POPULATION GROWTH, TRANSPORT POSITIONS AND INCOME CHANGES IN THE AGGLOMERATION AREA OF GYOR, HUNGARY

[1]ANETT BEDO, [2]CSABA KOREN, [3]EVA V. P. RACZ

[1]Department of Environmental Engineering, [2]Department of Transport Infrastructure, [3]Department of Mathematics and Computational Sciences Széchenyi István University, Győr, Hungary
E-mail: [1]bedoa@sze.hu., [2]koren@sze.hu, [3]raczev@sze.hu

Abstract- This paper investigates population dynamics and economic changes in the agglomeration of Győr in Hungary. Altogether 67 settlements were investigated. The goal of this paper is to identify those indicators which can explain the population growth (or decline) in the particular villages and the differences among them. Our study used 2D and 3D regression analysis. It was found that the distance from Győr, the travel time by car from Győr and the per capita personal income tax are the three indicators mostly influencing population changes in the villages of the agglomeration.

Keywords- Population change, economic change, agglomeration, distance, income.

I. INTRODUCTION

The notion of each generation's duty to its successors is at the heart of the concept of sustainable development and was captured by the Brundtland Commission [1] in its report 'Our Common Future', which defined sustainable development as "development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs." This concept is increasingly important in growing urban agglomeration areas.

Sustainable development means recognising that our economy, environment and social well-being are interdependent. It means protecting and, where possible, enhancing the environment, because a damaged environment will sooner or later hold back economic development and affect people's quality of life. It is about ensuring we satisfy people's basic needs, such as providing warm homes, accessible transport and safe streets and giving people the opportunity to achieve their potential through education, information, participation, good health and employment [2].

Economic activities and services, transportation development, and traffic flow all have profound implications for the agglomeration settlements and the cities. These are often no longer isolated but increasingly concentrated and inextricably linked together in the sharing infrastructure systems, environmental systems, economic linkages, land use patterns and culture [3,4].

Urban development through the agglomeration and decentralisation at the same time is associated with numerous environmental damages such as air pollution, greenhouse gases, waste and degradation of land and ecosystems [5]. Urban agglomeration is generally characterized by the size of the territory associated with continuity between separate urbanized areas, contiguous economic and social relationships, and a population concentration [6,7,8]. In 2017 Fang & Yu in their study Urban agglomeration: An evolving concept of an emerging phenomenon, the urban agglomeration is a highly developed spatial form of integrated cities [9]. It occurs when the relationships among cities shift from mainly competition to both competition and cooperation. Cities are highly integrated within an urban agglomeration, which renders the agglomeration one of the most important carriers for global economic development.

The definition of agglomeration according to the European Union was applied: 'agglomeration' shall mean a zone that is a conurbation with a population in excess of 250 000 inhabitants or, where the population is 250 000 inhabitants or less, with a given population density per km^2 to be established by the Member States [10]. Whether integration leads to agglomeration crucially hinges on the demographic properties of economies [11].

Population size has a significantly positive impact on per capita GDP growth, which is almost equal in magnitude and opposite in sign to the impact of population density [12]. Economic and social policy environment, the changes in demographic structure may boost economic growth [13]. As Wei and Hao (2010) point out, demographic changes affect economic growth [14].

The competitiveness of a region is largely determined by the state and development pattern of its rural areas and settlements. Therefore, research has been focused on sustainable countryside and its important elements, sustainable settlements [15].

The remainder of this paper is structured as follows: in Section 2, the agglomeration of Győr and the goals of the research are shown. Next, in Section 3, the research methods are presented. Section 4 shows the results, while Section 5 draws conclusions.

II. AREA AND GOALS OF THE RESEARCH

According to economic density and the degree of interconnections among settlements involved, there

are 21 urban settlement groups in Hungary. The urban settlement groups can be classified into three types: agglomerations, agglomerating areas and settlement groups. These denominations refer to the degree of interconnections among the settlements involved.

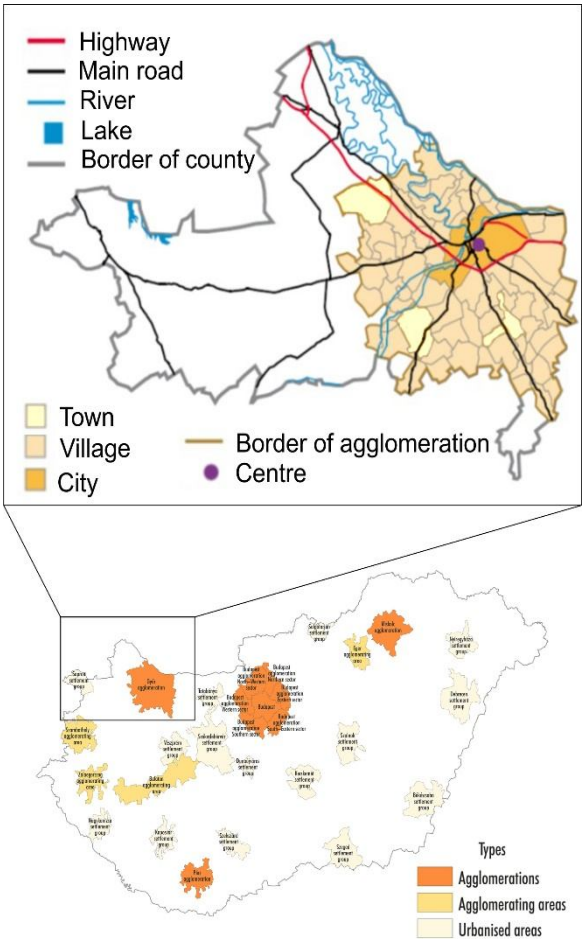

Fig. 1. Urban settlement groups of Hungary and the agglomeration of Győr; after [16]

In Hungary ten indicators of changes in agglomeration zones were determined by the Central Statistical Office. Beside Budapest's agglomeration there are three more urban agglomerations in Hungary. To the agglomeration of Győr 68 settlements are assigned. This area is 1,607 km^2 and had 228,941 inhabitants in 2016 [16].

The agglomeration of Győr is located in the North-Western part of Hungary in Fig. 1. Due to its economic, social, commercial, educational, health, administrative and cultural role, it is a dynamically developing region with growing population, while the total population of the country is decreasing [17]. Győr-Moson-Sopron County has a very unfavourable population distribution [18]. Suburbanization of Győr is more significant and this leads to some social, economic and environmental impacts [19,20]

Within the agglomerations two different population trends can be distinguished. On one hand the population of the core city is decreasing or stagnating, while on the other hand the population is the neighbouring villages is increasing.

The goal of this research is to find underlying factors to explain the growth. On the country level it was shown earlier by several authors [21,22] that the economic potential of Győr is the main contributing factor. However, there was no research undertaken about the distribution of growth on the micro, i.e. village level. Therefore the goal of this paper is to identify indicators which can explain the growth in the individual villages and the differences among them.

III. METHODS OF THE RESEARCH

Present study is based on two data sources: Hungarian Central Statistical Office (HCSO) and the National Information System of Regional Development and Planning [23,24]. Data available for the period 2000-2015 were searched to find indicators which could influence the changes in population. No distinction was made between natural population change and migration balance, i.e. the total population change was used.

As for the economic development, per capita personal income tax was used. The authors are aware that this is different from total income or wealth and their changes, but these are the only relevant related data available on the village level. The tax rates during the period studied are shown in the Annex.

Firstly, two-dimensional linear regression was applied to find explanatory variables showing correlation to population change. The list of these variables and R^2 values of the linear functions are shown in Table 1. R^2 is the coefficient of determination, which is the ratio of the sum of squares due to regression to the total sum of squares [25].

Table 1: Independent variables explaining population change between 2000 and 2015 and their R^2 values

No.	Independent variable	R^2
1.	per capita personal income tax	0.4232
2.	distance from Győr	0.5464
3.	travel time by bus from Győr	0.3631
4.	travel time by car from Győr	0.4710
5.	avg. square meter price of houses	0.2757
6.	number of businesses	0.1876
7.	number of shops	0.0309
8.	number of passenger cars	0.1347
9.	number of bus arrivals from Győr	0.0480
10.	size of green areas	0.0096
11.	length of the road network	0.0905
12.	population in 2000	0.0163

The distance from Győr, the travel time by car from Győr and the per capita personal income tax are the three indicators mostly influencing population

changes in the villages of the agglomeration. These three indicators showing the highest impact on population change in the villages around Győr were investigated in two-dimensional diagrams.

Linear regression function $Y=\beta_0+\beta_1 x_1$ (straight line) was fitted to the data with least squares method, where Y is the dependent variable and x the independent variable [26].

Later, multiple regression analysis was applied to investigate more combinations of parameters in an effort to find factors that better predict the outcome. The surface was fitted by $Z=C*e^{-(\alpha*x+\beta*y)}$ equation [27]. The analyses were calculated by STATISTICA software [28].

IV. RESULTS AND DISCUSSION

4.1. Two-dimensional results

First, the influence of the distance from Győr on the population change in the villages between 2000 and 2015 is shown in Fig. 2. ($R^2 = 0.5464$, $p < 0.0063$).

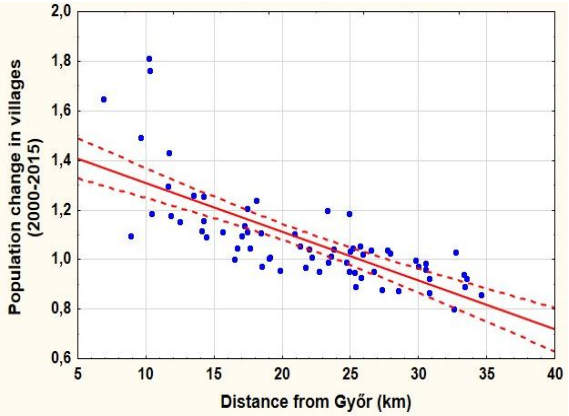

Fig. 2. Population change in villages (2000-2015), as a function of the distance from Győr. Data from [23].

The 95% confidence interval of the best fit-line is shown within the red dotted lines. It is visible that villages closer to the city are more attractive, as they show a higher population growth. 15 km seems to be a critical distance. Over this radius population change can be considered as linear, while within this distance the relationship shifts from linear to exponential. On the other end, 25 km is another critical distance, the population change turns into negative over this distance.

The next indicator investigated was the travel time by car from Győr to the concerned villages. This indicator is obviously closely related to the distances from Győr. The influence of the car travel time to or from Győr on the population change in the villages between 2000 and 2015 is shown in Fig. 3. ($R^2 = 0.4710$, $p < 0.0063$).

It is not surprising that villages which can be reached faster from the centre are more attractive, therefore they show a higher population growth. Similarly to the 15 km distance, 15 minutes seems to be a critical travel time: below this limit the population growth is higher. On the other end, over 25 minutes travel time the population change turns into a decline.

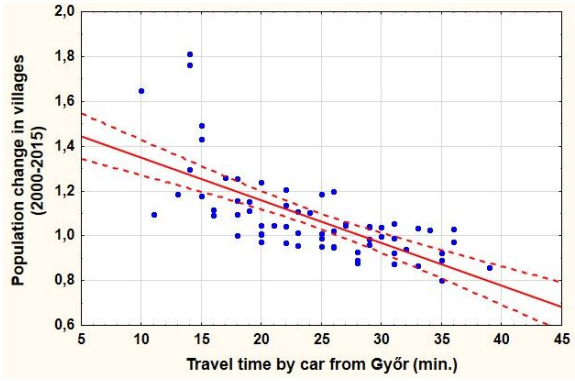

Fig. 3. Population change in villages (2000-2015) as a function of the travel time by car from Győr. Data from [23].

As it turned to be the third significant indicator, the impact of the per capita personal income tax (PIT) in HUF was also investigated. The influence of PIT on the population change in the villages between 2000 and 2015 is shown in Fig. 4. ($R^2 = 0.4232$, $p < 0.0063$).

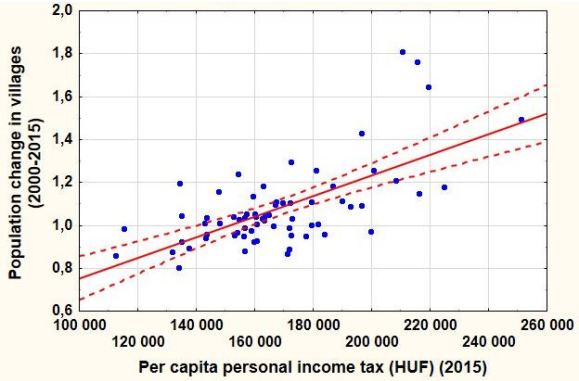

Fig. 4. Population change in villages (2000-2015) as a function of the per capita personal income tax. Data from [23, 24].

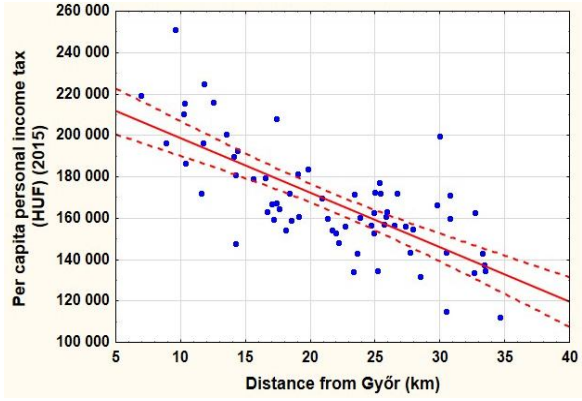

Fig. 5 Per capita personal income tax (2015) as a function of the distance from Győr. Data from [23, 24].

It is interesting to note in Fig. 4 that there is a positive correlation between income and population growth, i.e. villages with higher incomes are more attractive to new residents, while villages with low income inhabitants have a negative population balance.

Fig. 5 shows that the villages closest to Győr have the richest inhabitants, and the average income is decreasing with the distance from Győr.

In Fig. 6 the impact of the size of the population to personal income tax is investigated. Although the correlation is rather low, it is shown, that in larger villages the average income is higher than in smaller ones.

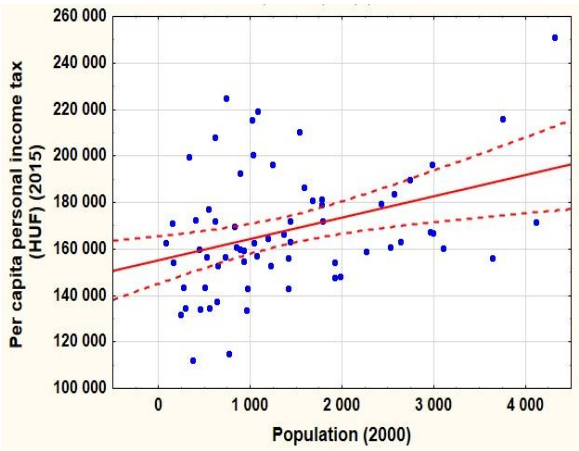

Fig. 6 Per capita personal income tax (2015) as a function of the population in 2000. Data from [23, 24].

The analysis of the relation between population growth, distance and wealth can be enriched by further investigation of the prices of properties in these villages.

Fig. 7 shows that the villages closest to Győr have the highest per square meter property prices, which drop about 20 percent in 30 km distance.

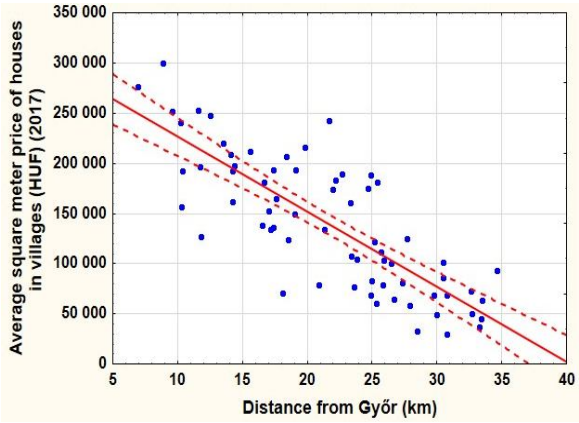

Fig. 7. Average square meter price of houses in villages (2017) as a function of the distance from Győr. Data from [23, 29].

Combining the lessons taught from Figures 2 to 7 it is visible that although property prices are higher in villages closer to Győr, still they are more attractive, than villages further away, i.e. distance is in general more important factor than property price. However, this priority depends on the income level of families, a number of them puts property price before travel distance.

Parameters of the 2D linear regression runs are summarized in Table 2.

Table 2: Parameters of 2D linear regressions

Dependent variable	Independent variable	β_0	$\beta 1$
population change	distance from Győr (km)	1.5064	-0.0197
population change	travel time by car (min)	1.5397	-0.0190
population change	per capita income tax (HUF)	0.2737	$4.8*10^{-6}$
average sq. m. price	distance from Győr (km)	301 256	-7487
per capita income tax	distance from Győr (km)	224 898	-2632.
per capita income tax	population (2000)	155 287	9.10

It is worth to mention that several indicators, which are commonly believed to be components of attractiveness, like the number of shops, the size or amount of green areas, bus frequencies and length of the road network or population size seems to show no impact on population growth.

4.2. Three-dimensional results

In the following, some results of the multiple regression analysis are reviewed. As in 2D cases there were some evidences to non-linear relationships, here exponential functions were fitted. In this part of the research, explanatory variables of the per capita personal income tax were looking for.

Fig. 8 shows the distance from Győr (x) and the population size in 2000 (y) as independent (explanatory) variables, while the personal income tax in 2000 is the dependent (z) variable.

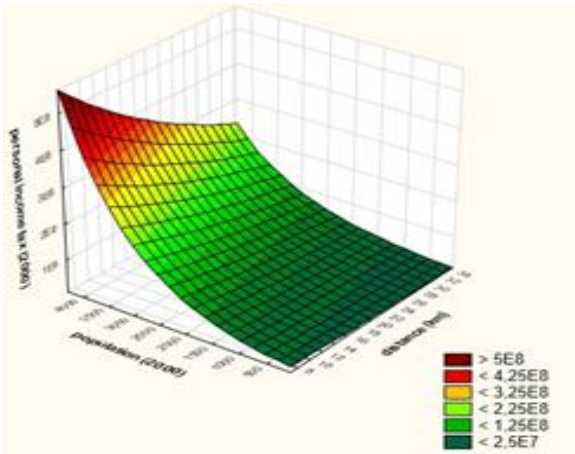

Fig. 8. Personal income tax (2000) as a function of the distance from Győr and population (2000) Data from [23, 24].

Personal income tax significantly depends both on distance and population size. According to Fig 8, smaller and further located settlements are less wealthy, indicating that only families with higher income can afford to settle down in villages being larger and/or near to the city.

Similarly to Figure 8, Fig. 9 has the distance from Győr (x) and the population size in 2000 (y) as

independent (explanatory) variables but the dependent variable (z) is now the change (increase) of per capita personal income tax between 2000 and 2015. The highest level of growth was achieved by the closest and smallest villages. The rapid growth of villages nearby can be attributed to the immigration of people with high income, while the growth of small villages is due to their low-income level in the base year (2000).

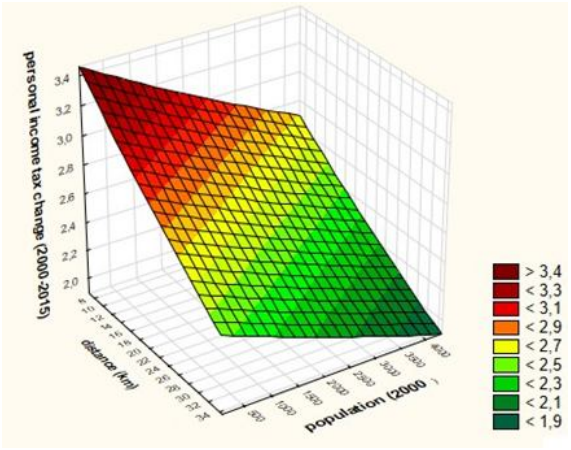

Fig. 9 Personal income tax change (2000-2015) as a function of the distance from Győr and population (2000) Data from [23,24]

Fig. 10 shows the distance from Győr (x) and the population size in 2000 (y) as independent (explanatory) variables, while the personal income tax in 2015 is the dependent (z) variable.

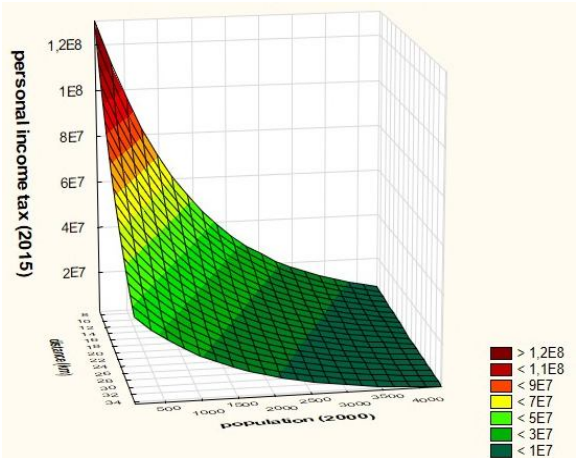

Fig. 10 Personal income tax (2015) as a function of the distance from Győr and population (2000) Data from [23,24].

Figure 10 is very similar to Figure 8. Personal income tax significantly depends both on distance and population size. According to Fig 10, further located settlements are less wealthy. As the increment between 2000 and 2015 was higher for villages closer to Győr, the differences in this dimension have grown. On the other hand, smaller villages became slightly richer during this period.

Parameters of the 3D regression runs are summarized in Table 3.

Table 3: Parameters of 3D regressions

Z	X, Y	R^2	C	α	β
PIT (2000)	D, P (2000)	0.9328	17.72	-0.0322	0.00074
PIT change (2000-15)	D, P (2000)	0.2022	1.33	-0.0127	-0.00006
PIT (2015)	D, P (2000)	0.8375	19.05	-0.0449	-0.00068

D = distance, P = population

CONCLUSIONS

This study focused on development of agglomeration around Győr city. In this agglomeration the growth of population is still continuous, so it is necessary to examine the influence of the population change concerning sustainability.

According to our data analysis the agglomeration around Győr can be divided into two rings. Settlements closer than 15 kms are richer, more closely connected (higher PIT, positive migration rate). On the contrary, settlements located about 15-35 kms show weaker dependency on distance from the city in most parameters. This difference also provides a basis for improvement of suburban transport services. Locations where conventional transport services are economically not viable might be better served by automated transport systems.

Alternatives of car in transport should be offered in a sufficiently attractive way in order to reduce traffic based on congestion and to obtain derived benefits like road safety and lower atmospheric and noise pollution. Travelling time turned to be an important parameter in deciding for public transport [30].

This research has been by far not comprehensive. The authors think that the number of the indicators studied should be increased. Some settlements have quite irregular parameters; these outlying data should be also a target of further investigations.

ACKNOWLEDGMENTS

The research presented in this paper was carried out as part of the EFOP-3.6.2-16-2017-00016 project in the framework of the New Széchenyi Plan. The completion of this project is funded by the European Union and co-financed by the European Social Fund.

REFERENCES

[1] WCED - World Commission on Environment and Development, "Our Common Future", Oxford University Press, Oxford, 1987,

[2] Department of the Environment, Transport and the Regions, "Local quality of life counts: A handbook for a menu of local indicators of sustainable development", London, 2000,

[3] J. Robinson, "Ordinary Cities: Between modernity and development", Psychology Press, London, 2006,

[4] C. L. Ross, and M. Woo, "Megaregions and mobility", Bridge, vol. 41, pp. 24-34, 2011,
[5] X. Q. Zhang, "The trends, promises and challenges of urbanisation in the world", Habitat International, vol. 54, pp. 241-252, 2016,
[6] C. He, T. Chen, X Mao, and Y. Zhou, "Economic transition, urbanization and population redistribution in China", Habitat International, vol. 51, pp. 39-47, 2016,
[7] W. Lang, T. Chen, and X. Li, "A new style of urbanization in China. Transformation of urban rural communities", Habitat International, vol. 55, pp. 1-9, 2016,
[8] F. M. Listengurt, "Criteria for delineating large urban agglomerations in the USSR", Soviet Geography, vol 16, pp. 559-568, 1975,
[9] C. Fang, and D. Yu, "Urban agglomeration: An evolving concept of an emerging phenomenon", Landscape and Urban Planning, vol. 162, pp.126–136, 2017,
[10] Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0050
[11] consulted 17 febr. 2016,
[12] T. Grafeneder-Weissteiner, and K. Prettner, "Agglomeration and demographic change", Journal of Urban Economics, vol. 74, pp. 1–11, 2013,
[13] J. Golley, and Z. Wei, "Population dynamics and economic growth in China. China economic review", Elsevier, vol (35), pp. 15-32, 2015,
[14] D. E. Bloom, and J. G. Williamson, "Demographic transitions and economic miracles in emerging Asia", World Bank Economic Review, vol. 12, pp. 419–56, 1997,
[15] Z. Wei, and R. Hao, (2010). "Demographic structure and economic growth: Evidence from China", Journal of Comparative Economics, vol. 38, pp. 472–491, 2010,
[16] J. Szlávik, and M. Csete, "Sustainable countryside and competitiveness", Agriculture, vol. 49, pp. 9-27, 2005,
[17] Hungarian Central Statistical Office, "The settlement Network of Hungary I. Agglomerations and settlement groups", Hungarian Central Statistical Office, Budapest, 2014,
[18] Local government of Győr-Moson-Sopron County, "Treasures of Győr-Moson-Sopron County", Local government of Győr-Moson-Sopron County, Győr, 2014,
[19] T. Dusek, "Comparison of counties and regions with indicators" Territorial statistics, vol. 55, pp. 142-156, 2015,
[20] T. Hardi, "Suburbanization around Győr" Place and society, vol. 16, pp. 57-83, 2002,
[21] Zs. Hantó, "Settlement, urbanization, lifestyle", In: T. Tóth (ed), "Studies of regional research", Transdanubian Scientific Institute of Hungarian Scientific Academy, pp. 191-208, Pécs, 1980,
[22] J. Rechnitzer, and M. Smahó, (ed.), „Economic Effects of the Vehicle and Automotive Industry in the Regions of Central and Eastern Europe and Hungary", Universitas-Győr Nonprofit Kft., Győr, 2012,
[23] J. Rechnitzer, and M. Smahó, (ed.), "Vehicle Industry and Competitiveness of Regions in Central and Eastern Europe", Universitas-Győr Nonprofit Kft., Győr, 2012,
[24] Hungarian Central Statistical Office database: http://statinfo.ksh.hu/Statinfo/haDetails.jsp?query=kshquery&lang=hu 10 april. 2018,
[25] National Information System of Regional Development and Planning: https://www.teir.hu/ 8 April. 2018,
[26] J. J. Kinney Probability. An Introduction with Statistical Applications. Second Edition John Wiley & Sons Colorado Springs, CO, 2015,
[27] J. Neter, W. Wasserman, and M. H. Kutn "Applied linear statistical models: Regression, analysis of variance and experimental designs", Irwin, Boston, 1990,
[28] N. Pandism multiple linear regression analysis https://www.ajodo.org/article/S0889-5406(16)00033-0/fulltext 01 okt. 2018,
[29] S. Kemény, A. Deák, K. K. Lakné and E. Vágó, "How do we use the Statistics program?" Perfact publisher, Budapest, 2011,
[30] Real estate statistics os Győr-Moson-Sopron County: https://www.ingatlannet.hu/statisztika/Gy%C5%91r-Moson-Sopron_megye, 08 jun. 2018,
[31] A. Bedő, and É. V. P. Rácz, "The influence of the changing population on the bus transport in the agglomeration of Győr", Sustainability - Utopia or Reality? Conference publication, Budapest University of Technology and Economics, Budapest pp. 89-99, 2016,
[32] National Tax and Customs Administration Hungary (NTCA), Tax tables 1988-2014. https://nav.gov.hu/nav/archiv/szolgaltatasok/adokulcsok_jarulekmertekek/adotablak/sav.html

ANNEX

Personal income tax rates (%) between 2000 and 2015 in Hungary. Source: [31]

Year(s)	Rate_1	Rate_2	Rate_3
2000-2003	20	30	40
2004	18	26	38
2005	18	38	-
2006-2009	18	36	-
2010	22	41	-
2011	20	-	-
2012	18	-	-
2013-2015	16	-	-

★★★