Analysis of the Development in Wage Distributions of Men and Women in the Czech Republic in Recent Years

Diana Bílková[a] | *University of Economics, Prague*

ABSTRACT

The paper presents the development of the distributions of gross monthly wages of men and women in the Czech Republic in the recent years and foreshadows future development of these distributions in next years providing the elimination of the effect of economic recession. For the characterization of the development of wage distributions of the recent years we used the following characteristics of location of frequency distribution – arithmetic mean, median and medial; within the frame of the characterization of the development of variability we used the moment characteristic of variability – standard deviation and in light of tracing of the development of shape of the wage distributions we used the moment characteristic – coefficient of skewness. Within the framework of modelling of these wage distributions we used the free-parametric lognormal curve, whereas the parameters of this curve were estimated using the moment method and the quantile method of the point estimation. Using the trend analysis we predicted the development of descriptive characteristics of wage distributions for the next two years, from which we obtained the lognormal model of wage distributions for the next two years, whereupon we estimated the shares of employees in bounds of the gross monthly wages namely for the total set of men and women together and separately for the set of men and for the set of women. These predictions present the development of wage distributions of men and women in the Czech Republic in the years 2009 and 2010 providing abstraction of the effects of economic recession, which broke out in the autumn of the year 2008. Comparing the predictions with the really observed wage distributions in the two years we can quantify the effect of economic recession on the development of the wage distributions of men and women in the Czech Republic.

Keywords

wage distributions, lognormal curve, probability density function, moment method of parameter estimation, quantile method of parameter estimation, prediction of wage distributions, shares of employees in the bounds of gross monthly wages

INTRODUCTION

Estimations of wage distributions development allow, among other things, to link the findings relating to wage differentiation with socio-political considerations for which the estimation of average wage development is often not sufficient and which also require estimations of the shares of workers with low, medium and high wages, or shares of workers in all wage groups. The estimation of wage distributions based on a certain idea

[a] *University of Economics, Prague, e-mail: bilkova@use.cz*

of wage differentiation also allows us to estimate, for example, the total volume of wages to be paid in the future, etc., see [22].

This study is based on the data presented by Czech Statistical Office – "Percentages of employees in bands of gross wage by gender" for the years 2002 to 2008 in the Czech Republic and the data on sampled worker numbers by gender. The investigated variable was the worker's gross monthly wage in CZK. The input data were provided in the form of tables with interval frequency distribution with open extreme intervals. Data relevant to a longer period of time could not be used due to their incomparability. The data were processed using Microsoft Excel and the SAS and Statgraphics statistic programs.

1 SETS OF DESCRIPTIVE CHARACTERISTICS

A description of a unimodal frequency distribution usually concerns basic characteristics, such as the position (level), variability, skew, or sharpness, see [15]. Sets of moments and moment characteristics or sets of quantiles and quantile characteristics, see [6], have been traditionally used for this purpose.

We will mark the centers of individual wage intervals as x_i, $i = 1, 2, \ldots, k$, and the absolute numbers in individual intervals as n_i, $i = 1, 2, \ldots, k$, where k is the total number of intervals. From the moment characteristics of the position, we can apply the arithmetic mean

$$\bar{x} = \frac{\sum_{i=1}^{k} x_i \cdot n_i}{\sum_{i=1}^{k} n_i}. \tag{1}$$

standard deviation

$$s_x = \sqrt{\frac{\sum_{i=1}^{k} (x_i - \bar{x})^2 \cdot n_i}{\sum_{i=1}^{k} n_i}}, \tag{2}$$

see [5]; or variation coefficient

$$v_x = \frac{s_x}{\bar{x}} \cdot 100 \tag{3}$$

to characterize the variability (absolute or relative). The third moment of the standard variable is used to characterize the skew of the observed distribution of frequencies.

$$\sqrt{b_1(x)} = \frac{\sum_{i=1}^{k} (x_i - \bar{x})^3 \cdot n_i}{s_x^3 \cdot \sum_{i=1}^{k} n_i}. \tag{4}$$

For right-side asymmetry it holds that $\sqrt{b_1(x)} > 0$, for left-side asymmetry it holds that $\sqrt{b_1(x)} < 0$, and for symmetric distribution of frequencies it holds that $\sqrt{b_1(x)} = 0$. Parameter $\left|\sqrt{b_1(x)}\right|$ grows with the growing asymmetry of the observed distribution of frequencies. Moment characteristics have an important advantage for the description of the distribution of frequencies – they react sensitively to a change of any characteristic feature of the distribution as a whole, see [17]. Except for the arithmetical mean, the disadvantage of the moment characteristics for description and comparison, is their difficult logical and in our case also economic interpretability, see [18].

The P% quantile of variable x is understood as value $\tilde{x}_P$, $0 < P < 100$, where P % of the observed values of variable x is less or equal to the value of P% quantile $\tilde{x}_P$ and the remaining (100 – P) % of the observed values of the x variable is larger or equal to the value of P% quantile $\tilde{x}_P$, see [12]. The most important quantile is the median (middle value), which divides the non-decreasing sequence of the observed values of variable x in two halves with equal count and which is marked as $\tilde{x}_{50}$, or only $\tilde{x}$. Quartiles represent three values (lower quartile = 25% quantile $\tilde{x}_{25}$, upper quartile = 75% quantile $\tilde{x}_{75}$ and the median), which divide the non-decreasing sequence of observed values of variable x in four parts with equal count. Apart from quartiles, there are also terciles (two values dividing the non-decreasing sequence of values of the observed variable x into three parts with equal counts), quintiles, sextiles, septiles, octiles, noniles. Deciles represent nine values dividing the non-decreasing sequence of the values of variable x in ten parts with equal count; the first decile is the 10% quantile $\tilde{x}_{10}$, the second decile is the 20% quantile $\tilde{x}_{20}$, etc., up to the ninth decile, which is the 90% quantile $\tilde{x}_{90}$. And finally, percentiles are 99 values, which divide the non-decreasing sequence of values of the observed variable x in 100 parts with equal count. There is the first percentile, which is the 1% quantile $\tilde{x}_1$, the second percentile, which is the 2% quantile $\tilde{x}_2$, etc., up to the 99th percentile representing the 99% quantile $\tilde{x}_{99}$. Quantiles lower than the median are called lower quantiles, while quantiles higher than the median are called the upper quantiles. Quantile characteristics are determined according to the quantiles, see [15].

In general, we can say that if we want to describe the characteristics of the entire frequency distribution, it is more convenient to construe characteristics that are based on quantiles more distant from the median, i.e. percentiles are more suitable than deciles and deciles are more suitable than quartiles. However, when the calculations are based on interval frequency distribution with open extreme intervals (our case), the extreme percentiles are often situated in these open intervals, and therefore have to be estimated using linear interpolation. As these estimations are not too accurate, we prefer, in such a case, characteristics based, for example, on deciles to those based on percentiles. Quantiles are conventionally used to determine the interval of medium wages. The first decile is used to define lower wages, while the ninth decile is used to determine high wages. The first percentile is used as a limit for minimum wages and the last percentile as a limit of maximum wages. The median is used to characterize the medium level of wages, see [7] and [8].

P% tantile is a value of $\check{x}_P$, $0 < P < 100$, where the sum of values lower or equal to the value of the P% tantile $\check{x}_P$ represents P % of the total sum of values of variable x and the sum of values higher or equal to P% tantile $\check{x}_P$ represents the remaining $(100 - P)$% of the total sum of values of variable x. An interesting characteristic of position is the medial, which represents the 50% tantile (sum centre) $\check{x}$. Employees whose wage is no more than equal to the medial value receive one half of the total volume of wages and employees whose wages are at least equal to the medial value receive the other half of the total volume of wages.

2 LOGNORMAL CURVE

The most important of the models used to model wage and income distributions is the lognormal distribution, see [1] and [2]; with various modifications in the form of two-parameter, three-parameter and four-parameter lognormal curve, see [14]. The importance of the lognormal curve for the modeling of empiric distributions is doubtless, see [3]. Typical features of the processes modeled using this curve are: gradual actuation of interdependent factors, tendency towards development in a geometric progression and transition of random variability to systematic variability, see [16]. Wages and incomes belong to the group of economic phenomena that can be interpreted using the lognormal model, see [23]; three-parameter lognormal distribution is most commonly used in these models, see [3].

The probability density function for random variable X with three-parametric lognormal distribution LN(μ; σ^2; ξ) with parameters μ, σ^2 a ξ, $-\infty < \mu < \infty$, $\sigma^2 > 0$, $-\infty < \xi < \infty$, is

$$f(x) = \frac{1}{\sigma(x-\xi)\sqrt{2\pi}} \cdot \exp\left\{-\frac{[\ln(x-\xi)-\mu]^2}{2\sigma^2}\right\}, \quad x > \xi, \qquad (5)$$
$$= 0, \quad x \le \xi,$$

see [19]. If the random variable X has three-parametric lognormal distribution LN(μ; σ^2; ξ), then the random variable

$$Y = \ln(X - \xi) \qquad (6)$$

has normal distribution N(μ; σ²) and the random variable

$$U = \frac{\ln(X - \xi) - \mu}{\sigma} \tag{7}$$

has a standardized normal distribution N(0; 1), see [9] and [10].

The basic moment characteristics of the location of the three-parametric lognormal distribution is the expected value of random magnitude *X*, having the form

$$E(X) = \xi + \exp\left(\mu + \frac{\sigma^2}{2}\right). \tag{8}$$

The quantile characteristics of the location of the three-parametric lognormal distribution is the 100 *P*% quantile x_P, which is determined as the value for which the value of distribution function *F*(x) of random variable *X* in point x_P is equal to *P*

$$F(x_P) = P, \quad 0 < P < 1, \tag{9}$$

i.e., for the three-parametric lognormal distribution the 100 *P*% quantile x_P has the form

$$x_P = \xi + \exp(\mu + \sigma u_P), \; 0 < P < 1. \tag{10}$$

If we use *P* = 0,5 in relation (10), we obtain the 50% quantile of the three-parametric lognormal distribution, also called the median, which is the basic quantile characteristics of location of this distribution

$$x_{0,50} = \xi + \exp(\mu). \tag{11}$$

The basic moment characteristics of the variability of the three-parametric lognormal distribution is the variance

$$D(X) = \exp(2\mu + \sigma^2) \cdot [\exp(\sigma^2) - 1], \tag{12}$$

the square root of the variance, i.e. the standard deviation

$$\sigma(X) = \sqrt{D(X)} = \exp\left(\mu + \frac{\sigma^2}{2}\right) \cdot \sqrt{\exp(\sigma^2) - 1}, \tag{13}$$

or the characteristics of the relative variability – variation coefficient

$$V(X) = \frac{\sigma(X)}{E(X)} = \frac{\exp\left(\mu + \frac{\sigma^2}{2}\right) \cdot \sqrt{\exp(\sigma^2) - 1}}{\xi + \exp\left(\mu + \frac{\sigma^2}{2}\right)}, \tag{14}$$

see [4]. The moment characteristics of the distribution shape include the skewness coefficient of the three-parametric lognormal distribution

$$\sqrt{\beta_1(X)} = [\exp(\sigma^2) + 2] \cdot \sqrt{\exp(\sigma^2) - 1} \tag{15}$$

and the kurtosis coefficient of this distribution

$$\beta_2(X) = \exp(4\sigma^2) + 2\exp(3\sigma^2) + 3\exp(2\sigma^2) - 3. \qquad (16)$$

2.1 Moment method for parameter estimation

Moment estimations of parameters μ, σ^2 and ξ of the three-parametric lognormal distribution are obtained by putting into equation three sample moments and the corresponding moments of this theoretic distribution. As we are estimating three parameters, we need three moment equations. Therefore we put into equation the arithmetic mean $\bar{x}$ obtained from the sample and the expected value of the three-parametric lognormal distribution (8), the second sample central moment m_2 is put in equation with the variance of three-parametric lognormal distribution (12) (given the large extent of the sets, it is not necessary to distinguish between the sample variance and the sample second central moment, as with such large extents of sample, their values are practically identical) and the sample third central moment m_3 is put into equation with the third central moment of the three-parametric lognormal distribution

$$\bar{x} = \tilde{\xi} + \exp\left(\tilde{\mu} + \frac{\tilde{\sigma}^2}{2}\right), \qquad (17.1)$$

$$m_2 = \exp(2\tilde{\mu} + \tilde{\sigma}^2)\cdot[\exp(\tilde{\sigma}^2) - 1], \qquad (17.2)$$

$$m_3 = \exp\left(3\tilde{\mu} + \frac{3}{2}\tilde{\sigma}^2\right)\cdot[\exp(\tilde{\sigma}^2) - 1]^2\cdot[\exp(\tilde{\sigma}^2) + 2], \qquad (17.3)$$

see [20].

By solving the system of moment equations (17) we obtain the moment estimates of the parameters of the three-parametric lognormal distribution

$$\tilde{\sigma}^2 = \ln\left[\sqrt[3]{1 + \frac{1}{2}b_1 + \sqrt{\left(1 + \frac{1}{2}b_1\right)^2 - 1}} + \sqrt[3]{1 + \frac{1}{2}b_1 - \sqrt{\left(1 + \frac{1}{2}b_1\right)^2 - 1}} - 1\right], \qquad (18.1)$$

$$\tilde{\mu} = \frac{1}{2}\ln\frac{m_2}{\exp(\tilde{\sigma}^2)\cdot[\exp(\tilde{\sigma}^2) - 1]}, \qquad (18.2)$$

$$\tilde{\xi} = \bar{x} - \exp\left(\tilde{\mu} + \frac{\tilde{\sigma}^2}{2}\right). \qquad (18.3)$$

The moment method of parameter estimation does not guarantee maximum efficiency of the estimate, however, in the case of wage distribution we handle very large samples, and therefore any consistent method of parameter estimation yields satisfactory results and the moment method of parameter estimation can be used.

2.2 Quantile method of parameter estimation

The quantile method of estimation of the three-parametric lognormal distribution parameters uses three sample quantiles, namely the $100P_1$% quantile x^V_{P1}, 50% quantile (median) $x^V_{0,50}$ and the $100(1 - P_1)$% quantile $x^V_{(1-P1)}$, $0 < P_1 < 1$. These three sample quantiles are equated with the corresponding quantiles of the three-parametric lognormal distribution (10), by which we create a system of three quantile equations

$$x^V_{P1} = \xi^* + \exp(\mu^* + \sigma^* u_{P1}), \tag{19.1}$$

$$x^V_{0,50} = \xi^* + \exp(\mu^*), \tag{19.2}$$

$$x^V_{(1-P1)} = \xi^* + \exp(\mu^* - \sigma^* u_{P1}). \tag{19.3}$$

From the system of quantile equations (19) we obtain quantile estimates of the parameters of the three-parametric lognormal distribution

$$\sigma^{2*} = \left[\frac{\ln \dfrac{x^V_{P1} - x^V_{0,50}}{x^V_{0,50} - x^V_{(1-P1)}}}{u_{P1}} \right]^2, \tag{20.1}$$

$$\mu^* = \ln \frac{x^V_{P1} - x^V_{(1-P1)}}{\exp(\sigma^* u_{P1}) - \exp(-\sigma^* u_{P1})}, \tag{20.2}$$

$$\xi^* = x^V_{0,50} - \exp(\mu^*), \tag{20.3}$$

see [20].

3 DEVELOPMENT OF WAGE DISTRIBUTIONS FOR MEN AND WOMEN IN THE CZECH REPUBLIC IN 2002–2008 AND PREDICTION FOR 2009 AND 2010

Table 1 shows the development of the medial value of gross monthly wages in the Czech Republic in 2002–2008 total for men and women together and also separately for men and women, including the prediction of the development of the medial value of gross monthly wages for 2009 and 2010. Tables 2–4 show the development of extreme deciles and extreme percentiles of gross monthly wages in the Czech Republic in 2002–2008. This development is also shown in Graphs 1–3. Table 2 shows that in the total group of all workers in 2002, 80% medium gross monthly wages were in the interval between CZK 9 243 and CZK 27 754, i.e., 10% of all wages were lower than or equal to CZK 9 243 and 10% of all wages were equal to or higher than CZK 27 754. As it is also shown in Graph 1, the interval between the first and ninth decile is slightly widening until 2008, when it can be said that 80% medium wages in the Czech Republic were in the interval from CZK 12 761 to CZK 40 548, i.e. 10% of gross monthly wages in the Czech Republic were not higher than CZK 12 761 and 10% of gross monthly wages were not lower than CZK 40 548. As for the development of extreme percentiles, Table 2 shows that 98% medium wages in 2002 were in the interval from CZK 6 365 to CZK 47 172, while the interval the first and the last percentile widens considerably

Table 1 Development of the sample medial value of gross monthly wages in the Czech Republic in 2002–2008 and prediction of the development of medial value of gross monthly wages for 2009 and 2010 (in CZK)

Group	Year								
	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total	18 389	19 835	21 139	22 317	23 358	25 530	27 183	**28 815**	**30 703**
Men	20 014	21 799	22 964	24 295	25 440	27 770	29 802	**31 448**	**33 513**
Women	16 148	17 548	18 554	19 562	20 555	22 130	23 027	**24 189**	**25 325**

Source: own research

Table 2 Development of sample extreme deciles and extreme percentiles of gross monthly wages in the Czech Republic in 2002–2008 total for men and women (in CZK)

Deciles and percentiles	Year						
	2002	2003	2004	2005	2006	2007	2008
$\tilde{x}_{0,01}$	6 365	6 680	3 090	4 135	8 070	2 587	3 324
$\tilde{x}_{0,10}$	9 243	9 814	10 235	10 634	11 248	12 127	12 761
$\tilde{x}_{0,90}$	27 754	29 590	31 082	33 292	35 229	37 904	40 548
$\tilde{x}_{0,99}$	47 172	47 719	56 369	56 852	57 326	86 461	88 866

Source: own research

over the time until 2008, when 98% medium wages were situated in the interval from CZK 3 324 to CZK 88 866. These values are usually considered to be the limits of minimum and maximum wages. However, it must be reminded here that the calculations are based on data organized in a table of interval frequency distribution with open extreme intervals. Therefore, the estimated values of extreme percentiles have to be handled with caution and should be understood only as orientation values. The same applies to the estimated values of extreme percentiles in Tables 3 and 4.

Table 3 shows the development of extreme percentiles of gross monthly wages of men and Table 4 describes the development of extreme deciles and extreme percentiles of gross monthly wages of women, both for the Czech Republic in 2002–2008. Table 3 demonstrates that in 2002 80% gross monthly wages of men were in the interval from CZK 10 778 to CZK 31 101, Graph 2 shows that the interval between the extreme deciles of gross monthly wages of men was then widening gradually until 2008, when 80% gross monthly wages of men lied in the interval from CZK 14 822 to CZK 46 364, in 2002 10% gross monthly wages of men did not exceed the amount of CZK 10 778 and 10% gross monthly wages did not fall below CZK 31 101, while in 2008 10%

Table 3 Development of sample extreme deciles and extreme percentiles of gross monthly wages in the Czech Republic in 2002–2008 for men (in CZK)

Deciles and percentiles	Year						
	2002	2003	2004	2005	2006	2007	2008
$\tilde{x}_{0,01}$	7 066	7 497	6 427	8 054	8 369	4 430	5 367
$\tilde{x}_{0,10}$	10 778	11 459	11 945	12 348	12 930	13 962	14 822
$\tilde{x}_{0,90}$	31 101	34 564	34 819	37 211	39 381	42 870	46 364
$\tilde{x}_{0,99}$	48 047	48 417	57 514	57 808	58 104	90 671	92 333

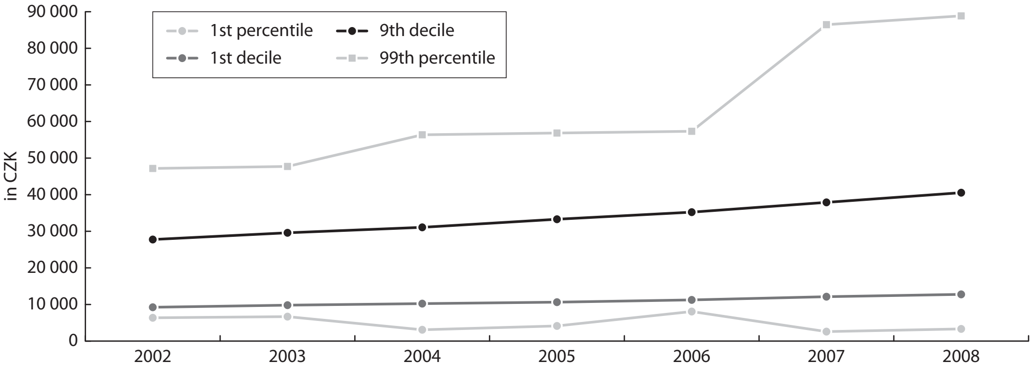
Source: own research

Table 4 Development of sample extreme deciles and extreme percentiles of gross monthly wages in the Czech Republic in 2002–2008 for women (in CZK)

Deciles and percentiles	Year						
	2002	2003	2004	2005	2006	2007	2008
$\tilde{x}_{0,01}$	6 098	6 277	1 835	2 442	6 458	1 652	2 199
$\tilde{x}_{0,10}$	8 296	8 819	9 056	9 445	10 178	10 855	11 403
$\tilde{x}_{0,90}$	23 292	24 637	25 776	27 503	29 082	31 201	33 398
$\tilde{x}_{0,99}$	43 339	44 883	50 776	52 509	54 054	68 415	73 470

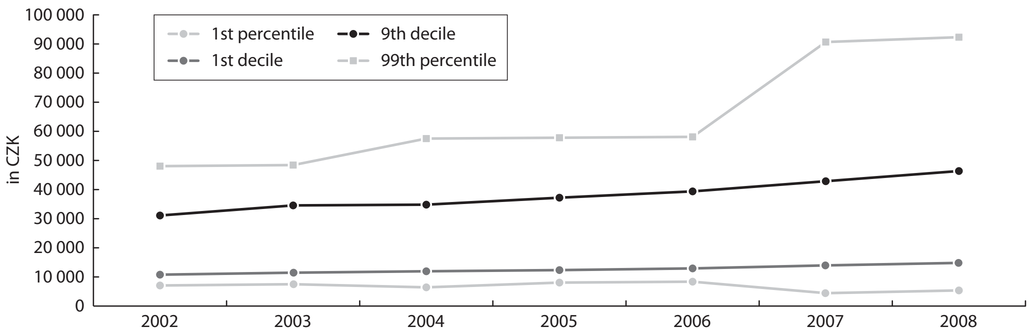
Source: own research

Graph 1 Development of sample extreme deciles and percentiles of gross monthly wages (in CZK) **in the Czech Republic in 2002–2008 overall for men and women**



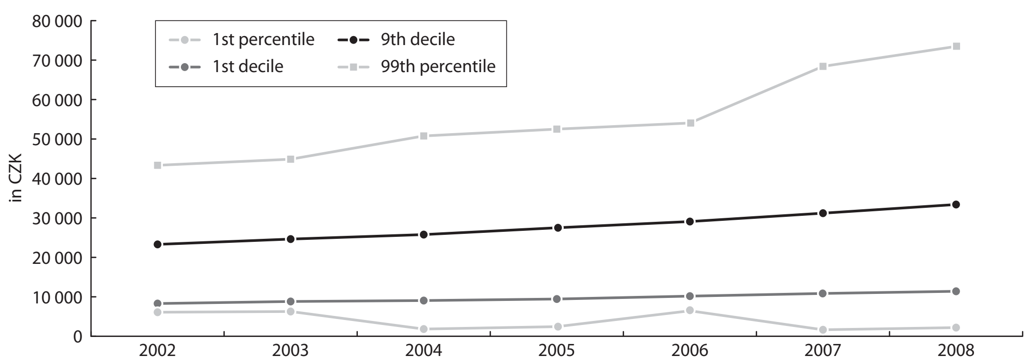
Source: own research

Graph 2 Development of sample extreme deciles and percentiles of gross monthly wages (in CZK) **in the Czech Republic in 2002–2008 for the set of men**



Source: own research

Graph 3 Development of sample extreme deciles and percentiles of gross monthly wages (in CZK) **in the Czech Republic in 2002–2008 for the set of women**



Source: own research

gross monthly wages of men did not exceed CZK 14 822 and 10 % gross monthly wages of men did not fall below CZK 46 364. In 2002, 98% men in the Czech Republic received gross monthly wages in the interval from CZK 7 066 to CZK 48 047, while in 2008, 98% men in the Czech Republic had their gross monthly wages in the interval from CZK 5 367 to CZK 92 333. However, these limits should be only used for orientation, as explained above.

Table 4 shows that in 2002, 80% gross monthly wages of women were in the interval from CZK 8 296 to CZK 23 292, i.e., 10% women did not have gross monthly salary higher than CZK 8 296 in that year, and the gross monthly wages of 10% women did not fall below CZK 23 292 in that year. Graph 3 illustrates that the interval between the extreme deciles of gross monthly wages of women was gradually slightly widening until 2008, when 80% women in the Czech Republic were paid gross monthly wage in the interval from CZK 11 403 to CZK 33 398, which means that the gross monthly wage of 10% women in the Czech Republic in 2008 did not exceed the amount of CZK 11 403 and 10 % women in 2008 had gross monthly wage at least in the amount of CZK 33 398. With a great caution, we can say that in 2002 98% women in the Czech Republic were paid gross monthly wage in the interval from CZK 6 098 to CZK 43 339, while in 2008 98% women in the Czech Republic had their gross monthly wage in the interval from CZK 2 199 to CZK 73 470.

Tables 5–7 illustrate the development of the basic descriptive moment characteristics of location (arithmetic mean), variability (standard deviation) and shape (skewness coefficient) of the frequency distribution of gross monthly wages in the Czech Republic in 2002–2008 including the predictions for 2009 and 2010, see [11]; which are based on the assumption that the current development continues. It is obvious that the location, absolute variability and skew of the distribution of gross monthly wages in the observed period have a growing trend in all three analyzed groups. Graphs 4 and 5 illustrate the development of the characteristics of the location of the medial and median values of gross monthly wages in 2002–2008, again including the predictions for 2009 and 2010, provided that the current development is sustained. It can be seen that the characteristics of the location of distributions of gross monthly wages continue to grow, both in the overall group of men and women, as well as in the separated groups of men and women.

Table 5 Development of arithmetic mean $\bar{x}$ (in CZK) **standard deviation s_x** (in CZK) **and skewness coefficient $\sqrt{b_1(x)}$ of gross monthly wages in the Czech Republic in 2002–2008 total for men and women including the predictions for 2009 and 2010, and the parameter values of the three-parametric lognormal distribution estimated using the moment method of parameter estimation, including the predictions for 2009 and 2010**

Year	Sample characteristics			Parameters estimated using the moment method		
	$\bar{x}$	s_x	$\sqrt{b_1(x)}$	$\hat{\mu}$	$\hat{\sigma}^2$	$\hat{\varsigma}$
2002	17 437	8 321	1,817	9,491 969	0,264 377	2 311,688 3
2003	18 663	8 657	1,354	9,837 351	0,166 428	– 1 681,293 4
2004	19 698	9 804	1,614	9,779 148	0,220 813	–25,694 7
2005	20 738	10 180	1,481	9,905 938	0,192 775	–1 339,601 2
2006	21 803	10 477	1,419	9,979 491	0,179 767	–1 805,527 0
2007	23 883	13 776	2,338	9,733 688	0,376 546	3 509,923 8
2008	25 478	14 485	2,191	9,851 185	0,345 251	2 920,380 8
2009	**27 355**	**16 796**	**2,875**	**9,717 849**	**0,487 340**	**6 160,024 6**
2010	**29 428**	**19 182**	**3,516**	**9,645 006**	**0,609 149**	**8 484,567 7**

Source: own research

Tables 5–7 also include parameter estimations of the three-parametric lognormal distribution of gross monthly wages in the Czech Republic in 2002–2008 obtained using the moment method of parameter estimation, Table 11 contains the values of the known test criterion χ^2 and the values of the sum of all absolute deviations S of empirical and theoretical frequencies, provided that the distribution of gross monthly wages is the three-parametric lognormal distribution with the stated parameter values estimated using the moment method. With such large extent of samples, values of the test criterion χ^2 practically always lead to a refusal of the tested hypothesis on the

Table 6 Development of arithmetic mean $\overline{x}$ (in CZK) **standard deviation s_x (in CZK) and skew coefficient $\sqrt{b_1(x)}$ of gross monthly wages in the Czech Republic in 2002–2008 for men, including the predictions for 2009 and 2010, and the parameter values of the three-parametric lognormal distribution estimated using the moment method of parameter estimation, including the predictions for 2009 and 2010**

Year	Sample characteristics			Parameters estimated using the moment method		
	$\overline{x}$	s_x	$\sqrt{b_1(x)}$	$\hat{\mu}$	$\hat{\sigma}^2$	$\hat{\varsigma}$
2002	19 267	8 757	1,400	9,814 123	0,175 870	−704,267 4
2003	20 588	9 109	1,213	10,001 729	0,138 386	−3 057,800 7
2004	21 791	10 401	1,510	9,904 654	0,199 674	−335,092 1
2005	22 884	10 757	1,364	10,046 728	0,168 503	−2 225,357 1
2006	23 923	11 080	1,262	10,156 320	0,148 098	−3 809,543 9
2007	26 501	14 927	2,199	9,877 357	0,347 021	3 325,133 0
2008	28 372	15 666	2,032	10,008 100	0,310 931	2 431,416 7
2009	**30 588**	**18 340**	**2,570**	**9,921 596**	**0,425 293**	**5 396,986 3**
2010	**33 082**	**21 090**	**3,062**	**9,880 774**	**0,524 119**	**7 673,648 3**

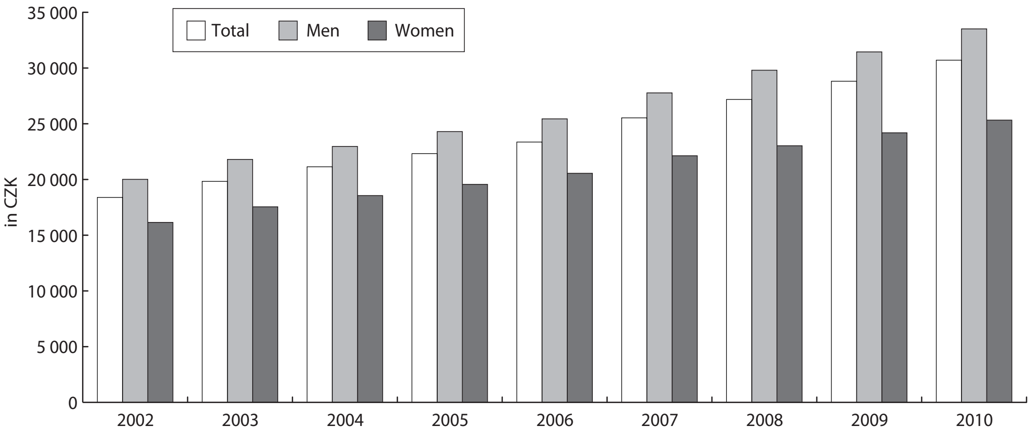
Source: own research

Table 7 Development of arithmetic mean $\overline{x}$ (in CZK) **standard deviation s_x** (in CZK) **and skew coefficient $\sqrt{b_1(x)}$ of gross monthly wages in the Czech Republic in 2002–2008 for women, including the predictions for 2009 and 2010, and the parameter values of the three-parametric lognormal distribution estimated using the moment method of parameter estimation, including the predictions for 2009 and 2010**

Year	Sample characteristics			Parameters estimated using the moment method		
	$\overline{x}$	s_x	$\sqrt{b_1(x)}$	$\hat{\mu}$	$\hat{\sigma}^2$	$\hat{\varsigma}$
2002	15 088	6 945	1,766	9,340 691	0,253 414	2 157,049 1
2003	16 246	7 373	1,566	9,525 959	0,210 500	1 013,400 9
2004	16 942	8 177	1,733	9,523 956	0,246 219	1 465,763 0
2005	17 886	8 563	1,642	9,625 870	0,226 788	914,663 6
2006	18 958	8 843	1,658	9,647 974	0,230 221	1 578,258 7
2007	20 324	11 085	2,517	9,439 541	0,414 353	4 853,088 0
2008	21 585	11 641	2,442	9,519 993	0,398 566	4 949,391 3
2009	**22 973**	**13 203**	**3,068**	**9,410 412**	**0,525 282**	**7 089,223 6**
2010	**24 474**	**14 812**	**3,667**	**9,343 947**	**0,636 080**	**8 765,031 6**

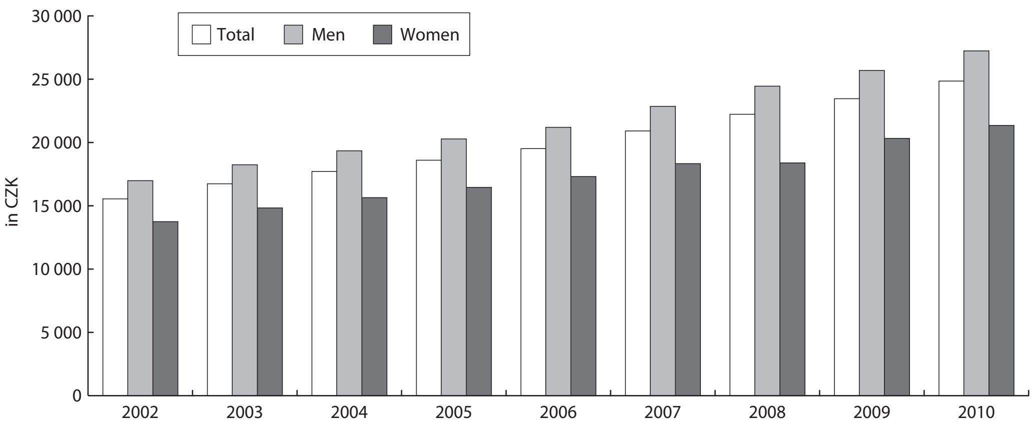
Source: own research

Graph 4 Development of the medial value of gross monthly wages (in CZK) **in the Czech Republic in 2002–2008, including the predictions for 2009 and 2010**



Source: own research

Graph 5 Development of the median gross monthly wages (in CZK) **in the Czech Republic in 2002–2008, including the predictions for 2009 and 2010**



Source: own research

assumed shape of distributions. This is caused by the fact that in the case of large sample extents, which are used for wage and income distributions, the test is strong enough to reveal the slightest deviations between the actually observed distribution and the model. Such hardly noticeable deviations have practically no importance for us and in such cases we usually "borrow" the model, see [21]. Tables 5–7 also show the predictions of the parameter values of the three-parametric lognormal distribution of gross monthly wages for 2009 and 2010 and Graphs 6 and 7 show the probability densities of the three-parametric lognormal distribution corresponding to these predicted parameter values.

Tables 8–10 present the development of quartiles of gross monthly wages in the Czech Republic in 2002–2008 including the predictions of this

Table 8 Development of quartiles (in CZK) **of gross monthly wages in the Czech Republic in 2002–2008 total for men and women including the predictions for 2009 and 2010, and parameter values of three-parametric lognormal distribution estimated using the quantile method of parameter estimation including the predictions for 2009 and 2010**

Year	Sample characteristics			Parameters estimated using the moment method		
	$\tilde{x}_{25}$	$\tilde{x}_{50}$	$\tilde{x}_{75}$	μ^*	$\hat{\sigma}^{2*}$	ξ^*
2002	11 944	15 545	20 215	9,663 345	0,148 549	–185,315 6
2003	12 728	16 735	22 224	10,152 882	0,217 827	–8 930,038 2
2004	13 416	17 709	23 077	10,561 268	0,109 631	–20 900,984 7
2005	14 063	18 597	24 470	10,469 561	0,147 272	–16 629,778 5
2006	14 717	19 514	25 675	10,558 943	0,137 760	–19 006,587 6
2007	15 769	20 910	27 545	10,609 483	0,143 087	–19 607,560 5
2008	16 853	22 225	29 404	10,526 808	0,184 906	–15 077,375 6
2009	**17 848**	**23 456**	**31 038**	**9,977 665**	**0,199 923**	**1 916,052 7**
2010	**18 995**	**24 849**	**32 934**	**9,962 441**	**0,229 164**	**3 634,481 8**

Source: own research

Table 9 Development of quartiles (in CZK) **of gross monthly wages in the Czech Republic in 2002–2008 for men including the predictions for 2009 and 2010, and parameter values of the three-parametric lognormal distribution estimated using the quantile method of parameter estimation, including the predictions for 2009 and 2010**

Year	Sample characteristics			Parameters estimated using the moment method		
	$\tilde{x}_{25}$	$\tilde{x}_{50}$	$\tilde{x}_{75}$	μ^*	$\hat{\sigma}^{2*}$	ξ^*
2002	13 415	16 985	22 604	9,188 668	0,452 625	7 199,144 0
2003	14 252	18 240	24 145	9,933 089	0,338 086	–2 360,410 4
2004	15 036	19 344	25 306	10,193 779	0,232 265	–7 392,304 1
2005	15 733	20 281	26 822	10,138 897	0,290 257	–5 027,572 6
2006	16 356	21 199	28 090	10,230 508	0,273 607	–6 537,666 0
2007	17 659	22 855	30 035	10,386 347	0,229 873	–9 558,722 0
2008	18 988	24 450	32 341	10,310 111	0,297 391	–5 584,489 9
2009	**20 171**	**25 692**	**33 843**	**9,747 471**	**0,333 616**	**8 581,098 5**
2010	**21 585**	**27 238**	**35 853**	**9,707 582**	**0,390 185**	**10 796,205 6**

Source: own research

development for 2009 and 2010, assuming that the current development is sustained. These tables also represent the estimated parameter values for the three-parametric lognormal distribution obtained using the quantile method of parameter estimation including the predicted parameter values for 2009 and 2010, which are also shown in Graphs 8 and 9. Values of test criterion χ^2 and values of the sum of absolute deviations *S* of the observed and theoretical frequencies for all intervals for the three-parametric lognormal curves obtained using the quantile method of parameter estimation are shown in Table 12.

Table 10 Development of quartiles (in CZK) **of gross monthly wages in the Czech Republic in 2002–2008 for women including the predictions for 2009 and 2010, and parameter values of the three-parametric lognormal distribution estimated using the quantile method of parameter estimation, including the predictions for 2009 and 2010**

Year	Sample characteristics			Parameters estimated using the moment method		
	$\tilde{x}_{25}$	$\tilde{x}_{50}$	$\tilde{x}_{75}$	μ^*	$\hat{\sigma}^{2*}$	ξ^*
2002	10 341	13 746	17 727	10,065 900	0,053 721	−9 781,211 9
2003	11 042	14 831	19 281	10,763 519	0,056 753	−32 433,466 5
2004	11 594	15 642	20 293	10,973 629	0,042 497	−42 673,921 9
2005	12 158	16 454	21 426	10,983 560	0,046 948	−42 443,890 0
2006	12 881	17 311	22 530	10,900 344	0,059 020	−36 884,048 9
2007	13 744	18 328	24 017	10,659 886	0,102 547	−24 284,072 8
2008	14 612	19 388	25 330	10,689 348	0,104 952	−24 498,268 7
2009	**15 512**	**20 326**	**26 446**	**10,023 877**	**0,126 647**	**−2 232,713 6**
2010	**16 499**	**21 347**	**27 679**	**9,937 197**	**0,156 760**	**661,328 8**

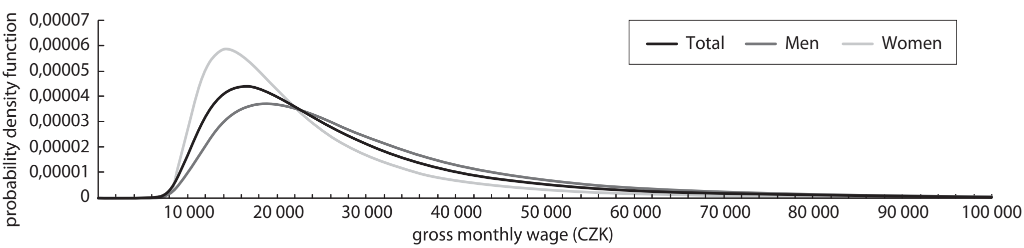
Source: own research

Table 11 Values of test criterion χ^2 and values of the sum of all absolute deviations S of the empirical and theoretical frequencies for the three-parametric lognormal curve obtained using the moment method of parameter estimation

		Set					
		Total		Men		Women	
Year	Criterion	χ^2	S	χ^2	S	χ^2	S
2002		25 576	114 691	34 003	105 690	9 696	45 033
2003		48 933	157 301	39 691	118 895	12 405	50 459
2004		67 967	226 646	46 447	142 165	23 653	94 724
2005		71 879	225 479	49 016	149 877	23 036	93 170
2006		86 368	248 955	56 518	167 314	27 491	95 430
2007		91 821	332 148	63 644	201 427	30 841	131 039
2008		94 290	341 796	68 516	212 555	29 195	132 684

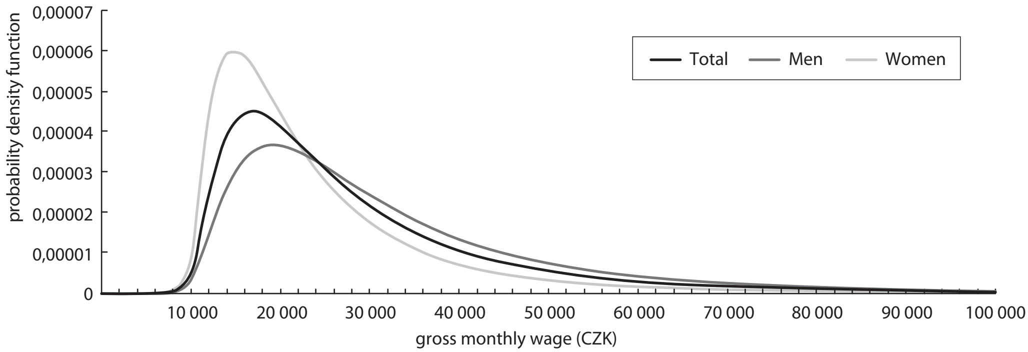
Source: own research

Graph 6 Densities of probability of the predictions of the three-parametric lognormal curves obtained using the moment method of parameter estimation for 2009



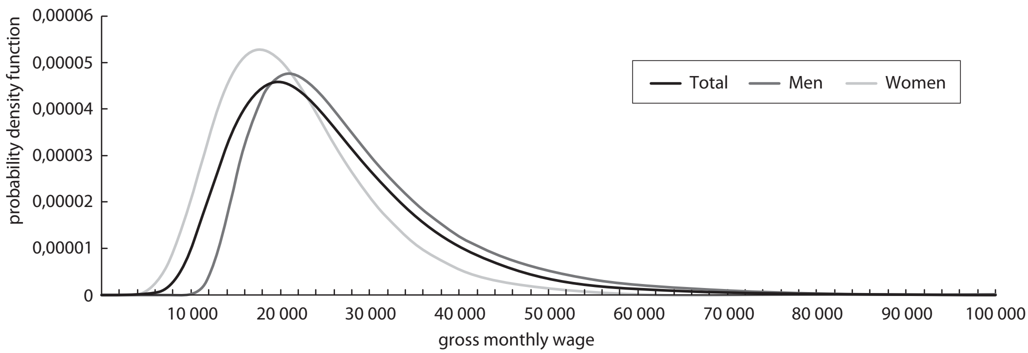
Source: own research

Graph 7 Densities of probability of the predictions of the three-parametric lognormal curves obtained using the moment method of parameter estimation for 2010



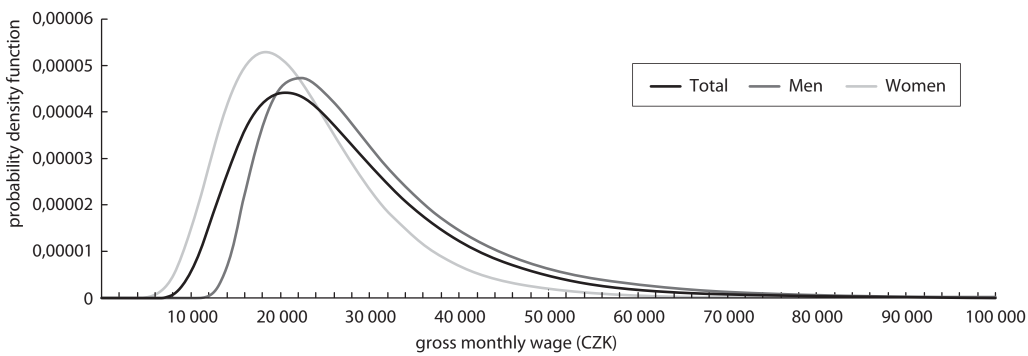
Source: own research

Graph 8 Densities of probability of the predictions of the three-parametric lognormal curves obtained using the quantile method of parameter estimation for 2009



Source: own research

Graph 9 Densities of probability of the predictions of the three-parametric lognormal curves obtained using the quantile method of parameter estimation for 2009



Source: own research

Table 12 Values of test criterion χ^2 and values of the sum of all absolute deviations S of the empirical and theoretical frequencies for the three-parametric lognormal curves obtained using the quantile method of parameter estimation

		Set					
		Total		Men		Women	
Year	Criterion	χ^2	S	χ^2	S	χ^2	S
2002		100 174	92 687	97 012	68 713	155 443	55 943
2003		365 753	547 743	165 094	270 380	230 874	291 421
2004		523 578	764 989	223 346	353 087	341 297	460 444
2005		541 900	798 876	226 467	369 835	365 954	491 762
2006		613 357	881 621	250 923	399 650	400 187	527 740
2007		617 231	930 856	272 421	436 956	344 095	502 185
2008		573 412	880 134	249 587	416 120	343 130	504 228

Source: own research

CONCLUSION

In the period 2002–2008, we can observe a significant growth of the level of gross monthly wages, both in the total set of men and women, as well as in the separate sets for both genders. This trend should continue also in the period 2009 and 2010. Throughout the observed period 2002–2008, the level of men's wages is considerably higher than the level of women's wages, and this difference continues to grow over the time and it is assumed that it will have a growing tendency also in the years 2009 and 2010.

As for the development of variability of gross monthly wages in 2002–2008, the absolute variability characteristics for this period are growing over the time, both in the total set as well as in the separate sets of men and women. Relative variability characteristics of all observed sets tend to stagnate. All the observed frequency distributions are characterized by positive skew, which means that in the given frequency distribution lower wages prevail over higher wages, which is typical for the distribution of wages and incomes. The skew of the frequency distribution is increasing over the time in all observed sets.

The parameters of three-parametric lognormal curves were estimated using two point estimation methods, namely the moment method and the quantile method. The results in Tables 11 and 12 indicate that the moment method has brought more accurate results than the quantile parameter estimation method.

Table 13 contains the prediction of the distribution of gross monthly wages for 2009 and 2010, assuming that the current development continues. These predictions are based on the moment method of parameter estimation, which yields more accurate results, as well as on the quantile method, which has yielded less accurate results. The question is to what extent the development of wage distributions will be affected by the current economic recession, see [13]; which has lead, for example, to considerable layoffs, concerning particularly workers with very low wages, which could paradoxically lead to a growth of the level of gross monthly wages accompanied by a decrease of the skew of frequency distribution. The impact of the economic recession on the development of gross monthly wages of men and women in the Czech Republic can be quantified more accurately when comparing the predictions of wage distributions with the wage distributions presented by the Czech Statistical Office. The respective data for 2009 have already been published, see Table 14.

By comparing the estimated shares of workers in gross salary wage bands for 2009 shown in Table 13 with the shares of employees in gross monthly wage bands in 2009 published by the Czech Statistical Office and shown in Table 14, we get an idea to what extent the predictions were fulfilled. The presented results reveal that in 2009 wages did not by far grow as fast as we had esti-

Table 13 Estimated shares of workers (in %) **in the bands of gross monthly wages** (in CZK) **for 2009 and 2010 by gender**

Method		Moment method						Quantile method					
Set		Total		Men		Women		Total		Men		Women	
Interval	Year	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
till–10 000		1,80	0,15	1,13	0,16	2,39	0,26	1,42	0,60	0,00	0,00	4,27	2,23
10 001–12 000		4,92	2,75	3,08	1,70	8,04	5,41	3,06	2,00	0,26	0,00	5,51	4,22
12 001–14 000		7,39	6,46	5,11	4,09	11,16	10,7	5,32	4,14	2,06	0,44	7,98	6,94
14 001–16 000		8,55	8,45	6,53	5,96	11,57	11,94	7,30	6,24	5,07	2,83	9,73	9,11
16 001–17 000		4,39	4,47	3,57	3,41	5,48	5,73	4,18	3,75	3,58	2,66	5,22	5,06
17 001–18 000		4,34	4,47	3,67	3,57	5,16	5,41	4,40	4,05	4,09	3,39	5,29	5,22
18 001–19 000		4,23	4,37	3,71	3,64	4,80	5,03	4,53	4,25	4,45	3,96	5,25	5,26
19 001–20 000		4,08	4,22	3,70	3,66	4,43	4,65	4,57	4,37	4,67	4,36	5,13	5,20
20 001–20 000		3,90	4,04	3,65	3,62	4,07	4,26	4,54	4,40	4,76	4,60	4,93	5,05
21 001–22 000		3,70	3,83	3,56	3,55	3,72	3,89	4,45	4,37	4,75	4,71	4,67	4,83
22 001–23 000		3,50	3,62	3,45	3,45	3,39	3,55	4,31	4,28	4,65	4,70	4,38	4,57
23 001–24 000		3,29	3,40	3,32	3,34	3,09	3,23	4,13	4,15	4,50	4,61	4,07	4,28
24 001–25 000		3,09	3,19	3,19	3,21	2,81	2,93	3,93	3,99	4,30	4,46	3,74	3,96
25 001–26 000		2,89	2,98	3,04	3,07	2,55	2,67	3,71	3,80	4,08	4,27	3,42	3,65
26 001–28 000		5,21	5,38	5,64	5,70	4,41	4,63	6,71	6,99	7,44	7,88	5,89	6,36
28 001–30 000		4,51	4,67	5,05	5,13	3,64	3,83	5,78	6,13	6,46	6,93	4,73	5,19
30 001–32 000		3,90	4,04	4,50	4,59	3,00	3,18	4,90	5,29	5,53	5,99	3,74	4,17
32 001–36 000		6,27	6,54	7,49	7,71	4,55	4,87	7,51	8,32	8,63	9,49	5,15	5,90
36 001–40 000		4,67	4,93	5,80	6,06	3,15	3,44	5,11	5,87	6,08	6,82	3,01	3,58
40 001–50 000		7,18	7,78	9,35	10,06	4,42	4,99	6,50	7,89	8,34	9,68	2,99	3,82
50 001–60 000		3,62	4,12	4,94	5,61	1,99	2,38	2,30	3,06	3,46	4,25	0,70	1,02
60 001–70 000		2,97	3,66	4,20	5,16	1,47	1,91	1,13	1,69	2,17	2,89	0,20	0,35
80 001–and more		1,63	2,48	2,32	3,54	0,68	1,09	0,20	0,37	0,67	1,07	0,01	0,03
Mean		**27 355**	**29 428**	**30 588**	**33 082**	**22 973**	**24 474**	**25 720**	**27 425**	**28 798**	**30 780**	**21 801**	**23 034**
Median		**22 771**	**23 929**	**25 762**	**27 224**	**19 304**	**20 194**	**23 456**	**24 849**	**25 692**	**27 238**	**20 326**	**21 347**
Stand. deviation		**16 796**	**19 182**	**18 340**	**21 090**	**13 203**	**14 812**	**11 198**	**12 073**	**12 722**	**13 805**	**8 831**	**9 217**
Var. coefficient		**61,40**	**65,18**	**59,96**	**63,75**	**57,47**	**60,52**	**43,54**	**44,02**	**44,18**	**44,85**	**40,51**	**40,01**

Source: own research

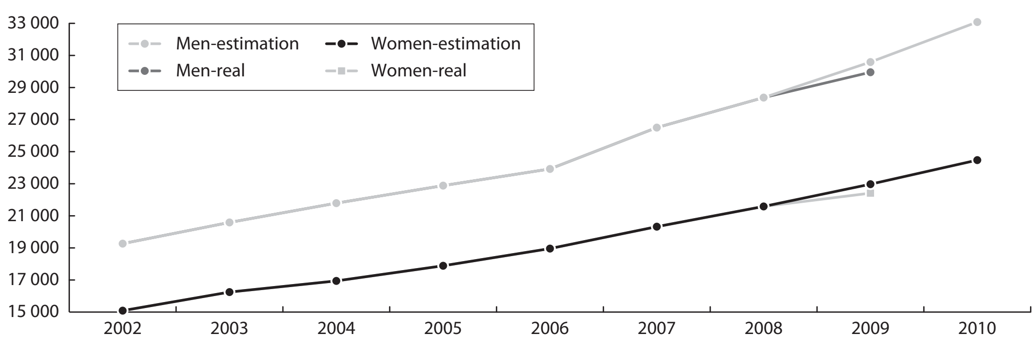
mated based on the development of wages until 2008 and it is therefore obvious that the economic recession has certainly lead to a considerable slowdown of wage growth. We can get a certain idea of the impact of the economic recession on the development of wages from Graph 10, again by comparing the prediction of the development of average gross monthly wages of men and women for 2009 with the values of average gross monthly wages presented by the Czech Statistical Office. It can be expected that the difference between the prediction and the values of average gross monthly wages published by the Czech Statistical Office for 2010 will be even bigger. Certain inaccuracies may also be caused by the fact that our calculations were based on data organized in frequency distributions, while the data presented by the Czech Statistical Office are calculated directly from microdata, which is reflected mainly in higher wages (upper percentiles).

Table 14 Shares of workers (in %) **in bands of gross monthly wages** (in CZK) **in 2009 by gender, published by the Czech Statistical Office**

Interval	Set		
	Total	Men	Women
till–10 000	3,02	2,03	4,32
10 001–12 000	4,69	2,49	7,54
12 001–14 000	6,30	3,66	9,72
14 001–16 000	7,61	5,70	10,10
16 001–17 000	4,30	3,72	5,05
17 001–18 000	4,50	4,27	4,79
18 001–19 000	4,59	4,45	4,76
19 001–20 000	4,67	4,62	4,74
20 001–20 000	4,78	4,85	4,69
21 001–22 000	4,54	4,70	4,34
22 001–23 000	4,34	4,54	4,09
23 001–24 000	4,03	4,30	3,67
24 001–25 000	3,84	4,10	3,51
25 001–26 000	3,64	3,91	3,28
26 001–28 000	6,25	6,66	5,71
28 001–30 000	4,98	5,66	4,09
30 001–32 000	4,01	4,72	3,08
32 001–36 000	5,67	6,90	4,07
36 001–40 000	3,64	4,53	2,48
40 001–50 000	4,83	6,15	3,11
50 001–60 000	2,13	2,84	1,20
60 001–70 000	1,79	2,43	0,94
80 001–and more	1,88	2,77	0,72
Mean	**26 677**	**29 953**	**22 414**
Variation coefficient	**0,97**	**1,05**	**0,66**

Source: own research

Graph 10 Development of average gross monthly wages in the Czech Republic by gender in 2008–2009 and prediction of gross monthly wages for 2009 and 2010



Source: www.czso.cz + own research

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