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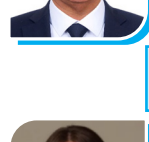
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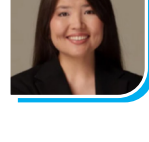
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ANALYSIS OF WAGE DYNAMICS IN THE EXAMPLE OF SURKHANDARYA REGION BASED ON PANEL DATA

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Abstract: The study analyzed the territorial stratification of population incomes in the regions of Surkhandarya region using econometric methods based on wage indicators. This study used panel data covering the years 2017-2024 to study spatial and temporal changes in wage levels in districts and cities within the region. The article also assessed economic and labor factors affecting wages, in particular, the volume of industrial production, the volume of services, per capita investment, the level of urbanization, and the age of the workforce using Fixed effects and Random effects models. The study used the Hausman specification test in the model selection process and justified the need to take into account individual regional characteristics. The results showed significant differences in wage levels between the regions of Surkhandarya region, and it was determined that the industrial and service sectors, as well as per capita investment in the region, affect regional income stratification. It was also analyzed how working age and the level of urbanization affect wage levels. The results of the study confirm that they have important scientific and practical significance in the formation of regional socio-economic policy and the development of measures aimed at reducing income disparities.

Keywords: population income, territorial stratification, Fixed effects, Random effects, Hausman test.

Annotatsiya: Mazkur tadqiqotda Surxondaryo viloyati hududlarida aholi daromadlarining hududiy tabaqalanishi ish haqi ko'rsatkichlari asosida ekonometrik usullar yordamida tahlil qilingan. Tadqiqotda viloyat tarkibidagi tuman va shaharlarda ish haqi darajasining makon va vaqt bo'yicha o'zgarishlarini o'rganish maqsadida 2017-2024-yillarni qamrab oluvchi panel ma'lumotlardan foydalanilgan. Shuningdek, maqolada ish haqi darajasiga ta'sir etuvchi iqtisodiy va mehnat omillari, xususan, sanoat mahsuloti hajmi, xizmatlar hajmi, aholi jon boshiga investitsiyalar miqdori, urbanizatsiya darajasi hamda mehnatga layoqatli aholi yoshi Fixed effects va Random effects modellari yordamida baholangan. Model tanlash jarayonida Hausman spetsifikatsiya testi qo'llanilib, hududlarning individual xususiyatlarini hisobga olish zarurligi asoslab berilgan. Tadqiqot natijalari Surxondaryo viloyati hududlari o'rtasida ish haqi darajasida sezilarli farqlar mavjudligini ko'rsatdi hamda mintaqadagi sanoat va xizmatlar sohasi rivojlanishi, shuningdek, aholi jon boshiga investitsiyalar hajmi hududiy daromadlar tabaqalanishiga ta'sir ko'rsatishi aniqlandi. Shuningdek, mehnatga layoqatli aholi yoshi va urbanizatsiya darajasining ish haqi ko'rsatkichlariga qanday ta'sir qilishi tahlil etildi. Tadqiqot natijalari hududiy ijtimoiy-iqtisodiy siyosatni shakllantirish va daromadlar tafovutlarini kamaytirishga qaratilgan chora-tadbirlarni ishlab chiqishda muhim ilmiy hamda amaliy ahamiyatga ega ekanligi bilan tavsiflanadi.

Kalit so'zlar: aholi daromadlari, hududiy tabaqalanish, Fixed effects, Random effects, Hausman testi.

Аннотация: В исследовании проанализирована территориальная стратификация доходов населения в регионах Сурхандарьинской области с использованием эконометрических методов на основе показателей заработной платы. Для изучения пространственно-временных изменений уровня заработной платы в районах и городах региона использованы панельные данные за 2017-2024 годы. Также проведена оценка экономических и трудовых факторов, влияющих на заработную плату, в частности, объема промышленного производства, объема услуг, инвестиций на душу населения, уровня урбанизации и возраста рабочей силы, с использованием моделей с фиксированными и случайными эффектами. В процессе выбора модели использован критерий спецификации Хаусмана, обоснована необходимость учета индивидуальных региональных особенностей. Результаты показали значительные различия в уровнях заработной платы между регионами Сурхандарьинской области, установлено, что промышленный и сервисный секторы, а также инвестиции на душу населения региона влияют на региональную стратификацию доходов. Проанализировано также влияние возраста трудоспособного населения и уровня урбанизации на уровень заработной платы. Результаты исследования подтверждают их важное научное и практическое значение в формировании региональной социально-экономической политики и разработке мер, направленных на сокращение неравенства в доходах.

Ключевые слова: доход населения, территориальная стратификация, фиксированные эффекты, случайные эффекты, тест Хаусмана.

INTRODUCTION

In many countries, there are regional disparities in economic activity and living standards, which are mainly expressed in income, education or health indicators. Scholars believe that high inequality reflects a lack of opportunities for socio-economic mobility, which can hinder the prospects for reducing poverty and increasing overall well-being over time. In countries with high levels of income or consumption inequality, higher growth rates have relatively little effect on reducing poverty [4]. Empirical assessments have shown that reducing inequality can have a significant impact on reducing poverty [3][8].

Regional income inequalities are not considered negative in themselves, as they can stimulate competition, foster innovation and accelerate socio-economic development [10]. Therefore, regional income inequalities are gaining importance as a focus of scientific research and political attention worldwide [14]. According to World Bank reports, the level of income inequality (Gini index) in Uzbekistan was 44.08 in 1998, and by 2024 this figure had decreased to 34.56¹. This shows a significant reduction in income inequality over this period. In economies with high economic inequality, this figure is estimated to be above 40, in economies with medium inequality it is between 30 and 40, and in economies with low inequality it is estimated to be below 30 [13].

According to this classification, Uzbekistan belonged to the high inequality group in 1998, but by 2024 it had moved to the group of economies with a medium level of inequality. Thus, the analysis of the above statistical data shows that the differences in income between regions and within regions in our country have been decreasing in recent years. However, since the manifestation of this process across regions is not uniform, this study provides a comprehensive analysis of the territorial characteristics of income inequality using the example of Surkhandarya region.

REVIEW OF LITERATURE ON THE SUBJECT

Within the framework of this study, the scientific works of foreign and local scientists on the topic are systematically analyzed. Also, through the analysis of the literature, their theoretical and practical approaches, empirical results, and the methodological approaches they used are summarized and their advantages or disadvantages are considered. On this basis, the scientific gaps in the research are identified and appropriate solutions are made. At the same time, the methods, data sources, and factor analysis used in the study are highlighted and justified in accordance with the purpose of the study through the econometric modeling approach. The methods selected in the study serve the reliability and accuracy of the empirical results.

The issue of model selection is of important methodological importance in empirical studies based on panel data. Economists Manuel Frondel and Colin James Vance, in their study "Fixed, random, or something in between? A variant of Hausman's specification test for panel data estimators," proposed an alternative to the Hausman test and scientifically substantiated the existence of intermediate estimation approaches between Fixed effects and Random effects models [5].

Another economist, Hausman (1978), proposed a specification test to check $E(u/X) = 0$, which serves to compare Fixed effects and Random effects models and assess the reliability of parameters [7].

Badi H. Baltagi (2005) in his book *Econometric Analysis of Panel Data*, studied Fixed effects (FE) and Random effects (RE) models in detail and analyzed their analysis in estimating model parameters. He emphasizes that by combining panel data, it is possible to effectively estimate parameters while controlling for individual heterogeneity [1].

James Stock and Mark Watson (4th edition, Global edition, 2020) in their *Introduction to Econometrics* define a fixed effects model as "a model that is widely used in panel data to control for variables that vary across subjects (e.g., region, district) but are left unchanged over time" [8].

Guggenberger, P. The impact of a Hausman pretest on the size of a hypothesis test: The panel data case study shows that the estimated marginal size of the two-stage Hausman test can be distorted because it depends on the time-varying effect of the regressors and the individual-specific effect variance. Therefore, it is recommended to use the Hausman-old test with caution when choosing between fixed and random effects models [6].

Hausman Specification Tests in Econometrics recommends using it to determine which of the fixed effects and random effects models to choose. According to it, the test checks whether the individual effects in the panel model are present or not in the regressors [7].

In the study of Schmidheiny, K. and Basel, U. (2011), the results of the Fixed effects and Random effects models were analyzed using the Stata program [12].

¹ The World Bank <https://pip.worldbank.org/poverty-calculator>

At the same time, many scientists have used regression models based on panel data (FE/RE) to take into account regional differences in regional wages and incomes.

RESEARCH METHODOLOGY

In this study, FE/RE models are used. Panel models (FE/RE) take into account regional differences and time-varying situations. In this way, the methodological foundations of existing studies are preserved and their practical value is increased. At the same time, the basic mathematical structure of the models is expressed using the following formulas.

The general regression model for panel data is expressed as follows [2]:

$$Y_{it} = \alpha + \beta X_{it} + \mu_i + \varepsilon_{it} \quad (1)$$

Here: Y - dependent variable;

B - vector of estimated parameters;

X - vector of explanatory variables;

μ_i - unobserved regional-specific effect;

ε_{it} - idiosyncratic error term; $i=1, 2, \dots, N$ - cross-sectional units (regions);

$t=1, 2, \dots, T$ - time periods.

The fixed effects model assumes that unobserved individual effects may be correlated with the regressors, necessitating the inclusion of a specific intercept for each cross-sectional unit [8].

$$Y_{it} = \beta_1 X_{1,it} + \beta_2 X_{2,it} + \dots + \beta_k X_{k,it} + \alpha_i + u_{it} \quad (2)$$

Here:

Y - dependent variable;

$X_1, \dots, X_k$ - vector of explanatory variables;

$\beta_1, \dots, \beta_k$ - vector of estimated parameters;

α_i - entity-specific fixed effects;

u - idiosyncratic error term;

i, t - indices for regions and time periods.

The random effects model assumes that individual-specific effects are stochastic and independent of the explanatory variables [10].

$$\text{Cov}(\mu_i, X_{it}) = 0$$

The model is specified as follows:

$$Y_{it} = \alpha + \beta X_{it} + u_{it}, \text{ here, } u_{it} = \mu_i + \varepsilon_{it} \quad (3)$$

Here:

Y - dependent variable;

α - intercept (constant term);

B - vector of slope coefficients;

X - vector of explanatory variables;

u - composite error term;

μ_i - individual random effect;

ε_{it} - idiosyncratic error term;

i, t - indices for entities and time periods.

The Hausman test is employed to choose between the fixed effects and random effects models. This test examines whether the individual effects are correlated with the regressors and is based on two fundamental hypotheses.

The null hypothesis of the Hausman test is formulated as follows:

$$H_0: \text{Cov}(\mu_i, X_{it}) = 0 \quad (4)$$

This implies that the Random Effects model is correctly specified and efficient.

The alternative hypothesis is stated as follows:

$$H_1: \text{Cov}(\mu_i, X_{it}) \neq 0 \quad (5)$$

This indicates that the individual effects are correlated with the regressors, in which case the Fixed Effects model is more appropriate [7].

ANALYSIS AND RESULTS

In this section of the study, the factors affecting the dynamics of wages in Surkhandarya region are modeled using Fixed effects and Random effects models based on formulas (2) and (3). We also determine which model is suitable for the study using the Hausman test (formulas 4-5).

The use of the average monthly wage in logarithmic form as a dependent variable in this model is based on several factors. One of the main goals of doing this process is to reduce the impact of some large values that arise as a result of the uneven distribution of wage indicators across regions and to reduce the differences between values.

Figure 1 shows that the average wage level had different trends across regions in 2017-2024. However, if we analyze the general situation, the average wage level in the regions has a mainly increasing trend. In 2019-2020, the lines converged - we can say that this may have occurred as a result of the influence of macroeconomic factors (for example, the pandemic). In 2021, there is a decrease in the trend in some regions for a certain period, but it can be seen that the overall trend has not changed.

In 2022-2024, there was a sharp increase in wages, which in turn may indicate a widening of differences between regions. Some regions (i.e., lines representing high growth) are growing faster than others - this, in turn, indicates that this situation can be interpreted as a factor of regional stratification between regions (Figure 1).

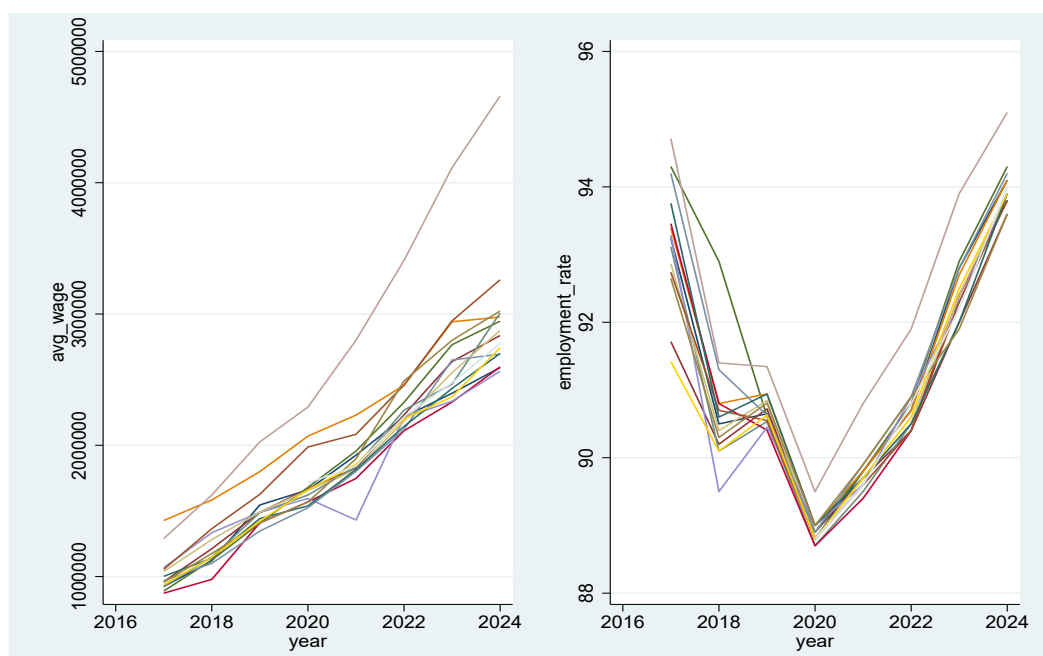


Figure 1. Dynamics of average wages and employment rates over time by region²

² Note: The graph shows the change in the average nominal wage by region over time.

Source: Calculated by the author based on data from the Surkhandarya regional statistics department. The graph was developed by the author using the Stata M/P 17.0 software.

As can be seen from the figure, if we analyze the employment rate in 2017-2018, this indicator was high and stable, approximately maintaining this situation around 92-94%. In 2018-2020, a decrease was observed and the lowest point was reached in 2020, reaching 88-89%, which can be explained by economic factors or random factors of COVID-19. In 2020-2024, growth will again slow down, and in 2024 we can see that this indicator will again reach 93-94%. It should also be noted that the graph clearly shows the existence of differences between regions, which can be explained by in some districts, the decline is stronger, but the increase is slower. Therefore, the employment rate in Surkhandarya region is sensitive to external economic influences and is subject to fluctuations depending on regional economic opportunities.

If we analyze the fixed effects model (Table 1), the results of the model are generally statistically significant ($F=583.251$, $p<0.01$). The coefficient of determination ($R^2=0.973$) indicates that the factors affecting the level of wages in the regions explain a large part of the dependent variable (Table 1).

Table 1. Estimation Results of the Fixed Effects Model³

log_avg_wage	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
employment_rate	-.027	.004	-7.13	0	-.035	-.019	***
ind_output_pc	0	0	1.54	.127	0	0	
services_pc	0	0	-2.78	.007	0	0	***
investment_pc	0	0	1.39	.168	0	0	
working_age	0	0	25.59	0	0	0	***
urbanization_rate	.691	.552	1.25	.214	-.404	1.787	
Constant	15.575	.414	37.61	0	14.753	16.397	***
Mean dependent var		14.413		SD dependent var		0.369	
R-squared		0.973		Number of obs		117	
F-test		583.251		Prob > F		0.000	
Akaike crit. (AIC)		-325.456		Bayesian crit. (BIC)		-306.120	
*** p<.01, ** p<.05, * p<.1							

We can see that the employment rate is inversely related to wages and is statistically significant ($\beta = -0.027$, $p<0.01$). This indicates that an increase in the employment rate can lead to an increase in labor supply, but at the same time act as a limiting factor for wage growth. In addition, a 1% increase in the employment rate leads to a decrease in the average wage by approximately 2.7%. Although industrial output per capita is positive, according to the model results, this variable is not statistically significant ($p<0.127$). In this case, we can say that the direct effect of industrial production on the wage level is limited, indicating that its effect may be manifested indirectly due to other factors.

Services per capita have an inverse relationship with wages, but we can see a statistically significant result based on the model data ($p=0.007$, $p<0.01$). This may explain the presence of employment types characterized by relatively low wages in the service sector in some regions.

Although investments in fixed capital per capita have a positive effect on the wage level, they have a statistically insignificant effect ($p=0.168$). This is indicated by the fact that the impact of investments on the wage level occurs with a time lag or the effect of investments may be manifested over a longer period.

The number of working-age population (30-59) has a positive effect on the wage level, which is also statistically significant ($p<0.01$). Despite the very small value of the coefficient, its high statistical significance indicates that the increase in the working-age population has a positive effect on the wage level by increasing the activity of the labor market and economic efficiency in the regions of the region.

If we analyze the level of urbanization, although this level has a positive character (direction), it is not statistically significant ($p=0.214$). We can describe this situation as the independent effect of the level of urbanization on the wage level is not significant when other factors are controlled.

In general, the results of our analysis show that labor market indicators and demographic factors play the main role in the formation of wage levels in the regions, while production and investment factors have a relatively indirect effect.

Analyzing the data in Table 2, the Random effects model has a high level of statistical significance in terms of the overall result ($\text{Prob}>\chi^2=0.000$, Overall $R^2=0.974$), that is, the selected factors almost completely

³ Author's calculations based on Stata MP 17.0.

explained the “average wage (log)”. A large part of the changes over time within the region were explained by the model (R^2 within =0.972) (Table 2).

Table 2. Estimation Results of the Random Effects Model⁴

log_avg_wage	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
employment_rate	-.028	.004	-7.91	0	-.035	-.021	***
ind_output_pc	0	0	1.69	.091	0	0	*
services_pc	0	0	-2.91	.004	0	0	***
investment_pc	0	0	0.47	.641	0	0	
working_age	0	0	39.34	0	0	0	***
urbanization_rate	.039	.062	0.63	.529	-.082	.16	
Constant	15.917	.322	49.43	0	15.286	16.549	***
Mean dependent var		14.413	SD dependent var		0.369		
Overall r-squared		0.974	Number of obs		117		
Chi-square		4118.276	Prob > chi2		0.000		
R-squared within		0.972	R-squared between		0.988		
*** p<.01, ** p<.05, * p<.1							

Differences between regions are also almost completely explained (R^2 between=0.988). If we analyze the influencing factors, we can see that the employment rate has an inverse effect on wages and is statistically significant at the 1% p value. This means that an increase in labor supply reduces the wage level. The impact of industrial production and the level of wages in the service sector is statistically significant, indicating that real sector activity increases the wage level. The working-age population is the strongest positive influencing factor, indicating that the wage level in regions with high labor resource potential is also higher than in other regions. So, if we add here, as the level of potential of personnel in the labor market increases, the wage level can also increase significantly. The volume of investment and the level of urbanization are not directly statistically significant in this model, but their effect can have an indirect effect. In conclusion, we can emphasize that the random effects model accurately reflects the factors affecting wage dynamics both over time and across regions and fully meets the research objectives.

Using the Hausman (1978) specification test, it was assessed which of the Fixed effects and Random effects models was most suitable for the study requirements [6] (Table 3).

Table 3. Hausman Test Results⁵
Hausman (1978) specification test

	Coef.
Chi-square test value	1.704
P-value	.426

Analyzing the test results, it can be seen from the values of Chi-square=1.704 P-value=0.426 that since P-value>0.05, the H0 hypothesis cannot be rejected, that is, the Random effects model was found to be suitable for the research requirements. At the same time, the Random effects model was implemented in the evaluation of the model parameters in the panel data analysis, which allows taking into account the random effect of individual (regional) differences.

We can say that during 2017-2024, the average wage in Surkhandarya region had a stable growth rate, while the employment rate decreased in 2020 due to some economic factors, in particular, under the influence of the COVID-19 pandemic factor, and then slowly recovered. There are differences between the wage and employment rate across districts, and in regions with high growth rates, regional stratification is observed. The panel data analysis was conducted based on the Fixed effects and Random effects models, and the

⁴ Author's calculations based on Stata MP 17.0.

⁵ Author's calculations based on Stata MP 17.0.

employment rate showed an inverse relationship with wages, while the working-age population showed a positive relationship. The industrial production and services sector have a positive effect on wages, while the level of investment and urbanization are not directly statistically significant. The Hausman test confirmed the Random effects model according to the results of the analysis, which, in turn, allows us to take into account the random effect of regional differences. It also clearly explains the factors affecting the average wage in terms of time and region, and also provides results consistent with the research results.

CONCLUSIONS AND SUGGESTIONS

The study analyzed the factors affecting the average wage level in the regions of Surkhandarya region for 2017-2024 based on panel data. Thus, if we draw a conclusion based on the above panel data, the model results show that the wage level is unevenly distributed across regions, and that the labor market and demographic factors play a decisive role in its formation. Empirical analysis showed that the employment rate has an inverse effect on wages and has a statistically significant relationship, and the working-age population is one of the main factors determining wage growth. Although the industrial production and service sectors had a positive effect on the wage level, it was found that the direct effect of the level of investment and urbanization was statistically insignificant. The Hausman specification test showed that the Random effects model is suitable for the study, which, in turn, made it possible to take into account the random effect of regional differences. Based on the results of this study, the following practical recommendations are proposed:

First, since the employment rate is inversely related to wages, the main focus in the labor market should be on labor productivity rather than increasing the number of jobs. Vocational training, retraining and advanced training programs should be adjusted based on the potential of the regions and stimulate wage growth by improving the quality of the workforce.

Second, the positive impact of industrial production and the service sector on wage levels indicates the need to prioritize value-added sectors in regional development programs. This will help reduce wage disparities between regions and strengthen economic balance.

Third, the high positive impact of the working-age population on wage levels indicates the need to increase investment in human capital. And as a result, the quality of education, professional skills and the development of the healthcare system will increase the potential of labor resources in the regions, ensuring long-term sustainable wage growth.

Fourth, the fact that the impact of investment volume and urbanization level on wages is statistically insignificant means that their impact is indirect or delayed. Therefore, regional investment policy should be aimed at ensuring long-term efficiency and regional development, rather than short-term results.

In general, our research results indicate that in the formation of regional wage policy, the labor market, demographic factors and the real sector should be developed together on the basis of an integrated approach and serve as a scientific basis for regional socio-economic policy.

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