Preprints of the 21st IFAC World Congress (Virtual)
Berlin, Germany, July 12-17, 2020

Ambient Assisted Living in Lifetime Neighbourhoods

David Bogataj*,, Valerija Rogelj**, Eneja Drobež** and Alenka Temeljotov Salaj*****
david.bogataj@ef-uni-lj.si
valerijarogelj@gmail.com
eneja.drobez@inrisk.net
alenka.temeljotov-salaj@ntnu.no

***University of Ljubljana, School of Business and Economics, Slovenia**
****Institute INRISK, Slovenia**
***** Norwegian University of Science and Technology, Norway**

Municipalities are responsible for organizing and financing long-term–care services. These expenditures will triple in the next 40 years (to 9.5% of the GDP of Norway). This study seeks to investigate the exposure to different risks presented by the built environments of current neighbourhoods and the valuation of the benefits attained through the development of lifetime neighbourhoods. Ambient assisted living technologies embedded in lifetime neighbourhoods can significantly decrease the risk of falls and other accidents. Digital social networks and other support to the community can facilitate inclusion and mitigate loneliness. The spatial planning, development, and management of lifetime neighbourhoods with embedded ambient intelligence as a risk mitigation strategy in fast ageing cities are of specific interest. We wish to evaluate how the development of lifetime neighbourhoods mitigates the risk of accidents and social exclusion, thereby creating value for the community. The creation of value by the mitigation of the risk of falls, diseases, and social exclusion will be measured with the actuarial present value generated using the multiple decrement model approach, which is a novelty. The actuarial present value will provide scientific evidence of the benefits of the development and management of various lifetime neighbourhoods and housing arrangements.

Keywords: ambient assisted living, lifetime neighbourhood, independent living, assisted living, housing with care, health care, long-term care, population ageing

Acknowledgement: This research has been partly supported by the Slovenian Research Agency under the grant no J6—9396 and J5-1784 in the framework of the programs P5-0364

1 INTRODUCTION

The ageing of the European population is rapidly progressing, and the proportion of citizens who are 65+ will surpass one quarter by 2040 (EC, 2017). Older adults have different needs regarding the safety of their environments and homes. According to the World Health Organization (WHO), physical and social environments are key determinants of whether people can remain healthy, independent and autonomous long into their old age. Falls often cause severe injuries and are one of the most costly health conditions among older adults. Many falls are preventable. Accessibility to an age-friendly environment that can accommodate the functional capacities of residents and the development of lifetime neighbourhoods are important factors that can enable older adults to live longer in the community. Creating age-friendly urban environments in lifetime neighbourhoods is, therefore, one of the most effective approaches to respond to the demographic changes. The primary components of a lifetime neighbourhood include: (a) support to residents to develop lifetime neighbourhoods – especially resident empowerment, (b) access, (c) services and amenities, (d) built and natural environments, (e) social networks/well-being, (f) housing.

The European Charter of Fundamental Rights ensures the rights of the elderly to lead a life of dignity and independence and participate in the social and cultural life (Article 25) as well as the right to social and housing assistance to ensure a decent existence to all those who lack sufficient resources (Article 34(3)).

Ambient Assisted Living (AAL) refers to concepts, products and services that combine new technologies and the social environment to improve quality of life at any age. Using ambient intelligent technologies enables older adults to live independently for as long as possible. Such technologies offer an ecosystem of different types of sensors, computers, mobile devices, wireless networks and software applications for personal healthcare monitoring and telehealth systems. These technologies should be used in combination with the development of an age-friendly environment in lifetime neighbourhoods. Buildings and public spaces without obstacles promote the mobility and independence of people with declined functional capacities. Families experience less stress if their older members have community support and a suitable living environment. AAL with ICT support embedded in age-friendly neighbourhoods serves as a safe and pleasant environment that is adapted to older adults' functional capacities. An age-friendly environment enables safe mobility, and the residents are provided ICT-supported services. AAL technologies embedded in lifetime neighbourhoods can create value for organisations managing supply networks and offering long-term care services (Božič and Dimovski, 2019), improve timing of operations (Bogataj and Grubbström,2012). improve efficiency and effectiveness and thereby decrease their operational costs which subsequently influences their sustainability (Peterlin et al., 2018). When developing home care service systems timing of operations is of utmost importance for preserving health and wellbeing of users so appropriate supply networks need to be developed (Usenik, and Bogataj,2005). Delays in the provision of services from the realisation of risk (events leading to poor health and disability) must be taken into consideration (Bogataj, M. and Bogataj, L., 2004). Location o service centers influencethe delays (Kovačić el. Al., 2015). Therefore, location of service centres in the neighbourhood is extremely significant (Grubbström et al., 2010). This is important since the ageing and shrinking of the workforce will reduce available human resources in lifetime neighbourhoods (Žnidaršič and Dimovski, 2009; Grah et al., 2018; Dimovski, Grah and Colnar, 2019), where a shortage of nurses is expected to present a special challenge. An improvement in education can significantly increase the productivity and sustainability of supply systems (Peterlin et al., 2018) especially when supported by smart technologies (Arh, Jerman-Blažič and Dimovski, 2012). Ambient assisted technologies can provide interactive learning environments (Škerlavaj and Dimovski, 2007) and support the development of knowledge-intensive learning environments (Škerlavaj el al., 2010). It enables the faster dissemination and acquisition of knowledge in organisations providing facilities and services to older adults. Intra-organisational learning (Dimovski et al., 2008) could contribute to a faster adaptation of ambient technologies and the development of personalised long-term care services in lifetime neighbourhoods that cater to the needs of older adults with declining functional capacities and improve their wellbeing while reducing the cost of services due to improved organisational performance (Dimovski and Škerlavaj, 2005; Hernaus, Škerlavaj and Dimovski, 2008). Optimal investments in supply networks need to be considered (Kovačić, Usenik, Bogataj, 2017). The possible development of Ambient Assisted living in Germany is described by Marsiske et al. (2010).

Several international covenants impose a binding obligation on the EU member states to fulfil the right to housing, such as the Universal Declaration of Human Rights (UN General Assembly, 1948) in Article 25 and the International Covenant on Economic, Social and Cultural Rights (UN General Assembly, 1966) in Article 11(1). According to the General Comment No. 4 on Adequate Housing, the right to housing is a right enjoyed by all individuals (UN Committee on Economic, Social and Cultural Rights, 1991). Although the General Comments are not binding, they impose a binding obligation on the state to fulfil the right to appropriately built housing units. The state's progressive commitments to take steps towards the full realisation of the right to proper housing was reaffirmed in the Mohamed Ben Djazia and Naouel Bellili v. Spain case.

According to our research undertaken in 2018, most of the municipality residents (58%) do not have experiences with a decline in functional capacities. They do not have a friend or family member who is dependent on the help of others. From this, we can conclude that a survey that includes the entire population in the sample is not properly constructed to capture the preferences of older adults who are dependent on the help of others. Demand for AAL housing to meet the needs of older adults with decreasing functional capacities could be calculated using the multiple decrement model. Therefore, we can determine the required structure of housing stock on the basis of the multiple decrement approaches developed by Bogataj et al. (2016), using the principles of actuarial mathematics (Gerber, 1997).

2 THE MULTIPLE DECREMENT MODEL

Functional capacities, both physical and cognitive, develop during childhood. The peak is reached in early adulthood, after which it starts to decline. Some earlier and others later, individuals reach the threshold when they need to find a more suitable living environment or move to a nursing home, both of which are associated with higher expenditures.

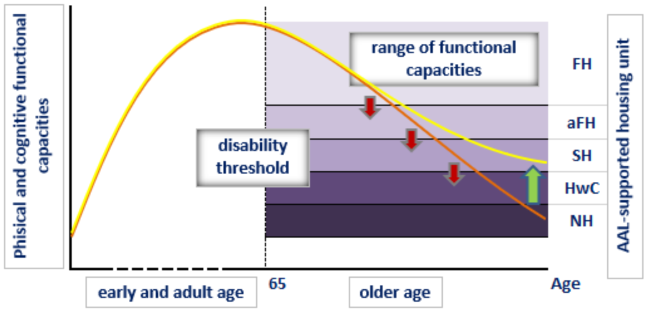

Figure 1: Supporting environment and decreasing the thresholds of functional capacities

AAL support environment accommodates functional decline of residents and supports mitigation of age-relates risk realisation of which is leading to ill health and disability (falls and) and therefore enables older adults with declining functional capacities to stay longer in the community, and therefore postpone or even prevent reallocation to nursing homes $(t_0 \rightarrow t_1)$. This is shown by movement from point A to point B and consequently by movement thresholds downwards.

An individual's independence and autonomy do not depend exclusively on their physical and cognitive abilities but also on the environment (Drobne and Bogataj, 2005, 2012, 2013, 2015, 2017; Drobne et al., 2011, 2011a, Bogataj et al., 2011, 2012; Lisec et al., 2008). The investments in specialised housing should be determined systematically (Janež et al., 2016, 2018; Janež and Bogataj, 2018).

The rate of decline is largely dependent on and linked to one's way of life and external social, environmental and economic factors.

Knowing (a) the possible and (b) desired options of older inhabitants to move in an AAL housing unit, we shall model the demographic structure of lifetime neighbourhoods and therefore demand for new and more accommodative housing stock with embedded AAL technologies.

The migrations should be monitored and reported based on the functional capacities of residents. Figure 1 shows the graph of migrations among AAL-supported dwellings that will be under consideration. The notation in the diagram is the following (see the details in Bogataj et al., 2016): adFH – adapted family house, FH – family home, SH – independent living housing: sheltered housing and HwC – AAL-supported housing units with care.

We denote the initial state as state 0 and the decrement which requires dwelling in lifetime neighbourhood of type j by the line of the graph from this parent node to the state (child node) j, $j = 1, 2, ..., m$. On this graph, we describe the probabilities of transition (move in the lifetime neighbourhood) from the state 0 to further states to the child node (state) $j \in H$ or in general from the parent node to the child node j at various ages. The probabilities depend on the age structure, functional capacities, preferences to move and the financial abilities and support networks of the potential users. All paths determine the required dynamics for constructing the appropriate capacity of the AAL network and available dwellings in lifetime neighbourhood of type j; it implies the inventories of AAL-supported housing units in the process that should be completed in the lifetime neighbourhood at the time forecasted. In the multiple decrement setup, transitions between any two states from i to j, $i > j = 1, 2, ..., m$ are not possible (directed graph) (see the basics in Gerber, 1997 and some advanced solutions in Deshmukh, 2012).

The transitions are successive according to the functional capacities, capacities of the neighbourhood AAL system, the available intensity of care and available AAL-supported housing in the neighbourhood. We will denote $i = 0$: FH family dwelling with fully functional and autonomous residents without the need for care;

$i = 1$: AAL-supported homecare in the adopted family home (adFH);
$i = 2$: AAL-supported housing unit in sheltered housing campus (SH);
$i = 3$: AAL-supported housing unit with available care services (HwC); and
$i = 4$: nursing home (NH); $i = 5$ dead (D).

We will denote the type of housing unit in which the resident is currently residing with i ($i = 0$ to 4); and the type of housing unit to which the resident is moving due to declining functional capacity with j (resettlement from the type of facility i to j; $j =$ 1 to 5). The details of the migrations can be modelled as a directed graph in Figure 1, as simplified in Figure 2. Based on the demographic statistics including the population's income, one can calculate the expected needs of older adults in the studied area and the probabilities of transitions among the different types of dwellings. Such transitions can be financed by personal insurance products, properly developed reverse mortgage schemes or on the basis of national insurance schemes (Bogataj et al., 2015, 2016)

To successfully forecast the different dwelling needs of seniors – and, therefore, the optimal structure of the housing stock – based on the decreasing functional capacities of residents and the effective demand, we must know the probability distribution of $T_i(x)$, the time that a senior resident will spend in the dwelling of type i, $i \in$H.

We suppose that the resident moves to the type of housing unit that optimally suits their functional capacities. The probability of transition in the model should be calculated based on the results of surveying the elderly and the observations of moving from one dwelling type to another if the supply is high enough and the state subsidies are adequate.

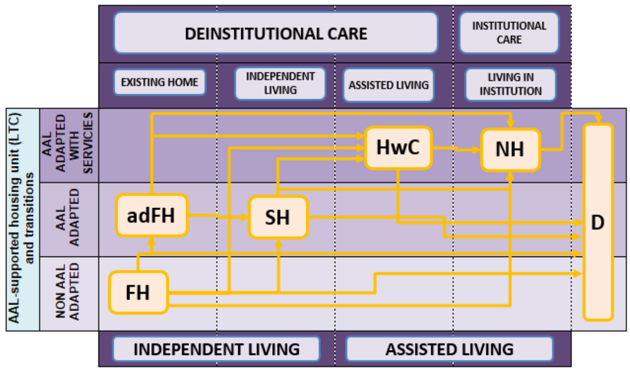

Figure 2: The graph of different paths between different types of dwellings from the existing home (EH) to nursing home (NH) in the multiple decrement model

In a multiple decrement setup, transitions between any two states from i to j, $i > j$=1, 2, …, m are not possible (directed graph). However, in a multi-state transition, we can also assume such reverse transitions of functional capacities (see advanced solutions in Deshmukh, 2012); therefore, the use of housing stock can also be modelled with a multi-state transition model, which is not the case below.

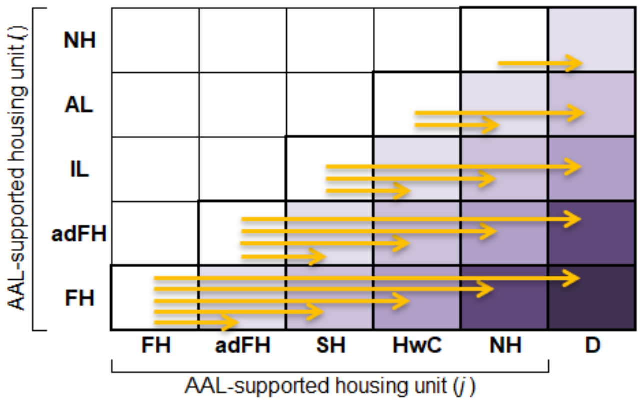

Figure 2: Admissible transitions of older adults from/to type of housing unit

The probability $q_x^{(i,j)}$ of moving from facility type i to facility type j due to declining functional ability for resident aged x is denoted as follows:

$$q_x^{(i,j)} = \frac{M_x^{(i,j)}}{S_x^{(i)}}; j = 1, 2, 3, 4; j > i \qquad (1)$$

Where $M_x^{(i,j)}$ is the number of residents who move from i to j, and $S_x^{(i)}$ is the total number of residents who were previously living in i-1. Here, $p_x^{(i)}$ is probability of staying in the dwelling.

In most of the existing neighbourhoods, AAL-embedded technologies and AAL-supported specialised housing units for older adults with declining functional capacities are not available. After a decline in functional capacities, the only options are home care and nursing homes. When older adults are no longer able to live in their family home, they have to move to a nursing home. In this case, we have the following transition matrix:

$$P_{x,\tau} = \begin{bmatrix} p_x^{(0)} & q_x^{(0,1)} & 0 & 0 & q_x^{(0,4)} & q_x^{(0,5)} \\ 0 & p_x^{(1)} & 0 & 0 & q_x^{(1,4)} & q_x^{(1,5)} \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & p_x^{(4)} & q_x^{(4,5)} \end{bmatrix}_\tau \quad (2)$$

When we introduce AAL-supported specialised housing for independent living (sheltered homes) and assisted living (housing with care), we increase the options and the transition matrix becomes as follows:

$$P_{x,\tau} = \begin{bmatrix} p_x^{(0)} & q_x^{(0,1)} & q_x^{(0,2)} & q_x^{(0,3)} & q_x^{(0,4)} & q_x^{(0,5)} \\ 0 & p_x^{(1)} & q_x^{(1,2)} & q_x^{(1,3)} & q_x^{(1,4)} & q_x^{(1,5)} \\ 0 & 0 & p_x^{(2)} & q_x^{(2,3)} & q_x^{(2,4)} & q_x^{(2,5)} \\ 0 & 0 & 0 & p_x^{(3)} & q_x^{(3,4)} & q_x^{(3,5)} \\ 0 & 0 & 0 & 0 & p_x^{(4)} & q_x^{(4,5)} \end{bmatrix}_\tau \quad (3)$$

The final allocation of residents by the type of housing unit for each cohort (x years old) in the year τ is described by the vector ${}_{(i)}S_{x,\tau}$, which represents the sum of the number of residents moving in different types of dwellings within the neighbourhood.

Where the migrations are added according to the gravity model presented by Janež et al. (2016, 2018) and Janež and Bogataj (2018), and the allocation of residents is by the type of facility for the studied cohort in the year τ+1 (when they are x+1 years old).

$$S_{x+1,\tau+1} = S_{x,\tau} P_{x,\tau} =$$

$$= \left[S_x^{(0)}\, S_x^{(1)}\, S_x^{(2)}\, S_x^{(3)}\, S_x^{(4)} \right]_\tau \cdot \begin{bmatrix} p_x^{(0)} & q_x^{(0,1)} & q_x^{(0,2)} & q_x^{(0,3)} & q_x^{(0,4)} & q_x^{(0,5)} \\ 0 & p_x^{(1)} & q_x^{(1,2)} & q_x^{(1,3)} & q_x^{(1,4)} & q_x^{(1,5)} \\ 0 & 0 & p_x^{(2)} & q_x^{(2,3)} & q_x^{(2,4)} & q_x^{(2,5)} \\ 0 & 0 & 0 & p_x^{(3)} & q_x^{(3,4)} & q_x^{(3,5)} \\ 0 & 0 & 0 & 0 & p_x^{(4)} & q_x^{(4,5)} \end{bmatrix}_\tau =$$

$$= \left[S_{x+1}^{(0)}\, S_{x+1}^{(1)}\, S_{x+1}^{(2)}\, S_{x+1}^{(3)}\, S_{x+1}^{(4)} \right]_{\tau+1} \quad (4)$$

We can subsequently evaluate lifetime expenditures for long-term care in normal neighbourhoods and AAL-supported lifetime neighbourhoods with actuarial present value.

The optimal care services and the housing stock for an older adult with decreasing functional capacity depends on the following: legal systems, fiscal systems, financial mechanisms and system of long-term care provisions and insurance.

The following notation will be used:

P_x^{LTC}	Single premium for LTC insurance for person x years old
$LTC\ddot{a}_x$	Actuarial present value of lifetime expenditures for LTC services for person x years old
${}_jp_x$	Probability that a person who is x years old will survive j years
$p_x^{ltc(i)}$	Probability that person x years old is in the category of care i
c_i	Yearly expenditure for LTC services in the category of care i
ir	Interest rate
$\vartheta = \frac{1}{1+ir}$	Discount rate
HS	Housing stock without specialised housing for older adults and age-friendly public spaces in a typical neighbourhood
HSAAL	AAL-supported housing stock for indented living (SH) and assisted living (HwC) with age-friendly public spaces in a lifetime neighbourhood

(1)1

$$p_{x+j}^{ltc\,x} = \frac{S_x^{(x)}}{S_x^{(0)} + S_x^{(1)} + S_x^{(2)} + S_x^{(3)} + S_x^{(4)}} \quad (5)$$

The actuarial present value of LTC expenditure of a person x years old who is dependent on the help of others living in the current neighbourhood can be calculated as follows:

$$LTC\ddot{a}_x(HS) = \sum_{j=0}^{100-x} {}_jp_x \cdot \vartheta^j \cdot \left(p_{x+j}^{ltc\,I} \cdot c_1 + p_{x+j}^{ltc\,II} \cdot c_2 + p_{x+j}^{ltc\,III} \cdot c_3 \right) \quad (6)$$

The actuarial present value of the LTC expenditure of a person x years old who is dependent on the help of others and living in a lifetime neighbourhood can be written as follows:

$$LTC\ddot{a}_x(HSAAL) = \sum_{j=0}^{100-x} {}_jp_x \cdot \vartheta^j \cdot \left(p_{x+j}^{HC} c_1 + p_{x+j}^{IL} c_2 + p_{x+j}^{AL} c_3 + p_{x+j}^{NH} c_4 \right)$$

(2) (3)

Lifetime neighbourhoods can create value for the community through the savings of public long-term care insurance or other public expenditures connected with long-term care provision.

$$LTC\ddot{a}_x(HS) - LTC\ddot{a}_x(HSAAL)$$

Savings can be invested in the development of an AAL system and age-friendly public spaces for the transformation of the existing neighbourhood to a lifetime neighbourhood.

3 CONCLUSION

The organisation of care for older adults in AAL-supported lifetime neighbourhoods reduces the risk of falls, social exclusion and loneliness, which postpones the need to move to nursing homes and substantially decrease the cost of health care and long-term care for older adults. Knowing the housing preferences of residents with declining functional capacities and who are dependent on the help of others, we can better forecast the demand for different types of housing units in lifetime neighbourhoods with embedded ambient intelligence, facility management and care networks. When an older adult is confronted with the barriers of built environment in public spaces and within their dwellings that they cannot negotiate, their preferences can change. The availability of a suitable specialised housing unit with embedded AAL technologies in their neighbourhood can also influence the decision on reallocation within the neighbourhood instead of moving to a nursing home. The dynamics of migration and tenure in the community can be measured with the multiple decrement model presented in this paper.

REFERENCES

Arh, T., Jerman-Blažič, B., Dimovski, V. (2012). The impact of technology-enhanced organisational learning on business performance : an empirical study. Journal of East European management studies, 17(3), 369–383.

Bogataj, D., Ros-McDonnell, D. Bogataj, M. (2015). Reverse mortgage schemes financing urban dynamics using the multiple decrement approach. *Springer proceedings in mathematics & statistics*, 135, 27–47.

Bogataj, D., Ros-McDonnell, D. Bogataj, M. (2016). Management, financing and taxation of housing stock in the shrinking cities of aging societies. *International journal of production economics*, 181, pt. A, 2–13.

Bogataj, M., Bogataj, L. (2004). On The Compact Presentation Of The Lead Times Perturbations In Distribution Networks, International Journal Of Production Economics, 88 (2), pp 145-155.

Bogataj, M., Grubbström, R. W. (2012). On the representation of timing for different structures within MRP theory, International journal of production economics, 140 (2), pp. 749-755

Bogataj, M., Drobne, S., Tuljak Suban, D. (2012). A fuzzy approach to forecasting the attractiveness of regions for human resources. Industrial engineering : innovative Networks : annals of industrial engineering. London: Springer. cop: 375-384.

Bogataj, M., Tuljak Suban, D. Drobne, S., (2011). Regression-fuzzy approach to land valuation. Central European Journal of Operations Research, 19(3), 253–265.

Božič, K., Dimovski, V. (2019). Business intelligence and analytics for value creation: the role of absorptive capacity. *International journal of information management*, 46: 93–103.

Deshmukh, S. (2012). Multiple Decrement Models in Insurance, An Introduction Using R, Springer.

Dimovski, V, Grah, B., Colnar, S. (2019). Modelling the industrial workforce dynamics and exit in the ageing society. *IFAC- PapersOnLine*, to appear.

Dimovski, V., Škerlavaj, M. (2005). Performance effects of organizational learning in a transitional economy. *Problems & perspective.s in management*, 2005, 3(4), 56–67.

Dimovski, V., Škerlavaj, M., Kimman, M., Hernaus, T. (2008) Comparative analysis of the organisational learning process in Slovenia, Croatia, and Malaysia. *Expert systems with applications*, 34(4), 3063–3070.

Drobne, S., Bogataj, M. (2005). Intermunicipal gravity model of Slovenia. *SOR '05 proceedings*, Ljubljana: SDI-SOR 2005, 207–212.

Drobne, S., Bogataj, M. (2012). A method to define the number of functional regions: An application to NUTS 2 and NUTS 3 levels in Slovenia. *Geodetski vestnik* 56(1), 105–150.

Drobne, S., Bogataj, M. (2013). Evaluating functional regions for servicing the elderly. SOR '13 proceedings. Ljubljana: SDI-SOR, 331–336.

Drobne, S., Bogataj, M. (2015). Optimal allocation of public service centres in the central places of functional regions. *IFAC-PapersOnLine*, 48(3), 2362–2367.

Drobne, S., Bogataj, M. (2017). The impact of public investments in facilities on the potential housing market for older persons. *Facilities,* 35(7/8): 422–435.

Drobne, S., Bogataj, M., Krivic, M., Lisec, A. (2011). Dynamics and local policy in commuting: attractiveness and stickiness of Slovenian municipalities. *SOR '11 proceedings*. Ljubljana: SDI-SOR. 323–328.

Drobne, S., Bogataj, M., Tuljak Suban, D., Železnik, U. (2011a). Regression-neuro-fuzzy approach to analyse distance function in internal inter-regional migrations in EU countries. SOR '11 proceedings. Ljubljana: SDI-SOR, 171–176.

EC. (2017). The 2018 Ageing Report: Undelying Assumptions and Projections Methodologies) Brussels.

Gerber, H.U. (1997). *Life Insurance Mathematics*, Swiss Association of Actuaries Zürich, 3rd Edition, Springer. Berlin.

Grah, B., Dimovski, V., & Peterlin, J. (2018). A Shift in Perceiving Organisational Metaphors among Business Administration Students in an EU Country: A Window into the Current Thinking of Future Employees. Društvena istraživanja: časopis za opća društvena pitanja, 27(1), 133–154.

Grubbström, R. W., Bogataj, M., Bogataj, L. (2010). Optimal lotsizing within MRP theory, Annual Reviews in Control, 34 (1), pp. 89-100

Hernaus, T., Škerlavaj, M., Dimovski, V. (2008). Relationship between organisational learning and organisational performance: the case of Croatia. *Transformations in business & economics*, 7(2), (14), 32–48.

Janež, P., Bogataj, M. (2018). The impact of real estate taxations on the inter-municipal migration which influences the housing construction dynamics. Engineering digital transformation. *Lecture notes in*

management and industrial engineering, Cham: Springer: 41–48.
Janež, P., Bogataj, M., Drobne, S. (2016). Impact of the real estate taxation and municipal revenue on dynamics of internal migration : case study for city Municipal of Ljubljana. *Geodetski vestnik* 60(4), 644–684.
Janež, P., Bogataj, M., Drobne, S. (2016). Impact of the real estate taxation and municipal revenue on dynamics of internal migration: case study for city Municipal of Ljubljana. *Geodetski vestnik* 60(4): 644–684.
Janež, P., Drobne, S., Bogataj, M. (2018). Forecasting dynamics of daily commuting to work to other municipality in the case of changing taxation policies. *Lecture notes in management and industrial engineering.* Cham: Springer: 105–112.
Kovačić, D., Usenik, J., Bogataj, M. (2017). Optimal decisions on investments in urban energy cogeneration plants - extended MRP and fuzzy approach to the stochastic systems. International journal of production economics, vol. 183, part b, pp. 583-595
Kovačić, D., Hontoria, E., Ros Mcdonnell, L., Bogataj, M. (2015) Location and lead-time perturbations in multi-level assembly systems of perishable goods in Spanish baby food logistics. Central European journal of operations research. 2015, vol. 23 (3), pp. 607-623.
Lisec, A., Drobne, S., Bogataj, M. (2008). The influence of the national development axes on the transaction value of rural land in Slovenia. *Geodetski vestnik* 52(1), 54–68.
Marsiske, M., Delius, J.A.M., Maas, I., Linderberger, U., Scherer H., Tesch-Romer C. (2010). Sensorische systeme im Alter. In: Lindenberger, U., Smith J., Mayer, K.U., Baltes P.B. *Die Berliner Altersstudie*. Berlin: Akademie Verlag GmbH. 403–427.
Peterlin, J., Dimovski, V., Tvaronavičiene, M., Grah, B., Kaklauskas, A. (2018). The strategic process of developing social aspects of sustainability through the vision reflection in business education. *Technological and economic development of economy*, 24(4), 1718–1736.
Škerlavaj, M., Dimovski, V. (2007). Towards network perspective of intra-organizational learning: bridging the gap between acquisition and participation perspective. *Interdisciplinary journal of information, knowledge, and management*, 2, 43–58.
Usenik, J., Bogataj, M (2005). A fuzzy set approach for a location-inventory model, Transportation planning and technology. 2005, 28 (6), pp.
Žnidaršič, J., Dimovski, V. (2009). Retaining older workers: fields of action - constituting a comprehensive Age Management Model. *Journal of Applied Business Research* 25(4):85–98.