Ministry of Environmental Protection and Regional Development (2014). Vides politikas pamatnostādnēs 2014-2020. gadam. http://www.varam.gov.lv/lat/pol/ppd/vide/?doc=17913 (14.01.2019)

Ministry of Environmental Protection and Regional Development (2016). Informatīvais ziņojums "Par pasākumiem aizsargājamo biotopu izplatības un kvalitātes apzināšanai". http://tap.mk.gov.lv/lv/mk/tap/?pid=40372506 (14.01.2019)

Ministry of Environmental Protection and Regional Development (2013). Informatīvais ziņojums par vides monitoringu un jūras zvejas kontroli. http://tap.mk.gov.lv/mk/tap/?pid=40259415 (14.01.2019)

Ministry of Environmental Protection and Regional Development (2001). EMERALD/ Natura 2000 projekta kopsavilkums. http://www.varam.gov.lv/lat/darbibas_veidi/daba/dabas_aizsardzibas_projekti/?doc=2920 (14.01.2019)

Ministry of Agriculture (2015). Meža un saistīto nozaru pamatnostādnēs 2015.-2020. gadam. https://www.zm.gov.lv/mezi/statiskas-lapas/meza-un-saistito-nozaru-attistibas-pamatnostadnes-2015-2020-gadam?id=6501#jump (14.01.2019)

PROJECTED CHANGES IN THE NUMBER OF INHABITANTS OF LATVIA IN THE EVENT OF THE STABILIZATION OF EMIGRATION

Latvijas iedzīvotāju skaita prognozējamās pārmaiņas, stabilizējoties starpvalstu migrācijai

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Abstract. The decline in population is a significant problem for Latvia, the causes and consequences of which have been brought to the attention of many researchers. The aim of this study is to perform a mathematical analysis of the population and the main components of its changes at the national level to evaluate the use of these indicators in the estimation of population changes. The methods of this research are based on data regression analysis. The statistical analysis of this work uses the data of the Central Statistical Bureau of Latvia. The study also utilised Statistical Office of the European Union (Eurostat) population projections at the national level. The results of this research are based on data regression analysis. Although linear regression models evaluate changes in the population of Latvia and show very strong correlation, they must be treated critically.

The population migration balance is not predictable based on historical observations and/or by using mathematical models. In migration balance forecast models that are based on mathematical statistical methods, the uncertainty is so great that the practical value of such models is negligible.

Keywords: *population of Latvia, regression analysis, population forecasts, natural growth, population migration balance*

Introduction

The decline in population is a significant problem for Latvia, the causes and consequences of which have been brought to the attention of many researchers. Most research is devoted to studying the impact of mobility and migration on territorial

disparities (Krišjāne et al. 2017; Zhitin et al. 2018; Arbidane and Markevica 2016; Göler et al. 2014; Apsīte et al. 2012; Krišjāne and Bērziņš 2012, etc.). The prediction of the population is important in planning the availability of labour (Arbidane and Markevica 2016; Kekla and Senfelde 2016, etc.) as well as other economic and social activities (Klavenieks and Blumberga 2016; Berloviene and Samusevich 2016 etc.).

The aim of this work is to perform a mathematical analysis of the population and the main components of its changes at the Latvian national level in order to evaluate the use of these indicators in the estimation of population changes.

Data and Methods

The statistical analysis for this work uses the data of the Central Statistical Bureau of Latvia (CSB) last updated on 1 January 2018. In turn, the calculation of the forecasts in Table 3 includes the more recent population figure on 1 January 2019. The research process also used Statistical Office of the European Union (Eurostat) population projections at the national level, as well as development planning documents by the government and government structures of Latvia.

Methods incorporated in this study are based on data regression analysis. As a regression co-efficient criterion for rejecting or accepting a zero hypothesis, a rule was set that the zero value would not be in the confidence interval of a regression co-efficient with a 95% probability. Unless otherwise stated in this work, a 95% probability was used to assess the statistical significance.

The strategic goal of Latvian population and population forecasts.

According to the main Latvian strategic planning document *Sustainable Development Strategy of Latvia until 2030* (approved by the Latvian Parliament in 2010) the aim of Latvia is to reach a population level of more than 2.02 million by 2030 (Sustainable... 2010). The Government of Latvia decided not to change this goal in 2015 (Latvijas Ilgtspējīgas... 2015), specifying that this goal is moving forward satisfactorily. This target was considered to be likely to be achieved if the population will exceed 1.93 million in 2020 (Indikatori… 2015). The exact same goal for 2020 was also included in the National Development Plan of Latvia for 2014-2020 (National Development Plan… 2012). Unfortunately, according to the CSB data, on January 1, 2019, there were only 1.92 million inhabitants in Latvia. Given the demographic and migration trends in Latvia, neither the 2020, nor the 2030 target can be achieved. Such conclusions follow from the Latvian population forecasts published by the Ministry for the Economy of Latvia (Informatīvais… 2018) and Eurostat (Table 1).

Forecasts for 2020 and 2030 were not published in the Labor Market Forecasts by the Ministry for the Economy of Latvia (Informatīvais… 2018). These values were calculated by the author based on the average size of population changes recorded in the report (negative 0.6% per annum in 2018-2025 and negative 0.2% in 2026-2035).

The population projection prepared by the Ministry for the Economy of Latvia is based on assumptions that natural growth will be -4.6 promile per year, while international migration will increase linearly reaching a positive value starting from 2024.

Table 1. **Latvian population forecasts (millions)** (Eurostat and Ministry for the Economy data)

Year	Baseline projections	Lower fertility	Lower mortality	Higher migration	Lower migration	Ministry for the Economy
2020	1.912	1.890	1.913	1.896	1.927	1.911
2025	1.831	1.791	1.835	1.799	1.863	1.864
2030	1.744	1.688	1.751	1.696	1.792	1.845
2035	1.662	1.592	1.673	1.600	1.724	1.818
2040	1.599	1.513	1.614	1.527	1.671	-

Eurostat's 2015 projection (Eurostat database 2015) looks at five scenarios by changing assumptions on birth rates, mortality (in different age and gender groups) and total migrant numbers.

When comparing the projections calculated by Eurostat in 2015 with real population data in 2019, it can be concluded that the Eurostat baseline projection was the most accurate one, but still too optimistic. On January 1, 2019, the population of Latvia was 5.6 thousand smaller than the Eurostat baseline projection. The projection based on lower mortality was 6.4 thousand lower, but the projection based on higher migration was 6.7 thousand higher than in reality.

Linear regression of changes in population in Latvia

In observing the numbers of the population in Latvia, which is decreasing year after year, there is a temptation to plug these numbers in to the regression model to predict future population.

By incorporating the annual change of the population of Latvia (from the restoration of independence, 1991-2018) into a simple linear regression analysis the determination co-efficient is 0.994 (Table 2). The regression co-efficient shows that the number of people in this period on average decreased by 26.6 thousand per year, while the confidence interval of the regression co-efficient (95%) ranged from between minus 25.5 and minus 25.7 thousand a year with a fantastically high level of confidence (t Stat = -63.6).

Looking at the period 2004-2018 and 2009-2018, the determination and regression co-efficient deteriorates, but the correlation remains almost functional. The linear regression determination co-efficient for the annual change in Latvia's population from EU accession (2004) to 2018 is 0.985. During this period, the population decreased by

26.1 thousand people per year on average, while the confidence interval of the regression co-efficient (95%) was between minus 24.1 and minus 28.0 thousand per year.

Table 2. **Linear regression analysis of the annual change of the population of Latvia**

Time	Determination co-efficient	Regression co-efficient x1000	Regression co-efficient lower 95%	Regression co-efficient upper 95%	Regression co-efficient t Stat
1991-2018	0.994	-26.609	-27.470	-25.749	-63.567
2004-2018	0.985	-26.081	-28.023	-24.140	-29.023
2009-2018	0.958	-24.094	-28.185	-20.004	-13.584

Looking at the most recent trends (after the 2008-2009 world financial crisis), the co-efficient of linear regression determination for the change in population of Latvia per year (2009-2018) is 0.958. During this period, the population decreased on average by 24.1 thousand per year, while the confidence interval of the regression co-efficient (95%) ranged from between minus 20.0 and minus 28.2 thousand per year.

The estimated number of inhabitants was calculated based on the actual population in 2018. Since the regression co-efficient is negative, it can be predicted that the population will decrease by the size of the regression co-efficient. The scenario for the most pessimistic population changes is formed by calculating the trend of 1991-2018. Looking at the population change 2009-2018, the linear regression model shows that in 2040 the population should be between 1.314 and 1.494 million.

In the linear regression model for population, the regression co-efficient is directly proportional to the arithmetic difference in population change over one year. Conversely, population changes are based on the sum of two components: the natural growth of the population and the balance of migration during the year. Both of these components in Latvia's case have been negative since 1991 and their sum was also negative.

To check the correctness of the linear regression model for the population, one should check whether both components are predictable with simple linear regression.

Statistical analysis of natural growth

The numerical changes in the absolute size of demographic variables depend on population size. With similar conditions (population structure, economic and demographic behaviour, etc.), a population of 2.7 million will show a higher birth incidence, and number of deaths and other demographic variables than a population of 1.9 million. According to the linear regression analysis, the natural increase in the absolute size of the Latvian population between 1994 and 2018 was almost functionally related to the population. The co-efficient of determination between

population and natural growth was 0.78 (Figure 1). With a population drop of 10,000, natural growth between 1994 and 2018 fell by an average of 152 people per year.

It follows that as the population decreases, the impact of natural growth on population size will decrease in absolute terms. To improve the regression model for forecasting, a relative indicator should be used instead of natural growth - the natural growth per 1000 population.

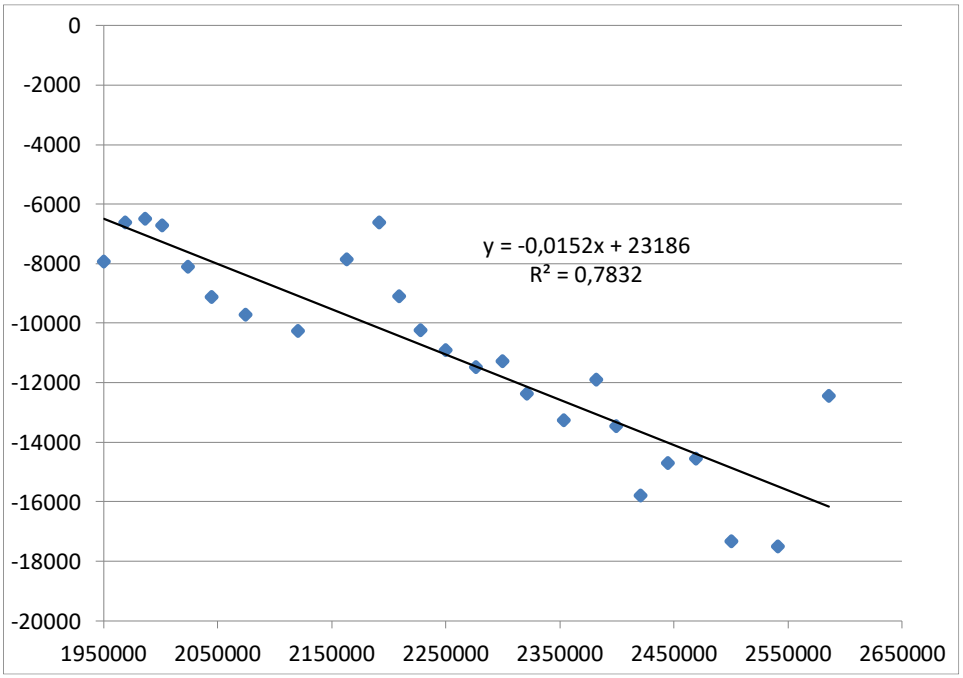

Figure 1. **Regression between population** (horizontal axis) **and natural growth** (vertical axis) (author's calculations using Statistical Bureau of Latvia data)

Before incorporating the natural growth per 1000 population in the model, it is necessary to determine whether this change in the indicator shows a statistically significant trend over time. According to the linear regression analysis, natural growth per 1000 inhabitants in Latvia between 1994 and 2018 had a statistically significant tendency to increase with a determination co-efficient of 0.78. During this period, natural growth per 1,000 inhabitants increased on average by 0.14 each year. The change in natural growth per 1000 inhabitants (regression co-efficient confidence interval) ranged between 0.11 and 0.17 per year (t Stat = 8.7). If the observed increase in natural growth per 1000 inhabitants will remain, the forecast model should take into account that natural growth per 1000 population will continue to increase. On the other hand, when evaluating the latest trends (2010-2017), one cannot say unambiguously whether natural growth per 1000 inhabitants is increasing or decreasing. Regression analysis shows that in 2010-2017 the confidence interval of the regression co-efficient for natural growth per 1000 inhabitants is very wide (t Stat is only 2.7) and with a 98% confidence in the regression co-efficient confidence interval includes null, which means that with a 98% reliability the zero hypothesis cannot be rejected. Evaluating the trend in 2010-2017 the natural increase per 1000 inhabitants could be considered

as a discrete random value that fluctuates around a certain average of -3.86847. It could be accepted that fluctuations in the near future will not exceed the intervals of two standard deviations (95% reliability) in the forecast model natural increase of 1000 inhabitants with 95% could range from -5.14 to -2.59. Forecasting the number of inhabitants may use the approach that in the near future the natural growth per 1000 inhabitants will fluctuate around the 2010-2017 average.

Statistical analysis of the migration balance

In theory, the absolute value of the migration balance should be closely related to the population. In countries with a high birth rate and many young people, it would be logical that the negative value of the migration balance would increase. In the developed countries, however, as the population grows, opportunities for emigrants to gain admittance are increasing, and so as the population increases, the positive balance of migration may increase. Conversely, as the population decreases, migration to the absolute value of the balance should decrease over time. By performing a regression analysis of Latvia's net migration data for the period from 1991 to 2017 and between 2004 and 2017 with a confidence level of 95%, the zero hypothesis that the migration balance changes according to population size cannot be rejected. Likewise, the zero hypothesis about the increase or decrease of the migration balance over time cannot be rejected. In all cases, the regression co-efficient confidence interval includes null.

Table 3. **Latvian population forecasts** (thousands)

Year	Natural growth per 1000 inhabitants will be between -5.14 and -2.59, while migration balance will be minus 10,000	Natural growth per 1000 inhabitants will be between -5.14 and -2.59, while the net migration will be zero	Eurostat projection with sensitivity test: no migration recalculated with correction based on 2019 actual population[1]
2025	1802-1831	1862-1890	1884
2030	1707-1758	1814-1866	1845
2035	1614-1685	1768-1842	1806
2040	1523-1614	1723-1818	1772

[1]The 2015 population forecast for Latvia was re-calculated to include the actual population of 2019. Eurostat projection Sensitivity test: no migration is reduced by difference between Eurostat projection Sensitivity test: no migration (2019) and the actual population (2019).

Between 1991 and 2017, the migration balance did not have a functional relationship with the population and change over time, so in using the mathematical statistical method it is not possible to predict the migration balance with a practical usable confidence interval. The average migration balance in 2008-2017 was 17.80 thousand inhabitants with a standard deviation of 10.20 thousand. This means that with 95% confidence (two standard deviations), the migration balance can be

between the threshold of plus 3.60 thousand and minus 38.2 thousand. Using such confidence intervals, the confidence interval of the forecasts was so broad that the practical use of forecasts was questionable.

By dividing population changes into two components, it can be concluded that population changes due to natural delivery are predictable using mathematical statistics, but changes in population due to migration balance are not rational to predict using mathematical statistics methods. Therefore Eurostat, in addition to the five forecast scenarios, also calculates the potential population change for no migration for all EU Member States. It is likely that a rational population forecast should be made by forecasting the change in the migration balance with qualitative research methods. For instance, by assuming that the natural growth per 1000 inhabitants will remain at the 2008-2017 average level, we will create two scenarios (Table 3). In the first, let us assume that from 2019 onwards, the average migration balance will stabilize at the 2015-2017 level (minus 10,000 inhabitants per year), while in the second, we may assume that from 2019 onwards, the average migration balance will stabilize at zero.

Conclusions

Decreasing population means less internal demand and less labour supply. It follows that there are presently no signs of a rapid change in Latvia's economic development. The population of Latvia will continue to decline even if the migration balance stabilizes at zero.

In turn, Eurostat's calculation based on assumptions about age and gender differences in mortality for each year is within the confidence interval of the forecast, based on a simple mathematical analysis of natural growth.

Though linear regression models evaluate changes in the population of Latvia and show very strong correlation, they must be treated critically.

The population migration balance is not predictable on the basis of historical observations and by using mathematical models. In migration balance forecast models that are based on mathematical statistical methods, the uncertainty is so great that the practical value of such models is negligible.

Kopsavilkums

Šī darba mērķis ir veikt iedzīvotāju skaita un tā pārmaiņu galveno komponentu matemātisko analīzi nacionālā līmenī, lai apzinātu šo indikatoru izmantošanu iedzīvotāju skaita pārmaiņu novērtējumā. Darba statistiskajā analīzē ir izmantoti Centrālās Statistikas pārvaldes dati un *Eurostat* veiktās iedzīvotāju skaita prognozes. Darba rezultātu pamatā ir datu regresijas analīze. Secinājums darba rezultātā: lai gan lineārās regresijas modeļi, vērtējot Latvijas iedzīvotāju skaita pārmaiņas, demonstrē ļoti augstus ciešuma rādītājus, pret tiem ir jāizturas kritiski. Savukārt iedzīvotāju migrācijas saldo nav viennozīmīgi prognozējams, ņemot vērā tā vēsturiskos novērojumus un izmantojot matemātiskos modeļus.

References

Apsite, E., Krišjāne, Z. and Berzins, M. (2012). Emigration from Latvia under economic crisis conditions, *International Proceedings of Economics Development and Research*, 31, 134-138.

Arbidane, I. and Markevica, L. (2016). Impact of labour force migration on Latvia's economy *Scientific Journal of Polonia University*, 18 (3), 69-78.

Berloviene, D. and Samuseviča, A. (2016). Topošo veselības aprūpes speciālistu motivācija vecu cilvēku sociālās labklājības veicināšanā. *Proceedings of the International Scientific Conference. Volume I*, May 27th - 28th, 57-66.

Eurostat database (2015). Population projections 2015 at national level (base year 2015) Population on 1st January by age, sex and type of projection http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=proj_15npms&lang=en (24.01.2019)

Göler, D., Krišjāne, Z. and Bērziņš, M. (2014). International migration in the periods of transition and crisis: the case of Latvia. *Baltic Region*, 6 (2), 75-85.

Indikatori 2015. gadā (2015). Latvijas ilgtspējīgas attīstības stratēģija līdz 2030.gadam. Nacionālais attīstības plāns 2014.-2020.gadam. Uzraudzības ziņojuma pielikums. Pārresoru koordinācijas centrs. https://www.pkc.gov.lv/sites/default/files/inline-files/MPzinP_07092015_Indikatori_5.pdf (24.01.2019)

Informatīvais ziņojums par darba tirgus vidēja un ilgtermiņa prognozēm (2018). Latvijas Republikas Ekonomikas ministrija.
https://www.em.gov.lv/files/tautsaimniecibas_attistiba/dsp/EMZino_06072018_full.pdf (24.01.2019)

Kekla, J. and Senfelde, M. (2016). Public finance sustainability in Latvia: assessing long-term challenges and policy options. *Economic Science for Rural Development Conference Proceedings*, 43, 274-282.

Klavenieks, K. and Blumberga, D. (2016). Forecast of waste generation dynamics in Latvia. *Energy Procedia*, 95, 200-207.

Krisjane, Z., Apsite–Berina E., Berzins M. and Grine I. (2017). Regional topicalities in Latvia: Mobility and immobility in the countryside. *Economic Science for Rural Development Conference Proceedings*, 45, 127-133.

Krisjane, Z. and Berzins, M. (2012). Post-socialist urban trends: New patterns and motivations for migration in the suburban areas of Riga, Latvia. *Urban Studies*, 49 (2), 289-306.

Latvijas Ilgtspējīgas attīstības stratēģija līdz 2030. gadam (2015). Latvijas Ilgtspējīgas attīstības stratēģijas līdz 2030. gadam, Nacionālā attīstības plāna no 2014.–2020. gadam un Laimdotas Straujumas vadītās valdības deklarācijas par iecerēto darbību īstenošanas uzraudzības ziņojuma, indikatoru pielikums. https://www.pkc.gov.lv/sites/default/files/inline-files/MPzin_07092015_Uzraudzibas_zinojums_4.pdf (24.01.2019)

National Development Plan of Latvia for 2014–2020 (2012). Cross-Sectoral Coordination Centre.
https://www.pkc.gov.lv/sites/default/files/inline-files/NDP2020%20English%20Final___1.pdf (24.01.2019)

Sustainable Development Strategy of Latvia until 2030 (2010). Saeima of the Republic of Latvia https://www.pkc.gov.lv/sites/default/files/inline-files/LIAS_2030_en_0.pdf (24.01.2019)

Zhitin, D.V., Krisjane, Z. and Sechi, G. (2018). The effect of migration on Latvia's sex And age composition. *Baltic Region*, 10 (1), 107-129.