Static and Dynamic Models of Network Interaction in Secondary Education

M. I. Razumovskaya[1][a] and O. L. Kondratyeva[2]
[1]Department of Economics and Commerce, Far Eastern State Transport University, Serysheva str, 47, Khabarovsk, Russia
[2]School administration, Secondary school № 44, Trekhgornaya str, 80A, Khabarovsk, Russia

Keywords: Services of Secondary Education, Network Integration, Provision of Service, Network's Member, Models of Economic Relations.

Abstract: This article shows the outcomes of modelling of areas of network integration regarding the provision of services of secondary education. We have developed static and dynamic models focused on the conditions of network's functioning on the base of a regional experimental area of the Municipal Budget Educational Institution "Secondary school № 44" (in the city of Khabarovsk). Both models belong to the category of the system's structure. Their characteristics reflect the content of the following processes within the network's members' interaction: production, organization, and regulation. The results of this modelling let us to make an assessment of the recourses essential for network's members for the implementation of an educational trajectory as a student's personal choice, on the one hand; and an educational program as a public choice, on the another. In this research we have used universal scientific methods, statistical analysis' techniques, economically social research, and vector-network assessment.

1 INTRODUCTION

In Russia, unification of funding of secondary education costs with regional and municipal budgets contributes to the following principal contradiction of secondary education: to provide the implementation of educational trajectory from the point of individual choice, on the one hand; and fulfilment of educational program as a public choice - on the other. The integration lets us to alleviate this contradiction. At market, sector, and sequenced value creation level, in J. Kommons' opinion (Uni, 2017), it should set the procedure of economic interaction of its initiator and his partners, facilitating mitigation of the conflict, and realizing mutual benefits. We shall agree with it, as well as with the following point: regarding the integration, J. Kommons emphasizes the importance of private nature of the interaction's settlement, based on a mutual agreement up-on personal opportunities and interests (Uni, 2017). Several analysts point to the fact that we can observe a decreasing tendency to the depth of integration, that is a concentration level of decision making at a unified company, joint administrative body of integrated organizations. Which means the future increasing popularity of network structures in organizations and open markets. (Mintzberg et all., 2000).

2 METHODOLOGY OF RESEARCH

Initiators of a network can become the schools implementing two following models of economic relations: "market model of education aimed at free market" (paid educational services), "market model of education aimed at public market" (budget funding upon the number of students). Apart from the above, among the participants of network interaction, we can also find public schools with a "non-market model of education". For both models of secondary education, their success or failures can be explained from the point of view of the following current scientifically economical approaches: the school of intellectual capital (Kamoche and Mueller, 1998), (Kogut and

[a] https://orcid.org/ 0000-0003-3269-0264

Razumovskaya, M. and Kondratyeva, O.
Static and Dynamic Models of Network Interaction in Secondary Education.
DOI: 10.5220/0010595606620668
In *Proceedings of the International Scientific and Practical Conference on Sustainable Development of Regional Infrastructure (ISSDRI 2021)*, pages 662-668
ISBN: 978-989-758-519-7

Zander, 2003), (Foss, 2006), (Spender, 2013); approach based on knowledge (Forcadell, 2004), (Barney, 2006), (Winter, 2003), (Priem and Butler, 2001); network and evolutionary economy (Dangayach and Deshmukh, 2001). Their supporters focus on a conscious creation of the demand, aiming at implementation of the unique benefit of the service' executor (provider). And basing on this, we decide what educational programs to offer in the markets. We recall that the researches by B. Vernelfelt (Young et al., 2018) and R. Rumelt (Knott et all., 2018) based on the J.A. Shumpeter and E. Penrose' (Shumpeter,1934), (Penrose, 1959) ideas have contributed to the establishment of the approaches mentioned above.

The network's participants must analyze the following critical factors and processes (Razumovskaya, 2019): 1) the system of elements and resources (people and their specific features, capital, technology, and information) involved into production processes and providing fulfilment of the actual demand of external environment; 2) arrangement of monetization of value (goods or services) created mutually upon a request of external environment (consumer); 3) regulation of mutual requirements linked by common tasks aimed at the achievement of the desired outcome or a goal within limited time and with required resources.

The assets specificity (resources and competences) used in an educational process, as well as an economically feasible frequency of enrollment into educational programs should be considered as the primary characteristics of secondary education services. Substantially, these are the characteristics offered by O. Williamson for classification of transactions (Williamson,1996). Non-specific assets are applied upon an implementation of a generally-pedagogical method aimed at standard programs of secondary education. While specific assets are used in a private pedagogical technology implementing remedial or gymnasium educational programs, featuring low reproducibility and narrow area of distribution. Both methods contain procedural, numerical, and theoretical components; however, the generally-pedagogical technology shows stable results and absence of various "if" (conditions - Translator's Note) (if the teacher is talented, if the children are smart, if the parents are caring, etc.)

In general, the amount of finance disposed by an institution of secondary education de-pends on the gap between the income (enrollment) and outcome (graduation or transfer) of students in an academic year. The flow of financing provides the interconnection of organizational-economic operations aimed, on the demand of external environment, at the achievement of re-producible and repeatable result stipulated by the technology of educational program implementation, in a certain time fame.

This approach follows the opinions of R. Coase., O. Williamson and their successors on sustainable frames of business partnership that depend not only on technology, but also on dynamic of costs financing and benefits of various organizational alternative options (Nicita, 2014), (Baggio and Sheresheva, 2014).

3 RESULTS OF THE STUDY FINDINGS

To model an integrated educational process, we developed a three-dimensional paradigm: "capabilities, skills – integration – technologies" (Razumovskaya, 2019). Upon this paradigm, the fulfilment of actual demands of external environment is characterized in three spheres: subject, quasi-organizational, and institutional. The research of the mentioned spheres led to the development of static and dynamic models of the areas of network integration in a territorially localized market of the services of secondary education (Razumovskaya, 2019). The development of static models is based on the research of general conditions, so each child (adolescent) could succeed in the solution of his/her personal educational tasks, develop a sense of self-worth, and realize what his/her social role is and what his/her truthful beliefs are. The development of dynamic models is based on the re-search of implementation of transactional costs of subject-object relations' coordination in pro-grams of secondary education, to provide the solution of common tasks to satisfy the demands of external environment.

Both models of network structure (static and dynamic) aim at "unsuccessful" students when pedagogical technologies are supplemented with network interactions with external environment. For the regional experimental area of the Municipal Budget Educational Institution "Secondary school № 44" (in the city of Khabarovsk) this environment is performed by social and medical services, law enforcement authorities, institutions of prevention of social orphan-hood, business structures, public organizations, and private individuals. Their resources were used not only as a factor of production of an educational service, but primarily as a system of

interrelationships built around every single student for the modification of negative perception of education being essential for the future achievement of socially relevant results. The reason for this is well known: the budget does not stipulate any funding of acquisition of specific assets in different fields of activity of children and adolescents at risk groups. The designation of these assets is a positive influence on lifestyle of "unsuccessful" students because it defines the system of notional relations (motives and goals) to the actions in educational process, and situations and their results regarding provision of services.

The static structural model has been developed basing on two following methods of re-search of secondary education services aimed at "unsuccessful" students. The first demonstrates a self-development of a network. We have modeled several situations of 2015-2018 when the members' interaction was having no exposure to any supervising impact (Figure 1). The second shows a mode of coordination (Figure 2).

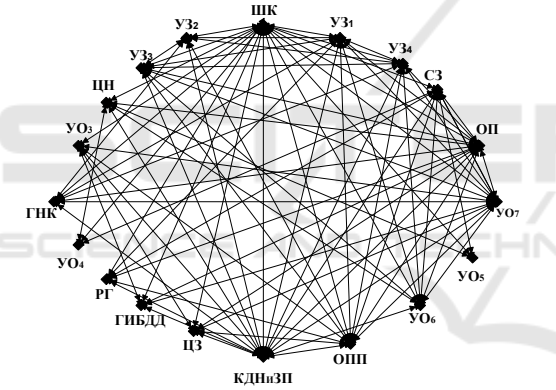

Figure 1: Static model of network structure of 2015-2018 (assessment).

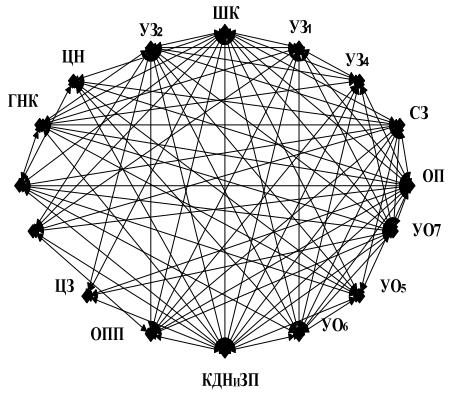

Figure 2: Static model of network structure of 2018-2020 (forecast).

An expert assessment of the coordinational impacts of the previous period of 2019-2020 was preceded by the detention of network's members and their target values of interaction. The estimation was based on an expected growth of a unit cost created within a network. For both methods we have calculated the values of density and the network's general centrality, as well as the centrality of each member of the network.

4 DISCUSSION OF THE RESULTS

Regarding the representation in detail of the evolution of initial indices of the number of interactions among the members, we have developed a dynamic model of network structure. It shows a transition of states of all considered variables to determine the positions of network's members and characteristics of the links. As a usual practice, the base of an empirical research of a model of this category is an economically social approach. In alignment with it, initial indices of the number of linkages are estimated in a range of [– 1; 1]. Upon the further movement forward with the step equal to 0.2, we have determined the qualitative interpretation of activity in a network interaction. The dynamic of network's self-development is shown by the Table 1, and the Table 2 demonstrates the mode of coordination. In order to learn the resulting values of network's interaction upon the mode of coordination, we have used the following formula:

$$x(t)=(IN+ A+ A1 +\ldots..At\ )x(0)+(IN+ A+ A1+ \ldots.. At\text{-}1)BU(0) \quad (1)$$

where $x(t)$ is a vector column of the resulting values that were determined after the launch of the mode of coordination (size$1\times n$);

N is a number of network's members;

A is a transposed matrix of interference, namely matrix of contiguity (size $n\times n$);

IN is a singular matrix (size $n\times n$);

$x(0)$ is a vector of initial tendencies of factors (size $1\times n$);

$U(0)$ is a vector of coordination, $U(0)=(u1(0),\ldots,up(0))$, where $u1(0)$ is an impulsive coordinating cooperation with the value within the interval equal to [0;1] supplied at the moment of time t=0 for the variable factor $x1$;

B - (0,1) is a matrix measured $p\times n$, whose non-zero elements identify the numbers of adjustable coordinates of the initial statement $x(0)$.

The expert assessment of a coordination impact on the previous period has been preceded by the

composition of the network's members and determination of target values of their interactions. The assessment was based on an expected unit cost created in the network. It should approach to the standard of funding per student at a school for the children and adolescents with special educational needs. We have learned that the target values of expected indices had reached the prevised level or were approaching to it, regarding the following partners: "The department of social support to the population of Kirovsky and Krasnoflotsky districts of the city of Khabarovsk"; Regional State Budget Institution "Khabarovsk Regional Centre of Psychological and Pedagogical Rehabilitation and Correction"; Regional State Budget Institution of Healthcare "Children Clinical Centre of Medical Reabilitation" "Amursky". However, among the institutions unable to achieve the target indices stated by the experts are the following: Regional State Budget Institution "Regional Youth Social Medical Pedagogical Centre "Contact"; Regional State-Owned Institution "Khabarovsk Social Rehabilitation Centre for Juvenile"; and the working group of Krasnoflotsky district in Khabarovsk.

Table 1: The assessment of indices of static and dynamic network structure providing the secondary education services for the students at a risk group on the base of the regional experimental area of the Municipal Budget Educational Institution "Secondary school № 44" (the city of Khabarovsk) in a mode of self-organization of network processes (productional, organizational, regulatory)

Characteristics of indices of static model of the structure		Characteristics of indices of dynamic model of the structure		
Network in a mode of self-organization (assessment)				
Network's characteristics	2015–2018	2008	2018	Modification, +/-
Network density, (L)	0,491			
Standard coefficient of centralization, (CD)	0,032			
Standard centralization of network's members, (CD (ni)), including				
У31 – Regional State Budget Institution of Healthcare "Children Clinical Hospital №3" in Khabarovsk	0,611	0,333	0,611	0,278 (low increase)
У32 – Regional State Budget Institution of Healthcare "Children Clinical Centre of Medical Reabilitation "Amursky"	0,389	0,555	0,389	–0,166 (slight decrease)
У33 – women's clinic of Krasnoflotsky district №3, Regional State Budget Institution of Healthcare "Maternity hospital №1" in Khabarovsk	0,500	0	0,500	0,500 (moderate increase)
У34 – Regional State Budget Institution of Healthcare "City Clinical Hospital № 10" in Khabarovsk	0,555	0	0,555	0,555 (moderate increase)
С3 – The department of social support to the population of Kirovsky and Krasnoflotsky districts in Khabarovsk	0,500	0,666	0,500	–0,166 (slight decrease)
КДНиЗП – Commission for Protection of Minors and their Rights of Krasnoflotsky district of urban district "The city of Khabarovsk"	0,889	0,555	0,889	0,334 (low increase)
УО1 – International Association of Universities "Centre of Development of Education"	-	0,222	-	Left the network
УО2 – Regional State Budget Educational Institution "Khabarovsk Regional Institution of the Development of Education"	-	0,222	-	Left the network
УО3 – Education Management of the Khabarovsk City Administration	0,333	0	0,333	0,333 (low increase)
УО4 – Regional State Budget Institution "Regional Youth Social Medical Pedagogical Centre "Contact"	0,167	0	0,167	0,167 (low increase)

УО5 – Regional State-Owned Institution “Khabarovsk Social Rehabilitation Centre for Juvenile”,	0,167	0	0,167	0,167 (low increase)
УО6 – Regional State Government-financed Institution “Khabarovsk Regional Centre of Psychological and Pedagogical Rehabilitation and	0,500	0	0,500	0,500 (moderate increase)
ОП – The department of guardianship and trusteeship in Khabarovsk	0,778	0,444	0,778	0,334 (low increase)
ГНК – Regional Administration of the Federal Service of the Russian Federation for drug trafficking control in Khabarovsky Krai and the city of Khabarovsk	0,389	0	0,389	0,389 (slight increase)
РГ – The working group of Krasnoflotsky district of the city of Khabarovsk	0,333	0,333	0,333	0 (unchangeable)
ГИБДД – The department of work with schools of the State Inspectorate for Road Traffic Safety of the Ministry of the Interior of Russia in Khabarovsk	0,222	0	0,222	0,222 (low increase)
ЦЗ – Regional State-Owned Institution “Employment center” in Khabarovsky Krai and the city of Khabarovsk	0,333	0	0,333	0,333 (low increase)
ОПП - The department of guardianship and trusteeship in the city of Khabarovsk	0,611	0,555	0,611	0,560 (slight increase)
ЦН – The Centre for Detention of Minor Offenders in the city of Khabarovsk	0,333	0	0,333	0,333 (low increase)
ОУ7 – The schools of Krasnoflotsky district in Khabarovsk (Municipal Budget Educational Institution “Gymnasium №7”, Municipal Autonomous Educational Institution “Economic Gymnasium”, Municipal Autonomous Educational Institution “Secondary school “Success”, Municipal Autonomous Educational Institution “Secondary Education School № 51”)	0,722	0	0,722	0,722 (significant increase)
ШК – Municipal Budget Educational Institution “Secondary school № 44”	1,000	1,000	1,000	0 (unchangeable)

Table 2: The assessment of indices of static and dynamic network structure providing the secondary education services for the students at a risk group on the base of the regional experimental area of Municipal Autonomous Educational Institution Secondary Education School № 44 (the city of Khabarovsk) in a mode of coordination of implementation of network processes (production, organizational, regulatory)

Characteristics of indices of static model of the structure		Characteristics of indices of dynamic model of the structure		
Network in a mode of coordination (forecast)				
Network’s characteristics	2019–2020 гг.	20018	2020	Modification, +/-
Network density, (L)	0,692			
Standard coefficient of centralization, (CD)	0,024			
Standard centralization of network’s members, (CD (ni)), including				
УЗ1 – Regional State Budget Institution of Healthcare “Children Clinical Hospital №3” in Khabarovsk	0,666	0,611	0,666	0,055 (slight increase)
УЗ2 – Regional State Budget Institution of Healthcare “Children Clinical Centre of Medical Reabilitation “Amursky”	0,800	0,389	0,700	0,311 (low increase)
УЗ3 – women's clinic of Krasnoflotsky district №3, Regional State Budget Institution of Healthcare “Maternity hospital №1” in Khabarovsk	-	0,500	-	Left the network

УЗ4 – Regional State Budget Institution of Healthcare "City Clinical Hospital № 10" in Khabarovsk	0,600	0,555	0,600	–0,005 (slight decrease)
СЗ – The department of social support to the population of Kirovsky and Krasnoflotsky districts in Khabarovsk	0,800	0,500	0,800	0,300 (low increase)
КДНиЗП – Commission for Protection of Minors and their Rights of Krasnoflotsky district of urban district "The city of Khabarovsk"	1,000	0,889	1,00	0,111 (незначительное увеличение)
УО1 – International Association of Universities "Centre of Development of	-	-	-	Left the network before 2018
УО2 – Regional State Budget Educational Institution "Khabarovsk Regional Institution of the Development	-	-	-	Left the network before 2018
УО3 – Education Management of the Khabarovsk City Administration	-	0,333	-	Left the network
УО4 – Regional State Budget Institution "Regional Youth Social Medical Pedagogical Centre "Contact"	0,600	0,167	0,600	0,433 (slight increase)
УО5 – Regional State-Owned Institution "Khabarovsk Social Rehabilitation Centre for Juvenile"	0,600	0,167	0,600	0,433 (slight increase)
УО6 – Regional State Government-financed Institution "Khabarovsk Regional Centre of Psychological and Pedagogical Rehabilitation and Correction"	0,733	0,500	0,700	0,200 (slight increase)
ОП – The department of guardianship and trusteeship in Khabarovsk	0,933	0,778	0,933	0,155 (slight increase)
ГНК – Regional Administration of the Federal Service of the Russian Federation for drug trafficking control in Khabarovsky Krai and the city of Khabarovsk	0,667	0,389	0,667	0,278 (low increase)
РГ – The working group of Krasnoflotsky district of the city of Khabarovsk	0,467	0,333	0,467	0,134 (low increase)
ГИБДД – The department of work with schools of the State Inspectorate for Road Traffic Safety of the Ministry of the Interior of Russia in Khabarovsk	-	0,222	-	Left the network
ЦЗ – Regional State-Owned Institution "Employment center" in Khabarovsky Krai and the city of Khabarovsk	0,333	0,333	0,333	0 (unchangeable)
ОПП - The department of guardianship and trusteeship in the city of Khabarovsk	0,600	0,611	0,600	–0,011 (slight decrease)
ЦН – The Centre for Detention of Minor Offenders in the city of Khabarovsk	0,467	0,333	0,467	0,134 (slight increase)
ОУ7 – The schools of Krasnoflotsky district in Khabarovsk (Municipal Budget Educational Institution "Gymnasium №7", Municipal Autonomous Educational Institution "Economic Gymnasium", Municipal Autonomous Educational Institution "Secondary school "Success", Municipal Autonomous Educational Institution "Secondary Education School № 51")	0,800	0,722	0,800	0,078 (slight increase)
ШК – Municipal Budget Educational Institution "Secondary school № 44"	1,000	1,000	1,00	0 (unchangeable)

5 CONCLUSIONS

A network is modeled as an organizational system of open type. Within the network we plan to achieve standard (reproducible) outcomes of the programs of secondary education, whose organization continually repeats within the time frame upon the modification of resources' condition impacted by the external environment. An existence of any network starts with self-organization ("organized disorganization") of its members and lasts while the actual demands of external environment are being fulfilled upon the use of external recourses.

Given that the network's opportunities are followed by the transactional costs of coordination of subject-object relations in programs of secondary education, a focus on an increase of the amount of finance and material resources within a network may become a guarantee of successful fulfillment of actual parameters of external environment. And thus, it can decrease an outflow of students at the levels of primary and secondary education.

The network's research regarding three dimensions of modification of attracted resources (subject, quasi organizational, and institutional) contributes to the solution of related tasks of synchronization of main processes (production, organization, regulation) and coordination of re-courses and competences of a school and its social partners.

And therefore, we provide an implementation of an educational trajectory from the perspective of private personal choice, on the one hand, and implementation of an educational program as a public choice, on the another.

REFERENCES

Baggio, R., Sheresheva, M.Y. (2014). Network Approach in Economics & Management: The Interdisciplinary Nature. *Bulletin of Moscow University*, 6(2):3–21, 2014. (In Russ).

Barney, J. B., (2006). Gaining and Sustaining Competitive Advantage, 3rd ed. Prentice Hall.

Dangayach, G.S., Deshmukh, S.G. (2001). Manufacturing strategy: literature review and some issues. *International Journal of Operations and Production Management*, 21:884–932.

Forcadell, F. J. (2004). A Dynamic Resource-based View of the Interaction between Technological Resources, Corporate Diversification and Performance, *Strategy and Performance*, pp.223–248.

Foss, N.J. (2006). Knowledge and Organization in the Theory of the Multinational Corporation: Some Foundational Issues, *Journal of Management and Governance*, 10(1):3–20.

Kamoche, K., Mueller, F. (1998). Human Resource Management and the Appropriation Learning Perspective, *Human Relations*, 51(8):1033–1060.

Knott, A.M., Hoopes, D.G., Richard, R. (2018). The Palgrave Encyclopedia of Strategic Management, *Palgrave Macmillan*, London, 2018.

Kogut, B., Zander. U. (2003). Knowledge of the firm and the evolutionary theory of the multinational corporation. *Journal of International Business Studies*, 34(6):516–529.

Mintzberg, H., Alsterd, B., Lempel, J. (2000). The School of Strategies, Saint-Petersburg, Piter. (In Russ).

Nicita, A. (2014). The legacy of R. Coase (1910–2013): toward a theory of institutional 'moving equilibrium'?, *International Review of Economics*, 61(2):93–108.

Penrose, E.T. (1959). The theory of the growth of the firm, New York: Oxford University Press.

Priem, R.L., Butler, J.E. (2001). Is the resource-based "view" a useful perspective for strategic management research? *Academy of management review*, 26(1):22–40, 2001.

Razumovskaya, M. I**.** (2019). Models of Integrated Interactions Organization in the Field of Environmental Education**,** *Journal of Environmental Treatment Techniques (JETT),* 7(4):576-580.

Razumovskaya, M. I**.** (2019). Abstract and pragmatic models of networking in General Education**,** *Journal of Environmental Treatment Techniques (JETT),* 7(4):847-852.

Shumpeter, J.A. (1934). The theory of economic development. Cambridge, MA: Harvard University Press.

Spender, J.-C. (2013). Nonaka and KM's Past, Present and Future, in Towards Organizational Knowledge, pp.24–59.

Uni, H. (2017). Contemporary Meanings of John R. Commons's Institutional Economics. An Analysis Using a Newly Discovered Manuscript, *Evolutionary Economics and Social Complexity Science*, vol. 5.

Williamson, O.E. (1996). Economic Institutions of Capitalism: Companies, Markets, Attitudinal Contracting, SPb.: Lenizdat, CEV Press. (In Russ).

Winter, S.G. (2003). Understanding dynamic capabilities, *Strategic Management Journal*, 24(10):991–995.

Young, S.L., Barney, J.B., Birger, W. (2018). The Palgrave Encyclopedia of Strategic Management, *Palgrave Macmillan*, London.