Simulation Modeling for School Development in Ādaži Municipality

Evija Mirke[1] Mg. sc. comp; **Sarma Cakula**[2] Dr. paed.
Rīga Technical University, Latvia[1]; Vidzeme University of Applied Sciences, Latvia[2]
evija.mirke@edu.rtu.lv[1]; sarma.cakula@va.lv[2]

Abstract: As a result of economic development in the past 20 years a geographical mobility and new settlement patterns in Latvia have occurred – wealthier people look for living space outside the big cities – in suburban areas and in closer rural territories. Houses and roads are built; more children are born. It has led to fundamental changes in society structure and lifestyle as well as caused growing demand for higher quality of education in the suburban rural territories. In Latvia, there are no models for evaluating the impact of school or municipality decisions or activities on the number of pupils in schools. To address the problem demographic and geographical migration processes in Riga region have been studied as well as theoretical aspects of decision making and the factors affecting parents' decisions before selecting the school. Methods of research: analysis and evaluation of scientific literature, data collection and descriptive analysis, simulation. The result of the research is the development of a theoretical and simulation model for analysing different the impact of different factors on the number of pupils in schools. The simulation model built during the research can be used as a supporting tool for decision-making and school planning in any municipality.

Keywords: simulation modeling, school planning, discrete choice model, school education.

Introduction

During the industrialization cities were the main places of attraction, and people from rural territories and smaller cities moved to the big cities. In the beginning of 21st century Latvia experienced economic development that led to another tendency in people's settlement patterns – wealthier people looked for a living space outside the capital Riga – in suburban areas and in closer rural territories. This process is called peri-urbanism (Kruzmetra, 2011).

Located just 25km from the Riga city centre, Ādaži region is strongly influenced by Riga, the number of inhabitants constantly increasing and thus leading to fundamental changes in society structure, lifestyles and causing more demand for education and other municipality services.

Ādaži Secondary school is a public school. The number of pupils in the school has been steadily growing for the last 10 years – in the school year 2003/2004 there were 993 pupils in the school, while in 2015/2016 the number of pupils reached 1250. Amount of births has increased – 87 new-born babies registered in 2000 and 154 babies in 2014.

Daily commuting Ādaži – Riga – Ādaži and vice versa for work/studies has also become more prevalent. A research conducted in Latvia in 2012 revealed 100 % of Ādaži population regularly commute to other regions or cities to obtain such services as education, healthcare, shopping, entertainment, recreation (Kruzmetra, 2011).

Since 1999 parents can choose any school for their child even if it is located in other administrative territory than the one where the child's place of residence is officially registered (Izglītības likums, 1998). When the geographical principle is not applied, parents and students are given full responsibility for the selection of the best school (Thelin, Niedomysl, 2015).

Previous study on this topic has investigated if parents would send their children to more distant educational establishments to offer them certain quality education or are there any other factors influencing their decisions (Burgess, Greaves, 2015). Some researchers claim that school reputation and exam/academic results are the main factors for decision (Bosetti, 2004).

There are several theories explaining decision making data. The "rational choice theory" was based on an assumption that human activity is based on rationality and that an individual makes decisions after comparing the possible gains and losses (Scott, 2000; Olssen, Peters, 2005). The "*Economic Man*" theory supported the idea that people take decisions based on the future economic results (Kahneman, Tversky, 1979; Eriksson, 2011). Other authors oppose this theory arguing that "*Economic Man has one fatal flaw: he does not exist*" (Lambert, 2006).

Following the economic rationality theory, children should go to the best schools corresponding to their abilities regardless of how far the school is located, what are the school premises and teachers' qualifications. In reality it does not happen (Chubb, Moe, 1990). Prospect theory states the most critical factors for decision making are the location of reference point and the way the individual sees the problem (Kahneman, Tversky, 1979).

Simulation (also called imitation) modeling is an approach when conducting an experiment with a model of real or non-existent system. In social sciences simulation modeling has been used since 1950s, it became more popular towards the end of 20th century.

The main purposes of simulation use are: prediction, performance, training, entertainment, education, proof, and discovery (Axelrod, 2005). K.E. Train suggests that choice models are mostly discrete and simulation gives opportunity for the researcher to approximate the choice probabilities. In "probabilistic discrete choice models" the number of alternatives is limited and the ranking and order of choices may matter in decision making process (Train, 2009).

In Latvia, some simulation models have been developed within universities, e.g., modeling foreign applicant flow in University in order to help higher education institutions attract more students (Nilanders, Cakula, 2014), however, mathematical modeling is used more.

The **problem** investigated in this study is that Ādaži municipality (one of 26 municipalities in Riga planning region) does not have a school development planning solution that would imply all the demographic/ migration data and the school selection factors.

The **goal** of the paper is to develop a theoretical and simulation model of impact factors on parents' school selection decisions and number of pupils in Ādaži Secondary School.

Methodology

To develop the simulation model author selected ISEE Systems *STELLA Modeling and Simulation Software version 9* with built-in functionality that helps to analyse the model and dynamics of a system by identifying the key variables (STELLA Professional, 2017).

The following data sources were used:

1) Statistical data from Central Statistical Bureau of Latvia (population data) (Population – Key…, 2015);
2) Statistical data from Ādaži municipality and Ādaži Secondary school (Ādažu novada..., 2016);
3) Ādaži municipality and neighbouring Carnikava municipality inhabitants' unpublished survey data in a research ordered by Ādaži municipality "par vienotas izglītības sistēmas attīstības iespējām Ādažu un Carnikavas novados" (Research "about joint education system possibility in Ādaži and Carnikava municipalities");
4) Partly structured expert interviews for validation of the theoretical and simulation model.

Before developing the simulation model a BPMN Process diagram was drawn. The diagram has been validated with Ādaži Secondary school principal and Ādaži municipality education expert. It is displayed in Figure 1.

After studying the theoretical sources and gathering the data collected from Ādaži and Carnikava municipalities' inhabitants' survey, 12 criteria were developed for implementation in the theoretical model of Ādaži Secondary School simulation model as 12 independent variables. The survey was conducted in May-June, 2015 by specialists hired by municipality. 477 respondents were questioned in total. These people were Ādaži and neighbouring Carnikava inhabitants with children <18 years of age. The collected survey results were processed in SPSS software to test the normality of data and to create frequency distribution tables for using the data in the simulation model.

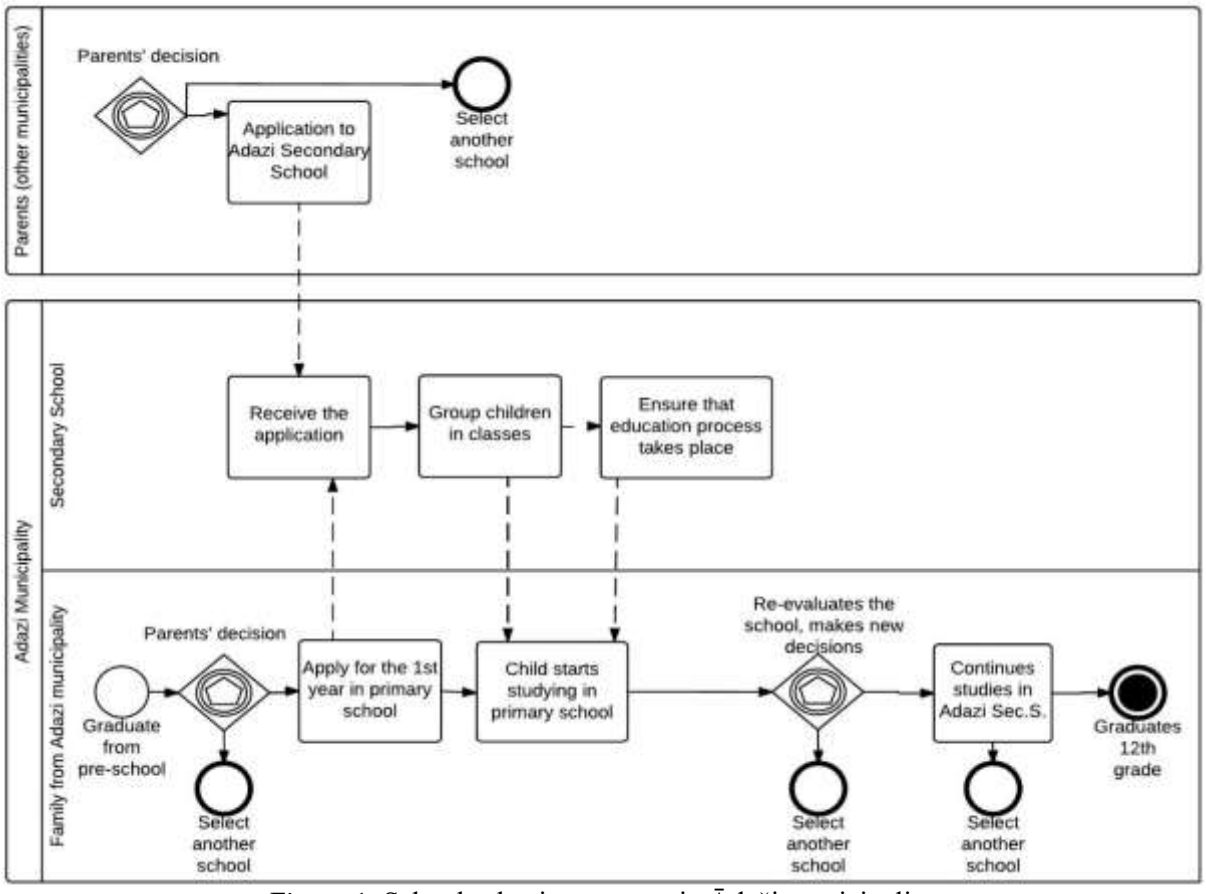

Figure 1. School selection process in Ādaži municipality.

Criteria are not absolute, and survey results show the relative importance of the weight of each factor. See (Table 4) for more detail and experts' commentary.

Table 4

School selection impact factors

Factor	Designation in the model	Experts' comment of importance for parents/pupils
F1	Music&Arts school nearby	For some parents it is important to develop their child's creativity and musicality from early childhood
F2	Various extra curricular activities	Similar as F1 but inhouse – school has to offer additional activities except the standard school programme
F3	Safety at school	Children shall be safe and feel safe at school
F4	Getting to school and transport	It has to be easy/ fast/ comfortable/ convenient to get to school by car or school bus
F5	Academic achievements	Parents are interested in current pupils' academic achievements and investigate existing pupils' grades and exam results
F6	Good infrastructure	Infrastructure shall be well planned and child-friendly (library, canteen, entrance, classrooms, wheelchair access)
F7	Distance to school	Parents have their subjective opinion about the distance how far they allow their children to travel to school
F8	Qualified teachers	A subjective factor – parents want the teachers to be highly qualified and professional, their experience is highly evaluated, parents ask for references

Factor	Designation in the model	Experts' comment of importance for parents/pupils
F9	School curriculum	When children grow older parents search for schools that develop their talents as languages, music, arts, mathematics.
F10	Qualitative equipment	School shall use modern equipment to enhance learning; these can be smartboards, laboratory equipment, computers, tablets.
F11	Location	Subjective factor of youngsters choice. Schools in the center are with higher image, schools in suburbs are not popular.
F12	Friends	For young people friends' influence is very serious – one might choose another school because of their friend.

The model was run for several times with real data on factors' impact, the results validated with education experts, and after that a new table for data input was created in *STELLA* interface see (Figure 2) to manually add new data simulating a situation of new yearly survey results received.

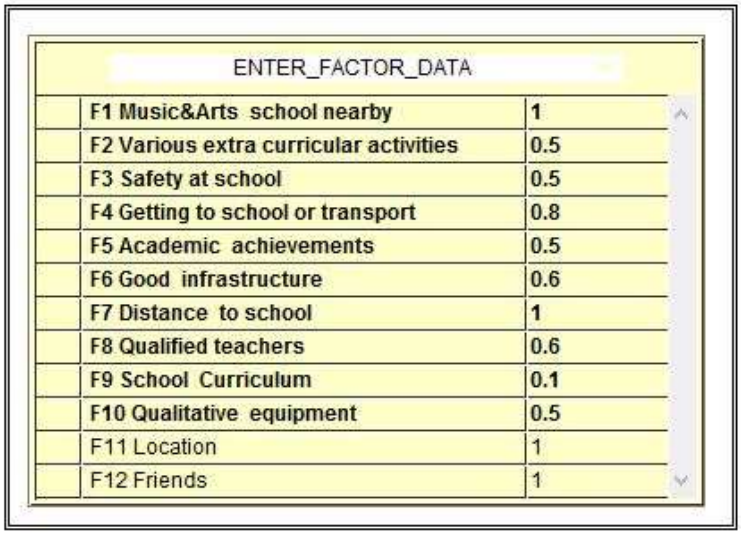

Figure 2. Table for manual survey data input (*STELLA* screenshot).

Testing the model with manual data offers the researcher opportunity to manipulate with the impact of different factors and see the results in number of pupils in primary/secondary school. School management or municipality specialists can see the possible future result of their actions, and that can help in improving the existing school services or introducing new ones.

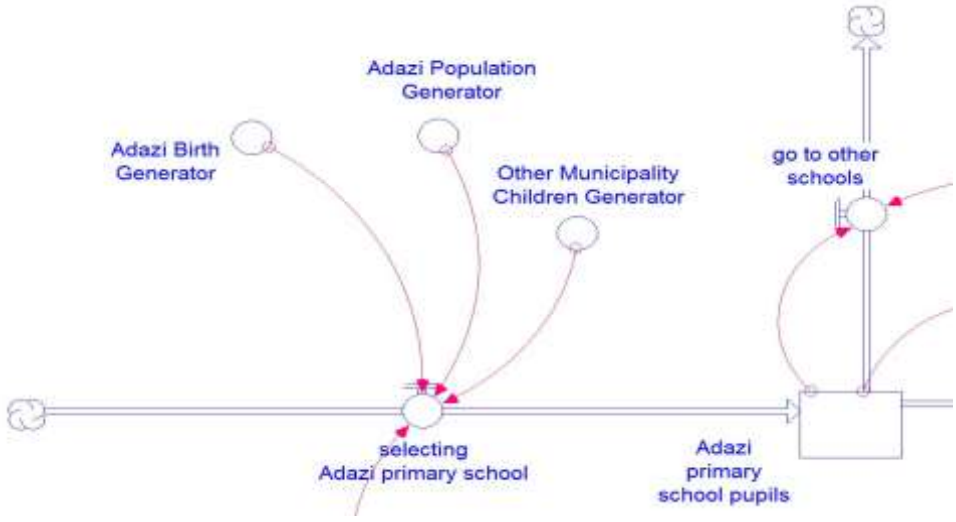

Figure 3. Flows and variables influencing number of pupils in the school (*STELLA* screenshot).

There are three data generators in the model – "Ādaži Birth Generator", "Ādaži Population Generator" and "Other Municipality Children Generator". These generators create data based on historical data statistically processed in SPSS software and influence the flow "selecting Ādaži primary school", and it is represented in the next figure (Figure 3).

As separate analysis of Ādaži and Carnikava municipality parents' answers before selecting the primary school was not the goal of the research, one decision was introduced in the model designated with "Parents' decision PP". After validation of the model with experts the second decision point was combined of 2 – parents "Parents' decision PS" and "Student decision S2", both together designated with "Family decision FD" as shown (Figure 4).

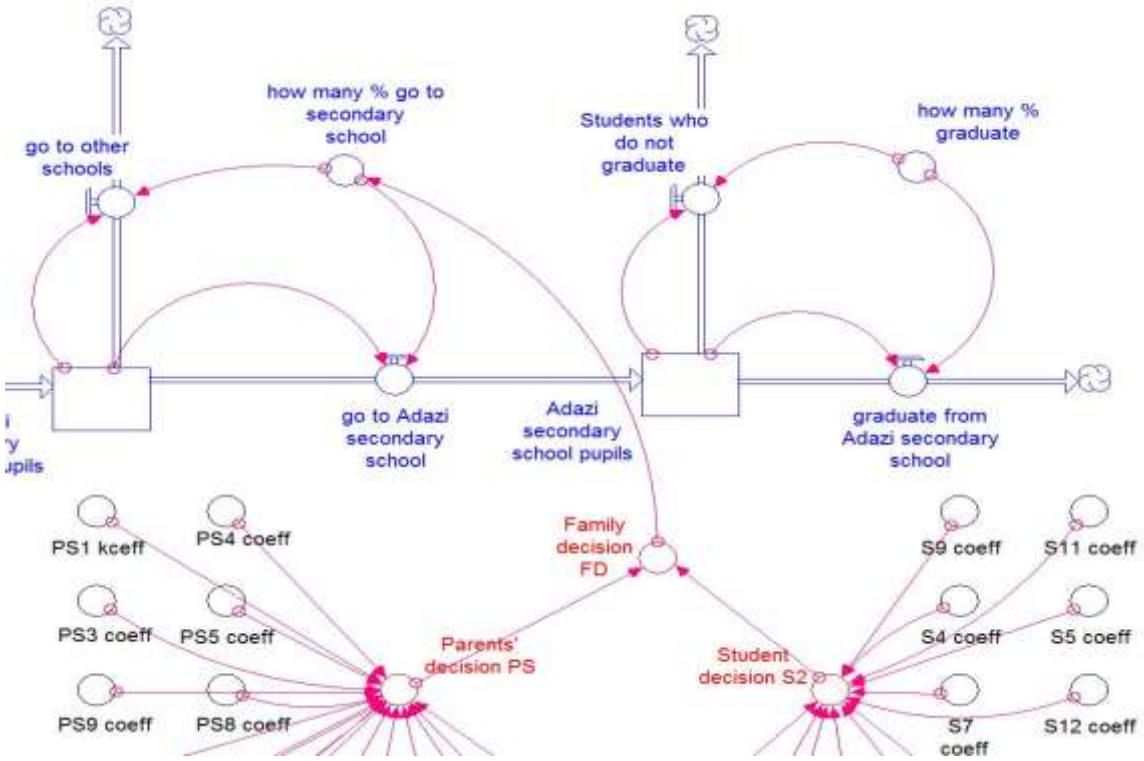

Figure 4. Example of family decisions' influence on school selection (*STELLA* screenshot).

Decision making converters ("how many % go to secondary school") and the connected flows influencing number of pupils in primary/secondary school ("go to Ādaži secondary school", "go to other schools") are also represented.

Results and discussion

A theoretical and simulation model of school decision impact factors on pupils' flows has been developed. School is an organisation with lots of children involved in the study process and it is not recommended to experiment with various decisions to see their impact in real life. The simulation model allows prioritizing actions for school development by doing the work that has the greatest impact on the total result.

The simulation model that has been developed within this research for Ādaži Secondary school implies demographic/migration data tested for normality and the school selection factors, which are used to simulate number of pupils in the school. In this way the simulation model can help to solve the school development planning problem investigated in this study.

Before expanding a school or building a new school building in suburban rural areas municipality staff could use the simulation model as it might play useful role in future development planning of education establishments as shown below (Figure 5).

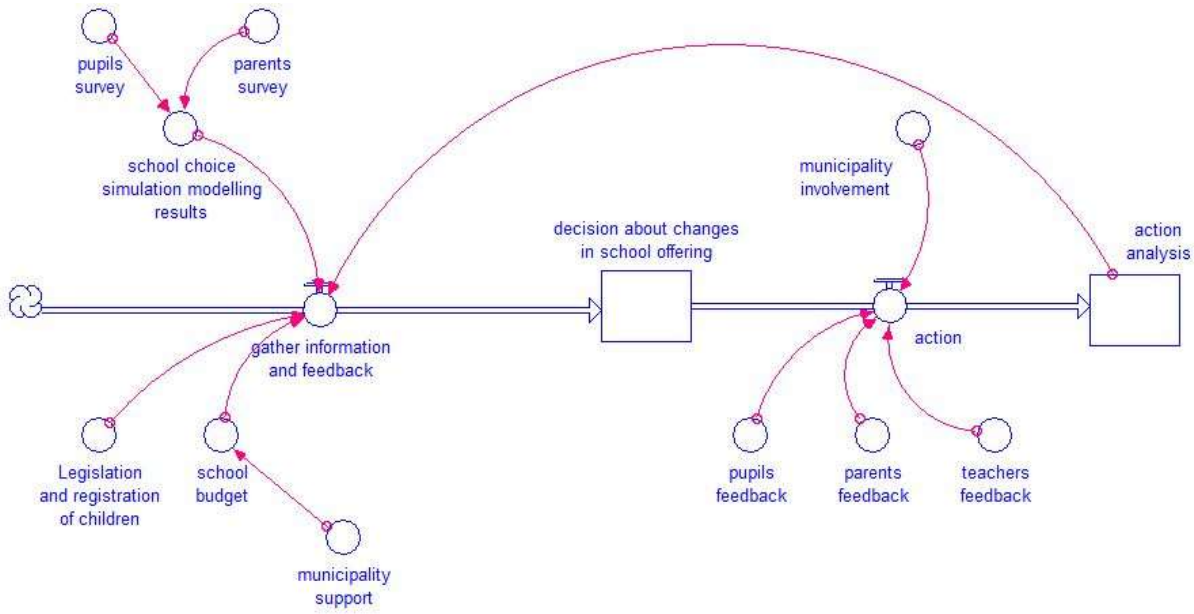

Figure 5. Role of the model in school development planning (*STELLA* screenshot).

The research was carried out in only one municipality in Riga suburban area. Quantity and quality of input data is essential for the simulation model to produce better results and to more accurately present the influence of various factors. In this case, due to Administrative territorial reform of Latvia implemented in 2009, there was a difficulty to gather older data. Regular (annual) parent & pupil surveys would contribute to collecting high quality data from all parents as well as from other inhabitants.

Recommendations for future studies

As it was evident from the theoretical model, pupils before secondary school (grade 9) are more involved in the family decision. Author sees an opportunity for doing a social research and developing the model to investigate how large is pupils' share in the school selection decisions in Latvia and to evaluate whether expanding of suburban rural schools is economically reasonable. The costs should be calculated and compared to other solutions, e.g., school buses driving from suburban rural areas like Ādaži to larger secondary schools and gymnasiums in Riga City.

Further investigation could be a deeper study of additional influence factors and their interrelationship for the simulation model. It is important to recognize simulation modeling as a supportive tool for school planning in developing municipalities.

Conclusions

Although the empirical research was carried out within one secondary school in Latvia, the author considers it topical in all municipalities in the Riga suburban area in general as certified by the interviewed education and urban planning experts.

Result of the research is a simulation model developed for a school, and it can be developed by adding new criteria such as "parents' income level", "parents' education", "friends' decision", to add new aspects to the next research. With amendments of criteria the model can be adapted for use in other areas, e.g., modeling the flows of library readers' or museum visitors. The results of this research might help municipality to plan the future of Ādaži Secondary School as well as to produce data to discover the relationship of municipality activities and the number of pupils in schools.

If municipality considers further school development an important issue for the local people, donating administrative or financial resources for local inhabitant surveys on a regular basis is crucial because the data in the model must be updated to comply with the reality. The model does not predict the future; however, simulation modeling can be a good supportive method for the school planning in addition to all the data tables and other calculations previously used for such work.

Acknowledgements

Author expresses her gratitude to Mr. Maris Sprindzuks, Ādaži Region Council Chairman, and all the experts – Mrs. Dace Dumpe, Ādaži Secondary School Principal, Mrs. Aija Tuna, Dr.paed., Director of the Initiative *Change Opportunity for Schools*, Mrs. Elita Kalnberza, Olaine 1st Secondary School Deputy Principal, Mr. Janis Turlajs, Bc.geogr., *Jāņa Sēta Map Publishers* Founder and Editor-in-Chief, for cooperation and sharing with valuable information.

Bibliography

1. *Ādažu novada izglītības stratēģija 2016-2022 (Education Strategy of Ādaži Region 2016-2022).* (2016). [online] [17.11.2017]. Available at http://www.adazi.lv/upload/attistibas_programma/1-5_pielikums_izglitibas_strategija.pdf
2. Axelrod R. (2005). Advancing the Art of Simulation in the Social Sciences. In Rennard J.P.(Ed.). *Handbook of Research on Nature Inspired Computing for Economy and Management.* Hersey, PA: Idea Group. [online] [24.01.2016]. Available at http://www-personal.umich.edu/~axe/research/AdvancingArtofSim.pdf
3. Bosetti L. (2004). Determinants of School Choice: Understanding how Parents Choose Elementary Schools in Alberta. *Journal of Educational Policy*, Vol. 19 (4). [online] [06.11.2016]. Available at https://www.researchgate.net/publication/233375254_Determinants_of_school_choice_Understanding_how_parents_choose_elementary_schools_in_Alberta
4. Burgess S., Greaves E., Vignoles A., Wilson D. (2015). What parents want: school preferences and school choice. *The Economic Journal*, Vol. 125 (587). pp. 1262 – 1289.
5. Chubb J. E., Moe T. M. (1990). Politics, Markets, and America's Schools. Washington, DC: Brookings Institution Press.
6. Eriksson L. (2011). *Rational Choice Theory: Potential and Limits*. New York: Palgrave Macmillan.
7. *Izglītības likums (Law on Education).* (1998). Latvijas Republikas tiesību akti, Rīga: LR Saeima. [online] [06.11.2016]. Available at http://likumi.lv/doc.php?id=50759 (in Latvian).
8. Kahneman D., Tversky A. (1979). Prospect Theory: An Analysis of Decision under Risk. *Econometrica*, Vol. 47 (2), pp. 263 – 291. [online] [06.11.2016]. Available at https://www.uzh.ch/cmsssl/suz/dam/jcr:00000000-64a0-5b1c-0000-00003b7ec704/10.05-kahneman-tversky-79.pdf
9. Kruzmetra Z. (2011). *Piepilsētas lauku teritorijas apdzīvojuma pārmaiņas Latvijā (Changes in Population in Suburban Rural Territory in Latvia)*. Doctoral thesis. Rīga: Latvijas Universitāte. (in Latvian).
10. Lambert C. (2006). The Marketplace of Perceptions. *Harvard Magazine*. [online] [15.11.2016]. Available at http://harvardmagazine.com/2006/03/the-marketplace-of-perce.html
11. Nilanders K., Cakula S. (2014). Modeling potential foreign applicant flow: Case of Vidzeme University of Applied Sciences. In proceedings of the *IEEE Global Engineering Education Conference (EDUCON)*, Vol. 5. Istanbul: Bogazici University.
12. Olssen M. Peters M.A. (2005). Neoliberalism, higher education and the knowledge economy: from the free market to knowledge capitalism. *Journal of Education Policy*, vol. 20 (3). pp. 313 – 345.
13. *Population – Key indicators.* (2015). Central Statistical Bureau of Latvia [online] [17.11.2016] Available at: http://www.csb.gov.lv/en/statistikas-temas/population-key-indicators-30624.html
14. Scott J. (2000). Rational Choice Theory. In Browning G., Halcli A., Webster F. (Eds.) *Understanding Contemporary Society: Theories of the Present*. Thousand Oaks, CA: Sage Publications. [online] [06.11.2016]. Available at http://msap-unlam.ac.id/download/bahan__bacaan/Rational%20choice%20theory.pdf
15. *STELLA Professional. The next generation modeling experience*. (2017). ISEE SYSTEMS [online] [19.11.2016]. Available at http://www.iseesystems.com/store/products/stella-professional.aspx
16. Thelin M., Niedomysl T. (2015). The (Ir)Relevance of Geography for School Choice: Evidence from a Swedish Choice Experiment. *Geoforum*, Vol. 67., pp. 110 – 120. [online] [06.11.2016]. Available at https://lup.lub.lu.se/search/ws/files/2087005/8230782.pdf
17. Train K.E. (2009). *Discrete Choice Methods with Simulation* (2nd ed.). New York: Oxford University Press. [online] [06.11.2016]. Available at http://eml.berkeley.edu/books/choice2.html