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Content

Population Ageing as a Factor of Structural Changes in Unemployment

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Abstract

The aim of the paper was to analyse the relationship between the unemployment rate and population ageing. Regression and correlation analysis was used. The Spearman and Pearson correlation coefficients were also used. The research question one examined the relationship between the average age of the ageing population and the unemployment rate, suggesting a likely non-linear relationship. The research question two focused on the relationship between the average age of the population and the number of job seekers aged 50-64. The analysis showed that the linear model had limited accuracy while the use of a non-linear approach significantly improved the quality of the results and more complex and non-linear relationships between the investigated variables were pointed out. The research does not take into account socio-economic factors that may have a significant effect on the non-linear relationships between variables.

Keywords: Unemployment, population ageing, average age, regression analysis, correlation, Czech Republic, labour market

Introduction

Population ageing has recently become one of the most important demographic trends with significant impacts on the economy, the labour market and other economic variables. This trend is mainly associated with an increase in life expectancy and a decline in

fertility. Population ageing is associated with several phenomena. These include rising income inequality, linked to lack of skills or health problems. Of course, these problems can significantly affect the individual's employability and thus have a significant impact on the level of overall unemployment (Hwang et al., 2021).

Population ageing can also result in a lower risk appetite among potential employers, which may eventually change the overall productivity (C. Liu et al., 2024). The COVID-19 pandemic was another factor, which has exacerbated problems of long-term unemployment, especially among young workers, pointing to the need to apply active labour market policies (Dhingra & Kondirolli, 2022). We can also examine the association between older populations and innovative activity in the context of unemployment. This relationship suggests that the innovative activity of older workers significantly decreases from a certain age onwards (Irmen & Litina, 2022). However, many older people choose to remain active, often bringing valuable knowledge and perceiving themselves as useful employees; this may contribute to the fact that even retired people remain at work or show a desire to return to work (Bjuhr et al., 2022). However, whether older people can be employed is also strongly affected by their health, especially chronic diseases. It is these barriers that may also contribute to higher unemployment rates (Cylus & Al Tayara, 2021).

Population ageing has far-reaching economic implications, and as it has recently become a hot topic, several important studies on this complex subject have been produced in the last few years. These studies have provided different views of the issue and helped us to better understand this socio-economic problem we are facing. In relation to the research questions of this thesis, field research addressing similar issues have been reviewed.

Grzenda (2019) examines socio-economic aspects of long-term unemployment in Polandin his 2019 study: Socio-economic aspects of long-term unemployment in the context of the ageing population of Europe: the case of Poland. Using Bayesian statistics, this paper finds significant shortcomings in the public / national family policy where especially post-maternity women and the elderly have a considerable disadvantage in the labour market. The study highlights that lack of knowledge and health problems largely contribute to their unemployment. Hsieh (2023) reached similar results using panel analysis where he found that lack of knowledge and skills may contribute to unemployment of older workers. At the same time, lack of access to training and good education are also important factors. It is also confirmed that the proper application of policies could mitigate the impact of overall unemployment and the impact on the labour market (Petrosky-Nadeau & Zhang, 2021). Fortunately, there is a growing interest in the topic of population ageing and adaptation, and the economic effects are subject to increasing investigation (Oprea & Vlădescu, 2024). The results of the study by Wang & Li (2021) suggest that even increased demand for health and social services may lead to significant market competition and unemployment. The Age Differences in Unemployment Risk and Reemployment Outcomes in Late Working Life in Sweden study conducted using regression Probit analysis identified that the risk of unemployment does not change significantly with age groups, but older people have much lower chances of

re-employment (Öylü et al., 2024). Long-term unemployment also reduces the chance of returning to a permanent job. According to research conducted in China by Liu et al. (2023), population ageing can have an adverse impact on the country's economic growth. Panel analysis, which captures population changes over a longer period and correlation analysis were used to conduct this research. The study associates this negative impact on the economy with a reduction in the labour force, lower rates of innovation and a greater burden on the social and health systems. Dhingra & Kondirolli (2022) examined unemployment and specifically how the COVID-19 pandemic affected the labour market. However, the survey was primarily based on young people data between 2017 and 2021 using panel analysis. It was found that the unemployment rate did not change significantly with the pandemic, and young people are primarily at risk. But the population ageing effects may be responsible for many more changes. For example, the Population ageing, unemployment and house prices in South Africa study analysed the correlation between population ageing and house prices using panel and regression analysis. It was concluded that population ageing deteriorates housing market conditions, with rising unemployment slowing the growth of these prices (Simo-Kengne, 2019). A similar question to the one posed in this thesis was addressed by a German university, which examined the effect of age groups on unemployment in the US and how population ageing affects the regional levels of employment between 2000 and 2014. The study results suggest that the ageing U.S. population could reduce overall unemployment and the population ageing effects are long-lasting (Ochsen, 2021).

In order to answer the first research question, we need to look at methods addressing or dealing with similar issues. The first method to be used will be regression analysis, which was used in the research to describe the relationship between unemployment and house prices in the Simo-Kengne (2019) study. Next, correlation analysis used in research on China's ageing population on its economic growth could be applied. These methods will be used to measure their dependence.

The increase in the average age of the population may lead to an increase in the retirement age, which may result in more older workers and more job seekers. For example, Securing Employment of the Elderly legislation was passed in Japan, which mandates employers to provide employment until the age of 70 (Mori et al., 2024). Raising the retirement age may also have a direct effect on unemployment. A data analysis from 30 developed countries found that raising the retirement age can increase youth unemployment, but on the other hand reduce unemployment among older workers (Rozen-Bakher, 2020). This, in turn, may cause older workers to face specific challenges in the workplace and the overall labour market. These include adapting to new technologies, automation, robotics and using artificial intelligence (Alcover et al., 2021). Thus, the position of the older generation is strongly affected by their lack of familiarity with modern technologies. A study by Van Borm et al. (2021) was primarily focused on working people over the age of fifty and the result of their research was that older job seekers have in overall lower retraining / requalification opportunities, which may cause job concerns. It is certain that job fears can occur in any age group due to a variety of

circumstances. Over the last few years, several research papers have always come to different conclusions when examining the older generation. However, for example, the Gender-Age Differences in Hiring Rates and Prospective Wages. Evidence from Job Referrals to Unemployed Workers study clearly shows that older job seekers (50-54 years old) are more successful in finding higher-paying jobs, and this success rate even increases when the job seeker is male. To analyse the data, the authors used the following statistical methods: regression analysis, descriptive statistics elements such as means and medians, and Propensity Score Matching (PSM), to compare groups with different characteristics as accurately as possible (Bamieh & Ziegler, 2023). Thus, the conclusion is that there are several influences in the labour market that work in favour and against older job seekers.

Regression and correlation analysis will be used to analyse data between the average age of an ageing population and the number of job seekers aged 50-64 using Spearman and Peason correlation coefficients as well as the coefficient of determination. The ability to use this secondary data allows the research to be focused and conducted for the research questions.

For both research questions, correlation and regression analysis will be used as the data processing method.

The aim of the thesis is to identify the relationship between population ageing and changes in unemployment. Specifically, the research focuses on the relationship between the average age of the ageing population and the unemployment rate in the Czech Republic between 2014 and 2023.

The following research questions are set to reach the goal:

Research on the relationship between unemployment and population ageing in the Czech Republic is relevant because it represents a significant demographic change, which our current society is facing, and has a major impact on the labour market and the economy as such. By understanding this relationship, public institutions can better design, develop and subsequently apply new policies.

RQ1: What is the relationship between the average age of the ageing population and the unemployment rate in the Czech Republic?

As the population becomes older, not only are the average ages increasing, but the labour market is also changing significantly. As a result of this demographic change, both the supply and demand for labour may change. Answering this question will determine whether there is a relationship between increasing average ages of the Czech population and the number of job seekers.

RQ2: What is the relationship between the average age of the ageing population and the number of job seekers aged 50-64 in the Czech Republic?

Methods and Data

Data collection will be based on secondary data collected by the Czech Statistical Office (CSO, 2024) and the Ministry of Labour and Social Affairs (MoLSA, 2024). All secondary data concerning the average age of population and the unemployment rate will be taken from the Czech Statistical Office (CSO, 2024) website and will be adjusted for seasonal effects. The input data will include a column with the average age, a column with the unemployment rate and a column with the given year, seeTab. 1.

The secondary data concerning job seekers will be taken from the Ministry of Labour and Social Affairs (MLSA, 2024) website. All data are publicly available from the institutions' websites. The input data consists of a column with the average age of the population and a column with the number of job seekers (aged 50-64), seeTab. 1.

Tab. 1: RQ2 input data: Average age of the population and the number of job seekers

Year	Average Age	Jobseekers
2014	41.70	157,328
2015	41.87	140,472
2016	42.05	125,970
2017	42.20	100,724
2018	42.33	82,670
2019	42.48	75,578
2020	42.58	97,796
2021	42.78	93,689
2022	42.61	95,656
2023	42.80	95,264

Source: Authors using the Czech Statistical Office and Ministry of Labour and Social Affairs data (2024).

Regression and correlation analysis methods will be used for the research, including the Spearman and Peason correlation coefficient and the coefficient of determination. These statistical methods will be applied using the TIBCO Statistica software and MS Excel will also be used for simpler analysis. For the research questions, the correlation analysis will investigate the relationship between the average age of the population and the unemployment rate and the relationship between the average age of the population and the number of job seekers aged 50-64.

This method will be used to identify the dependence between the variables and their mutual intensity, as shown by the value of the Pearson correlation coefficient using the least squares method.

Pearson correlation coefficient:

$$r_{xy} = r_{yx} = \frac{s_{xy}}{\sqrt{s_x^2 \cdot s_y^2}} = \frac{s_{xy}}{s_x \cdot s_y} \quad (1)$$

s_{xy}.....sample covariance, can be the values (-∞;∞)

s_x.....standard deviation of x empirical values
s_y.....standard deviation of y empirical values

The numerator of the formula contains covariance, which has the following form:

$$S_{xy} = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x}) \cdot (y_i - \bar{y}) \quad (2)$$

The Pearson correlation coefficient can be the values from -1 to +1, and this very number will indicate whether there is a dependence, or how strong the dependence is. The value of rxy = 0 indicates that the variables are not correlated and therefore there is no dependence. The coefficient rxy = +1 indicates increasing dependence and rxy = -1 indicates decreasing dependence. The more the Pearson coefficient value approaches the absolute value of 1, the stronger is the dependence considered.

Next, a regression analysis will be carried out to construct a mathematical model and subsequently create a regression graph using a MS Excel spreadsheet. An inductive method will be used to assess the type of the regression function - the function will be selected based on the point graph. Subsequently, the coefficient of determination will also be simply determined using a MS Excel spreadsheet.

$$R_{yx}^2 = \frac{s_Y^2}{s_y^2} \quad (3)$$

sY..... variance of the actual observed values
sy..... variance of equilibrium values

The coefficient of determination shows how well the secondary input data fits a given regression curve. Most of the literature provides that the function can be considered sufficient quality from a value of 0.7 onwards. Of course, the higher the value, the better quality of the function.

Spearman's correlation coefficient will be applied using TIBCO Statistica and will be particularly useful for non-linear relationship of variables. This coefficient also measures non-linear relationships, specifically it measures the strength of the relationship between two quantities. For this coefficient, it is useful to choose hypotheses from which to infer the correlation:

- Null hypothesis H_0: a correlation exists.
- Alternative hypothesis H_1: a correlation does not exist

Whether the hypothesis is accepted or rejected will depend on p-value with a significance level of 0.05. If the p-value is greater than 0.05, the result is considered statistically significant. In general, the lower the p-value, the less likely it is that the selected statistical method or test indicates the truth of the null hypothesis. If the p-value is lower than 0.05, the result is considered statistically insignificant, and we accept the alternative analysis

The results of correlation and regression analysis are similar statistical methods complementing each other. Based on other studies of the topic, a dependence relationship between the two variables could be expected. Based on research and the results of other studies, a stochastic or minimal dependence can be expected.

Results

This chapter will present results of the analysis that we conducted. The analysis was aimed at obtaining answers to the defined research questions. For clarity, the results are divided into two sections, each focusing on one of the questions and graphically illustrating the results.

Research Question 1 Results

For research question 1, the data used will include the unemployment rate and the average age of the population with data set characteristics as shown inTab. 2.

Tab. 2: Data set characteristics: unemployment rate and average age of the population

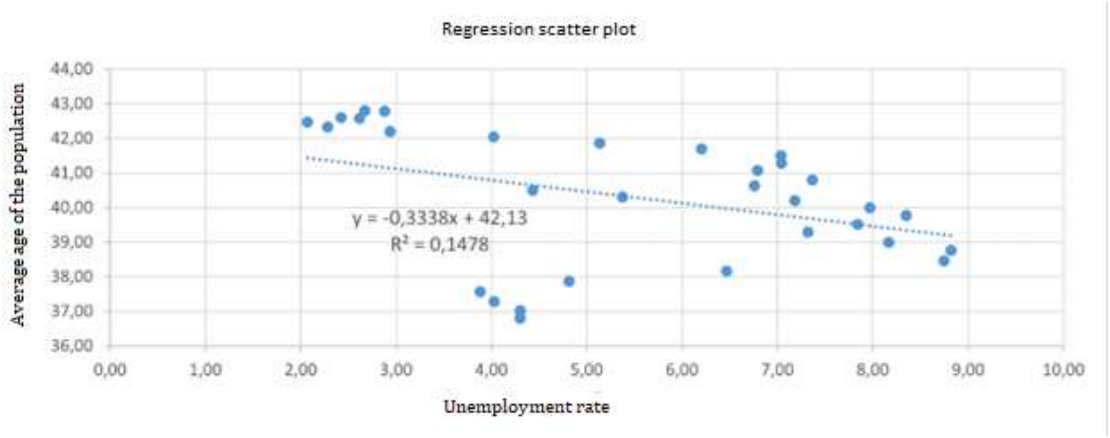
Parameter	Unemployment Rate	Average Age of the Population
Mean	5.491710913	40.29658015
Standard error of the mean	0.388590924	0.337328617
Median	5.376145103	40.5
Standard deviation	2.163582701	1.87816625
Selection variance	4.681090102	3.527508464
Peakiness	-1.380748968	-1.071512547
Slant	-0.08977807	-0.35953738
Max-min difference	6.754570426	6.00640635
Minimum	2.068436941	36.79775
Maximum	8.823007367	42.80415635
Total	170.2430383	1249.193985
Number of values	31	31

Source: Authors using a data analysis add-in in MS Excel (2024).

The following results were collected using the above methods for research question 1. The Pearson correlation coefficient was (using the = EARSON function) -0.38451. This value describes a negative weak dependence of the variables (from 0.4 onwards it would be a medium dependence). Since the Person coefficient only describes a linear dependence, it is important to verify that it is indeed a linear dependence and, if necessary, verify the dependence using the Spearman coefficient.

Using a MS Excel spreadsheet, the input data was converted into a dot plot. By looking at the points, we cannot clearly determine whether there will be a dependence and whether the trend line will be linear. A linear trend line was used for a basic view of the dependence, which is shown inGraph 1.

Graph 1 : Regression dot plot with a linear trend line for the research question 1

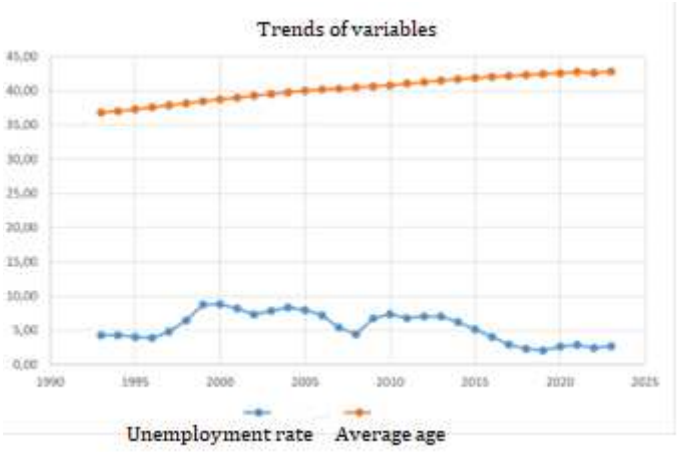


Source: Authors using MS Excel (2024).

The Graph shows that the regression dot plot equation is **y = -03338x + 42.13** and the coefficient of determination "R squared" (shown as R^2 in the Graph) is **0.1478** or **14.78%**. The coefficient of determination determines the quality of our estimated regression function, where we could conclude that the regression function is good quality from 0.7 onward.

Since the coefficient of determination is low, we need to consider other shapes of the trend line. Graph 2 shows that the average age has an increasing trend indicating population ageing while the unemployment rate has a fluctuating trend.

Graph 2 : Variables trends for the research question 1

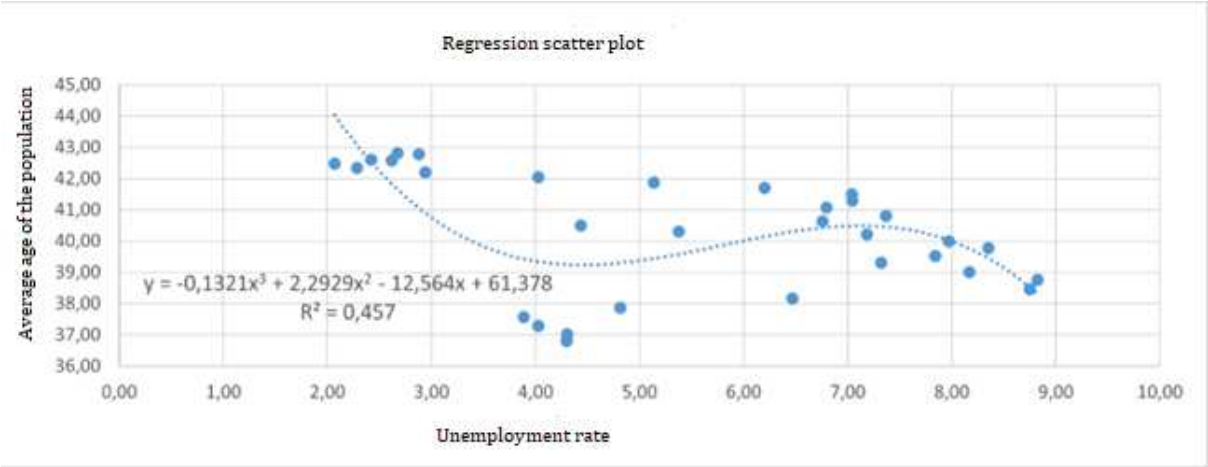


Source: Authors using MS Excel (2024).

Therefore, a polynomial trend line was applied, which fits the dots better and the coefficient of determination indicates a higher quality of the regression function: **45.7%,** see

Graph 3.

Graph 3 : Regression dot plot with a polynomial trend line for the research question 1



Source: Authors using MS Excel (2024).

Once the non-linearity of the relationship was established, the Spearman correlation coefficient (seeTab) was found to be **-0.48346.** This is a moderately strong negative relationship that describes how well the parameters fit the monotonic nonlinear function. The p-value is **0.005863**.

Tab. 4: Spearman correlation coefficient

Valid N	Spearman R	p-value
31	-0.483468	0.005863

Source: Authors using TIBCO Statistica (2024).

If we consider a significance level of 0.05, the result shows that it is statistically significant. Therefore, we reject the null hypothesis. This would imply that the alternative hypothesis H1 will be accepted as likely true. A correlation probably exists here.

Research Question 2 Results

The data set characteristics for the average age of the population and the number of job seekers aged 50-64 are provided in

Tab. 3.

Tab. 3: Data set characteristics: Average age of the population and the number of job seekers aged 50-64

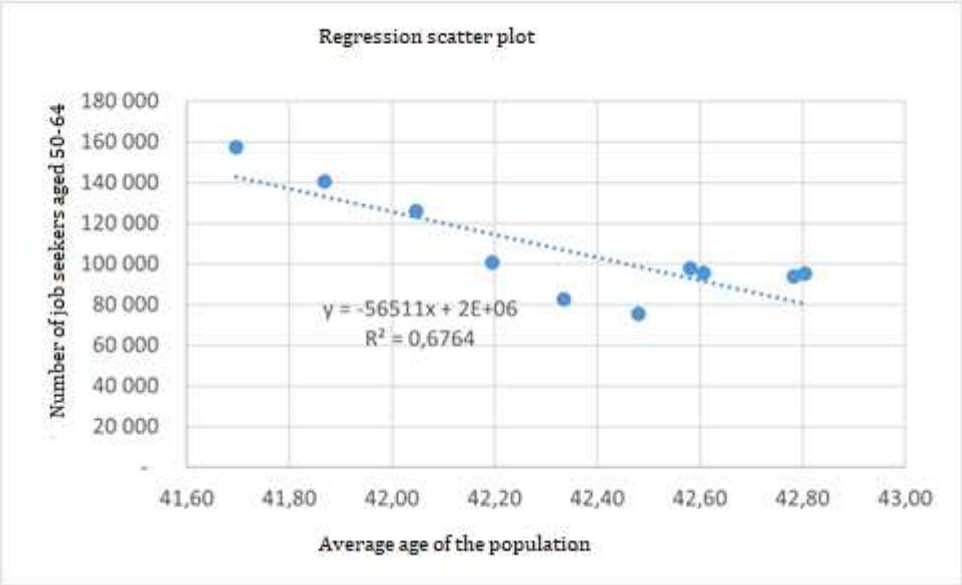
Parameter	Average Age of the Population	Number of Job Seekers (50-64 years)
Mean	42,33957657	106514,7
Standard error of the mean	0,120381997	8271,627299
Median	42,40739229	96726
Standard deviation	0,380681299	26157,18222
Selection variance	0,144918252	684198181,8
Peakiness	-0,986987155	0,063185802
Slant	-0,443018921	1,000201314
Max-min difference	1,10817635	81750
Minimum	41,69598	75578
Maximum	42,80415635	157328
Total	423,3957657	1065147
Number of values	10	10

Source: Authors using a data analysis add-in in MS Excel (2024).

The Pearson correlation coefficient was **-0.822440243** (again using the =PEARSON function), which indicates a strong negative correlation. This means that if the average age of the population is increasing, the number of job seekers aged 50-64 is decreasing. This coefficient describes a linear relationship (dependence), which in this case also describes the relationship of these variables.

Using a MS Excel spreadsheet, the data were entered into a dot plot (Graph 4), which illustrates the downward trend of a likely linear relationship. A linear trend line with the equation $\mathbf{y= - 56511x+2*10^9}$ and the coefficient of determination $\mathbf{R^2 = 0.6764}$ or **67.64%** were entered into the Graph. The coefficient of determination then shows that this is a medium quality regression model, and this model therefore explains the data reasonably well.

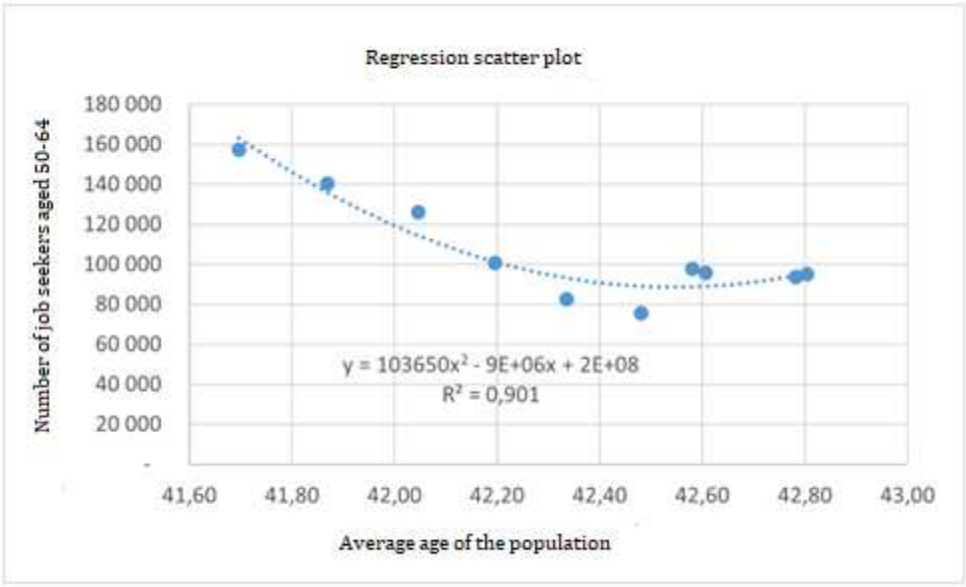
Graph 4 : Regression plot with a linear trend line for the research question 2



Source: Authors using MS Excel (2024).

Even though the coefficient of determination was 67.64%, the possibility that this was not a linear trend line was considered. When a polynomial trend line (Graph 5) was applied, the coefficient of determination increased to **R^2 = 0.901** or **90.1%**. Thus, there is a possibility that no linear relationship exists here.

Graph 5 : Regression dot plot with a polynomial trend line for the research question 2



Source: Authors using MS Excel (2024).

For a possible nonlinear relationship, the Spearman correlation coefficient (Tab. 4) was also applied and the result was -0.696970, indicating a strong negative correlation.

Tab. 4: Spearman correlation coefficient

Valid N	Spearman R	p value
10	-0.696970	0.025097

Source: Authors using TIBCO Statistica (2024)

Furthermore, the p value was also calculated using TIBCO Statistica, which is 0.025097. The result illustrates a statistical significance, and hence rejection of the null hypothesis and acceptance of the alternative hypothesis, which would imply a likely absence of correlation.

Discussion

The following research questions were asked:

RQ1: What is the relationship between the average age of the ageing population and the unemployment rate in the Czech Republic?

The Pearson correlation coefficient of -0.38451 revealed a weak relationship (dependence) between the variables. The same was revealed by the regression analysis of the linear dot plot where the coefficient of determination illustrated a low-quality function (14.78%), i.e. the function only simulates the relationship between the variables at 14.78%. Higher quality can be achieved by applying a non-linear trend to the dot plot. The polynomial trend line corresponds to a coefficient of determination 45.7%. This is a slight improvement, but still not a high enough value to consider the function as good quality. The Spearman correlation coefficient -0.48346 and the p-value 0.005863 indicate a moderately strong negative relationship between the variables. Based on a significance level of 0.05, the statistical significance was established and subsequently the null hypothesis was rejected. These results conclude likely not correlated variables. If there is a relationship between the variables, it is not a linear relationship but a different type of non-linear relationship. The possible non-linearity of this relationship was also concluded by Ochsen (2021) who also pointed to various factors that may influence this relationship such as commuting and younger workers entering the workforce more quickly. Similar results were also obtained by Rozen-Bakher (2020) who emphasised the non-linear effect, namely increasing youth unemployment and decreasing senior unemployment. The research conducted for the first research question only focused on quantitative research and one of the identified shortcomings / limitations of the research is mainly that the research does not take into account socio-economic factors, and therefore the results may lead to general conclusions. Another limitation may be the time scale for observing the variables.

RQ2: What is the relationship between the average age of the ageing population and the number of job seekers aged 50-64 in the Czech Republic?

The Peason correlation coefficient reached -0.82244, indicating a significant negative relationship. Regression analysis from the dot plot demonstrates moderate model quality with a coefficient of determination 0.6764. This level of the coefficient of determination could indicate a linear relationship (dependence) of these variables. The coefficient of determination increases to 90.1% when using the non-linear model, indicating that this model better explains the relationship between the variables. The Spearman correlation coefficient is -0.696970. It is therefore appropriate to consider, similar to the first research question, whether the model is linear or non-linear. The p-value reached a value of 0.025097. Based on the significance level of 0.05, the result was concluded as statistically significant. This p-value result indicates a likely absence of correlation. Although the results provided valuable and important insights into unemployment and population ageing, the limitations of the research should be considered. Although the linear regression function suggests a moderate quality function, the validation of the non-linear model suggests that the relationship may be much more complex, thus other alternative methods need to be used, and deeper data analysis is required to provide clearer results. The Propensity Score Matching method, for example, could provide more accurate results as it also takes into account other factors that could bias the result (Bamieh & Ziegler, 2023).

Conclusion

The aim of this paper was to analyse the relationship between the unemployment rate and population ageing. Specifically, the research questions investigated the relationship between the unemployment rate and the average age of the population. The research question two dealt with the average age of the population and the level of career interest in the 50-64 age group in the Czech Republic. The methods such as Pearson and Spearman correlation coefficient and regression analysis were used to meet the research aim of this thesis.

The results revealed that relationships exist between the variables, but they are not completely linear and are affected by other factors. The research question one concerning the relationship between the average age of the ageing population and the unemployment rate showed a likely non-linear relationship between these variables. The research question two was aimed to examine the relationship between the average age of the population and the number of job seekers aged 50-64. The methods used for this question showed a moderate quality model assuming a linear relationship between the variables while the model quality improved significantly when a non-linear approach was applied. Similar to the research question one, the results indicate a more complex and likely non-linear relationship between the variables.

A summary based on the conducted research is that the aim of the thesis was fulfilled providing important insights about unemployment in the Czech Republic. The main contribution of the thesis is that a complex relationship was identified between the research variables.

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Appendix

Tab. 1 : RQ1 Input Data: Unemployment Rate and Average Age of the Population

Year	Unemployment Rate	Average Age
1993	4.30	36.80
1994	4.30	37.02
1995	4.03	37.28
1996	3.88	37.57
1997	4.81	37.86
1998	6.47	38.16
1999	8.75	38.46
2000	8.82	38.76
2001	8.17	39.00
2002	7.32	39.30
2003	7.84	39.52
2004	8.35	39.77
2005	7.97	39.99
2006	7.18	40.21
2007	5.38	40.30
2008	4.43	40.50
2009	6.76	40.63
2010	7.37	40.80
2011	6.79	41.08
2012	7.04	41.28
2013	7.04	41.50
2014	6.20	41.70
2015	5.14	41.87
2016	4.03	42.05
2017	2.94	42.20
2018	2.28	42.33
2019	2.07	42.48
2020	2.62	42.58
2021	2.88	42.78
2022	2.42	42.61
2023	2.673855	42.80

Source: Authors using the Czech Statistical Office data (2024).