Regional Wage Differentiation and Qualitative Determinants of Economic Development: Evidence from Poland
Regionalne zróżnicowanie wynagrodzeń a jakościowe determinanty rozwoju gospodarczego – przypadek Polski

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ABSTRACT

Objective: The article shows the differences in salaries in Polish voivodeships and between poviats of individual voivodeships. It also identifies factors, particularly qualitative development ones, which affect them.

Research Design & Methods: Ranking, spread indices, coefficients of variation, and grouping methods were used. Parameters of panel econometric models with random effects and fixed effects were also estimated.

Findings: In the years 2010–2020, wage variation between voivodeships decreased slightly. This indicates a weak process of sigma convergence, but the data about average annual wage growth do not show a clear tendency to beta convergence. The highest average wages were found in Mazowieckie, Śląskie and Dolnośląskie voivodeships, and the lowest in Warmińsko-

-mazurskie, Podkarpackie, Lubuskie, Kujawsko-pomorskie and Świętokrzyskie. The econometric analysis confirmed that the following factors had a positive impact on wage levels: labour productivity, the share of people with higher education, the number of patents and the share of innovative enterprises, and a negative impact of the unemployment rate. The 2020 pandemic also had a significant positive impact on wages in voivodeships.

Implications/Recommendations: The analyses confirm a significant impact of qualitative development factors on wages in voivodeships.

Contribution: The research complements the Polish literature on the impact of qualitative development factors on regional differences in wages and confirms the validity of using panel models for this type of analysis.

Article type: original article.

Keywords: wage differentiation, grouping of Polish voivodeships, wage differentiation between poviats, wage determinants.

JEL Classification: J3, J31, R11.

STRESZCZENIE

Cel: Celem artykułu jest ukazanie zróżnicowania wynagrodzeń w polskich województwach i między powiatami poszczególnych województw oraz identyfikacja czynników, w szczególności z grupy jakościowych czynników rozwoju, które na nie wpływają.

Metodyka badań: Wykorzystano metody rankingu, wskaźniki rozpiętości, współczynniki zmienności, a także metody grupowania województw. Oszacowano również parametry panelowych modeli ekonometrycznych z efektami losowymi i efektami ustalonymi.

Wyniki badań: W latach 2010–2020 zmienność płac między województwami nieznacznie się obniżyła, co wskazuje na słaby proces konwergencji sigma, a także na brak wyraźnej tendencji do konwergencji beta, jeśli wziąć pod uwagę średnioroczne tempo wzrostu płac w badanym okresie. Najwyższe przeciętne wynagrodzenia występowały w województwach mazowieckim, śląskim i dolnośląskim, a najniższe w warmińsko-mazurskim, podkarpackim, lubuskim, kujawsko-pomorskim i świętokrzyskim. Analiza ekonometryczna potwierdziła pozytywny wpływ na poziom wynagrodzeń takich zmiennych, jak: wydajność pracy, udział osób z wyższym wykształceniem, liczba patentów i udział przedsiębiorstw innowacyjnych oraz negatywny wpływ stopy bezrobocia. Potwierdzono również istotny pozytywny wpływ pandemii COVID-19 w 2020 r. na płace w województwach.

Wnioski: Analizy potwierdzają istotny wpływ jakościowych czynników rozwoju na wynagrodzenia w województwach.

Wkład w rozwój dyscypliny: Uzupełnienie literatury polskiej o badania dotyczące wpływu jakościowych czynników rozwoju na regionalne zróżnicowanie wynagrodzeń oraz potwierdzenie zasadności wykorzystania modeli panelowych w tego typu analizach.

Typ artykułu: oryginalny artykuł naukowy.

Słowa kluczowe: zróżnicowanie wynagrodzeń, grupowanie polskich województw, zróżnicowanie wynagrodzeń między powiatami, determinanty wynagrodzeń.

1. Introduction

2010–2020 was a period of relatively good economic performance in the Polish economy. Although in the years 2012–2013 there was a slowdown in economic growth due to fallout from the global financial crisis, and in the pandemic year 2020 GDP fell by 2.2%, in the remaining years GDP growth rates were relatively high. For the decade, the average GDP growth rate came in at 3.1%. If we add to this falling unemployment rates, particularly in the final years of the decade, the fact that average real wages rose throughout the decade should come as no surprise (see: www.stat.gov.pl/wskazniki-makroekonomiczne/, accessed: 22.05.2022). However, questions arise as to whether these favourable wage trends exist in all voivodeships, and whether differentiation of wages between voivodeships and between poviats in individual voivodeships were more extensive in some than in others.

In this article, we have three primary aims. First, to show the differentiation of wages in Polish voivodeships and identify groups of voivodeships with relatively high and relatively low wages in 2010–2020. Second, to present the differentiation of wages between poviats in individual voivodeships for the period. And third, to indicate the most important factors, particularly qualitative development ones, that influence wages in voivodeships and the differentiation of wages between poviats in voivodeships. Statistical data on Polish voivodeships and poviats in 2010–2020 are used as the basis for the conclusions.

2. Literature Review

The problem of regional differentiation of wages has been widely addressed in the literature. Theoretical aspects explaining the determinants of wages and empirical research undertaken in various countries are extensively covered.

In his textbook on labour economics, Robert J. Willis (1986) described three groups of factors that influence wage levels: personal ones, environmental ones and markets. This idea was used by Combes, Duranton and Gobillon (2008), who in their well-known article examined the spatial differentiation of wages in France. They focused on four basic factors: the spatial distribution of the workforce in terms of skills; the differentiation of local non-human endowments; the size of the market in individual regions; and the links between companies and employees, which affect their degree of concentration of production and urbanisation. The authors concluded that as much as half of the wage differentiation is attributable to the differentiation of the spatial distribution of employees' qualifications.

Combes, Duranton and Gobillon's ideas were used in another empirical study of regional wage differentiation in the Netherlands by Groot, de Groot and Smit (2014). Using individual data on workers from the 2000–2005 census and labour force surveys, they attempted to explain the regional wage differentiation at the level

of NUTS-3 regions by factors including the size of the regional labour market, the degree of urbanisation, industrial employment and population density.

A strong emphasis on the uneven distribution of qualifications in shaping the spatial differentiation of wages can be found in research on human capital and its importance for wages. This area was developed especially by Schultz (1961), Becker (1962) and Mincer (1958, 1974). In particular, Becker's attention to investment in human capital paved the way for research on the role of education and training in shaping human capital and remuneration. Empirical research on the relationship between education and wage levels undertaken in various countries (Acemoglu & Angrist 1999, Card 1999, Harmon, Oosterbeek & Walker 2000) confirmed the existence of a wage bonus for education. The Polish economics literature has repeatedly confirmed the presence of a wage premium for education in Poland (Newell & Socha 2005, Strawiński 2006, 2008, Myck, Nicinska & Morawski 2009). At the same time, a study of the wage bonus for education for the years 1995–2013 showed a decrease in bonuses for higher education and an increase in bonuses for vocational education. This was largely attributable to an increase in the number of employees with higher education and a decrease in the number of employees with vocational education (Strawiński, Majchrowska & Broniatowska 2018).

Magda *et al*. (2011) analysed the structure and determinants of inter-industry wage differentiation in four countries: Latvia, Lithuania, the Czech Republic and Poland, based on individual data from 1996–2006. They found not only sectoral wage differences, but also spatial differentiation of such variables as individual employee characteristics, workplace characteristics, job and employer characteristics. The study confirmed the existence of significant wage differences between sectors, even when the characteristics of workers, jobs and employers were controlled.

A good deal of research has been done on regional differentiation of wages in Poland. Tokarski and his team have been particularly active. Rogut and Tokarski (2007) analysed the regional differentiation of real wages at the voivodeship level and the determination of the main factors determining this differentiation in the years 1995–2003. They found that labour productivity and the unemployment rate caused regional differences in wages. Ultimately, wages proved to be the variable characterised by the lowest level of regional differentiation in the model. At the same time, the lack of regional wage convergence in Poland has also demonstrated. In another publication, Adamczyk, Tokarski and Włodarczyk did a statistical analysis of the factors determining regional wage differences in Poland in 2002–2006 (Adamczyk, Tokarski & Włodarczyk 2009). The team used a theoretical model that combined Solow-Summers' neo-Keynesian efficiency wages model and neoclassical growth models to determine the role of labour productivity and the unemployment rate in shaping regional wage differentiation. The study confirmed a strong correlation between regional disparities in wages and labour productivity.

Zieliński (2011) conducted an analysis of wage differentiation by examining the degree of regional wage convergence or divergence in 1999–2007 using convergence measure, known as σ-convergence. Zieliński found labour productivity to be the main determinant of wage levels, but he also pointed to the important role of a different sectoral economic structure in the regions due to the occurrence of wage differences in individual sectors. Rokicki (2013) empirically verified the convergence of real wages in Poland at the voivodeship level in the years 2000–2011. The study confirmed a clear divergence of trends for nominal and real wages. However, the regional differentiation in real wages declined after 2006. Wesołowska (2018) conducted a statistical analysis of the determinants of wage differentiation (unemployment rate, labour productivity) in Polish voivodeships in the years 1999–2015. The analysis was based on a compilation of Solow-Summers efficiency wage models and neoclassical models of economic growth. It found a statistically significant positive relationship between increased relative work efficiency and increased relative remuneration. However, at the voivodeship level, it was not possible to prove the existence of a statistically significant negative correlation between the level of the unemployment rate and relative wages in the analysed period.

Research was also undertaken on the differentiation of wages in Polish poviats. Using data from 2002–2011, Dykas and Misiak (2014) verified the determinants of basic labour market variables. They found that relative real gross wages were explained by the unemployment rate and relative labour productivity. Tokarski (2012) analysed the spatial differentiation of wages in poviats in the years 2003–2009. Poviats located in large and medium-sized agglomerations had the highest wage levels in Poland, while wages in poviats west of the Vistula river were higher than those to the east of it.

This partial review of research done in Poland shows important conclusions on factors explaining regional disparities in wages, and they are relevant to the research undertaken for this article. However, there are also research gaps, especially with regard to explaining the regional disparities in wages in Poland. With this study, we seek to address some of them.

3. Data and Methodology

The research undertaken in this article was conducted in two stages. The first presents the differentiation of wages in Polish voivodeships and between the poviats of individual voivodeships in the years 2010–2020, while the second attempts to explain the factors influencing wages in voivodeships and the degree of differentiation of wages between poviats of individual voivodeships in this period, in particular from the group of qualitative development factors.

The research is based on annual statistical data on Polish voivodeships and poviats from 2010–2020. Data on wages concern average monthly gross wages

in economic entities employing 10 or more employees, as well as budgetary units, regardless of the number of employees. Moreover, data on variables influencing wages in voivodeships were used. These will be characterised in further parts of the article. All data come from Central Statistical Office reports and Labour Force Surveys (LFS). They are available on the Central Statistical Office website, in the Local Data Bank (www.stat.gov.pl, accessed: 22.05.2022).

Nominal data on average monthly gross wages in voivodeships and poviats were transformed into real magnitudes on the basis of consumer price indexes (CPI) for individual voivodeships, with 2010 prices being used as the base. Other nominal variables used in the analysis were handled similarly.

To show the differentiation of wages in voivodeships, ranking, spread indices and coefficients of variation, and grouping methods (to group the voivodeships) were used. The voivodeships were divided into three groups based on the arithmetic mean and standard deviation of average monthly gross earnings, in accordance with the principle:

– group I: $w_i > w^* + \frac{1}{2}\,\delta$,

– group II: $w^* + \frac{1}{2}\,\delta \geq w_i \geq w^* - \frac{1}{2}\,\delta$,

– group III: $w_i < w^* - \frac{1}{2}\,\delta$,

where the following designations were adopted:

– w_i are salaries in i-th voivodeship,

– w^* is the arithmetic mean of salaries in voivodeships,

– δ is the standard deviation of salaries in voivodeships.

To determine the differentiation of wages between poviats in individual voivodeships, the coefficients of variation of these wages were used.

For the second stage of the study, we constructed econometric models to verify the impact of economic factors on wage levels in voivodeships and differentiation of wages between poviats in individual voivodeships. The nature of the dependent and explanatory variables dictated the choice of econometric models used. Since the variables adopted in the analyses are based on cross-sectional annual data on 16 voivodeships from the years 2010 and 2020, panel model was chosen for the estimations. The power analytical form was adopted for the regression equations. After logarithmisation, they are linear with respect to the estimated parameters. The general form of the estimated equations is as follows:

$$\ln\_W_{it} = \alpha_0 + \alpha_1 \ln\_X_{1,it} + \dots + \alpha_n \ln\_X_{n,it} + \varepsilon_{it}, \tag{1}$$

$$\ln\_V_{it} = \alpha_0 + \alpha_1 \ln\_X_{1,it} + \dots + \alpha_n \ln\_X_{n,it} + \varepsilon_{it} \tag{2}$$

where:

W_{it} – the level of average monthly real gross remuneration in the voivodeship and in year t,

V_{it} – coefficient of variation of average monthly real gross wages between poviats in the voivodeship and in year t,

$X_{1,it} - X_{n,it}$ – explanatory variables in the voivodeship and in year t,
ε_{it} – random component,
α_0 – intercept,
$\alpha_1 - \alpha_n$ – parameters for explanatory variables.

The explanatory variables for the models were chosen on the basis of theoretical achievements in economics on factors determining wages and the achievements of empirical research on regional wage differentiation, as well as the availability of statistical information at the voivodeship level. Whether the variables were among qualitative development factors was also considered. For these reasons, in the model explaining the level of wages in voivodeships and in the model explaining the differentiation of wages between poviats in voivodeships, the basic determinants include:

– labour productivity,
– unemployment rate,
– share of people with higher education in total employment,
– share of high and medium-high technology products in manufacturing industry sales,
– share of innovative enterprises in the total number of enterprises,
– number of patents granted per 100,000 residents.

All variables were expressed in relative formulas that allow for comparisons between voivodeships.

In the model explaining the level of remuneration in voivodeships, the pandemic zero-one variable was added to the group of explanatory variables. It has a value of 1 in 2020 and of 0 in other years.

Expectations regarding the impact of the variables on the average wages in voivodeships can be justified by economic theory and the results of empirical research.

The dependence of wages on labour productivity is thoroughly covered in neoclassical economics (Marshall 1890, Pigou 1933). The microeconomic perspective emphasised in this theory emphasises the determining influence of the marginal product of labour on wage levels. However, assuming a macroeconomic perspective, it is easy to move from the marginal product of labour to labour productivity. In line with this approach, higher wages and greater wage differentiation can be expected where labour productivity is higher.

The impact of unemployment rates on wage developments is firmly entrenched in Keynesian and neo-Keynesian labour market theories. This impact is based on the belief that higher unemployment rates simply mean that workers are in a worse bargaining position in negotiations with employers and lead to a reduction in wage pressure (Lipsey 1960). Hence, lower wages and greater wage differentiation are to be expected when unemployment rates are higher.

The notion that individuals with higher education influence the shaping of average wages is broadly justified in the theory of human capital, particularly in the work of Mincer (1974), as well as empirical research undertaken in various countries (Strawiński, Majchrowska & Broniatowska 2018). These authors emphasised the existence of a wage premium for higher education that results from the impact of higher education on the growth of human capital and employee productivity. Hence, one can expect higher average wages and greater wage differentiation in regions with a better educated workforce.

Two other variables – the shares of high and medium-high technology industry and innovative enterprises – were included among the factors determining average wages. The inclusion references the importance of sectoral wage differentiation for their regional differentiation, a fact that has been emphasised in empirical research. The literature emphasises that regions achieve a higher degree of competition on the market when high-tech products lead sales, because the increased demand for such products is much higher than for traditional products (Wysokińska 2001). The increased demand helps boost both revenues and wages. It should therefore be expected that the higher the share of high and medium-high technology products[1] a region produces, the higher its average wage level and the greater its wage differentiation will be.

A higher shares of innovative enterprises in the region should also translate into higher average wages. The literature emphasises that product innovation related to technological progress leads to an increase in profits, employment and wages, though the possibility of reducing employment and wage polarisation as a result of process innovation has also been observed (Pianta & Tancioni 2008). In the short term, however, the effect of product innovation seems to be stronger. This led us to adopt the hypothesis that voivodeships with a greater share of innovative enterprises will have higher average wages and greater wage differentiation. We further hypothesise that the number of patents granted will have an effect similar to high and medium-high technology products. That is, the higher the number of patents produced in an area, the higher its average wage level and the greater its wage differentiation should be. Lastly, demand, production and sales revenues declined in a number of areas of activity during the pandemic, leading us to hypothesise that average wages decreased during the pandemic.

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[1] Sections of high and medium-high technology industry have been distinguished on the basis of the official OECD classification of production industries into categories based on the intensity of research and development work done in them and their level of technological advancement. These sections include high-tech industries: airplanes and spacecraft production, pharmaceuticals, computer, office and accounting machines, radio, television and communication equipment, medical, precision and optical devices; and medium-tech: electrical machinery and apparatus, motor vehicles, trailers and semi-trailers, chemicals, railway and transport equipment, other machinery and equipment.

4. Wage Differentials between Voivodeships and Poviats

The analysis of the wage differentiation will be carried out in two stages. In the first, the differentiation in the first (2010) and last (2020) years of the period under review will be compared. The second stage examines wage variation between the poviats of individual voivodeships.

Table 1 presents data on nominal and real wages by voivodeships in 2010 and 2020. The table shows a significant differentiation between voivodeships in both analysed years, both in nominal and real wages. The table also shows that nominal wages increased in all voivodeships (by over 62% on average) in this period, while the increase in real wages was significantly lower (by over 39%), indicating the existence of inflation.

Table 1. Average Monthly Nominal and Real Gross Wages in Voivodeships in 2010 and 2020

Voivodeship	Nominal Wages (Current Prices)			Real Wages (in 2010 Prices)		
	2010 (PLN)	2020 (PLN)	2020 2010 = 100	2010 (PLN)	2020 (PLN)	2020 2010 = 100
Dolnośląskie	3,412.37	5,693.69	166.9	3,412.37	4,908.35	143.8
Kujawsko-pomorskie	2,910.82	4,831.73	166.0	2,910.82	4,119.12	141.5
Lubelskie	3,099.60	4,914.95	158.6	3,099.60	4,270.16	137.8
Lubuskie	2,920.43	4,832.07	165.5	2,920.43	4,067.40	139.3
Łódzkie	3,066.02	5,148.38	167.9	3,066.02	4,419.21	144.1
Małopolskie	3,169.90	5,536.07	174.6	3,169.90	4,656.07	146.9
Mazowieckie	4,279.55	6,581.81	153.8	4,279.55	5,693.61	133.0
Opolskie	3,137.29	5,078.51	161.9	3,137.29	4,374.25	139.4
Podkarpackie	2,877.43	4,707.81	163.6	2,877.43	4,020.33	139.7
Podlaskie	3,019.83	4,929.64	163.2	3,019.83	4,282.92	141.8
Pomorskie	3,383.58	5,484.46	162.1	3,383.58	4,707.69	139.1
Śląskie	3,528.19	5,450.86	154.5	3,528.19	4,764.74	135.0
Świętokrzyskie	2,971.58	4,800.21	161.5	2,971.58	4,102.74	138.1
Warmińsko-mazurskie	2,879.97	4,709.12	163.5	2,879.97	4,007.76	139.2
Wielkopolskie	3,126.36	4,985.75	159.5	3,126.36	4,207.38	134.6
Zachodniopomorskie	3,120.15	5,099.49	163.4	3,120.15	4,369.74	140.0
Polska	3,181.44	5,174.03	162.9	3,181.44	4,435.72	139.6

Source: the authors, based on: Local Data Bank, https://bdl.stat.gov.pl/bdl/dane/podgrup/wymiary (accessed: 25.08.2022).

The growth rate of real wages between these years varied in individual voivodeships (the lowest was in Mazowieckie, the highest in Małopolskie). Range indicators, i.e. the difference between the highest and the lowest wages in voivodeships,

were higher in 2020 than in 2010, but the increase in nominal wages was much greater (from PLN 1,402.12 in 2010 to PLN 1,874.0 in 2020) than in real wages (from PLN 1,402.12 to PLN 1,685.85, respectively).

The coefficients of wage variation between voivodeships decreased slightly during the analysis period (see Fig. 1), suggesting the occurrence of sigma convergence, but it was relatively weak.
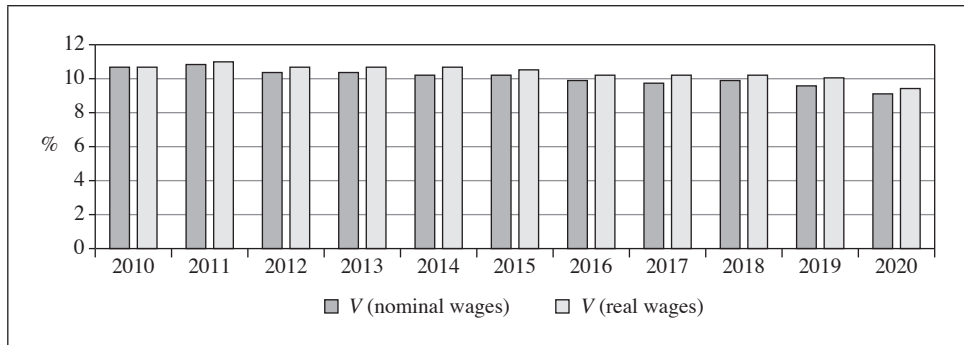

Fig. 1. Coefficients of Variation of Average Monthly Nominal and Real Gross Wages between Voivodeships in the Years 2010–2020

Source: the authors, based on: Local Data Bank, https://bdl.stat.gov.pl/bdl/dane/podgrup/wymiary (accessed: 25.08.2022).

The data in Table 1 are the basis for grouping voivodeships according to the rules presented in the previous part of the article, as well as for their rankings for 2010, 2020 and 2010–2020 (see Table 2). Real wages are the focus in this table.

As shown in Table 2, the voivodeships with the highest wages were Mazowieckie, Dolnośląskie, Śląskie and Pomorskie, with Małopolska joining the group in 2020. Group III, which had the lowest average salaries, included Warmińsko-mazurskie, Podkarpackie, Lubuskie, Świętokrzyskie and Kujawsko-pomorskie in both years, with Wielkopolskie joining the group in 2020. The last voivodeship, which was 7th in the voivodeship ranking in 2010, fell to 11th in 2020, while the greatest advance was recorded in the Łódzkie voivodeship, which moved from position 10 in the 2010 ranking to 6th in 2020. Groupings and rankings of voivodeships based on average wages for the entire period under study (2010–2020) do not differ much from the classification for 2010 and 2020. The highest wages based on periodic averages are found in Mazowieckie, and the lowest in Warmińsko-mazurskie.

While searching for common features among voivodeships in the same group and differentiating features with voivodeships from other groups, a few general characteristics should be observed. First, the voivodeships in group I are characterised by significantly higher GDP per capita indicators than the average national indicators and generally higher analogous indicators than the voivodeships of group III.

Table 2. Groupings and Rankings of Voivodeships by Real Average Monthly Gross Wages in 2010, 2020 and 2010–2020

Group of Voivodeships	Groupings and Rankings for 2010	Groupings and Rankings for 2020	Groupings and Rankings for 2010–2020
Group I	1. Mazowieckie 2. Śląskie 3. Dolnośląskie 4. Pomorskie	1. Mazowieckie 2. Dolnośląskie 3. Śląskie 4. Pomorskie 5. Małopolskie	1. Mazowieckie 2. Śląskie 3. Dolnośląskie 4. Pomorskie
Group II	5. Małopolskie 6. Opolskie 7. Wielkopolskie 8. Zachodniopomorskie 9. Lubelskie 10. Łódzkie 11. Podlaskie	6. Łódzkie 7. Opolskie 8. Zachodniopomorskie 9. Podlaskie 10. Lubelskie	5. Małopolskie 6. Łódzkie 7. Zachodniopomorskie 8. Opolskie 9. Lubelskie 10. Wielkopolskie 11. Podlaskie
Group III	12. Świętokrzyskie 13. Lubuskie 14. Kujawsko-pomorskie 15. Warmińsko-mazurskie 16. Podkarpackie	11. Wielkopolskie 12. Kujawsko-pomorskie 13. Świętokrzyskie 14. Lubuskie 15. Podkarpackie 16. Warmińsko-mazurskie	12. Świętokrzyskie 13. Kujawsko-pomorskie 14. Lubuskie 15. Podkarpackie 16. Warmińsko-mazurskie

Source: the authors, based on: Local Data Bank, https://bdl.stat.gov.pl/bdl/dane/podgrup/wymiary (accessed: 25.08.2022).

For example, in 2020 the average value of GDP per capita in the voivodeships of group I was 16.6% higher than the average indicator for Poland, while the group III voivodeship was 25.2% lower for this indicator. Secondly, unlike the voivodeships of group I, the group III voivodeships are typically agricultural. The average share of agriculture and forestry in total employment in the entire 2010–2020 period was 21.1% in the group III voivodeships, while the country as a whole stood at 16.2%, and 8.6% as in the group I voivodeships. Thirdly, the voivodeships of groups I and III do not differ much in terms of the share of industry and construction in the total number of employees: for the period 2010–2020, these indicators averaged: 28.6% in group I and 27.7% in group III, while the national rate was 26.8%. Fourth, there were significant differences between the voivodeships of groups I and III in terms of service sector development – it was much higher in the group I than in the group III voivodeships. Fifth, the group III voivodeships had higher unemployment rates than those in group I.

Taking into account the rankings of voivodeships for 2010 from Table 2, one can consider average annual growth rates of real wages in voivodeships in the years 2010–2020 dependent on their wage levels. The appropriate data are presented in Figure 2, where voivodeships are ordered according to decreasing wage levels. Clear

beta-convergence is not observed until Dolnośląskie and Małopolskie are removed from the analysis.
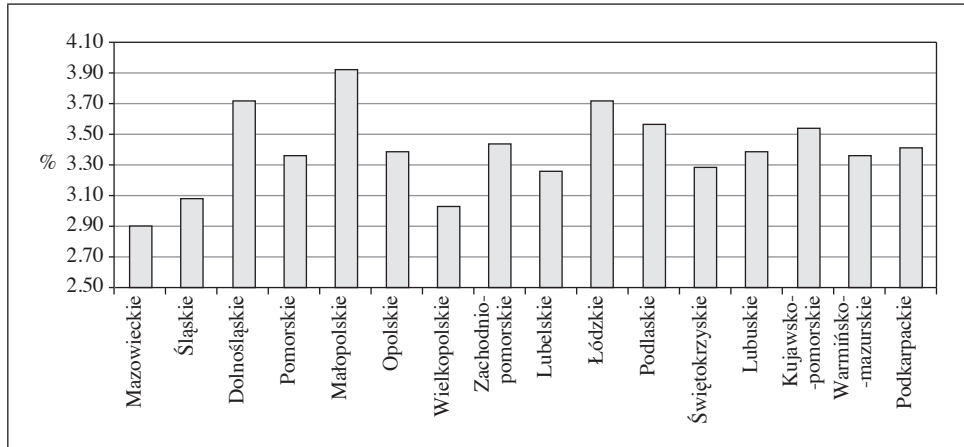

Fig. 2. Average Annual Growth Rate of Real Wages by Voivodeships in 2010–2020

Source: the authors, based on: Local Data Bank, https://bdl.stat.gov.pl/bdl/dane/podgrup/wymiary (accessed: 25.08.2022).

We will now look at the degree to which real wages differ between poviats in individual voivodeships. Wage variation coefficients were adopted to measure this differentiation. The coefficients of wage variation between the poviats in individual voivodeships were strongly diversified (Table 3). The highest volatility of wages was recorded in the the Śląskie (20.6% in 2011) and Dolnośląskie voivodeships (20.2% in 2010), while the lowest was found in the Lubuskie (5.1% in 2018) and Świętokrzyskie voivodeships (6.2% in 2013 and 2020).

Table 3. Coefficients of Variation of Average Real Wages between Poviats in Individual Voivodeships in 2010–2020 (in %)

Voivodeship	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Dolnośląskie	20.2	19.5	19.4	19.1	18.9	18.4	18.1	18.0	17.4	16.6	16.6
Kujawsko-pomorskie	7.2	7.4	7.2	7.3	7.5	7.9	7.8	7.7	7.5	7.7	7.4
Lubelskie	13.9	14.3	14.3	14.6	14.8	13.2	12.9	13.0	12.6	12.4	11.0
Lubuskie	7.2	6.3	6.5	6.2	5.5	6.0	5.8	5.5	5.1	5.6	5.6
Łódzkie	15.9	16.5	17.2	17.7	16.9	16.9	15.8	15.0	14.4	14.3	13.1
Małopolskie	8.7	9.0	9.5	9.7	9.6	10.6	11.1	11.4	11.8	12.4	12.3
Mazowieckie	15.6	15.3	14.9	15.4	15.1	15.5	15.5	15.1	15.1	14.7	13.0
Opolskie	11.9	10.6	9.3	9.8	10.3	10.5	10.4	10.1	9.2	8.4	7.9
Podkarpackie	7.3	6.9	7.0	7.2	7.7	7.7	7.7	7.9	7.7	7.5	6.8

Table 3 cnt'd

Voivodeship	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Podlaskie	6.7	7.5	7.5	8.0	7.1	6.8	7.3	7.8	7.4	7.4	7.2
Pomorskie	13.8	13.6	13.6	13.4	13.5	13.8	13.9	13.2	12.9	12.9	12.1
Śląskie	17.4	20.6	17.8	19.0	18.1	16.7	15.5	15.1	17.6	16.3	14.5
Świętokrzyskie	6.7	7.1	7.4	6.2	6.6	6.6	6.8	7.4	6.9	7.0	6.2
Warmińsko-mazurskie	8.0	7.8	7.4	7.4	7.5	7.9	7.6	7.4	7.1	6.8	6.9
Wielkopolskie	10.7	10.6	10.3	10.5	10.1	10.5	10.5	10.0	9.5	9.2	8.6
Zachodniopomorskie	10.0	9.8	9.8	10.0	10.1	10.7	10.2	9.6	9.1	9.2	8.4

Source: the authors, based on: Local Data Bank, https://bdl.stat.gov.pl/bdl/dane/podgrup/wymiary (accessed: 25.08.2022).

The data in table 3 suggest a weak downward trend in the coefficients in the subsequent years. The average indicator of variation for all voivodeships decreased from 10.5% in 2010 to 9.8% in 2020. This trend occurred in most voivodeships, though not in Małopolskie, where there was an upward trend. In several voivodeships the indicators stabilised (Kujawsko-pomorskie, Podkarpackie, Podlaskie, Świętokrzyskie). As for the average levels of these coefficients in voivodeships during the entire period of analysis, the highest wage variability between the poviats was recorded in Dolnośląskie, Śląskie and Łódzkie, while the lowest was recorded in Lubuskie, Świętokrzyskie and Warmińsko-mazurskie (see Fig. 3).
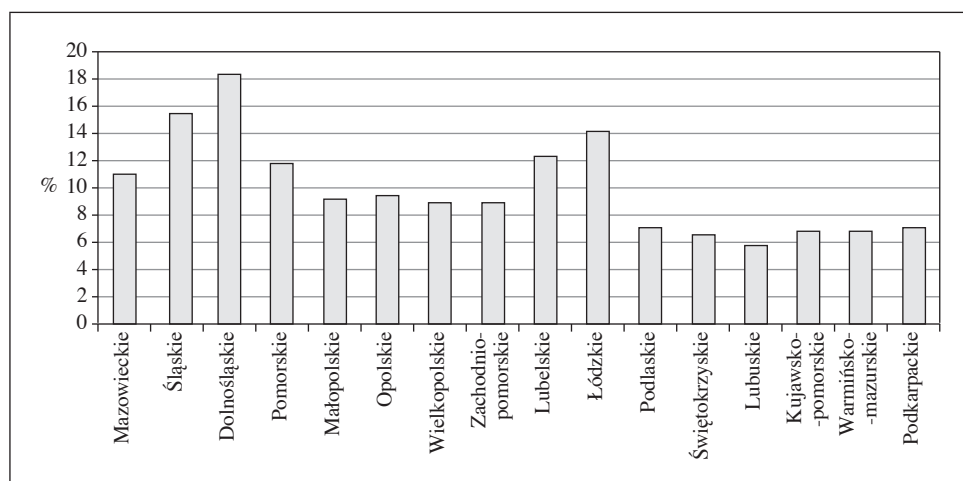

Fig. 3. Average Coefficients of Variation of Real Wages between Poviats by Individual Voivodeships in 2010–2020

Source: the authors, based on: Local Data Bank, https://bdl.stat.gov.pl/bdl/dane/podgrup/wymiary (accessed: 25.08.2022).

Voivodeships shown on the horizontal axis in Figure 3 are ordered according to decreasing wage levels in 2010. Comparison of the coefficients of poviat wage variation between groups of voivodeships with different wage levels reveals that there is a clear regularity. The average coefficient of wage variation between poviats, calculated for the entire period of 2010–2020, amounted to 15.9% for the voivodeships of group I (Mazowieckie, Śląskie, Dolnośląskie and Pomorskie) and 7.0% for the voivodeships of group III (Warmińsko-mazurskie, Podkarpackie, Lubuskie, Kujawsko-pomorskie and Świętokrzyskie). This shows that in the voivodeships with the highest wage levels, there is a greater variation of wages between poviats than in the voivodeships with the lowest levels of wages.

5. The Results of Model Analysis

To verify factors determining wages in voivodeships and differentiation of wages between poviats of individual voivodeships, an econometric analysis was carried out based on panel data (annual data for 16 voivodeships in 2010–2020), using power functions. Following logarithmisation, it takes this form:

$$\ln W_{it} = \alpha_0 + \alpha_1 \ln \text{PROD}_{it} + \alpha_2 \ln \text{HIGH\_EDU}_{it} + \alpha_3 \ln \text{PROD\_TECH}_{it} + \\ + \alpha_4 \ln \text{UNEMPL}_{it} + \alpha_5 \ln \text{ENT\_INNO}_{it} + \alpha_6 \ln \text{PATENT}_{it} + \varepsilon_{it} \tag{3}$$

$$\ln W_{it} = \alpha_0 + \alpha_1 \ln \text{PROD}_{it} + \alpha_2 \ln \text{HIGH\_EDU}_{it} + \alpha_3 \ln \text{PROD\_TECH}_{it} + \\ + \alpha_4 \ln \text{UNEMPL}_{it} + \alpha_5 \ln \text{ENT\_INNO}_{it} + \alpha_6 \ln \text{PATENT}_{it} + \alpha_7 \text{PANDEMIA} + \varepsilon_{it} \tag{4}$$

$$\ln V_{it} = \alpha_0 + \alpha_1 \ln \text{PROD}_{it} + \alpha_2 \ln \text{HIGH\_EDU}_{it} + \alpha_3 \ln \text{PROD\_TECH}_{it} + \\ + \alpha_4 \ln \text{UNEMPL}_{it} + \alpha_5 \ln \text{ENT\_INNO}_{it} + \alpha_6 \ln \text{PATENT}_{it} + \varepsilon_{it} \tag{5}$$

$$\ln V_{it} = \alpha_0 + \alpha_1 \ln \text{PROD}_{it} + \alpha_2 \ln \text{HIGH\_EDU}_{it} + \alpha_3 \ln \text{PROD\_TECH}_{it} + \\ + \alpha_4 \ln \text{UNEMPL}_{it} + \alpha_5 \ln \text{ENT\_INNO}_{it} + \alpha_6 \ln \text{PATENT}_{it} + \alpha_7 \text{PANDEMIA} + \varepsilon_{it} \tag{6}$$

where the following symbols have been adopted:

W_{it} – the average monthly gross salary in the voivodeship and in year t in PLN (in 2010 prices),

V_{it} – coefficient of variation of average wages between poviats in the voivodeship and in year t,

PROD_{it} – labour productivity measured as GDP per 1 employee in the voivodeship and in the year t in PLN (in 2010 prices),

UNEMPL_{it} – average LFS unemployment rate in the voivodeship and in year t,

HIGH_EDU_{it} – share of people with higher education in the total employment in the voivodeship and in year t,

PROD_TECH_{it} – share of the value of sales of products of entities classified as high and medium-high technology in net revenues from sales of products by entities classified in the manufacturing industry in the voivodeship and in year t,

ENT_INNO$_{it}$ – share of the number of innovative enterprises in the total number of enterprises in the voivodeship and in year *t*,

PATENT$_{it}$ – number of patents granted by the PPO per 100,000 inhabitants in the voivodeship and in year *t*,

PANDEMIA – a zero-one variable, taking into account the pandemic effect (2020 = 1; other years = 0),

ε_{it} – random component,

α_0 – intercept,

$\alpha_1 - \alpha_7$ – parameters for explanatory variables.

When assessing potential explanatory variables in terms of statistics, their decent variability (the value of the coefficients of variation in the range of 9–54%) must be indicated. The correlation analysis using Pearson's linear correlation coefficient did not show any particularly strong statistical relationships between the explanatory variables (correlation coefficients in the range of 8–52%).

In the econometric analysis, parameters of panel models were estimated with the programme GRETL, using Generalised Least Squares. The models were estimated in two versions: fixed-effects (FE) and random-effects (RE), with and without the pandemic as an explanatory variable. Based on the Hausman test, the FE models were found to be more efficient than RE models. Moreover, taking into account the likelihood ratio, models with a pandemic variable turned out to be better adjusted to empirical values than models without a pandemic variable. The Shapiro-Wilk tests indicate that models (3) and (4) in the FE version are characterised by a normal distribution of residuals.

Referring to statistically significant parameter estimates, the following relationships can be indicated, assuming the *ceteris paribus* assumption (see Table 4).

In the FE model (3), the majority of variables turned out to be statistically significant. The estimates show that, with other factors unchanged, an increase in the level of labour productivity by 1% resulted in an increase in the average level of wages in voivodeships by 0.94%. This confirms the thesis, grounded in neoclassical theory, that labour productivity plays a roles in shaping wages.

On the other hand, an increase in the unemployment rate by 1% resulted in a decrease in average wages in voivodeships by 0.08%. This dependence is consistent with the statements of economic theory, in particular with neo-Keynesian models of the relationship of wages and unemployment. As for the impact of the share of people with higher education in the total number of employees, estimates indicate that the increase in this indicator by 1% was related, *ceteris paribus*, to the increase in the level of average wages in voivodeships by 0.11%. This confirms a thesis put forward in human capital theory – that highly skilled jobs are better paid.

Factors related to the technological advancement and enterprise innovation also had an impact on wage levels. An 1% increase in the share of innovative companies

Table 4. Results of the Estimation of Regression Models

| Specification | $\ln W_{it}$ | | | | $\ln V_{it}$ | | | |
| | Model (3) | | Model (4) | | Model (5) | | Model (6) | |
	FE	RE	FE	RE	FE	RE	FE	RE
Intercept	−3.10*** (0.0001)	2.69*** (<0.0001)	−2.05*** (0.008)	2.93*** (<0.0001)	3.12 (0.23)	−0.01 (0.994)	0.74 (0.779)	−1.77 (0.449)
ln PROD	0.94*** (<0.0001)	0.43*** (<0.0001)	0.86*** (<0.0001)	0.42*** (<0.0001)	−0.14 (0.53)	0.11 (0.566)	0.04 (0.843)	0.24 (0.219)
ln UNEMPL	−0.08*** (<0.0001)	−0.13*** (<0.0001)	−0.09*** (<0.0001)	−0.13*** (<0.0001)	0.05* (0.063)	0.08*** (0.001)	0.06** (0.019)	0.09*** (0.0004)
ln HIGH_EDU	0.11*** (<0.0001)	0.15*** (<0.0001)	0.10*** (<0.0001)	0.13*** (<0.0001)	0.13* (0.087)	0.13 (0.100)	0.15** (0.035)	0.15** (0.038)
ln PATENT	0.004 (0.4099)	0.02*** (0.0017)	0.01** (0.016)	0.02*** (<0.0001)	0.01 (0.588)	0.01 (0.573)	−0.01 (0.612)	−0.008 (0.656)
ln PROD_TEC	0.01 (0.3640)	0.01 (0.1688)	0.02 (0.153)	0.02* (0.099)	0.08 (0.113)	0.10** (0.028)	0.06 (0.183)	0.09** (0.049)
ln ENT_INNO	0.02*** (0.0001)	0.03*** (<0.0001)	−0.001 (0.87)	−0.0005 (0.964)	−0.03 (0.183)	−0.03 (0.231)	0.03 (0.243)	0.04 (0.189)
PANDEMIA			0.04*** (<0.0001)	0.05*** (<0.0001)			−0.09*** (0.0011)	−0.09*** (0.0007)
Observations N	176	176	176	176	176	176	176	176
Likelihood Ratio	450.29	247.89	464.0	246.96	240.69	−39.07	246.88	−36.49
Shapiro-Wilk	0.996 (0.979)	0.958 (4.7e−005)	0.986 (0.202)	0.958 (4,8e−005)	0.980 (0.014)	0.971 (0.001)	0.981 (0.017)	0.966 (0.0002)
F-statistic Test	43.91 (<0.001)		52.25 (<0.0001)		127.96 (<0.001)		137.03 (<0.0001)	
Breusch-Pagan		160.17 (<0.0001)		179.71 (<0.0001)		455.25 (<0.0001)		459.8 (<0.0001)
Hausman Test	123.05 (<0.0001)		115.36 (<0.0001)		22.46 (0.0009)		21.26 (0.0016)	

Notes: The *p*-values are given in parentheses. Asterisks indicate the statistical significance of the coefficients of independent variables.

Source: the authors.

increased average remuneration by 0.02%, *ceteris paribus*. The impact of the revenues from the sale of high and medium-high technology production and the number of patents turned out to be statistically insignificant.

Model (4), enriched with the PANDEMIC variable, turned out to be significant in the FE version. Thus, the pandemic period significantly affected wages in the voivodeships, boosting them to some degree. This is attributable to state policy supporting the economy and protecting jobs, contributing to the increased wages. The other explanatory variables – labour productivity, the unemployment rate and the share of people with higher education – affected wage levels similarly to the FE model (3).

The estimations of models (5) and (6) turned out not to be statistically satisfactory. The Shapiro-Wilk tests suggest that these models are not characterised by a normal distribution of residuals. This is why the parameter estimates presented in Table 4, including those marked with asterisks, may be biased. The wage variation between poviats requires further research.

6. Conclusions

The analyses conducted herein allow for a number of conclusions. Firstly, in 2010–2020 wage differentiation between voivodeships, as measured by the wage variation coefficients, decreased slightly, suggesting weak sigma convergence. In addition, taking into account the average annual growth rate of real wages in the voivodeships in 2010–2020, no clear beta convergence can be observed, unless the Dolnośląskie and Małopolskie voivodeships are omitted from the analysis.

Secondly, the differentiation of wages between voivodeships was basically stable over time. The groupings of voivodeships for 2010, 2020 and the entire period show that in group I, including the voivodeships with the highest average wages, the following voivodeships invariably appeared: Mazowieckie, Śląskie, Dolnośląskie and in group III comprising the voivodeships with the lowest wages were: Warmińsko-mazurskie, Podkarpackie, Lubuskie, Kujawsko-pomorskie and Świętokrzyskie. Only Małopolskie, Wielkopolskie and Łódzkie voivodeship had larger shifts between the groups. The characteristic features differentiating the group I and group III voivodeships include the level of GDP per capita (relatively high in group I and relatively low in group III) and the sectoral structure of the employed. The voivodeships of group III are agricultural, while the voivodeships of group I are characterised by a highly developed service sector.

Third, the real wage differentiation between poviats decreased in 2010–2020 in the vast majority of voivodeships, with the exception of Małopolskie, where the differentiation increased. The analysis shows that the wage variation between poviats is significantly higher in the voivodeships of group I than in those of group III.

Fourth, econometric analysis of panel data confirmed that the following varia-bles had a statistically significant and positive impact on the level of wages: labour productivity, the share of people with higher education, the number of patents and the share of innovative enterprises. They had a significant and negative impact on the unemployment rate. The 2020 pandemic had a significant positive impact on wages in voivodeships.

Fifth, econometric analysis of wage variation between poviats did not yield satis-factory results. Further research is needed to explain the poviat variation of wages in voivodeships.

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