Impact of ageing on economic growth at regional level in the Czech Republic

Jan POKORNÝ (pokorny@fek.zcu.cz)
Department of Finance and Accounting, Faculty of Economics, University of West Bohemia

ABSTRACT

The process of population aging represents an important phenomenon in society. Therefore, this phenomenon is given wide attention. Population aging has many significant impacts. The purpose of this study is to analyse the impact on economic growth at the regional level in the Czech Republic. First, there is a literature search on the issue of population aging and economic growth. It is possible to use the view of the Cobb-Douglas production function or product creation as a component of the gross domestic product. Based on the studies, it is possible to expect a negative relationship, that a larger share of the elderly population leads to decreased economic growth. The study examines this relationship at the level of regions in the Czech Republic. The ordinary least squares model is used for this analysis. Based on the results of the study, it is possible to state that the aging process is present in all regions except the capital city of Prague. Economic growth was the highest in the Moravian-Silesian region. Thus, these two regions represent outliers. Based only on the comparison of the two extreme values of the time 2000-2021, it is possible to state that there is a noticeable decrease in economic growth in connection with the aging of the population. In time series analysis, this statement cannot be declared. That is why five-year periods were used, which partially eliminated the problem of being influenced by the cycle. However, the result still needs to be confirmed. The limitation of the research is the limited time series and the variables used. Further research can focus on a more detailed analysis involving other parameters.

Keywords: *ageing, economic growth, regions, Czech Republic*
JEL Classification: *O18, O47, R11*

1. INTRODUCTION

Population ageing is a crucial process in current society. This process influences many different areas as health (Yu, 2021), long-term care (McCormack, McNally & O'Shea, 2021), active ageing (Ortega, 2021), pension systems (Bazzana, 2020; Mesa-Lago, Moreno & Kay, 2022) and connected income inequality (Hwang, Choe & Choi, 2021).

In this paper, the impact of ageing is examined with regard to economic growth. This topic is very connected with the pension system, respectively, with the public pension scheme in the Czech Republic.

This paper develops the issue on which the author focuses. This issue is Age management as a process of responding to the aging of the population. Age management issues from various angles are then dealt with Fabisiak & Prokurat (2012) or Gorzeń-Mitka, Sipa & Skibiński (2017). Effects of the aging process thus play an important role that needs to be addressed.

Based on the research intent, the aim could be defined. The paper aims to analyse the ageing effect on economic growth.

The literature review is used for analysing the issue ageing and economic growth in this paper. Then the ordinary least squares (OLS model) is used to quantitatively analyse both parameters. Lastly, the synthesis method is used for summaries.

This paper is divided into six parts. Section 2 Literature review describing the issue ageing connected with economic growth based on the description. Section 3 defines the data used for the processing of this paper. Then the results are described in Section 4. Lastly, Section 5 summarizes the paper in the Conclusion.

2. LITERATURE REVIEW

The aging of the population is a significant process that affects all societies. However, this effect is particularly noticeable in the countries of Europe and Japan, and the United States of America. This situation can be illustrated using the so-called old-age dependency ratio, i.e., the ratio of people over 65 and the age group from 15 to 64. While globally this ratio was 13% in 2015, it is expected to increase to 38% in 2100. The higher rate will be in the mentioned countries, which will burden public finances (Conesa & Kehoe, 2018).

Nwakeze (2014) describes her summary of research on the relationship between macroeconomics and demography in Nigeria:

"The major findings indicate that population size affects gross domestic product positively. The age dependency ratio was also found to have a negative effect which reflects the Nigerian situation as a country with a youthful population and unemployment crisis."

Given this, primary analysis of population and age cohort changes is appropriate because each country can have different effects of this process.

While Nigeria is a country with a young population, European countries have an older population. However, society is gradually reacting to this and creating its mechanisms, which also means financing replacement income, i.e., pensions.

More than ten years ago, Herrmann (2012) came to a conclusion that, despite the aging of the population, there is no shortage of labour. This could be given mainly in the context of the given time.

This is also helped by the focus on higher added value and changes within the production process (digitalization and automation). This can be doubted in some countries today, given the very low unemployment rate and the overheated labour market.

This paper uses economic growth as the parameter for evaluating ageing outputs. Thus, the gross domestic product is an important indicator, and the views could be utilized. Firstly, the Cobb-Douglas production function is part of the overlapping generations (OLG) model and affects the output:

$$Y_t = A_t \, K_t^{\alpha} L_t^{\,1-\alpha} \tag{1}$$

The real economic output Y_t is composed of a scaling variable A_t, capital K_t and labour L_t. The exponent represents constant return in both factors, which means capital and labour (Lindh & Malmberg, 2009).

However, on the real economic output could use the second view based on final goods output, then:

$$Y_t = C_t + G_t + I_t^n \tag{2}$$

where is variable for consumption C_t, government expenditures G_t and net investment I_t^n (Fougère & Mérette, 1999).

Both equations could be connected, then the output of equation (1) and (2) is:

$$A_t \, K_t^{\alpha} L_t^{\,1-\alpha} = C_t + G_t + I_t^n \tag{3}$$

Then the parameters could be defined with regard to dependency on the population and related indicators. On the left side equation (3) labour is highly dependent on the population because labour force is affected by the size population and population distribution between age cohorts. Labour force is simplified and composed of age cohorts from 15 to 64 years. The lower limit is also limited by legislation.

However, it is possible to define this age group further more closely, as entry into the labour market is rather delayed. Thus, this age cohort could be defined from 20 years. This could lead to the definition of partial age cohorts participating in the labour market.

At the same time, people aged 65 and over can participate. However, the such representation will be lower. Therefore, it is possible to define the main working group between 20 and 64. Due to the data, the range mentioned above of 15-64 years is more often used, which will continue to be used.

Capital is affected by savings (Lindh & Malmberg, 2009). Thus, the population has a significant effect on this variable because their net income is divided into consumption and savings. The income can be a wage for a worker or a social benefit. For retirees, this is typically a pension, which can be from public sources (from insurance premiums or taxation) or a private source based on the previous appreciation of savings. As a result, when private resources are drawn down, the accumulated capital decreases. Similarly, when drawing down earlier savings, which can affect the entire population, however, it is more evident in the case of pensioners.

On the right side of equation (3), there is a different breakdown of what is mentioned here. Consumption is defined by the size of the population and its tendency to consume or to save.

Consumption is then defined by the purchase of a product that depends on a sub-age group, i.e., again within a more detailed definition, e.g., in five-year intervals. A different level of consumption can be expected, even with regard to the shopping basket, which is differentiated not only according to income but also according to age.

Net savings are then affected by the residual value between income and consumption. This indicator has already been described above. Again, there is a strong dependence on age.

Government spending is then affected by income and any additional resources. In contrast, it was providing goods to a given population. It also fulfils a redistributive function, which is an important part, as it is represented by taxes (reducing possible consumption and savings) and transfers (increasing possible consumption, it is impossible to think about savings since social transfers are aimed more at low-income people).

Thus, defining the outcome of economic growth within the aging process is complex. On the one hand, there is a negative effect, as there is a decrease in the labour force, which stimulates higher economic growth with regard to the level of potential output. At the same time, there is a possible increase in savings, i.e., levies (insurance and taxation), which can then be used as part of government spending without the influence of other funds.

On the other hand, savings are drawn, which are reallocated from investments to consumption which positively affects the product as part of multiplier effects.

The author expects negative effects associated with population aging on the final product. However, it is necessary to consider partial positive and negative effects that depend on other conditions of the given economy, especially within the given technological development or use of capital and its further development.

Maestas, Mullern & Powell (2023) add that, based on empirical data from the United States of America in the period 1980-2010, the aging process leads to a decrease in gross domestic product growth per capita. Specifically, with a 10% increase in the population aged 60 and over, GDP per capita should decrease by 5.5%. Based on the impact analysis, the authors conclude that 2/3 of the impact is due to lower growth in labour productivity. At the same time, the remaining part is affected by the low growth of employment per capita.

A similar result is reached by Gagnon, Johannsen & López-Salido (2021), again using the example of the USA.

3. DATA AND METHODS

The paper aims to analyse the ageing effect on economic growth. To achieve this goal, the OLS model is used to find the relationship between the demographic structure and economic growth.

The OLS model is composed of the dependent variable and independent variables, also known as explanatory variables. For this paper is used:

$$GDP_{ij} = \beta_0 + \beta_1 Y_{ij} + \beta_1 M_{ij} + \beta_1 O_{ij} + \varepsilon_{ij} \quad (4)$$

The dependent variable is gross domestic product GDP_{ij}, which the demographic structure affects. Three parts of the population describe this, which could be defined as young, middle, and old. Firstly, the young age is under 15 years. This group has not representation in the labour market. Then, middle age is the main group in the labour market. The employment rate influences it. However, the younger part of the second group (students) could have an effect on the development of economic growth.

Lastly, old age is associated with retirees. The part of this group can be active in the labour market. On the other hand. The main part of the group is inactive in the labour market.

Based on this description as well as based on the Section 2 Literature Review, the author expected a positive effect on economic growth with the

increasing share of middle age. On the other hand, a negative effect is expected with the increasing number of other groups (young and old age).

Data used in this paper are described in Table 1. Firstly, the time horizon is from 2000 to 2021. This time is affected based on a statistical database that is used. It means Czech Statistical Office.

Data Description

Table 1

Variable	Description	Source
i	Time from 2000 to 2021	X
j	Regions of the Czech Republic	X
GDP_{ij}	Gross domestic product at the time and in the region	Czech Statistical Office (2023a)
Y_{ij}	Population under 15 years at the time and in the region	Czech Statistical Office (2023b)
M_{ij}	Population from 15 to 65 years years at the time and in the region	
O_{ij}	Population above 65 years at the time and in the region	

Source: own processing, 2023

The regions of the Czech Republic are used for analysis in this paper. The Czech Republic has 14 regions, 13 regions, and the capital city, respectively. It is about Prague as the capital city and regions: Central Bohemian, South Bohemian, Pilsen, Karlovy Vary, Ústí nad Labem, Liberec, Hradec Králové, Pardubice, Vysočina, South Moravian, Olomouc, Zlín, and Moravian-Silesian Region.

Share of Gross Domestic Product at Regional Level (differences against 2000)

Table 2

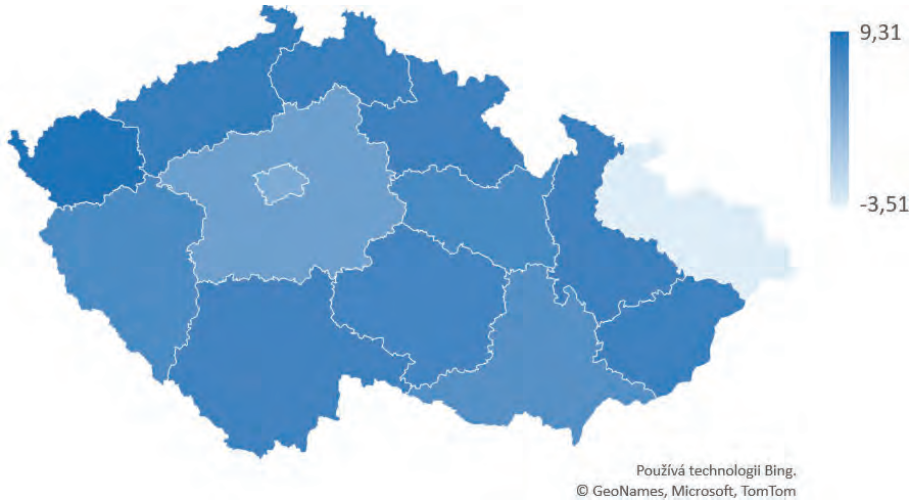
Region	2000	2005	2010	2015	2020	2021
Prague	22.7	2.6	1.7	-0.4	0.7	4.7
Central Bohemian	10.8	-0.4	0.1	0.6	0.2	0.5
South Bohemian	5.7	-0.3	-0.5	-0.1	0.1	-1.0
Pilsen	5.0	0.0	-0.1	0.0	-0.2	-0.1
Karlovy Vary	2.5	-0.3	-0.2	-0.2	-0.2	-0.9
Ústí nad Labem	6.7	-0.2	-0.3	-0.3	-0.5	-1.4
Liberec	3.8	-0.3	-0.3	0.0	-0.1	-0.8
Hradec Králové	5.0	-0.4	-0.2	0.0	0.2	-0.3
Pardubice	4.2	-0.3	0.0	0.0	0.1	-0.3
Vysočina	4.2	-0.1	-0.2	0.0	0.1	-0.3
South Moravian	10.0	-0.2	0.4	0.3	0.3	1.0
Olomouc	5.0	-0.4	-0.1	0.1	0.1	-0.3
Zlín	4.7	-0.1	0.0	0.1	-0.1	-0.1
Moravian-Silesian	9.6	0.4	-0.5	-0.2	-0.8	-0.7

Source: own computations based on CZSO (2023a), 2023

Table 2 shows the share of gross domestic product at the regional level. In 2000, Prague had the highest share (22.7 %) in other years. Since 2005, Prague has created over a quarter of the gross domestic product. It meant an increase of about 4.7 percentage points in 2021.

Differences of Old Age Share between 2000 and 2021 (percentage points)

Figure 1



Source: own computation based on CZSO (2023b), 2023

Other important regions are Central Bohemian and South Moravian. Both regions created more than 10 % of the gross domestic product in the monitored period.

In this contrast, the increasing share in 2021 against 2000 has Prague, Central Bohemian, and South Moravian regions. Other regions have to decrease their shares from -0.1 to -1.4 percentage points.

The next variable is the share-based age. The population increased by about 0.25 million people from 2000 to 2021. The old-age cohort is incising about 52 % from 1.42 to 2.17 million people. Middle age is decreasing from 7.18 to 6.65 million people, about -7.31 percentage points. The share of young is relatively similar in 2000 and 2021, 16.21 % of the population, respectively 16.1 %.

Figure 1 shows the changes in the share of retirees in the population from 2000 to 2021. The greatest change is 9.31 percentage points in Karlovy Vary Region. On the other hand, the lowest change is -3.51 percentage points in Moravian-Silesian Region. Thus, this region is the only part of the

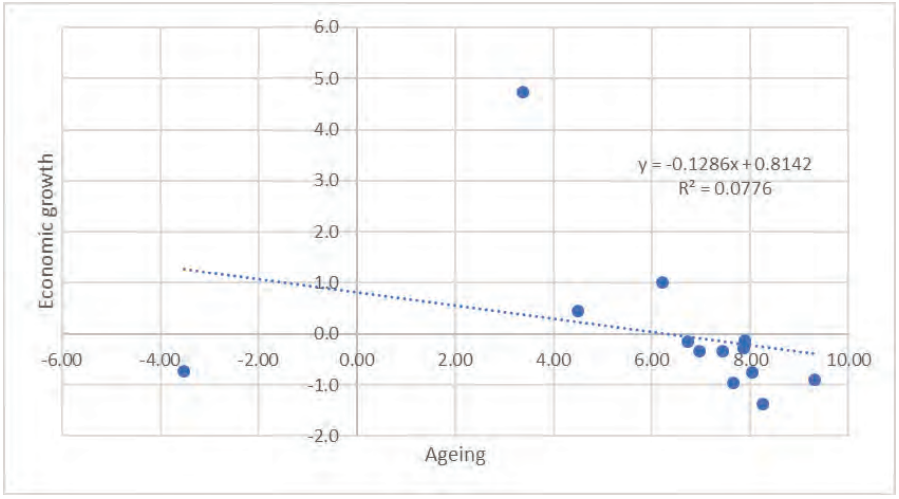
Czech Republic where the share decreased. The second lowest value is 3.38 percentage points in Prague.

4. RESULTS

Before proceeding to the analysis based on the model, it is possible to mention a certain similarity due to Section 3. Based on Table 2 and Figure 1, the differences in the index approach have certain similarities. Figure 2 shows regression between these parameters.

Index of Ageing and Economic Growth

Figure 2



Source: own computation based on CZSO (2023a; 2023b), 2023

Figure 2 uses the index between 2000 and 2021 with respect to the previously described data. The regression using 14 samples, it means very few observations. However, the changes do not show clearly that higher ageing corresponds with lower economic growth. The adjusted coefficient of determination has a low declarative value. This lower value is mainly due to two outliers: Prague and the Moravian-Silesian region.

Based on this, outliers were removed, which differ from other regions by a lower rate of aging, thus limiting the indicative value.

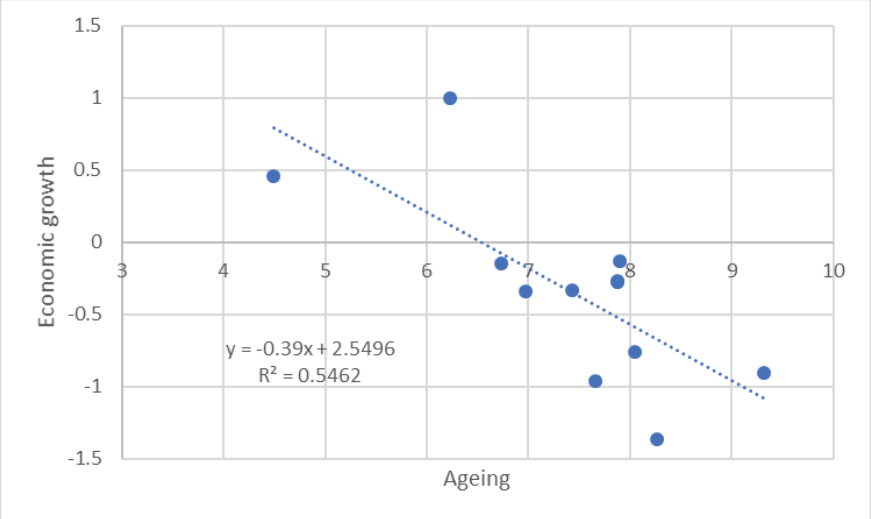
Due to the adjustment, there was an increase in the adjusted coefficient of determination, which increased from 0.07 to 0.55, i.e., to a level of relatively strong dependence. In the second regression in Fig. 3, the relationship between

population aging and lower economic development at the regional level is more evident. A study from the USA confirms this.

Pearson correlation could be used, and 14 variables show a correlation of -0.279, which means – there is a weak negative relationship. The correlation is very positive without outliers (Prague and Moravian-Silesian Region), with 0.997.

Index of Ageing and Economic Growth without outliers

Figure 3



Source: own computation, 2023

Based on the mentioned changes, there is a noticeable difference within the regions mentioned, which deviate from these assumptions. The OLS model is also used to improve the estimate, which is applied to the time horizon 2000-2021, i.e., with respect to the available data set.

Table 3 shows OLS models for every region in the Czech Republic. Table 4 reflected the issue outliers and thus showed Czechia regions without Prague and Moravian-Silesian regions.

Ordinary Least Squares Model

Table 3

	Model 1	Model 2	Model 3	Model 4
HDP_{ij}	Basic	Ln	I	Δln
Constant	-14 338 (-6.29)***	-3.89 (-8.44)***	0.89 (3.35)***	0.05 (14.44)***
Y_{ij}	-4.43 (-5.40)***	-1.11 (-5.19)***	-0.39 (-2.64)***	-0.39 (-2.70)***
M_{ij}	0.55 (3.50)***	0.83 (5.22)***	0.79 (3.72)***	0.74 3.64***
O_{ij}	5.36 (11.21)***	1.57 (18.28)***	-0.24 (-1.66)*	-0.22 (-1.56)
Adj R	0.64	0.86	0.11	0.11
Sample	308	308	294	294

Source: own computation, 2023

In both models, the OLS model is created on the basic data (models 1 and 5) and on adjustments, which are the logarithm of the original data (models 2 and 6). In addition, indices (models 3 and 7) and differences in logarithms (models 4 and 8) are created. Due to the modification, 308 data are used for the first part, or 264 data without two regions. In the second part, the number of data is reduced to 294 (252).

In table 3, models 1 and 2 show a similarly adjusted coefficient of determination level of 0.95, which is a very high value. In contrast, for models 3 and 4, the value is at the level of 0.1, and the explained part of the model is very low. The statistical significance of the variables is in all cases only in model 2. In other cases, the problematic population is under 14 years.

Model 2 finds a negative relationship between the young and older part of the population, which is due to the fact that the given part of the population will enter the labour market only in the future. In other cases, model 2 shows a positive relationship, which, however, is higher for the aging part of the population, which is surprising on two levels: 1. the assumption based on foreign studies is not confirmed, and 2. the value is higher than in the case of the working part. Based on this, it would be possible to assume a high increase in consumption, which compensates for other decreases.

Models 3 and 4, however, show the expected reduction in both the young and the elderly population. However, in the case of the younger part of the population, there is no statistical significance. At the same time, the model explains only 10 %.

Ordinary Least Squares Model without Prague and the Moravian-Silesian region

Table 4

	Model 5	Model 6	Model 7	Model 8
HDP_{ij}	Basic	Ln	I	Δln
Constant	-46 245.70 (-10.23)***	-1.45 (-5.35)***	1.21 (3.16)***	0.05 (9.42)***
Y_{ij}	0.26 (-1.22)	-0.41 (-3.87)***	-0.18 (-0.89)	-0.18 (-0.93)
M_{ij}	-0.14 (-3.46)***	0.20 (2.24)**	0.63 (2.47)**	0.59 (2.41)**
O_{ij}	2.76 (27.76)***	1.36 (33.16)***	-0.52 (-2.09)**	-0.50 (-2.03)**
Adj R	0.95	0.95	0.10	0.10
Sample	264	264	252	252

Source: own computation, 2023

Table 4 adjusts the version to fewer regions (without Prague and the Moravian-Silesian region). However, the results are similar. Therefore, the original assumption, when a change is compared to table 3 was expected, is not fulfilled. Considering this, it is not necessary to reflect on this part further.

Due to the previous results, there is an expansion of the table 5, where five-year periods are analysed, which limits the number of data. The aim is similar studies to those presented above, but drawn from different periods and with different explanatory variables. Due to the small differences between the results in tables 3 and 4, there is no use of differentiation for all regions and a narrower selection. Models 9-12 have a relatively high rate of explanation for the models. The results are similar to the above. The basic model and its logarithmic form (models 9 and 10) negatively correlate economic growth and the young generation. There is a positive trend in other parts. At the same time, the data are statistically significant. This changes in models 11 and 12, where there is a negative relationship between the young and older generations with economic growth. However, there is no statistical significance in the data.

Ordinary Least Squares Model 5-years

Table 5

	Model 9	Model 10	Model 11	Model 12
HDP_{ij}	Basic	Ln	I	Δln
Constant	-133 778 (-3.06)***	-3.92 (-4.37)***	0.81 (3.12)***	0.20 (14.13)***
Y_{ij}	-4.62 (-3.04)***	-1.30 (-3.74)***	-0.14 (-0.51)	-0.26 (-1.58)
M_{ij}	0.64 (2.12)**	0.99 (3.23)***	0.44 (4.30)***	1.70 (5.91)***
O_{ij}	5.07 (5.74)***	1.58 (9.96)***	-0.13 (-1.59)	-0.24 (-1.55)
Adj R	0.63	0.86	0.36	0.48
Sample	84	84	70	70

Source: own computation, 2023

5. CONCLUSION

In addition to the size of the population, the distribution of the population between individual age cohorts also matters. Population aging is an important phenomenon in today's world that affects various human aspects, including a country's economic performance.

When the population ages, it is possible to expect a reduction in the economic performance of countries, which can be observed through the Cobb-Douglas production function, which is composed of labor and capital. At the same time, capital is affected by savings.

On the other hand, the product as a gross domestic product is characterized, among other things, by consumption, which is increased due to the reduction in savings of the elderly population.

The influence on the economic product is thus two-sided and is influenced by the given conditions.

Based on the presented data, it is evident that the Czech Republic is also struggling with an aging population within the individual regions, except for Prague. However, a negative effect on economic growth cannot be confirmed because, on the contrary, there is a positive relationship between an older population and economic growth. This would mean outweighing this effect.

A limitation of the study is the limited data set, which also includes economic fluctuations. Another limitation is the limited number of variables included in this study. However, this study aimed to explain the relationship between economic growth and population ageing. An alternative could be to

expand the number of age cohorts and a more detailed analysis, which can be used for further research.

Further research can also be focused on other explanatory variables that will expand the model, which may lead to a better explanation. On the other hand, in this case, it is possible to pay attention to the model of overlapping generations and its versions, which better captures this issue about the prediction of further development over time.

ACKNOWLEDGMENT

This paper was created within the project SGS-2023-007 'Current Challenges and Problems of Modern Society from the Perspective of Finances and Accounting' at the University of West Bohemia, Faculty of Economics.

REFERENCES

1. Bazzana, D. (2020). Ageing population and pension system sustainability: reforms and redistributive implications. *Economia Politica, 37*(3), 971-992. https://doi.org/10.1007/s40888-020-00183-8
2. Conesa, J. C., & Kehoe, T. J. (2018). An introduction to the macroeconomics of aging. *The Journal of the Economics of Ageing*, *11*, 1-5. https://doi.org/10.1016/j.jeoa.2018.03.002
3. Czech Statistical Office (2023a). *Regional accounts.* Retrieved from https://vdb.czso.cz/vdbvo2/faces/en/index.jsf?page=vystup-objekt&z=T&f=TABULKA&skupId=4809&katalog=30832&pvo=NUCD05&pvo=NUCD05&str=v324
4. Czech Statistical Office (2023b). *Distribution of the population by age as at 31.12. (basic group) - territory selection*. Retrieved from https://vdb.czso.cz/vdbvo2/faces/en/index.jsf?page=vystup-objekt&z=T&f=TABULKA&katalog=30845&pvo=DEMZU04&u=v8__VUZEMI__100__3018
5. Fabisiak, J., & Prokurat, S. (2012). Age Management as a Tool for the Demographic Decline in the 21st Century:An Overview of its Characteristics. *Journal of Entrepreneurship, Management and Innovation, 8*(4), 83-96. https://doi.org/10.7341/2012846
6. Fougère, M., & Mérette, M. (1999). Population ageing and economic growth in seven OECD countries. *Economic Modelling, 16*(3), 411-427. https://doi.org/10.1016/S0264-9993(99)00008-5
7. Gagnon, E., Johannsen, B. K., & López-Salido, D. (2021). Understanding the New Normal: The Role of Demographics. *IMF Economic Review, 69*, 357–390. https://doi.org/10.1057/s41308-021-00138-4
8. Gorzeń-Mitka I., Sipa M., Skibiński A. (2017). Multifaceted Character of the Issues of Age Management. *Polish Journal of Management Studies, 16*(2), 110-121. https://doi.org/10.17512/pjms.2017.16.2.10
9. Herrmann, M. (2012). Population Aging and Economic Development: Anxieties and Policy Responses. Popu*lation Ageing, 5*, 23–46. https://doi.org/10.1007/s12062-011-9053-5
10. Lindh, T., & Malmberg, B. (2009). European Union economic growth and the age structure of the population. *Economic Change and Restructuring* 42, 159-187. https://doi.org/10.1007/s10644-008-9057-1

11. Maestas, N., Mullen, K. J., & Powell, D. (2023). The effect of population aging on economic growth, the labor force, and productivity. *American Economic Journal: Macroeconomics, 15*(2), 306-332. https://doi.org/10.1257/mac.20190196
12. McCormack, R., McNally, S., & O'Shea, D. (2021). AGEING POPULATION: THE IMPACT ON ADMISSIONS TO LONG-TERM CARE. *Age and Ageing, 50*(3), ii9–ii41. https://doi.org/10.1093/ageing/afab219.97
13. Mesa-Lago, C., Moreno, C., & Kay, S. J. (2022). The financial sustainability of public pensions in Cuba: The impact of ageing, structural reforms and the economic crisis. *International Social Security Review, 75*(2), 25-46. https://doi.org/10.1111/issr.12293
14. Nwakeze, N. M. (2014). The Nexus Between Macroeconomics and Demographics: Implications for Sustainable Development. *The Economic and Social Review, 45*(2), 285–298
15. Ortega, J. A. (2021). Is Active Ageing Coping with Population Ageing? Draft Submitted to Journal of Population Aging. *Journal of Population Ageing, 14*(1), 37-52. https://doi.org/10.1007/s12062-020-09265-8
16. Seokchae, H., Choe, C., & Choi, K. (2021). Population ageing and income inequality. *The Journal of the Economics of Ageing*, 20, 100345. https://doi.org/10.1016/j.jeoa.2021.100345
17. Yu, Y. (2021). Healthy ageing in urban China: Governing the ageing population. *Geographical Journal, 187*(1), 28-38. https://doi.org/10.1111/geoj.12372