FACTORS OF GENDER PAY GAP IN THE HIGHEST WAGES OF EMPLOYEES IN THE SLOVAK REPUBLIC

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Abstract: *The article contains the results of empirical analysis of data on one percent of employees with the highest salaries in the Slovak Republic in 2020. The starting point for the analysis there is 11,570 anonymized individual values of average gross monthly wage and also personal data of the employees whose wage exceeded the 99th percentile of the sample survey The Informational System on Labour Costs, implemented in the Slovak Republic since 1992 by the company Trexima Bratislava. The aim of the article is to assess the gender pay gap for the best-earning men and women and assess the significance of the impact of selected factors that contribute it. Given the availability of data the monitored factors of the gender pay gap there are education, region of residence, the type of occupation, and the categorized age of employees. To achieve the objective, selected quantitative methods were used, namely methods of descriptive statistics and statistical inference, as goodness-of-fit tests, chi-squared tests of independence and machine learning methods, as normalized Shannon entropy and regression decision tree models. The results of analyses by these methods have been preferably presented in a graphical form. Based on the application of the above methods the significant wage differences by gender at the highest wages (over the 99th percentile of the sample) and significant impact of monitored factors has been confirmed not only on the gender pay gap, but also on the structure of their employment. The results of the analyses lead to the conclusion that the significant wage differences by gender at the highest wages are caused precisely by unequal representation of men and women on the different levels of the monitored factors.*

Keywords: *Comparisons, gender pay gap, factors, highest wages, chi-squared tests, regression tree.*

JEL Classification: *D31, J31, J71.*

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Introduction

Reducing the gender pay gap is one of the key priorities of gender policies at both the European Union and at the national levels. At the European Union level, the European Commission priority is "reducing the gender pay, earnings, and pension gaps and thus fighting poverty among women" as one of the key areas in the framework of the Union of Equality: Gender Equality Strategy 2020–2025 (European Commission, 2020). The unadjusted gender pay gap indicator is used to monitor imbalances in earnings between men and women (Eurostat, 2021a).

The unadjusted gender pay gap (GPG) is defined as the difference between the average gross hourly earnings of men and women expressed as a percentage of the average gross hourly earnings of men. It is calculated for enterprises with 10 or more employees (Eurostat, 2021b).

Eurostat publishes gender pay gap statistics on an hourly rather than an annual basis. According to the latest available data for the year 2019, women's gross hourly earnings were on average 14.1% below those of men in the EU. The biggest gender pay gap was identified in Estonia (21.7%), Latvia (21.2%), Austria (19.9%), and Germany (19.2%). The smallest differences in average pay between the gender categories were found in Italy (4.7%), Romania (3.3%), and Luxembourg (1.3%). In Slovakia, GPG was recorded at a level of 18.4% in the year 2019 (Eurostat, 2021b).

Various factors contribute to the gender pay gap, such as differences in labour force participation rates, differences in the occupations and activities that tend to be male-dominated, or female-dominated. They are often not insignificant either differences in the extent to which men and women work on a part-time basis, as well as the attitudes of personnel departments within private and public organizations towards career development and unpaid and/or maternity/ parental leave. Some underlying factors that may, at least in part, explain gender pay gaps include sectoral and occupational segregation, education and training, awareness and transparency, as well as direct discrimination. Gender pay gaps also reflect other inequalities, in particular, women's often-disproportionate share of family responsibilities and associated difficulties of reconciling work with private life. Many women work part-time or under atypical contracts: although this permits them to remain in the labour market while managing family responsibilities, it can have a negative impact on their pay, career development, promotion prospects, and pensions (Eurostat, 2021b).

Up until relatively recently, most of the research on the gender pay gap focused on analysing the mean pay gap between men and women. In general, the mean gender pay gap is smaller in the public sector compared to the private sector in most EU countries (Eurostat, 2021a). The public sector offers desirable benefits for women such as maternity leave, job flexibility and job security. In addition to this, anti-discrimination legislation is more likely to be actively enforced than in the private sector (Gregory & Borland, 1999). This is confirmed by findings in other publications, such as Lucifora and Meurs (2004) or Melly (2005).

There is substantial evidence of the gender pay gap widening at the higher end of the pay distribution in the public sector of other countries too, indicating so-called a 'glass ceiling' effect. The presence of glass ceilings is a metaphor used to illustrate the artificial barriers that make it difficult for women to progress to higher at the lower levels of the occupational ladder. Wahlberg (2010) provides evidence of a glass ceiling effect within the public sector for Sweden. Similarly, Castagnetti and Giorgetti (2019) find a glass ceiling effect present in the Italian public sector. In recent years the literature has begun to differentiate more fully with respect to lower-pay and higher-pay workers, given the gap is not constant across the pay distribution (Barón & Cobb-Clark, 2010).

The gender pay gap in the Slovak Republic on the whole wage interval confirm and analyze, e.g., articles Tartaľová and Sovičová (2013), Holubová (2013) and Gottwald et al. (2013). This article focuses only on the upper end of the distribution of wages of employees in the Slovak Republic with aim to verify these three hypotheses:

H1: During the time interval from 2010 to 2020, the highest wages of employees in the Slovak Republic increased, but the gender pay gap did not change significantly.

H2: The gender pay gap in the Slovak Republic is also characteristic of employees with the highest wages and is significantly influenced by factors education, occupation, age and region of residence.

H3: Different levels of above-mentioned factors cause different employment structure for men and women with the highest salaries.

Verification of these assumptions is made possible by individual data on employees that for this purpose have been provided by the company Trexima. The data file contains 11,570 anonymized individual values of the gross monthly wages and also personal data of those employees in the Slovak Republic whose average gross monthly wage exceeded the 99th percentile of the sample data in 2020. The entire sample obtained by stratified

random sampling covers more than half of the employees in the Slovak Republic (Trexima, 2022). The survey includes payroll and personnel data on employees.

At the beginning of the research, attention was paid to quantification and graphical presentation of the changes in one percent of the highest wages of men and women in the Slovak Republic in one decade. Then, good-fitted probability models of the upper end of the wage distributions have been constructed and parameters of the distributions have been compared. The results of the structural difference analysis by mentioned above factors and relevant statistical tests for the one percent of the highest-pay workers have been summarized and graphically compared by gender.

The identified dependencies between gender and other characteristics of employees (education, occupation, age and region) were supported by the results of measuring the variability of these variables separately for men and women. Normalized Shannon entropy was used to measure variability. Finally, the results of the analysis using the regression decision tree model are presented.

The inspiration for the presented analysis in the article were also the publications Pacáková and Foltán (2011) and Pacáková et al. (2012), the results of which have been used to compare the gender pay gap of the employees with the highest wages in 2020 and 2010 in the Slovak Republic.

1. Theoretical Background

Labour plays a major role in the functioning of an economy. The principle of equal pay for equal work is one of the pillars of social equity in the European Union. With the existence of the pay gap, especially related to gender, a wide range of publications is targeted to identify the causes of these differences. The gender wage gap has also been accentuated by international organizations such as the International Labour Organization (ILO, 2020) and The Organization for Economic Co-Operation and Development (OECD, 2021). Other, less-cited measures, examine the gap at different parts of the wage distribution, or for different demographic subgroups, or are adjusted for factors such as education level and occupation (Gould et al., 2016).

The main challenge in determining the GPG is to make a distinction between discrepancies in female and male wages resulting from different labour market characteristics (skills, education, participation rates, etc.) and indirect or direct wage discrimination due specifically to gender. Since women and men have different average levels of education and experience and commonly work in different industries and occupations, multiple factors can influence the gender pay gap (Kahn, 2015). Indirect discrimination includes institutional settings, pay policies, or social norms, which could contribute to a difference in female and male wages. Direct discrimination refers to a situation in which women and men with similar education, skills and work experience receive different wages for the same job position (Corley et al., 2005).

Much has been written on gender wage inequalities and a huge amount of literature exists on explaining the reasons why men continue to be paid more than women all around the world. Theoretical backgrounds of wage inequality go back to Edgeworth (1922), and the human capital theory along with the discrimination theory (Becker, 1957) are the two principal complementary theories of gender wage inequality coexisting in literature.

The gender pay gap seems to be country-specific and many publications focus just on them. The article of Hara (2018) used Japanese data to conduct a decomposition across the wage distribution, focusing on the wage structure effect, which is the portion of the gender wage gap that is unexplained by gendered differences in human capital. The study of Wahlberg (2010) examines gender wage differentials across the wage distribution in the Swedish private and public sectors using quantile regression. There is a glass ceiling effect for women in both the private and the public sectors in Sweden. Although this is true for both sectors, it is especially pronounced in the public sector. The gender wage differentials across the whole distribution in the private sector are lower in Sweden than in the USA and 11 European countries, whereas the opposite can be said about the public sector; here the gap is higher across the entire distribution in Sweden. In the study of Koral and Mercan (2021), the gender wage gap and gender wage discrimination in Turkey are estimated and evaluated based on data taken from the nationally representative Turkish Household Labour Survey for 2002 to 2019. It was found that the gender wage gap is small in the

Turkish labour market, while most of this gap originates from discrimination against women. Böheim et al. (2021) examine the gender wage gap in Austria from 2005 to 2017 using data from EU-SILC. Decompositions of the wage gap indicate that both the explained and the unexplained part of the gender wage gap decreased substantially over the last ten years. The article by Smith and Whitehouse (2020) examines the main principle applied in the pursuit of gender equality in Australian wage-setting systems (equal remuneration for work of equal value) through the lens of a typology of contrasting approaches to gender (and overall) wage equality. The collection of Whitehouse and Smith (2020) of the same authors includes studies of advances and retreats in Australia and New Zealand, shaped by political and economic trends, changing wage-setting arrangements, and varying interpretations of formal provisions. Costa Dias et al. (2020) document the evolution of the gender pay gap in the UK over the past 25 years and its association with fertility. The study demonstrated that in the UK, the gender pay gap is still large and that an important explaining factor is a working experience, especially for women who gave birth. Working part-time after childbirth seems to act as a penalty factor for women's earnings.

The growth in the gender wage gap reflects the disproportionate impact of family responsibilities on women's careers. From the beginning of their working lives, women experience a gender wage gap that is still expected to swell significantly over the course of their careers, regardless of education or work experience (Goldin, 2014). While women are more likely to graduate from college than men, and are more likely to receive a graduate degree than men, at almost all education levels, women are paid less than men (Gould & Schieder, 2016). Furthermore, evidence shows that as women's participation in a particular occupation rises, pay within that occupation falls (Gould et al., 2016). Some researchers attribute this phenomenon to 'devaluation', in which employers ascribe a lower value to work done in female-dominated occupations and thus pay them less (Gould et al., 2016; Levanon et al., 2009).

The most comprehensive studies on the gender wage gap in the Czech Republic are those of Jurajda (2003, 2005) and are concerned mainly with segregation effects. Jurajda (2003, 2005) used data from 1998 and, most importantly, showed that one-third of the observed gender wage gap is caused by unequal male and female representation in a particular occupation in both the Czech Republic and Slovakia. Mysíková (2012) quantifies the basic structure of the gender wage gaps in four Central European countries and finds the highest gender wage gap in the Czech Republic by using the EU-SILC 2008 data.

Tartaľová and Sovičová (2013) based on income data from EU-SILC in the years 2005–2009 by statistical methods verify the gender pay gap in Slovakia in this period. By Holubová (2010) in a pan-European comparison, Slovakia is a country with a significant gender division of labour in families and in the labour market, with persistent vertical and horizontal gender segregation in economic sectors and occupational classes, with an extremely low representation of women at all levels of government and with insufficiently reflected consequences of gender inequalities. Gottwald et al. (2013) analysing the wage determinants in Slovakia based on data from the survey Information system on labour cost realized by the company Trexima confirm gender as a particularly important determinant of wages.

Several publications examine the impact of minimum wages on the size and composition of the gender wage gap in different countries. Fewer published studies examine the gender pay gap at the upper end of the wage distribution. Office for National Statistics (ONS) provides information about the gender pay gap for the top 20% of earners in the UK based on the Annual Survey of Hours and Earnings. A few publications that analyse inequalities at the very top of the wage distribution, such as Bell and Van Reenen (2013), or Tomaskovic-Devey et al. (2020) monitor various factors of the differentiation of highest wages.

The gender pay gap is only part of the investigation of the global gender gap. The Global Gender Gap Index benchmarks the evolution of gender-based gaps among four key dimensions (Economic Participation and Opportunity, Educational Attainment, Health and Survival, and Political Empowerment) and tracks progress towards closing these gaps over time. The methodology of the index has remained stable since its original conception in 2006, providing a basis for robust cross-country

and time-series analysis. The Global Gender Gap Index measures scores on a 0 to 100 scale and scores can be interpreted as the distance to parity, i.e., the percentage of the gender gap that has been closed. (World Economic Forum, 2021).

2. Research Methodology

The starting point for the analysis there is 11,570 anonymized individual values of the variable *salary_gm* and also personal data of those employees in the Slovak Republic whose average gross monthly wage exceeded the 99th percentile equal to EUR 4,863.17 in 2020 of the sample data of all employees. The entire sample has been obtained from the sample survey The Informational System on Labour Costs, which has been implemented in the Slovak Republic since 1992 by the company Trexima Bratislava (Trexima, 2022). The survey includes payroll and personnel data on Slovak employees.

The confirmed and subsequently analysed factors of *salary_gm* is the *gender* with categories: male (man); female (woman), together with classification variables as the *level of education*, the *region* of residence, the type of employment labeled as *occupation*, and the categorized *age*.

The categories of the factor *education* are: 0 – Unspecified education; 1 – Basic; 2 – Apprenticeship; 3 – Secondary (without GCSE); 4 – Apprenticeship with graduation; 5 – Complete medium general; 6 – Full secondary vocational; 7 – Higher professionals; 8 – University (1st degree); 9 – University (2nd level); 10 – University (3rd degree). The factor *region* of residence has categories according NUTS 3 classification: 1 – Bratislavský; 2 – Trnavský; 3 – Trenčiansky; 4 – Nitriansky; 5 – Žilinský; 6 – Banskobystrický; 7 – Prešovský; 8 – Košický. The classification of employment expresses the variable, which generalized type of jobs of employees. It was labelled as an *occupation* with its original categories from the sample survey: 0 – Unspecified employment; 1 – Legislators, executives; 2 – Specialists; 3 – Technicians and professionals; 4 – Administrative staff; 5 – Service and trade workers; 6 – Skilled workers in agriculture, forestry, and fishing; 7 – Skilled workers and craftsmen; 8 – Operators and fitters of machinery and equipment; 9 – Auxiliary and unskilled workers. The *age* categories are 1: up to 20; 2: 20–24; 3: 25–29; 4: 30–34; 5: 35–39; 6: 40–44; 7: 45–49; 8: 50–54; 9: 55–59; 10: 60+, i.e., 60 and older.

Descriptive characteristics of the central tendency and the level (sampling average, median, quartiles, and other selected percentiles), variability (coefficient of variation), and visualization by box-plots (Labudová et al., 2021) provide clear information about the values of *salary_gm* in the sample and its subsets.

Always is sampling influenced by randomness, so it is useful to generalize the information from the sample data to the population by methods of statistical inference (Pacáková et al., 2015). The best and the most comprehensive generalization of information from sample data is to find the proper good-fit probability model of the observed variable in the population. It allows calculation of important parameters of the population, quantiles, and probabilities of any intervals of values. As an appropriate probability model for values exceeding the threshold a high enough (e.g., 99th percentile of variable), even with the existence of extreme values, it is considered to be 2-parameter Pareto distribution with distribution function in the form:

$$F_a(x) = 1 - \left(\frac{a}{x}\right)^b, x \geq a \tag{1}$$

where: *b* is the shape parameter.

The basic parameters of this probability model, that are mean $E(X)$, variance $D(X)$ and skewness y_1, so the basic measures of wage probability distribution in the population, express the following formulas:

$$E(X) = \frac{ab}{b-1}, b > 1 \tag{2}$$

$$D(X) = \frac{a^2 b}{(b-1)^2(b-2)}, b > 2 \tag{3}$$

$$\gamma_1 = \frac{2\sqrt{b-2}(b+1)}{\sqrt{b}(b-3)}, b > 3 \tag{4}$$

The goodness-of-fit tests as a chi-squared test, Kolmogorov-Smirnov test (*K-S test*), Cramer-Von Mises W^2, and Watson U^2 tests were used to determine whether the distribution of the variable *salary_gm* can be adequately modelled by an estimated 2-parameter Pareto distribution. The chi-squared test compares the number of observed values of variable

salary_qm in intervals to the expected number based on the fitted 2-parameter Pareto distribution. The K-S test computes the maximum distance between the cumulative distribution of *salary_qm* and the *CDF* of the fitted 2-parameter Pareto distribution. Cramer-Von Mises W^2 and Watson U^2 tests compare the empirical distribution function to the fitted *CDF* in different ways. When the resulting *p*-values of the performed tests are greater than 0.05, we cannot reject the idea with 95% confidence, that *salary_qm* comes from a 2-parameter Pareto distribution with parameters fitted by the maximum likelihood estimation method.

To verify the hypothesis that gender causes a different employment structure by different categories of these factors have been used chi-squared test of independence between the gender and education, gender and employment, gender and age, and gender and region. The magnitude of the Cramer's V contingency coefficient expresses the power of this relationship (Agresti, 2019; Labudová et al., 2021).

How the variability of individual categories of the factors is affected by the action of the *gender* was determined by the measure of *normalized entropy* with its expression for each of the considered factors' category, with the frequencies summarized in the contingency table.

Shannon Entropy in information theory is perceived as the measure of uncertainty. Consider a discrete random variable X with possible outcomes x_1, x_2, ... x_k, which occur with probability p_1, p_2, ... p_k. The entropy of X is formally defined as (Masisi et al., 2008):

$$H(X) = \sum_{i=1}^{k} p_i . log\ p_i \quad (5)$$

and the normalized Shannon entropy is expressed by:

$$H(X)_{norm} = \frac{1}{log\ k} \sum_{i=1}^{k} p_i . log\ p_i \quad (6)$$

The decision tree (regression tree) model is also used to achieve the objectives of the article. Decision tree models may be effectively used to define the most critical attributes in a data set (Breiman, 2001).

A decision tree is a structure that can be used to divide a large set of records into successively smaller sets of records by applying a sequence of simple decision rules (Berry & Linoff, 2004). Decision trees split the data into subgroups based on empirically derived associations between the response (target) and one or more input variables. The goal is to use the set of input variables to form groupings (nodes) that are as homogeneous as is possible with respect to the target variable (maximize node purity). In the situation where the response variable is continuous, the goal of node purity is one of minimizing the variability of the response. The algorithm selects input variables using *F*-test (Terek et al., 2010). The models were built by means of SEMMA methodology with SAS Enterprise Miner 12.1 software.

3. Research Results

In the next part of the text, we draw conclusions about the gross monthly wage (average gross monthly wage in euros), considering only the gross monthly wage which exceeded the 99th percentile of wages of employees of the Slovak Republic in the sample (variable labeled *salary_gm*). A comparison of the basic descriptive statistics of the one percent of the highest wages in 2010 and 2020 allows the Tab. 1.

Tab. 1: Comparison of descriptive statistics of *salary_gm* (EUR) in 2010 and 2020

Year	Count	Average	Median	Coefficient of variation (%)	Minimum	Maximum	Lower quartile	Upper quartile
2010	9,900	6,109.57	4,662.10	88.65	3,434.86	165,970	3,915.86	6,387.11
2020	11,570	7,726.92	6,193.77	78.86	4,863.17	218,333	5,366.60	8,061.09
Diff. Δ	–	1,617.35	1,531.67	−9.79	1,428.31	52,363	1,450.74	1,673.98

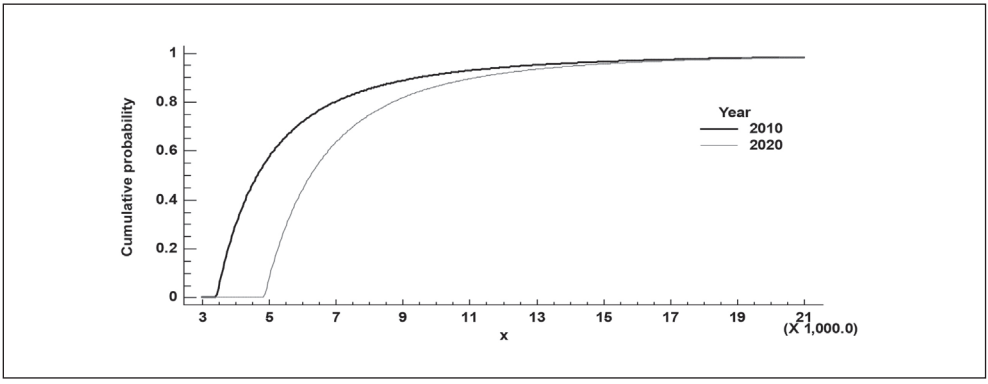
Source: own based on Trexima and Pacáková et al., 2012

Information from the sample data has been generalized to the set of all employees in the Slovak Republic in 2020 whose *salary_gm* exceeded the value of EUR 4,863.17 by 2-parameter Pareto models (1) valid by goodness-of-fit tests. Since the smallest *p*-value amongst Cramer-Von Mises W^2 and Watson U^2 performed tests is greater than or equal to 0.05, we cannot reject the hypothesis that sample data of variable *salary_gm* comes from a 2-parameter Pareto distribution (with lower threshold *a* = 4,863.17 and estimated shape parameter *b* = 2.75362 with 95% confidence. In the article Pacáková et al. (2012), the Kolmogorov-Smirnov test confirmed at the 0.05 significance level a good fit with the Pareto distribution (1) with the parameters *a* = 3,434.84 and *b* = 2.26487 (*p*-value 0.3348 > 0.05). A graphical comparison of the distribution functions of gross monthly wages exceeding the 99th percentile (*salary_gm*) in 2010 and 2020 provides Fig. 1.

The graphic shape (Fig. 1) and the percentiles of the Pareto distribution functions of the variable *salary_gm* in the monitored years reveal a shift to higher values in the coarser lower end and in the middle part, but indicate lower values of extremes – outliers in the right end in 2020 (Tab. 2). This fact may explain the lower variability measured by the coefficient of variation in the year 2020 (Tab. 1).

Chi-squared tests confirm the good-fit of the 2-parameter Pareto models (1) of *salary_gm* separately for men and for women. Since the smallest *p*-value = 0.696624 is higher than 0.05, we cannot reject with 95% confidence the assumption that *salary_gm* of men comes from the 2-parameter Pareto distribution (with lower threshold *a* = 4,863.17and estimated shape parameter *b* = 2.63536) and for women with estimated lower threshold *a* = 4,863.17and estimated shape parameter *b* = 3.26251 (*p*-value > 0.05 for women). According to the distribution functions of both good-fitted models, the probability of lower values is higher for women than for men, i.e., higher values of *salary_gm* are more likely for men than for women in both years 2010 and 2020 (see the

Fig. 1: Graphical comparison of distributions of *salary_gm* in 2010 and 2020 (EUR)



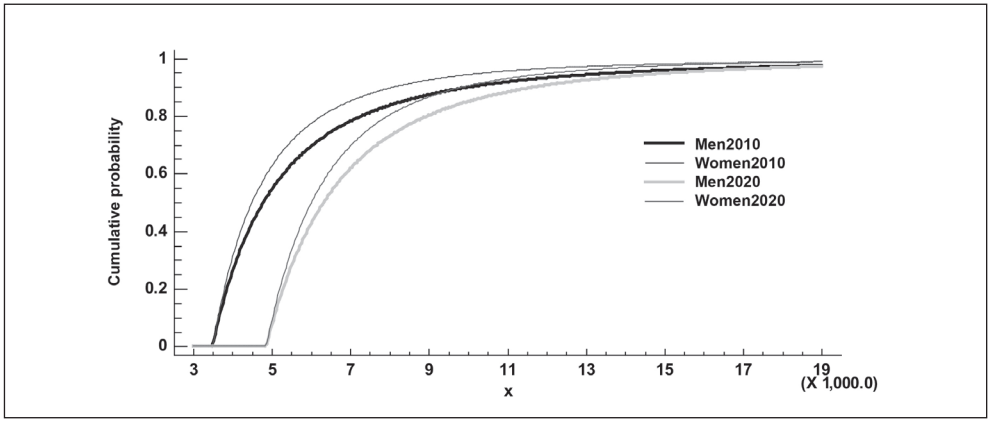
Source: own based on Trexima

Tab. 2: Comparison of percentiles of *salary_gm* in 2010 and 2020 (EUR)

Percentile	1%	10%	25%	50%	75%	90%	99%
2010	3,450.14	3,598.42	3,900.07	4,664.68	6,334.82	9,493.70	26,239.89
2020	4,880.95	5,052.85	5,398.73	6,255.20	8,045.68	11,222.19	25,896.20

Source: own based on Trexima

Fig. 2: **Distribution function of the highest monthly wages of men and women in 2010 and 2020**



Source: own based on Trexima

Tab. 3: **Percentiles of the Pareto distributions of *salary_gm* in 2010 and 2020 by gender (EUR)**

Percentiles	Male2010	Female2010	Dif 2010	Male2020	Female2020	Dif 2020
1%	3,504.83	3,502.54	2.29	4,881.75	4,878.33	3.42
10%	3,661.04	3,625.51	35.53	5,061.54	5,022.95	38.59
25%	3,979.51	3,872.89	106.62	5,424.10	5,311.64	112.46
50%	4,790.61	4,485.23	305.38	6,326.26	6,014.55	311.71
75%	6,578.26	5,764.57	813.69	8,229.51	7,438.28	791.23
90%	10,003.86	8,032.18	1,971.68	11,651.30	9,850.23	1,801.07
99%	28,685.59	18,486.88	10,198.71	11,651.30	9,850.23	1,801.07

Source: own based on Trexima

distributions functions in Fig. 2 and also the quantiles of the Pareto distributions in Tab. 3).

Other results are focused on the assessment of wage inequality by gender and its factors in 2020 based on the analysis of individual data on 11,500 employees in the Slovak Republic.

The basic characteristics of *salary_gm* in 2020 are all higher for men than for women (Tab. 4) with the differences given in the last row of the table. Just the fact that among the best-earning employees is 3.47 times more men as women (Diff. = 6,398) indicates significant gender pay inequality. This is also confirmed by the Gender Pay Gap (GPG = 10.27%) according to Diff. Δ of average of *salary_gm* in Tab. 4.

Not only that women are less represented in the one percent of the best-paid employees in the Slovak Republic in the year 2020, the shift to lower-wage values for women is also evident from the box plots in Fig. 3.

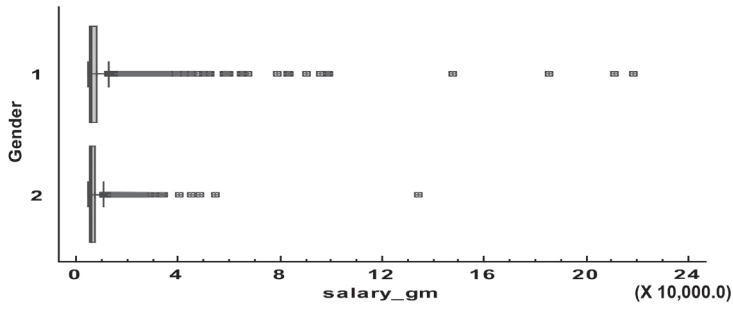
In the individual categories of *occupation*, the most noticeable differences between the gross monthly wages of men and women are in the category of Legislators, executives (category 1). In this category, the average gross monthly wage of men is higher on average by approximately EUR 246 and for women it is lower on average by EUR 913 than the overall average of category 1. The employed women in the category Operators and fitters of machinery and equipment (category 8) earn on

Tab. 4: Comparison of descriptive statistics of *salary_gm* by gender in 2020 (EUR)

Gender	Count	Average	Median	Coeff. of variation (%)	Minimum	Maximum	Lower quartile	Upper quartile
1 – Male	8,984	7,908.38	6,260.61	82.19	4,863.17	218,333	5,397.69	8,282.49
2 – Female	2,586	7,096.53	5,979.41	61.13	4,863.33	133,909	5,269.46	7,426.61
Diff. Δ	6,398	811.85	281.20	21.06	0	84,424	128.23	855.88

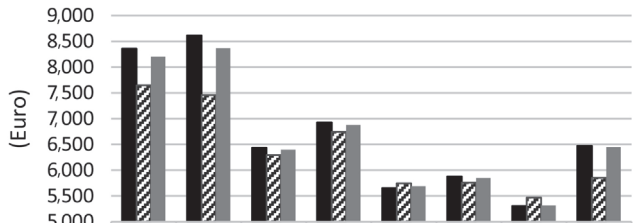
Source: own based on Trexima

Fig. 3: Box plots of the highest monthly wages by gender in 2020



Source: own based on Trexima

Fig. 4a: Average gross monthly wage by occupation and gender in 2020 (EUR)



	0	1	2	3	4	5	7	8
Men	8,360	8,617	6,429	6,924	5,650	5,874	5,306	6,468
Women	7,648	7,458	6,292	6,746	5,743	5,755	5,468	5,853
Total	8,200	8,371	6,397	6,878	5,687	5,845	5,319	6,446

Source: own based on Trexima

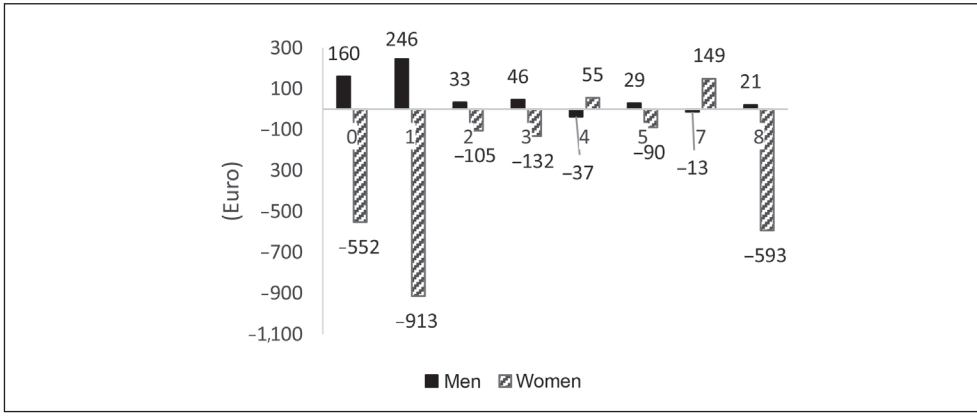
Note: 0 – Unspecified employment; 1 – Legislators, executives; 2 – Specialists; 3 – Technicians and professionals; 4 – Administrative staff; 5 – Service and trade workers; 7 – Skilled workers and craftsmen; 8 – Operators and fitters of machinery and equipment.

average EUR 593 less than the total average gross monthly wage of category 8 (Fig. 4a, 4b).

When comparing the average gross monthly wage of men and women by *age*, the biggest difference is in category 60+ (in category 10 men earn on average EUR 1,412 more than women) and in the *age* group 45–54 (categories 7 and 8) the average gross monthly wage of men is higher on average by more than EUR 1,200 (Fig. 5). At the same time, women in this age group are more represented. In *age* category 45–49 (category 7) their share is higher by 2.47% and in category 50–54 (category 8) it is higher by 2.32%.

Education is another factor determining the differences of the average monthly wage of men and women (Fig. 6). The average monthly salary of men was higher than of

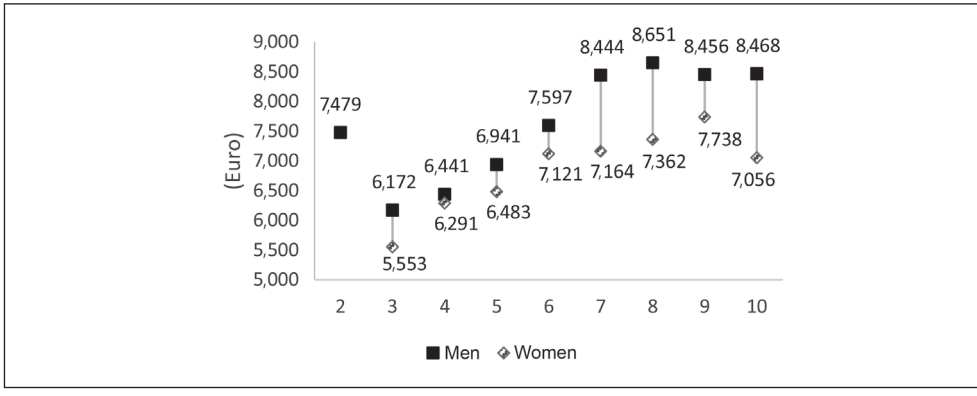
Fig. 4b: Differences between the average gross monthly wage and the total gross monthly wage by gender and occupation in 2020 (EUR)



Source: own based on Trexima

Note: 0 – Unspecified employment; 1 – Legislators, executives; 2 – Specialists; 3 – Technicians and professionals; 4 – Administrative staff; 5 – Service and trade workers; 7 – Skilled workers and craftsmen; 8 – Operators and fitters of machinery and equipment.

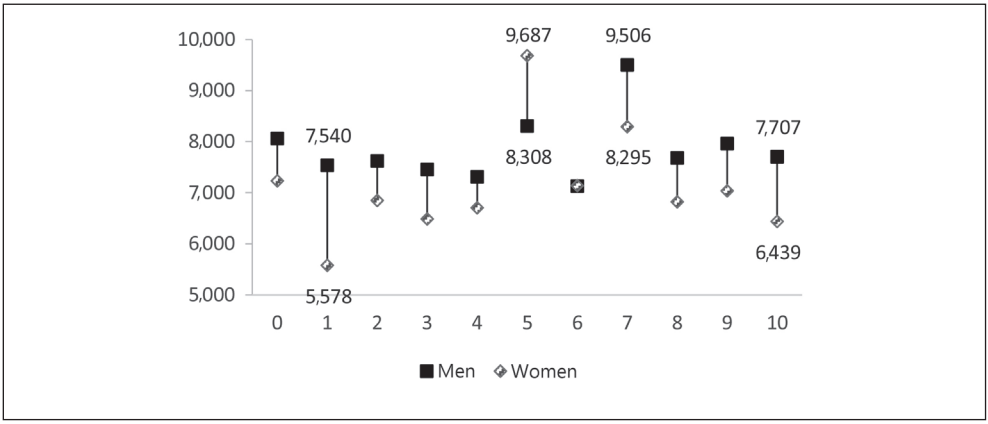
Fig. 5: Average gross monthly wage by gender and age categories in 2020 (EUR)



Source: own based on Trexima

Note: 2: 20–24; 3: 25–29; 4: 30–34; 5: 35–39; 6: 40–44; 7: 45–49; 8: 50–54; 9: 55–59; 10: 60+.

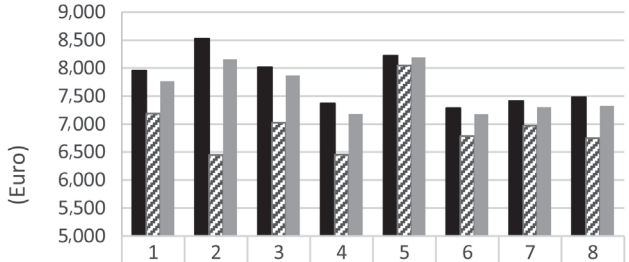
Fig. 6: Average gross monthly wage by gender and education in 2020 (EUR)



Source: own based on Trexima

Note: 0 – Unspecified education; 1 – Basic; 2 – Apprenticeship; 3 – Secondary (without GCSE); 4 – Apprenticeship with graduation; 5 – Complete medium general; 6 – Full secondary vocational; 7 – Higher professional; 8 – University (1st degree); 9 – University (2nd level); 10 – University (3rd degree).

Fig. 7: Average gross monthly wage by gender and region in 2020 (EUR)



	1	2	3	4	5	6	7	8
Men	7,955	8,527	8,015	7,371	8,219	7,288	7,413	7,481
Women	7,188	6,450	7,021	6,458	8,046	6,785	6,976	6,747
Total	7,768	8,157	7,870	7,180	8,191	7,179	7,303	7,329

Source: own based on Trexima

Note: 1 – Bratislavský; 2 – Trnavský; 3 – Trenčiansky; 4 – Nitriansky; 5 – Žilinský; 6 – Banskobystrický; 7 – Prešovský; 8 – Košický.

women by more than EUR 1,000 in education categories 1, 7, and 10. Employed men with basic education (category 1) had an average wage of approximately EUR 1,962 higher, higher professional men (category 7) about EUR 1,211 higher, and with University – 3rd degree (category 10) about EUR 1,268 higher wages than employed women with the

same category of education in 2020. Women with University – 3rd-degree education worked mainly as Legislators, executives (37.5% of women with this education), and as Technicians and professionals (22.9% of women with this education, which represented a higher share of women than men about 10.8%). Only in category 5 – Complete medium general education did women's wages exceed men's wages by EUR 1,379.

Compared to other regions and the categories of the other factors, a very large difference was found between the average monthly wages of men and women in the Trnava region (category 2), where the male wage in average was higher by about EUR 2,077. In the Trenčín region (category 3) and the Nitra region (category 4) was the average monthly men's salary was higher by more than EUR 900. Detected the smallest difference between the average monthly wage of men and women was in the Žilina Region (category 5) in which the average monthly wage of women was also the highest of all regions. Graphical analysis in Fig. 7 offers the comparison of the total average monthly wage of employees by region together with a presentation broken down by gender.

A statistically significant relationship between gender and each of the variables considered as factors of the pay gap between men and women (education, employment, age, and region) was confirmed by the chi-squared test of independence at any commonly used level of significance (p-value < 0.0001; Tab. 5). The recognized highest intensity of the relationship with the gender by Cramer's V contingency coefficient was found for the region factor (Cramer's V = 0.0784) and the lowest for the

Tab. 5: The results of chi-squared tests of independence and Crame's V contingency coefficients – Part 1

Explanatory variables (2020)	Frequency by gender		Cramer's V; chi-squared (p-value)	GPG (%)
	Male (%)	Female (%)		
Age (years)				
20–24	0.03	0.00	Cramer's V = 0.0579; chi-squared (p-value) < 0.0001	100
25–29	0.45	0.10		10
30–34	3.43	1.08		2
35–39	12.39	2.88		7
40–44	20.48	5.26		6
45–49	16.88	5.41		15
50–54	10.00	3.40		15
55–59	6.97	2.30		8
60+	7.00	1.92		17
Occupation/Job				
0 – Unspecified employment	11.45	3.31	Cramer's V = 0.0597; chi-squared (p-value) < 0.0001	9
1 – Legislators, executives	42.05	11.31		13
2 – Specialists	19.12	6.00		2
3 – Technicians and professionals	3.55	1.25		3
4 – Administrative staff	0.47	0.31		–2
5 – Service and trade workers	0.37	0.12		2
7 – Skilled workers and craftsmen	0.40	0.03		–3
8 – Operators and fitters of machinery and equipment	0.24	0.01		9

Tab. 5: The results of chi-squared tests of independence and Crame's V contingency coefficients – Part 2

Explanatory variables (2020)	Frequency by gender		Cramer's V; chi-squared (*p*-value)	GPG (%)
	Male (%)	Female (%)		
Education				
0 – Unspecified education	10.64	3.38	Cramer's V = 0.0645; chi-squared (*p*-value) < 0.0001	10
1 – Basic	0.16	0.02		26
2 – Apprenticeship	1.11	0.17		10
3 – Secondary (without GCSE)	0.47	0.09		13
4 – Apprenticeship with graduation	2.15	0.25		8
5 – Complete medium general	2.06	0.41		–17
6 – Full secondary vocational	3.73	0.96		0
7 – Higher professionals	0.32	0.11		13
8 – University (1st degree)	1.97	0.47		11
9 – University (2nd level)	52.29	15.77		12
10 – University (3rd degree)	2.74	0.72		16
Region				
1 – Bratislavský	46.59	15.07	Cramer's V = 0.0784; chi-squared (*p*-value) < 0.0001	10
2 – Trnavský	5.22	1.13		24
3 – Trenčiansky	5.31	0.91		12
4 – Nitriansky	4.65	1.23		12
5 – Žilinský	5.54	1.08		2
6 – Banskobystrický	3.23	0.90		7
7 – Prešovský	2.27	0.76		6
8 – Košický	4.84	1.27		10

Source: own based on Trexima

age factor (Cramer's V = 0.0579). Resulted values of above-mentioned tests for all analyzed factors are summarized in Tab. 5.

The acquired results of measuring the variability of each factor for men and women by normalized entropy (Tab. 6) confirmed the assumption of dependencies between the *gender* categories and other characteristics of the employee (according to the factors: *education*, *occupation*, *age,* and *region*).

To explain the effect of the monitored factors (*education*, *occupation*, *age,* and *region*) on the amount of average gross monthly wage, we also used a regression decision tree. The algorithm used in the generation of the decision tree applied a maximum of triple branching of nodes, the growth of the tree was limited by defining its maximum depth and the selection of branching variables was made based on the *p*-value of the *F*-test.

Decision tree identified the most significant variables occupation, age, and gender, and their values that give the best homogeneous sets of the population. The tree structure of the tree contains a total of 17 leaves. Each of them provides information about the average gross monthly wage. The resulting effect of the distribution of the original set of 11,570 employees, in which the average level of gross monthly wage was EUR 7,727, is the specific subsets of employees differing in average monthly wage (Fig. 8).

The factor *Occupation* had the strongest influence on branching in the decision tree (Fig. 8). By applying for the *Occupation/Job*

Tab. 6: The resulting entropy of variables (education, occupation, age, and region) with gender

Variable	Entropy				Contingency table	Entropy
	Total	Male	Female	|Δ|		
Age	0.841	0.840	0.842	0.003	*Age by gender*	0.822
Occupation	0.583	0.578	0.598	0.020	*Occupation by gender*	0.628
Education	0.496	0.508	0.448	0.060	*Education by gender*	0.556
Region	0.674	0.691	0.606	0.085	*Region by gender*	0.696

Source: own based on Trexima

as the branching variable, were all employees divided into two groups. The first is a group of employees within categories 0 – Unspecified employment, 1 – Legislators, executives, or category with the missing information about their occupation (Mis) (see node 2 in Fig. 8). The second group of employees is with any other occupation/*job* category (node 3). This breakdown increased the typical average gross monthly wage in the first group by EUR 607 and decreased by approximately EUR 1,297 in the second group.

The influence of gender was present only at the third level of branching. Based on this variable, were branched employees within categories: 0 – Unspecified employment, 1 – Legislators, executives, or category with the missing information about their occupation (Mis) aged 45 and over. Average gross monthly salary of this group before branching was EUR 8,866 (node 5). After branching, the average gross monthly salary in the group of men was EUR 9,188 (node 11) and in the group of women was only EUR 7,743 (node 10).

If we exclude from this group women who are trained in a profession (education category 2 Apprenticeship) or have completed upper secondary general education (education category 5 Full secondary vocational), their average gross monthly wage is up to EUR 12,890 (node 21). We assume that in this node 21 are mostly women who have not stated their type of *occupation*.

Gender variable was also used to branch the node with employees aged 40–44 with an average gross monthly salary of EUR 7,966 (node 6). After dividing them into men and women, the average gross monthly salary increased by EUR 143 (node 13) in the group of men and decreased by EUR 549 (node 12) in the group of women.

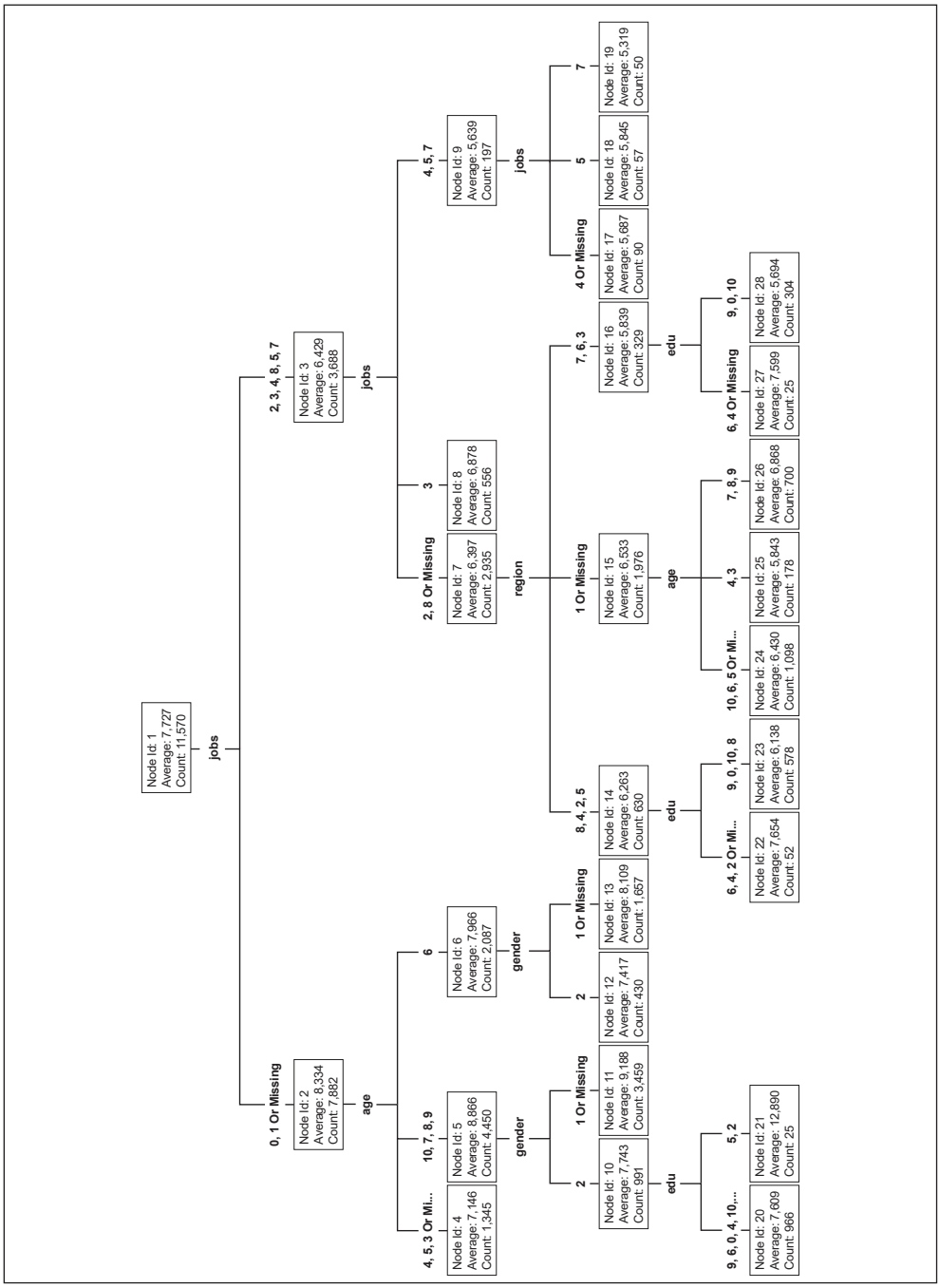
The branching in node 3 brings three more homogeneous groups. The average gross monthly wage is lower than the overall average by up to EUR 2,408 for *occupation/job* category 7 – Operators and fitters of machinery and equipment (node 19). Lower by EUR 2,040 is also for the 4 – Administrative staff or with missing information (node 17) and are less by EUR 1,882 for employees with *occupation*/job category 5 – Service and trade workers (node 18).

Specialists, operators, and fitters of machinery and equipment (node 7) have a very low average gross monthly wage of EUR 6,397, which is EUR 1,330 less than the total average gross monthly wage. If we exclude from them those who do not state education or, paradoxically, have completed university education (node 23), then the decrease in the average gross monthly wage is EUR 1,640. In the group of specialists, operators, and fitters of machinery and equipment, those living in the Bratislava region and aged 25–34 (node 25), wages were on average EUR 1,884 less than the average wage. To contrast the Bratislava region, the employees in the same category of *age* and *occupation* living in the Trnčianský, Banskobystrický, or Prešov regions, who have completed university education or do not state their education (node 28) earned EUR 2,033 less.

4. Discussion

The aim of this article was to analyse the gender pay gap for the best-earning men and women in the Slovak Republic. Why were we concerned with the top of the income distribution? Rising income inequality has received a lot of attention in the past decade. A distinct feature of such discussions is the concentration of wealth and income in the highest income groups (e.g., Roine & Waldenström, 2015). The World

Fig. 8: The regression decision tree



Source: own based on Trexima

Inequality Report (Alvaredo et al., 2018) states that the top 1% has captured twice as much of global income growth as the bottom 50% since 1980. There are studies that support the idea that gender pay gaps are typically bigger at the top of the wage distribution (Arulampalam et al., 2004; Roine & Hauser, 2020).

We analysed the income of 11,570 employees in the Slovak Republic whose average gross monthly wage exceeded the 99th percentile of the sample data in 2020. The sample contained 22.4% women and 77.6% men. In 2010, in the sample of 9,069 employees with the highest 1% gross monthly wage, there were 19.7% women and 80.3% men (Pacáková et al., 2012). Although the representation of women in the highest income group has increased, women are greatly under-represented.

The under-representation of women at the top of the wage distribution is commonly referred to as the 'glass ceiling'. Albrecht et al. (2003, p. 146), in their study of Swedish data, define the glass ceiling as a "phenomenon whereby women do quite well in the labour market up to a point after which there is an effective limit on their prospects". In 2020, the average of women's highest 1% gross monthly wages was EUR 7,096.53 and the average of men's highest 1% gross monthly wages was EUR 7,908.38, the GPG value equal 10.3%. In 2010, women had average gross monthly wage EUR 5,436.1 and men EUR 6,275.3, which caused the GPG value equal 13.4% (Pacáková et al., 2012). Despite having fallen in recent decade there remains a substantial pay gap between the average wages of men and women. The differences between the average gross monthly wages of men and women were also confirmed by the results of income modelling using the Pareto distribution. The Pareto distribution is often used to describe the shape of the income distribution at the top (Cowell, 2011; Atkinson et al., 2011) and provides a measure of the concentration of income. According to the Pareto cumulative distribution function for each wage level, the probability of lower wages for women is higher than for men in both years 2010 and 2020.

Atkinson et al. (2018) investigated the incomes of women and men across nine high-income countries. They also state that women are greatly under-represented in top income groups; they make up much less than 50% across each of the nine countries. Within the top 1%, women account for around 20%. In a paper Boschini et al. (2020) study developments of men and women in top income groups in Sweden using detailed registry data on the full population for the almost 50-year period since. It is evident that the share of women in top income groups has increased significantly, yet women remain clearly under-represented, and more so the higher up in the distribution one moves. "The existence of a glass ceiling would imply that women's wages fall behind men's more at the top of the wage distribution than at the middle or bottom" (Albrecht et al., 2003, p. 146).

Differences in earnings between men and women capture differences across many possible dimensions, including education, experience, age, and occupation. The subject of our further research was to find out how these differences manifest themselves at different levels of the observed factors. These differences are expressed in detail in Fig. 4a–8. They are expressed in absolute terms, a more realistic view would be provided by the calculation of GPG values for each level of the factor. Further, more detailed research would help reveal the dependencies between the different levels of wages in individual categories of monitored factors and the different representation of both sexes. In our article, we used the chi-squared test and the decision tree model to determine the influence of the factors on wage differentiation. Oaxaca–Blinder decomposition (Blinder, 1973; Oaxaca, 1973) is used to assess the effect of human capital variables on GPG in similar analyses (Blau & Kahn, 2017; Böheim et al., 2021). Just like Castellano and Rocca (2020), we also state that: "The actual determinants of gender disparities in the labour market are very difficult to identify because of the lack of adequate data and the difficulties in measuring some factors determining female behaviour."

Conclusions

In the EU countries, the unadjusted gender pay gap (GPG) indicator is used to monitor imbalances in earnings between men and women, whose definition is given in the introduction to the article. An analogous indicator, adapted to the nature of the data, is used in this article to achieve its objectives. The gender pay gap (GPG) in this paper is defined as the difference between the average gross

monthly wages of men and women expressed as a percentage of the average gross monthly wages of men.

In the sample of 11,570 employees with the highest wages in 2020 in the Slovak Republic by Tab. 3 were found only 22.4% of women and up to 77.6% of men. The average of women's wages was EUR 811.85 lower than the average of men's wages, which caused the GPG value equal 10.3%.

This paper aimed to test three basic hypotheses, referred in the introduction of the article.

Individual data on employees with the highest wages made it possible to find suitable Pareto probability models of these wages for both sexes in both 2010 and 2020. According to the Pareto cumulative distribution function (Fig. 3) for each wage level is probability of lower wages higher for women than for men in both years 2010 and 2020. In 2020 compared to 2010, the distribution of wages of men and women shifted towards higher wages, but differences in the shape of distributions by gender are almost identical. This confirms the first hypothesis that the highest wages of employees in the Slovak Republic increased, but the gender pay gap did not change significantly in time period from 2010 to 2020.

The mentioned procedure is also a guide for verifying the same hypothesis in the future, but the condition is the knowledge of individual values of employees' wages.

The sub-objective of the article, which is formulated in the second hypothesis, was to confirm the gender pay gap of the employees with the highest wages in the Slovak Republic is caused by factors education, age, occupation, and region of residence. This assumption has been confirmed by the graphical presentation of gross monthly wage differences by gender at different levels of the monitored factors in Fig. 4a–7 and by comments below the pictures. Comprehensive information on GPG values depending on different levels of monitored factors is given in the last column of Tab. 5. Except for three cases out of 36 possible, all GPG values are positive, so men's wages mostly exceed women's wages. If we do not consider the age category 20–24 years, in which women do not occur, the maximum of the positive value of GPG was equal to 26% for basic education, which concerns only 0.18% of employees. GPG values signal large differences in the gross monthly wages of men and women in the age categories 40–49 and 60 years, in job category 1 – Legislators, executives and in Trnavský region of residence. According to the GPG values, the largest wage differences are caused by the education factor, where in category 5 – Complete medium general education women's wages are higher than men's wages. There are small pay gaps for the benefit of women in jobs' categories 4 – Administrative staff and 7 – Skilled workers and craftsmen.

Despite the above, according to Tab. 5, the monitored factors do not have such a significant impact on wage differences as on differences in the representation of men and women at their different levels. This result is also confirmed by regression decision tree. Based on this analysis the most significant variables of wages' differences there are occupation and age, that give the best homogeneous sets of the population. Gender showed to be a differentiating factor only in a smaller number of more homogeneous groups of employees who were already selected based on their age and occupation.

The results summarized in Tab. 5 confirm also the validity of the third hypothesis that different levels of factors age, occupation, education and region of residence cause different employment structure for men and women with the highest salaries. The different frequencies by gender, so varying representation of men and women in different categories according to monitored factors in second and third columns of the Tab. 5 are evident. The validity of this hypothesis was clearly confirmed also by chi-squared independence tests.

The anonymized individual data about 1% of employees with the highest gross monthly wages in the Slovak Republic made it possible to use a wide range of statistical methods and machine learning methods to meet the set objectives of this article. The results of the analyses bring us to the conclusions that gender pay gap exists also in the highest wages in the Slovak Republic.

The implementation and enforcement of the equal pay for equal work principle remain a challenge, but the gender pay gap in the EU is still above 14% (Eurostat, 2019).

According to scientific studies, listed in theoretical background of the article, women face lower earnings as well as fewer years of service due to career breaks due to raising

children or caring for relatives. However, many women do not see this as gender discrimination, but like a result of different priorities of women in a real life compared to men, with lower focus on high earnings and a successful career.

Of course, this assumption cannot be verified on the basis of the data available for the article. An extensive international questionnaire survey would be needed to obtain the appropriate data to verify it.

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