and outcomes (also see, e.g., Graves et al., 2008). Evaluation of interactivity is crucial in evaluation of synergistic effects since it is necessary condition to achieve synergy. In order to eval-

uate the outcomes of a synergy, and specify whether they ensure better results than what could be achieved in case of separate activity of individual business entities it is necessary to consider the specific objectives, and contexts reflecting the business cluster specialties. The main challenge concerning the assessment of synergistic effect is related to uncertainty and poses a need to evaluate adequately the potential benefits prior to making decisions to engage business entities, and to estimate whether or not synergistic benefits from some of its components, have been achieved (for more details, see, e.g., Graves et al., 2008).

Many uncertainties still remain in assessment of innovation creating clusters synergistic effect. Few attempts have been made to assess whether first best results are obtained, go beyond efficiency in use of given resources to encompass economic results, or take into account interactions and synergies in the performance of different agents. Further, most evaluations of cluster policies pursued are focussed on single tools, which fits poorly with the systemic notion of cluster policy (Garone et al., 2012).

One of the main challenges in evaluating synergies between multilateral entities is to set the coverage of variables of the evaluative exercise, i.e. define what factor must be included and what excluded form evaluation of synergistic effects (for more details, sii Graves et al., 2008). On the other hand, it is not clear how to establish the relevance of quality characteristics of business cluster members. External (statistical) data are not useful in this case since every business cluster creating innovations is unique with unique processes of business actvity.

Approaches of assessment of synergistic effects of business cluster can be based on the methods of evaluation of individual companies in the cluster that usualy are based on level of costs, comparative analysis of activity with respect to competitors and market benchmark and level of revenues. Following Zakharova et al. (2015), the most adequate quantitative evaluation of the synergistic effect can be accessed by applying the evaluation of revenues of business companies, as well as their total profit is the result of diffusion of innovations within the business entities in cluster. Following this approach, synergistic effect is treated as the total net profit and depreciation costs resulting from the implementation of investment projects of business cluster (for more details, see Zakharova et al., 2015). However approach of discounted cash flow depends on the assumptions on the level of interest rates in financial markets that is stochastic and the term of investment project in this case, i.e. external parameter values.

There are different approaches of evaluation of synergistic effect. Analysis of collaborative relationships generating synergistic effect between entities in business cluster is based on the relationship between amounts assigned to entities, i.e., business cluster members and the amount assigned to a common outcome of business cluster. This relationship may fall into two broad cases: additive and nonadditive. As a superadivity factor of common asset value synergistic effect refers to a situation in which the total effect is simply the sum of the independent effects for each business entity (for more details, see von Eye et al., 1998). Since the synergistic effect means the superaditivity

of created value in the business cluster, it can be defined by the following formula at each time *t*:

$$S_C(t) = V_C(t) - \sum_{i=1}^{n} V_i(t), \quad (1)$$

where *n* = 1,2,… is the number of members of business cluster, $\{S_C(t), t \geq 0\}$ is the generalized total synergistic effect, $\{V_C(t), t \geq 0\}$ is the asset value of all business cluster entities, $\{V_i(t), t \geq 0\}$ is the asset value of each business cluster member. This relationship captures the subclassiffications of superadditive, subadditive, and isolated synergy. Superadditive synergy occurs when $S_C(t) > 0$, and subadditive synergy is denoted by the "whole being less than the sum of parts", i.e., when $S_C(t) < 0$. Synergy refers to the success of a business cluster only if it is positive and if it is higher than the cluster operating costs. These relations are defined by both an additive component for each member's of business cluster impact on the outcome and an interactive component for the interactivity among enities inaffecting the outcome. Isolated synergy involves the interactive component among agents, but without the influence of any additive effects for individual agents.

One of the crucial problems in assessing the synergistic effect is that it is impossible to distinguish whether the business cluster profit is determined more by more the successful cooperation reduced costs, increased complementarity, more efficient use of resources or due to innovation commercialization success mostly driven by external factors, which created a new product or new technology demand.

Structure of synergistic effect of innovation creating business cluster

Synergistic benefits can appear in many areas such as use of technology, R&D activities, manufacturing, logistics and marketing etc. Ansoff (1999) identified five types of synergy: sales synergy, operational synergy, investment synergy, management synergy, information synergy. However there are more tar ypes of synergy in innovation creating clusters. Also, the persistence of these types of synergies means a need to use an unified information framework of data collection and knowledge exchange, integration of information resources, creating collective intelligence the use of common management models and business process integration (also, see, e.g., Ilin, Anisiforov, 2014). Usually some types of synergistic force appeear in cooperation process of business entities, and it would be naive to expect the fulfillment of all types of synergy, therefore cooperation in activity of business cluster or even further inrtegration processes should take place in response to a specific target. In addition, synergies can be accidental (whose distribution is unknown) or planned therefore it should be treated as stochastic process and therefore, the structure of overall synergistic effect of business cluster is also stochastic. In addition, accidental synergies may well be identifiable in retrospect but, by definition, they have not been managed. According to Zakharova et al. (2015), consideration of cluster as a synergetic system suggests that the integration process should lead to the emergence of asynergistic effect and this reveals administrative synergies, synergy infrastructure, financial synergies, operational synergies, synergies in sales.

The members of business cluster collaborate and contribute and pool resources (financial, technical, staff, and reputational) toward achieving objectives over time. It is assumed that the cluster members do not cooperate together to reduce the tax burden in legal ways. As important component of collaboration synergy is defined by the literature as increments of wealth of the business entities belonging to business cluster. Synergistic effect of business cluster can be treated as a compound stochastic process which can be roughly decomposed into financial, managerial and operating synergy:

$$S_C(t) = S_F(t) + S_I(t) + S_O(t) + S_{res}(t), t \geq 0, \quad (2)$$

where $\{S_F(t), t \geq 0\}$ is the synergistic effect due to reduction of activity costs, $\{S_I(t), t \geq 0\}$ is the synergistic effect due to demand of innovative product, $\{S_O(t), t \geq 0\}$ is the synergistic effect due to operational issues, is $\{S_{res}(t), t \geq 0\}$ is residual part of synergy due other factors. Formula (1) means that synergistic effect as stochastic process depends on time and, on the other hand its components also variate during the time.

Remark 1. Synergistic effect and its components are stochastic processes.

In addition, synergistic effect has an adidtivity property with respect to idiosyncratic synergistic effects and can be expressed by the following formula:

$$S_C(t) = \sum_{i=1}^{n} S_i(t),\ t \geq 0, \quad (3)$$

where $\{S_i(t), t \geq 0\}$ is the idiosyncratic synergistic effect of *i*-th business entity belonging to cluster and $S_i(t) \leq V_i(t), t \geq 0$, *i* =1,2,…,*n*. Also, idiosyncratic synergy effect has the same structure as one of business cluster. In addition, it is possible to exploit additivity property of the respective components of business cluster synergistic effects:

$$\begin{cases} S_F(t) = \sum_{i=1}^{n} S_{F,i}(t), \\ S_I(t) = \sum_{i=1}^{n} S_{I,i}(t), \\ S_O(t) = \sum_{i=1}^{n} S_{O,i}(t), \\ S_{res}(t) = \sum_{i=1}^{n} S_{res,i}(t), \end{cases}, t \geq 0, \quad (4)$$

where $\{S_{F,i}(t), t \geq 0\}$ is the idiosyncratic synergistic effect due to reduction of activity costs of *i*-th business entity, $\{S_{I,i}(t), t \geq 0\}$ is the idiosyncratic synergistic effect due to demand of innovative product, $\{S_{O,i}(t), t \geq 0\}$ is the idiosyncratic synergistic effect due to operational issues of *i*-th business entity, $\{S_{res,i}(t), t \geq 0\}$ is the idiosyncratic residual synergistic effect of *i*-th business entity, *i* =1,2,…,*n*.

Remark 2. It is possible to parameterise additionaly the components of synergistic effect and systemic risk of business cluster if needed and if data are accessible, e.g., the synergy of financial activity depends not only on mutual trust and financial transactions, but also on external factors (level of interest rates, exchange rates and their changes in financial markets etc.).

The financial result of comercialization of innovation (long-term profit or loss) is relevant component of synergistic effect of generating innovation cluster. Also, it is worth to note that the value of generalized synergies can be negative, and it means that innovation appears unviable and generates losses. On the other hand, because the creation of innovation faces with increased business uncertainty, it is not clear how the synergistic effect is distributed over time and how this affects the viability of a business cluster (with particular reference to its life cycle) and each of its members (business entities) results. In principle, this effect is individual to each company and depends on its economic situation. In addition, in special case, it is not clear what should be synergistic effects to R&D institutions (despite the increased experience in commercialization which is also complicate to assess by applying quantitative approach).

Analysis of the main approaches of modelling of synergistic effect

Evaluation of synergy is important namely because it helps to define and evaluate the performance of business cluster creating innovative products which also has no additivity property. Also it is important to emphasize that relatedness of the business entities in innovation creating business cluster and relatedness of the ones in M&A case are absolutelty different because in business cluster the management and decision making of any entity remains independent in legal terms. The idea how to evaluate the synergstic effect is based on the comparative analysis that for any evaluation framework reveals what difference it would make if the cluster members were acting independently; what is the relation between interactivity inside cluster and the synergistic effect, i.e, additional outcome; what are the outcomes from different types of synergy; and what unintended outcomes (see also Graves et al., 2008). But the crucial problem is the lack of empirical data to that are necessary to compare these different approaches.

Synergy degree and synergy coupling degree models. In this case synergy degree is treated as the level of harmony between each system element in the development process, which reflects the trend of the system from disorder to order. I n the work of Yang et al. (2011) geometric mean formula adapted could be generalized by defining weighting coefficients for each cluster member. In such case it should be pissible to measure the vcontribution of each cluster member to the total synergistic effect.

It is not clear how to optimally choose the parameters characterizing each cluster member activities. This selection means the expert evaluation and depends on the available data. Selection of parameters for each cluster member would have to be an individual. Another shortage of this approach is a presumption that the same parameters are equally important for different cluster members that basically does not meet the innovation-generating cluster concept.

One of the shortages of synergy degree is the fact that it does not reveal strictly the values that are "good" or "bad." In addition, the separate ranges means uncertain interpretation of separate variable of individual entities since different cluster members'

contributions in comparison is only possible after a normalization procedure, which do not reveal each cluster member business risk burden and contribution to the final output of the business activity of the cluster. There is also the problem of how individual cluster member to identify its contribution to defining the limits (e.g., describing the individual participation in the cluster plan, the optimistic and pessimistic scenario parameters). On the other hand, this problem can be partially solved, but since the business cluster members belong to different sectors of economic activity, it is not possible to evasluate adequately their individual contribution to the synergy effect using reall data describing their activity.

Remark 3. It is possible to classify the activities of business cluster members in another ways by applying this method, not necessarily by sector of activity (and not necessarily the sector or sub-classes should be 2). However, in this case the problem of how quickly assess the effects of selecting and classifying the cluster members appears.

This evaluation method cannot be applied in the case where the quantity of cluster members is random, i.e., when the cluster members can default or join the cluster activities at any time, therefore appears the necessity to adjust this model. In addition, it is meaningful to apply the synergy degree models for assessment of systemic risk of business cluster.

Gray correlation degree. Gray correlation method is based on the gray system theory and is a multi-factor analysis technique which uses grey correlation to describe the strength, degree and sequence of the correlation between the factors. This approach allows not only solve the problems of evaluation indexes well that the evaluation indexes are difficult to quantify and accurately statistic, but also exclude the effects of personal factors. Also, this approach has a low requirement on the sample size and its regularity. It can be applied to the evaluation study with few statistical data, large data grey, great data fluctuation or non-typical distribution regularity. In addition, The calculated value of the correlation degree falls on the interval [0,1]. The larger the value is, the stronger the influence between things is. The geometric significance of the correlation degree is the difference degree of the geometrical shapes between curves which represent different things or factors (for more details, see Chen, 2012). In the case of business cluster this approach means that only aggregated data at idiosyncratic level of each cluster member can be used. As a result, it is possible to estimate the impact of each business cluster member activity on synergistic effect taking into account all relevant factors. By analogy, alo it is possible to estimate the impact of each factor on synergistic effect of business cluster activity. However this approach does not provide more detailed information about the impact of the most relevant factors of each business cluster member. In addition, unobservable variables can generate relevant impact on the synergistic effect of business cluster, and this means the serious shortage of this approach.

Entropy equation approach. The modelling of synergistic effect by applying the entropy equation approach is based on the concept of relatedness (for more details, see

Rumelt, 1974) and diversifitcation. The advantage of the entropy measure is that it is derived from a theoretical basis and not a personal preference, and that it takes into consideration small values with appropriately small weights. However this approach does not provide more detailed information about the impact of the most relevant factors of each business cluster member since it is possivble to obtain the aggretaged result: or the impact of business entity or the one of separate factor (for more details, see, e.g. Fan and Lang, 2000).

Data envelopment analysis approach (DEA). The DEA is a multivariate and non-parametric approach of evaluation productivity and providing some insights on possible directions of improvments. DEA can be carried out with either input or output orientation. In the case of innovaton creating business cluster it is possible to compare input/output data without prior assumptions about the probability distribution under study. The most relevant shortage of this approach is that it is nonparametric therefore the interpretation of evaluation results becomes more complex or uncleasr at all. Also, it is more complex to define the dependence of synergies volume on parameters. As a result, it is difficult to apply this method in order to support business decisions related to the innovative cluster activities and in order to measure impact of each business entity and each activity factor on the synergistic effect. On the other hand, unlike the parametric approach of stochastic frontier analysis, DEA is not limited to the non-linear form of multi-level of inputs and outputs (Niu et al., 2013).

In the measuring the efficiency of business cluster DEA approach does not take into account the impact of the size of the members of the business cluster on common efficiency (Novikov et al., 2016). Therefore following this approach almost always the business cluster with bigger staff will be big-effective, since it is obvious that the sum of its output will be incommensurable with the business cluster with smaller staff. On the other, hand the total input, in condition when the staff is not taken into account, leads towards the underperformance.

Interval value judgment. This approach is similar to the framework of decision tree models and it means the expert assessment that has aforementioned disadvantages. But the problem is that the evaluation is not exhaustively grounded and the scalling in this case is unclear.

Synergy as a Source of Risk

Persistence of external and internal threats to the development of innovation in business cluster is one of the reasons why it is necessary to determine why it is important to take into account the whole cluster synergy effect, which is also closely linked to the appearance of systemic risk. Synergy is also consistent with the systemic risk of a business cluster and its essence is the direct and indirect consequence of appearance of risk of diverse types (changes in the market, liquidity, credit risk, operational, moral, etc.).

Remark 4. The cluster members are systematically more relevant, the higher their level of complementarity. In this case, appear other tasks: optimal diversification of systemic risk and distribution of activities in order to maximize results and mitigate threats.

Remark 5. A large number of roughly equivalent members of cluster help to reduce systemic risk. However, a large number of cluster members itself is not sufficient to increase the degree of additionality (on the contrary, it can reduce the level of complementarity).

Usually participation of business entities in the innovation creating business cluster is a significant intervention to its substantial actvity and can therefore lead to a negative result of the co-operating companies. Therefore besides the efforts to achieve a positive synergistic effect it is necessary to look for opportunities to avoid any negative synergy. Systemic relevance and systemic risk of any entity in business cluster can be defined using so called centrality indices. Impact of the activity of individual member to entire cluster synergy is limited and depends on its systemic relevance in the whole cluster. On the other hand, essentially the same level is a systemic risk of separate cluster member throughout the business cluster. The indegree index shows the normalised number of business entity's creditors and the outdegree index the normalised number of debtors respectively. It is appropriate to calculate weighted indegree and outdegree centrality indices that describe more exhaustively the positions of credit institutions in the interbank market and they are expressed by the following respective formulas:

$$vd_{in}(i) = \frac{\sum_{j \in N(i)} x_{ji}}{\sum_{k,l=1}^{n} x_{lk}}, \quad vd_{out}(i) = \frac{\sum_{j \in N(i)} x_{ij}}{\sum_{k,l=1}^{n} x_{kl}}, \; vd_{in}(i), \; vd_{out}(i) \in [0,1], \; i = 1,2,\ldots, n, \tag{5}$$

where x_{kl} are the exposures of k-th business enity to l-th entity, k, l = 1,2,3,…, n, $k \neq l$. vd_{in} - weighted in-degree centrality index, vd_{out} - weighted out-degree centrality index, $N(i)$ is the set of all remaining business entities that have linkages with i-th, $i = 1,2,..,n$ business entity that belongs tio cluaster and satisfying the following condition:

$$|N(i)| \begin{cases} = n-1, \text{if the business cluster is complete} \\ \leq n-1, \text{if the business cluster is incomplete} \end{cases} i, j = 1,2,...,n. \tag{6}$$

In this case exposures x_{kl} are expressed in financial amaounts but in collaborating terms it can represent any transaction between several entities that creates additional value. In-closeness and out-closeness centralities of i-th business entity are given by the following formulas:

$$I_{in}(i) = \frac{n-1}{\sum_{j \in N(i)} d(i,j)}, \; I_{out}(i) = \frac{n-1}{\sum_{j \in N(i)} d(j,i)}, \quad I_{in}(i), \; I_{out}(i) \in [0,1], \; i = 1,2,\ldots, n, \tag{7}$$

where $d(i, j)$ is the distance between two business entities inside cluster, measured by the number of linkages that are needed to reach *i*-th business entity from j-th business entity $i, j = 1,2,\ldots, n, i \neq j$.

Discussion

Sinergy as the correlation of the ollaborating business entities. It is meaningful to use the approaches of correlated defaults of credit risk.to describe the cluster synergies. In this case, the business cluster is treated as a risky organization which as a social network allows sharing of mutual trust and resources specific to each individual member of the risks affecting the viability of the whole cluster (including the risk of becoming not only an individual but also systemic in nature). However, in this case, it is difficult to determine the cluster inter-relatedness level in real terms or the probability of correlated defaults- on the basis of empirical data because basically this information is inaccessible (due to the related case of insolvency, the assessment is statistically quite rare). Sisteminės rizikos perdavimo kanalai taip pat galėtų būti interpretuojami kaip verslo klasterio sinergijos pasidalijimo kanalai.

Further synergy parameterization and evaluation problems. One of the problems related to evaluation of synergistic effect is the fact that information about mutual collaboration of business entities usually is not observed. In addition, modelling of business cluster risk is also complicate due the lack of data about possible correlated defaults because such events are very rare. On the other hand, the structure of synertgistic effect in the case of innovation creating cluster, unlike as in the case of M&A, is not entirely clear, since business cluster and the merging companies act in different legal frameworks as well as increased business uncertainty generated by the innovation and commercialization process that is unique.

Quantitative evaluation of synergistic effect in the context of the cluster performance evaluation captures the following directions. Evaluation of synergistic effect can be provided by comparing the performance indicators (absolute and relative and their changes) of companies acting in business cluster and companies that are nots the members in clusters. On the other hand, the cluster organization pursues political objectives associated with maintaining enterprise attributable to certain economic activities or certain territory, and in such cases, the business cluster can receive subsidies from the budgets of different levels or investment injections on favorable terms, tax breaks. Therefore in this case, the formal basis of these external influences can also be attributed to the additional, i.e., synergistic effect of the activity in business cluster.

It is necesasary additional parameterization of business clusters performance (and in particular, the synergistic effect) to be able to describe in detail each component of synergy. In reality, the data about company performance due to collaboration with other business entities in cluster is not trackeable and, on the other hand, synergy is implicit and intuitive (e.g., in the case of M&A) result of collaboration. Therefore this information is not sufficient to evaluate adequately whether the performance of com-

panies cooperating in the innovation creating cluster is determined by the membership in the cluster namely, or depends more on another factors outside the membership of the business cluster.

Conclusions

It is possible to define necessary conditions for positive synergistic effect only, but it is not clear how to develop the sufficient conditions. Of course, it depends on the quality of collaboration inside business cluster and on the pfavourable external conditions.

Innovation creating business cluster synergies are the output of effectively coordinated and harmonized activities. Prerequisites synergies result is a sufficient mutual trust of cluster members and ability to use available resources at the most efficient way in order to supplement the other cluster member's resources and activity. Despite the fact that the cluster is often informal organization usually acting as a social network, the synergy significantly influenced by its internal structure and coordination, and execution.

Researchers do not unify structure of synergy of business clusters performance, as each innovation, generating and commercializing business cluster is unique as unique is every innovation development process.The concept proposed generalizes the structure of sybergistic effect and describes more exhaustively their properties.

Related scientific literature rather sparsely emphasizes on synergy as a source of risk (because it can acquire negative values). Analyzed approaches in use deterministic tools in modelling of synergy, and are not based on the concept of stochastic processes. Treatment of synergistic effect as an output of stochastic processes, ,making assumptions on their distributions and additional parameterization of is necessary especialy in modeling its structure and nature of synergy. Therefore, the need of observable data arises. On the other hand, it is complicated to verify synergy properties statistically due to lack of data and empirically unclear structure of synergy.

The proposed approach to determine the amount of synergistic effect is conceptual only but it helps to clearly distinguish the key factors that define efficiency of performance of innovation creating business cluster.

References

Ansoff, I. 1999 New corporative strategy, Piter-Press.

Anderson, T., Hansson, E., Schwaag, S., Sörvik, J. 2004 The cluster policies white book, Iked, Malmo.

Arikawa, Y., Takechi, K. 2012 In Search of Synergistic effects: Mergers and Productivity.

Avdonina, S.G. 2012 The synergistic effect of cluster formation and the parameters of its evaluation // Regional economy and management: electronic scientific journal, 1(29).

Boekholt, P., Allinson, R., Izsak, K., Griniece, E. 2013 Analysis of Synergies Fostered by the EIt in the EU Innovation Landscape. European Institute of Innovation and Technology: 1-41.

Chatterjee, S. 1986 Types of Synergy and Economic Value: The Impact of Acquisitions on Merging and Rival Firms. Strategic Management Journal, 7: 119-139.

Chen, B. 2012 The Application of the Grey Correlation Method in the Principal Component Analysis, Advanced Engineering Forum, 6-7: 676-681.

Damodoran, A. 2005 The Value of Synergy. Stern School of Business: 1-47.

von Eye, A., Schuster, Ch., Rogers, W.M. 1998 Modelling Synergy using Manifest Categorical Variables. International Journal of Behavioral Development, 22(3), 537-557.

Fenggeng, Q. The Research of Industrial Cluster Synergistic Effect.: 442-446.

Ficery, K.; Herd, T.; Pursche, B. 2007. Where has all the synergy gone? The M&A Puzzle, Journal of Business Strategy 28(5): 29–35.

Garone, L.F., Maffioli, A., Rodriguez, C.M., deNegri, J.A. 2012 Assessing the Impact of Cluster Policies. The Case of the Arranjos Productivos Locais in Brazil. IDB Working Paper Series No. 360, Inter-American Development Bank.

Graves, S., Wheeler, V., Foresti, M., Burall, S. Highton, N. 2008. Synergies between Bilateral and Multilateral Activities, Ministry of Foreign Affairs of Denmark, Danida, Evaluation Study 2008/2: 1-59.

Fan, J.P.H., Lang, L.H.P. 2000 The Measurement of Relatedness: An Application to Corporate Diversification: 73(4): 629-660.

He, Y 2016 Industrial Transfer under Synergy Development Analysis between Key Industries and Logistics Capability. Open Journal of Social Sciences, 4: 96-104.

Ilin, I.V., Anisiforov, A.S. 2014 Improvement of Strategic and Operational Efficiency of Clusters Based on Enterprise Architecture Model. Recent Advances in Mathematical Methods in Applied Sciences: 432-437.

Iversen, M. 1997 Concepts of synergy - Towards a clarification: 1-11.

Krishnan, H.A., Krishnan, R., Lefanowicz, C. E. 2009 Market perception of synergies in related acquisitions, Academy of Strategic Management Journal, 8: 99-119.

Kuah, A.T.H. 2002 Cluster Theory and Practice: Advantages for the Small Business Locating in a Vibrant Cluster. Journal of Research in Marketing and Entrepreneurship: 4(3): 206-228.

Maçães, M.A.R., Farhangmehr, M., Pinho, J.C. 2007 Market Orientation and the Synergistic Effect of Mediating and Moderating Factors on Performance: the Case of the Fashion Cluster. Portuguese Journal of Management Studies, 12(1): 27-43.

Niu, D., Wang, R., Zhang, X., Song, W. 2013 Comparative Studies on Efficiency of China's Regional Innovation System on the Basis of Cooperation Measurement Model, Journal of Emerging Trends in Economics and Management Sciences (JETEMS) 4(2): 147-157.

Novikov, V., Shipulina, L., Sapun, O. 2016 Accounting the Scale and Synergies in the DEA Analysis, Scientific Journal of Logistics, 12(2): 123-128.

Radeva, I. 2013 Multi-Criteria Models for Clusters Design, Cybernetics and Information Technologies, 13(1): 18-33.

Rumelt, R.P. 1974. Strategy, Structure, and Economic Performance. Division of Research, Harvard Business School, Boston.

Teece, D. 1983 Towards an economic theory of the multiproduct firm', Journal of Economic Behavior and Organisation, 3(1): 38-63.

Todeva, E., Knoke, D. 2005 Strategic Alliances & Models of Collaboration. Management Decisions,

43(1): 123-148.

Yang, Q., Yan, F., Ye, F. 2011 An Analysis of Synergy Degree of Primary-Tertiary Industry System in Dujiangyan City. International Journal of Business and Management, 6(8): 291-297.

Zakharova, E.N., Prokhorova, V.V., Shutilov, F.V., Klochko, E.N. 2015 Modern Tendencies of Cluster Development of Regional Economic Systems. Mediterranean Journal of Social Sciences, 6(5 S3): 154-163.