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LABOR PRODUCTIVITY IN RETAIL TRADE

ПРОДУКТИВНІСТЬ ПРАЦІ В РОЗДРІБНІЙ ТОРГІВЛІ

In the conditions of the war and the post-war Urainian economic recovery, human capital is one of the determining factors of the state's existence and ensuring its competitiveness. The loss of human capital has caused a shortage of labor resources in various sectors of the economy, which affects the possibilities of generating income and, as a result, financial results of economic entities. One of the largest components of the Ukrainian economy, which fills the budgets of all levels and creates jobs, is retail trade, which accounts for a significant share of employees among all types of economic activity. The dependence of the revenue amount from the sale of products (goods, services) on the amount of use of economic resources, including labor resources, is widely known. In view of the need for post-war reconstruction against the background of a shortage of labor resources, the aim was set to verify the truth of the principles of the relationship between the scope of activities and the amount of resources used, formulated back in the days of neoclassical economics. Verification of the truth of the formulated

В умовах воєнного стану та повоєнного відновлення економіки України саме людський капітал є одним із визначальних чинників існування держави та забезпечення її конкурентоспроможності. Втрати людського капіталу обумовлюють дефіцит трудових ресурсів у різних галузях економіки, що впливає на можливості формування обсягів доходів та, як наслідок, фінансових результатів у суб'єктів господарювання. Однією з найбільших складових української економіки, що наповнює бюджети усіх рівнів та створює робочі місця, є роздрібна торгівля, на яку припадає помітна частка найманих працівників серед усіх видів економічної діяльності. Широковідома залежність обсягу виручки від реалізації продукції (товарів, послуг), обсягів використання економічних ресурсів, у тому числі ресурсу праці. З огляду на потребу повоєнної відбудови на тлі дефіциту трудових ресурсів поставлено мету перевірити істинність сформульованих ще за часів неокласичної економіки принципів взаємозв'язку обсягів діяльності та величини задіяних ресурсів. Перевірку істинності

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hypotheses was carried out on the basis of the use of correlation methods and regression analysis. According to the calculation results, it was not possible to fully illustrate the direct proportional dependence of revenue on the average number of employees for the formed sample of retail trade enterprises. There is also a lack of direct relationship between revenue and labor productivity for both larger and smaller retail enterprises. Further research will be aimed at substantiating other samples of Ukrainian retail trade enterprises and finding interdependencies between their scope of activity and the amount of economic resources involved in the conditions of war and post-war recovery.

Keywords: human capital, labor resources, labor productivity, scale effect, retail trade enterprises, correlation analysis, regression analysis.

сформульованих гіпотез проведено на основі використання методів кореляційно-регресійного аналізу. За результатами проведених обчислень повною мірою не вдалося проілюструвати прямопропорційну залежність виручки від середньої кількості працівників для сформованої вибірки підприємств роздрібної торгівлі (ПРТ). Також спостерігається відсутність прямопропорційного зв'язку між виручкою та продуктивністю праці як для більших ПРТ, так і для менших. Подальші дослідження будуть спрямовані на обґрунтування інших вибірок ПРТ України і пошук взаємозалежностей між їх обсягами діяльності та величиною задіяних економічних ресурсів в умовах війни і повоєнного відновлення.

Ключові слова: людський капітал, трудові ресурси, продуктивність праці, ефект масштабу, підприємства роздрібної торгівлі, кореляційний аналіз, регресійний аналіз.

Introduction

On February 24, 2022, Russia launched a full-scale invasion of the territory of Ukraine, as a result of which Ukraine suffered significant losses of human capital, which should be divided into two groups: direct and indirect. Direct losses include forced migration, forced deportation of the population of Ukraine to Russia, the killing of civilians, and the death of military personnel. Indirect losses should include the lack of business income by entrepreneurs and wages by employees and, most importantly, the inability to fully use the intellectual and creative potential of human capital due to military operations on the territory of Ukraine. These losses cause a shortage of labor resources in various sectors of the economy, which affects the possibilities of generating income and, as a result, financial results of economic entities.

One of the largest components of the Ukrainian economy, which fills the budgets of all levels and creates jobs, is retail trade. And in wartime, this area of business remains one of the key ones, providing civilians and military with food, medicine, means of communication and other vital goods. According to official data of the State Statistics Service of Ukraine (State Statistics Service of Ukraine, 2024), the number of employees in business entities of economic activity type G "Wholesale and retail trade; repair of motor vehicles and motorcycles" in 2022 amounted to 1 309 998 people (21.5% of the total number of employees in all types of economic activity), including the number of employees in trade enterprises there are 962 354 people.

Taking into account the significant economic and social importance of retail trade, we consider it expedient to use statistical tools to analyze the dependence of the activity of retail trade enterprises on changes in the number

of employees under martial law. The research is based on two hypotheses. Hypothesis 1 is about a larger volume of the enterprise's operational activity, characterized by a larger volume of sales of products (goods, services) for a certain short-term unit of time, implies an increase in the use of the economic resource of labor and capital, if there is no increase in the intensity of labor, the development of technologies and innovations in business processes that make it possible to reduce the need for resources. Hypothesis 2 deals with an increase in the volume of products sales (goods, services) of the enterprise for a certain short-term unit of time increases the effect of scale and, as a result, increases the return (efficiency) of the economic resources used, including labor and capital resources.

The given hypotheses, if considered under other equal conditions (ceteris paribus), intuitively do not cause objections and are fully consistent with the general principles of neoclassical economic theory, whose representatives include such foreign scientists as: Alfred Marshall (Marshall, 1997), Vilfredo Pareto (Pareto's, 2014), John Clark (Clark, 1925), Irving Fisher (Fisher, 1913), Jacob Viner (Viner, 1940), Frederick M. Scherer, David Ross (Scherer & Ross, 1990) and others.

The neoclassical concept is distinguished by its analytical approach, in which mathematical methods play an important role. Speaking about the dependence of the volumes of activity and the amount of costs incurred/resources used, microeconomic analysis involves, among other things, the use of correlation-regression analysis methods in order to build a paired (study of the relationship between resource costs and the volume of activity) or multiple (taking into account such variables, such as the degree of capacity utilization, differences in the service life of elements of fixed capital (in technologies), prices for production factors, the number of product names, the total volume of activity, etc.) regression dependencies (Azmuk & Shcherbatyuk, 2014).

The theoretical and methodological foundation of the research is also formed on the basis of resource concepts, which assume that the competitive advantage in the market is not products or strategic market segments, but resources that form the strategic competencies of enterprises of various types of economic activity.

Thus, A. Loyshyn (Loyshyn, 2021) in his research conducted an analysis of economic theory and the theory of strategic management regarding the presence of theoretical provisions on the transformation of the content of the economic category "resources" and resource concepts for understanding their scientific content and prerequisites for development for the development of a modern concept of resource provision security and defense sector of Ukraine. Features of resource provision of strategic development based on an innovative approach in tourism in modern conditions are highlighted in the article by N. I. Hladynets (Hladynets, 2018). The problem of managing the resource potential of transport enterprises is disclosed in the work (Borysyuk & Simkova, 2020). There are numerous scientific studies devoted to the effective use of

resources by agricultural enterprises. In particular, in the works (Bagan, 2021; Smirnova, Smirnov & Yuzik, 2020), thorough studies of the peculiarities of the formation and use of the resource potential of agricultural enterprises were conducted. The article Adamenko, Vysochyn, Sytnyk, Olesenko & Blazhenko (2023) talks about the impact of resource provision on the forecast volume of retail turnover of Ukrainian trade enterprises in conditions of uncertainty and global fluctuations.

One of the key elements of the resource potential of enterprises is labor resources; the study of the state of their use in wartime conditions is of great importance. Thus, a thorough assessment of the level of loss of labor resources in Ukraine due to forced migration was carried out in the work of Y. Chirva and A. Zaverbny (Chirva & Zaverbny, 2022). Seryogina (Seryogina, 2022) also investigated the impact of the war on productive employment in Ukraine. O. S. Zhuk and T. V. Pashkuda (Zhuk & Pashkuda, 2022) conducted an analysis of the main approaches to improving labor efficiency management at the enterprise in wartime conditions. At the same time, systematic studies of the state of use of labor resources by enterprises in the trade sphere of Ukraine in wartime conditions were not conducted.

The aim of the article is to identify arguments in favor of confirming the given hypotheses on the basis of empirical data for a group of the same type of enterprises of a particular type of economic activity under the conditions of shocks in the economy caused by the war. For Ukraine, the confirmation of both hypotheses is fundamentally important in view of the need for post-war reconstruction against the background of a significant shortage of economic resources (primarily, labor resources).

The object of the research is the operational activity of enterprises belonging to class 47.11 "Retail trade in non-specialized stores mainly of food, beverages and tobacco products" according to the economic activity classifier (National Classifier DK 009:2010, 2010), under martial law.

Consideration of enterprises whose main activity belongs to only one class of economic activity is related to the need to observe the condition of homogeneity to test the given hypotheses, since data for different classes are unsuitable for this.

The choice of class 47.11 is due to the fact that in 2022 it was one of the largest both in terms of activity and in terms of resources used among enterprises not only in section G "Wholesale and retail trade; repair of motor vehicles and motorcycles", but also in general in the sphere of non-financial business[*] economy of Ukraine. As evidenced by the data in the *Table 1*, class 47.11 has a second weighted average rank, which was calculated on the basis of four key indicators, taking into account their importance in the current situation, established by an expert.

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[*] Terminology is subject to the Regulation (EU) 2020/1197 of 30.07.2020 on European enterprise statistics and non-financial business economy (Commission Implementing Regulation (EU), 2020). It unites enterprises with the main type of economic activity such as
B+C+D+E+F+G+H+I+J+L+M+N+95 according to KVED-2010 (National Classification SC 009:2010, 2010).

The rank of class 46.90 "Non-specialized wholesale trade" turned out to be the highest, but this class includes so many different enterprises (from classic wholesale enterprises that have a powerful warehouse base and participate in settlements to agent enterprises that work for a commission fee) that based on their data, testing any hypotheses is problematic (the homogeneity condition for key indicators is not met). This determined the choice for the study of class 47.11, and not the entire general population, but only the largest enterprises of this class that have a network of retail facilities (stores).

Table 1

The largest classes among types of economic activity of enterprises of the non-financial business economy in Ukraine for 2022

Class (according to KVED-2010)		Number of operating enterprises, units	Volume of sold products*, billion UAH	The number of employees, thousand persons	Total value of assets, billion UAH	Rank**
code	Title					
41.20	Construction of residential and non-residential buildings	10262	116,1	99,9	351,1	4
46.73	Wholesale of wood, building materials and sanitary-technical equipment	5126	100,4	34,7	79,3	8
46.90	Non-specialized wholesale trade	15203	551,5	105,8	596,9	1
47.11	Retail trade in non-specialized stores mainly of food, beverages and tobacco products	3116	451,1	206,2	174,2	2
49.41	Freight road transport	5664	117,9	79,7	139,6	5
52.29	Other auxiliary activities in the field of transport	3704	115,6	58,1	119,7	6
62.01	Computer programming	3621	124,0	27,5	49,6	7
68.20	Leasing and operation of own or leased real estate	23276	110,7	107,2	699,4	3
69.10	Activities in the field of law	3843	14,5	13,6	22,9	11
71.12	Activities in the field of engineering, geology and geodesy, provision of technical consulting services in these areas	3178	20,2	30,1	80,5	9
80.10	Activities of private security services	3136	17,8	51,2	12,4	10

* According to the institutional approach.
** Weighted average taking into account the weight (significance) of indicators: number of operating enterprises – 1; volume of sold products – 3; number of employees – 4 (the most important and scarce resource in wartime); total value of assets – 2.

Source: author's development based on data (State Statistics Service of Ukraine, 2024).

Despite the difficult situation in the country, the State Statistics Service of Ukraine and projects supporting analytical systems and open data portals, in particular (YouControl, 2024) and (Opendatabot, 2024), continue to publish information about the activities of domestic enterprises, providing an opportunity to create a database of empirical data for economic research. In this study, the data on the activities of the largest 135 retail trade enterprises (RTE) of class 47.11, in which the net income from the sale of products (goods, services) in 2022 exceeded UAH 100 million, served as the information base. The choice of this limit is connected with the need to form such a sample, for which the condition of homogeneity was ensured for the main indicators of the return of economic resources – in the case of the inclusion of enterprises smaller in terms of activity, the condition of general homogeneity of the sample was not fulfilled.

The *Table 2* is characterized the main parameters of the formed sample of enterprises.

Table 2

The main parameters of the retail trade enterprise, belonging to class 47.11 according to KVED-2010, in Ukraine for 2022

Indicator	All enterprises of class 47.11	Enterprise samples of class 47.11	Sample share, %
Number of operating enterprises, units	3 116	135	4.3
of them: large	22	22	100.0
Medium	163	113	69.3
Volume of sold products, million hryvnias	451 116	422 792*	93.7
Number of employees, persons	206 241	178 730**	86.7
Total value of assets***, million UAH	174 171	156 579	89.9
of them, negotiable	96 856	82 323	85.0

* Net income from product sales according to the financial results report.
** Aggregate average number of employees according to the data of the preamble (initial information) of the balance sheets of enterprises concluded in accordance with NP(S)BO 1 (NP(S)BO 1, 2013)
*** Here, in the following tables and text for indicators that are items of the balance sheet (report on the financial condition) of the enterprise, the values at the end of the year are given.

Source: Author's development based on data (State Statistics Service of Ukraine, 2024; YouControl, 2024; Opendatabot, 2024).

Although the sample covers only 4.3% of the total number of class enterprises, it accounts for the main share of the volume of products sold and resources used, as evidenced by the data in the *Table 2*.

In the first section of the article, methodological caveats are defined and the composition of the sample of researched retail enterprises is substantiated. In the second, a correlation analysis was conducted between sales revenue for a sample of retail trade enterprises belonging to class 47.11 and the amount of economic resources involved. The third section is devoted to conducting a regression analysis of the relationship between the average number of employees and revenue for a sample of the studied enterprises. In the last, fourth chapter, labor productivity is analyzed.

1. Methodological caveats and sample composition

The data of the specified sample of enterprises do not allow to fully verifying the truth of the formulated hypotheses, all other things being equal (ceteris paribus), as required by economic theory, but they can illustrate a statistical relationship that should not contradict essential laws.

The identification of a statistical relationship between the indicators for the formed sample of enterprises does not yet provide sufficient grounds for ascertaining the existence of an economic regularity, since, firstly, the sample unites a large number of various enterprises, each of which, although it has a common main type of economic activity, functions in specific (sometimes unique) conditions, has a special system of factors influencing internal and external environments; secondly, in the data for 2022, the numerical values of economic indicators reflect at least 3 different stages associated with the deployment of large-scale military operations on the territory of Ukraine and characterized by structural shifts within the sample of enterprises, as well as institutional changes in the economy and society in general:

• January – February (until February 24) – the stage before the start of a large-scale invasion;

• from February 24 to (approximately) the beginning of April – the shock stage (a large part of the enterprises did not function);

• since April – functioning under martial law.

The enterprises included in the sample can be divided into 4 groups depending on the amount of net income (revenue) from the sale of goods[*] for 2022:

the largest – with revenue exceeding UAH 2 billion;

larger medium ones – with revenue from UAH 500 million to UAH 2 billion;

smaller average ones – with revenue from UAH 200 million to UAH 500 million;

the smallest – with revenue not exceeding UAH 200 million.

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[*] The titles of indicators that take into account the specifics of the main activity of trade enterprises are used hereby.

The composition of the sample in terms of the specified groups is illustrated in the *Table 3*.

Table 3

Composition of retail trade enterprise samples, belonging to class 47.11 according to KVED-2010, in Ukraine for 2022

Indicators	Group of enterprises				Total
	largest	higher average	smaller average	smallest	
Number of enterprises, units.	20	45	32	38	135
Revenue, UAH million	365 500	41 147	10 441	5 705	422 792
Average number of employees, persons	142 062	23 970	8 472	4 226	178 730
Total assets, UAH million of which:	131 859	15 455	4 091	5 174	156 579
current	60 128	13 743	3 514	4 938	82 323
irrevocable	71 731	1 712	577	235	74 255

Source: author's development based on data (YouControl, 2024; Opendatabot, 2024).

As evidenced by the data in the *Table 3*, the sample is dominated by the group of the largest RTEs – it accounts for the main share of revenue and resources used. The share of this group of enterprises in the total revenue of the sample (*Figure 1*) is especially significant – 86.4%, and even more in the amount of non-current assets – 96.6%.
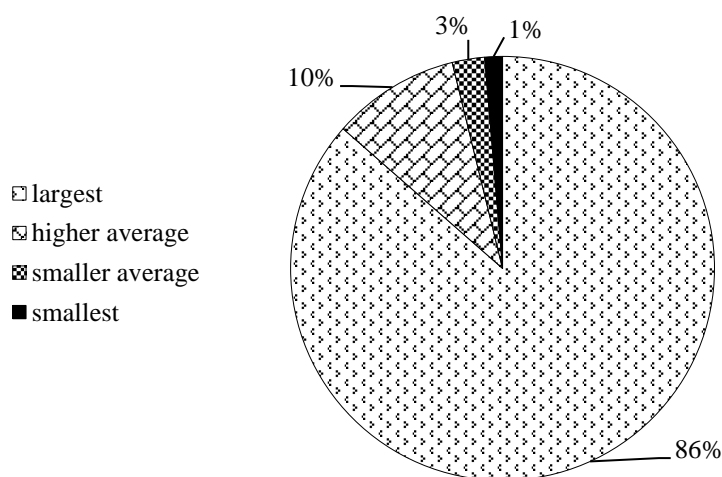

Figure 1. The structure of revenue in a sample of retail trade enterprises belonging to class 47.11 according to KVED-2010 in Ukraine in 2022.

Source: Author's development based on data (YouControl, 2024).

The share of the group of the largest enterprises in the sample for other key indicators is: number of enterprises – 14.8%; average number of employees – 79.5%; total assets – 84.2%; current assets – 73.0%.

Thus, a feature of the formed sample is the presence in its composition of two leading enterprises, LLC "ATB-MARKET" and LLC "SILPO-FOOD", which account for more than half of the entire revenue of the sample (*Table 4*).

Table 4

Leading companies in the sample of retailers, belonging to class 47.11 according to the Classifier of Types of Economic Activities 2010 in Ukraine in 2022

Indicators	ATB-MARKET	SILPO-FOOD	Leading companies, total	Share of leading enterprises, %	
				in a group of large enterprises	in the sample in general
Revenue, UAH million	148 333	69 991	218 323	59.7	51.6
Average number of employees, persons	48 872	36 496	85 368	60.1	47.8
Total assets, UAH million	41 086	33 934	75 021	56.9	47.9
of which: current	17 979	11 454	29 433	49.0	35.8
irrevocable	23 107	22 481	45 588	63.6	61.4

Source: Author's development based on data (YouControl, 2024; Opendatabot, 2024).

This dominance of the group of the largest and leading enterprises in the sample is a factor that increases its heterogeneity. However, it does not lead to the recognition of the overall heterogeneity of the sample and, as a result, the impossibility of using the sample data to identify statistical patterns.

2. Correlation analysis

The values of the pairwise correlation coefficients obtained using the Excel Data Analysis – Correlation procedure and contained in the correlation matrix (*Table 5*) indicate a very strong direct statistical relationship between the key performance indicators of the sample companies, except for equity.

Given the sufficiently large sample size, it makes no sense to test the statistical significance of the correlation coefficients presented in *Table 5* using Student's t-test (or any other alternative method). It is only necessary to pay attention to the debatable analytical value of the pairwise correlation

coefficients for the total amount of assets with the indicators that are its components, namely the amounts of: non-current assets, current assets and current liabilities.

Table 5

Correlation matrix for a sample of retailers,
belonging to class 47.11 according to KVED – 2010 in Ukraine for 2022

Indicators	Revenue	ANE	NCA	CA	A	EC	CL
Revenue	1						
ANE	0.9753	1					
NCA	0.9314	0.9768	1				
CA	0.9641	0.9615	0.9341	1			
A	0.9600	0.9864	0.9891	0.9764	1		
EC	–0.0478	–0.2014	–0.3451	–0.1639	–0.2761	1	
CL	0.9355	0.9783	0.9814	0.9660	0.9910	–0.3544	1

Conventional notation: ANE – the average number of employees; NCA – non-current assets; CA – current assets; A – assets, total; EC – equity capital; CL – current liabilities.

Source: Author's development based on data (*YouControl, 2024; Opendatabot, 2024*).

The results obtained, which indicate a strong linear statistical relationship, do not contradict hypothesis 1 – a larger volume of operating activities of the sample enterprises, characterized by a larger annual volume of sales of goods (higher revenue for the year), implies a larger volume of use of the economic resource of labor and capital. Similarly, an increase in the use of one economic resource within an annual period is accompanied by a directly proportional increase in the use of other resources.

A special situation is observed with regard to the equity capital of the sample enterprises: all values of the pairwise correlation coefficients for this indicator are negative and indicate a weak statistical relationship with revenue and other resources involved. This phenomenon requires further in-depth research.

3. Regression analysis of the relationship between the average number of employees and revenue.

Hypothesis 1 and the obtained value of the correlation coefficient of 0.9753 for the average number of employees and revenue in the sample of enterprises (*Table 5*) caused the initial choice of a simple (paired) linear regression model to describe the statistical relationship between these indicators.

The use of the Excel Data Analysis – Regression procedure made it possible to calculate the parameters of this model and check their statistical significance. At the initial stage, it was found that the free term in the equation of the straight line is not statistically significant, therefore it is removed from the model, as a result of which the following paired linear regression function is obtained:

$$Y = 2.61952\ X, \tag{1}$$

where Y – is revenue;
   X – is the average number of employees.

Although the coefficient of determination (R-square) for model (1) is 0.9506, it turned out to be unsuitable for explaining the variation of the variable Y due to the presence of heteroskedasticity of the residuals.

The verification of the statistical hypothesis about the absence of heteroscedasticity of the residuals of model (1) was carried out using the Goldfeld-Quandt test. During the implementation of the method (Kondius, 2022), 2 subsamples of the largest and smallest values of X with 51 values each were selected. Linear regression models were constructed for both subsamples and residuals were calculated. The calculated value of the Fisher statistic (1098.87), calculated as a fraction of the sum of the squared residuals for the subsample of the largest values divided by the sum of the squared residuals for the subsample of the smallest values, turned out to be significantly greater than the tabular (critical) value of the Fisher statistic (1.607) for the significance level $\alpha = 0.05$ and degrees of freedom (freedom) v_1 and v_2, which are determined by the number of values in the subsamples and the number of parameters of the linear regression model ($v_1 = v_2 = 4_9$, taking into account the removal of the free term from the equation of the line). This made it possible to reject the H_0 hypothesis about the absence of heteroscedasticity of the residuals for model (1).

If you build a paired linear regression model based on logarithmic data, trying to eliminate heteroscedasticity, the result will be a function (*Figure 2*)[*]:

$$Y^* = 0.89394\ X^* + 1.20496, \tag{2}$$

where Y^* – is the natural logarithm of revenue (ln Y);
   X^* – is the natural logarithm of the average number of employees (ln X).

If we perform the potentiation of equation (2), we will obtain a power function:

$$Y = 3.33664\ X^{0.89394}. \tag{3}$$

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[*] Both parameters of this model, the angular coefficient (slope) and the free term (shift) are statistically significant, as evidenced by the SUMMARY OUTPUT data of the Excel Data Analysis – Regression procedure. The obtained p-values (p-value) for both parameters are much smaller than the significance level $\alpha = 0.05$

In function (3), the power indicator of 0.89394 is the coefficient of elasticity of revenue to changes in the number of employees. Its value is less than one, which could indicate a low elasticity of income from the use of labor resources in case of confirmation of the adequacy of the regression model.

But functions (2) and (3) are not the final results of the regression analysis of the relationship between the average number of employees and revenue for the sample of retail trade enterprises, because they are not statistically adequate for two main reasons.
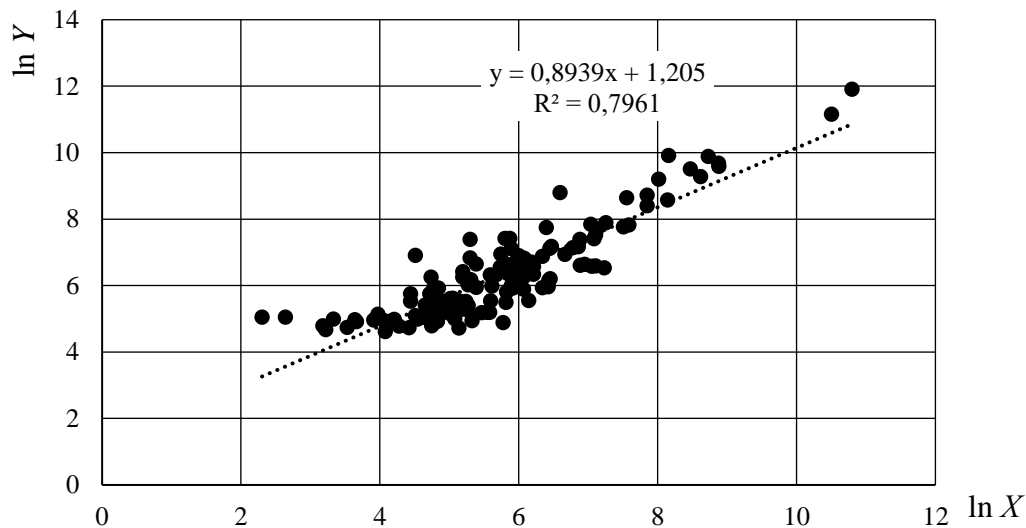
Figure 2. Statistical linear relationship between the logarithmic values of the average number of employees and revenue in a sample of retail trade enterprises belonging to class 47.11 according to KVED-2010 in Ukraine for 2022

Source: Author's development based on data (*YouControl, 2024; Opendatabot, 2024*).

First, the logarithmization of the data did not allow to completely eliminate the heteroscedasticity of the residuals. Checking the statistical hypothesis H0 about the absence of heteroscedasticity of the residuals of model (2) using the Goldfeld-Quandt method made it possible to obtain the estimated value of the Fisher statistic – 1.6655, which exceeds the critical value – 1.6154 (for the significance level $\alpha=0.05$ and degrees of freedom $v_1 = v_2 = 48$). This result gives reason to reject the H_0 hypothesis about the absence of heteroscedasticity of the residuals. Given that the detected excess is insignificant, heteroskedasticity can be ignored only if the significance level of α is reduced, or the sample data is further transformed using more complex statistical techniques, or the least squares method is abandoned for determining the regression parameters in favor of more complex methods.

Secondly, the residuals of model (2) visually demonstrate a complex serial correlation (*Figure 3*), the verification of which using the Durbin-Watson test was inconclusive (it did not allow drawing certain conclusions).
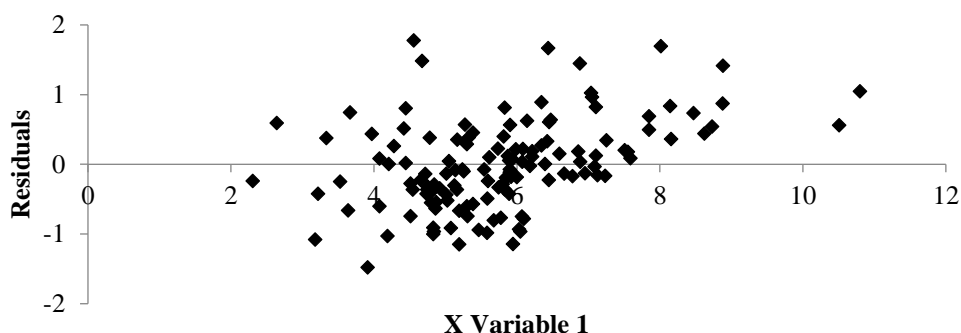
Figure 3. Residuals of the linear regression model for logarithmic values of the average number of employees and revenue in a sample of retail trade enterprises belonging to class 47.11 according to KVED-2010 in Ukraine for 2022

Source: Result of Excel Data Analysis – Regression based on data (*YouControl, 2024; Opendatabot, 2024*).

Therefore, for the final justification of the conclusion about the adequacy of regression models (2) and (3), it is necessary to apply more complex statistical methods.

A similar result (without final certainty regarding the adequacy of the regression model) was obtained for the group of the twenty largest enterprises, which account for the bulk of the revenue and number of employees of the formed sample of retail trade enterprises. Unlike the entire sample, in the paired linear regression model, based on logarithmic data, it was necessary to remove the free term, which turned out to be statistically insignificant. The model illustrates *Figure 4*.
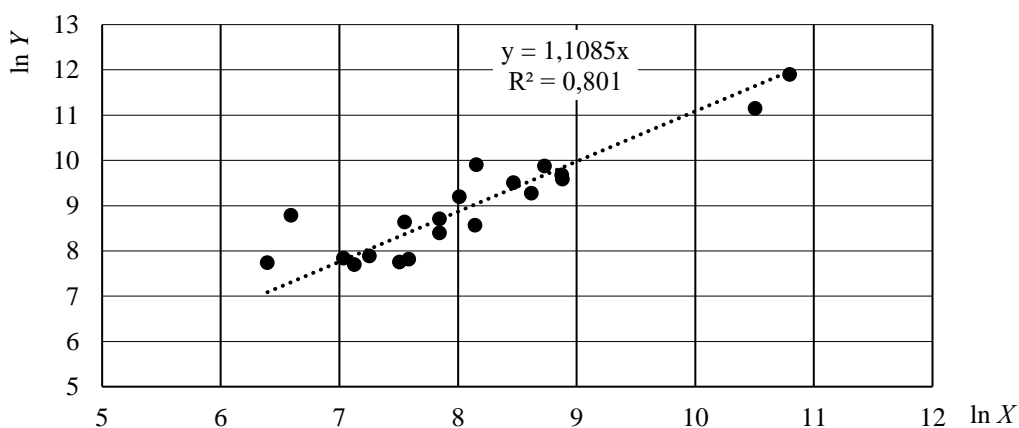

Figure 4. Statistical linear relationship between the logarithmic values of the average number of employees and revenue in the group of the largest enterprises of the formed sample for 2022[*]

Source: Author's development based on data (*YouControl, 2024; Opendatabot, 2024*)

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[*] According to the SUMMARY OUTPUT of the Excel Data Analysis – Regression procedure, the p-value (p-value) of the only parameter – the angular coefficient – of the constructed regression model is 2.47913E-25, which is practically equal to 0 and indicates its statistical significance.

Power function for the group of the largest enterprises based on the result of potentiation of the function in *Figure 4* has the form:

$$Y = X^{1.1085},$$
(4)

where Y – is revenue;

X – is the average number of employees.

In contrast to the entire set of enterprises in the sample, the revenue of the largest enterprises is elastic to changes in the average number of employees, since the exponent in function (4) is greater than one.

Also, unlike the entire sample, for the group of the largest enterprises, it is impossible to verify the statistical hypothesis H_0 about the absence of heteroscedasticity of the residuals of the model in *Figure 4* using the Goldfeld-Quandt method due to insufficient number of observations. In our opinion, the simplest approach to substantiating the conclusion about the adequacy of the model in this situation is to check the statistical hypothesis H0 about the normal distribution of residuals using the Shapiro-Wilk test, which is adapted specifically for a small number of observations (Shapiro & Wilk, 1965). The results of this test turned out to be ambiguous: the calculated value of the Shapiro-Wilk statistic – 0.892 is less than the critical value for the significance level α=0.05 – 0.905, but exceeds the critical value for the significance level α=0.02 – 0.884. In the case of using the significance level α=0.05, the statistical hypothesis H0 about the normal distribution of the residuals of the regression model in *Figure 4* contradicts the actual observation data and should be rejected, accordingly, the model itself is recognized as inadequate. And in the case of using the significance level α=0.02 – on the contrary, H_0 does not contradict the actual observational data and the model can be recognized as adequate (heteroscedasticity and serial correlation of model residuals are ignored).

The specified problems (primarily – significant heteroskedasticity of the residuals) during the construction of a paired regression model to formalize the statistical relationship between the average number of employees and revenue both in the formed sample of enterprises in general and in the group of the largest enterprises are associated with a number of reasons, including the main ones are: firstly, the presence of two leading enterprises: LLC "ATB-MARKET" and LLC "SILPO-FOOD", secondly, a certain heterogeneity between groups of enterprises in the sample.

In contrast to the largest enterprises in the sample, for the rest of the groups no significant statistical relationship between the average number of employees and revenue was found (*Figure 5*).
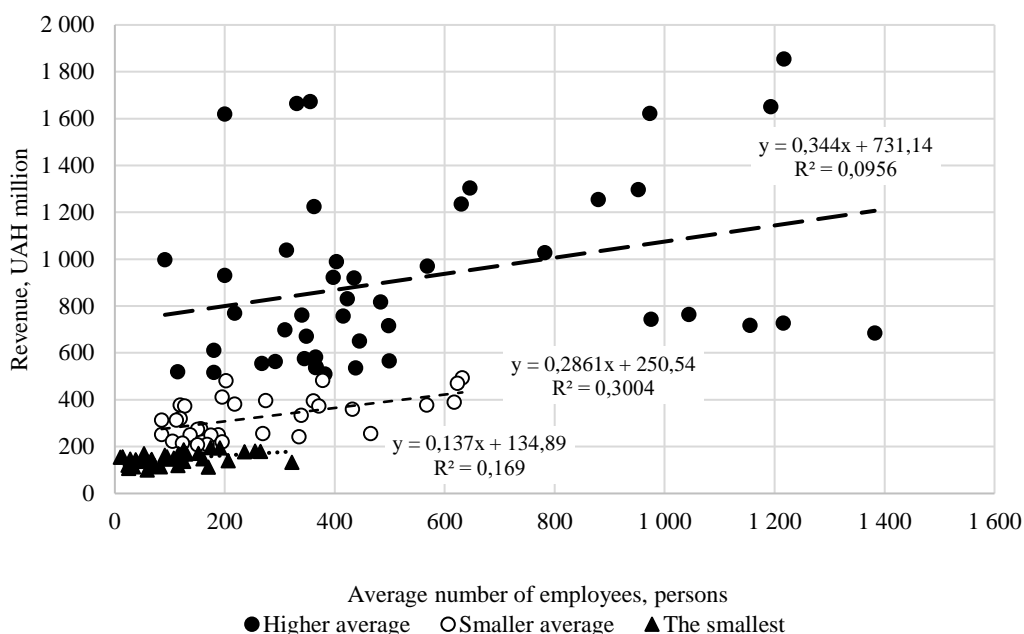
Figure 5. Statistical linear relationship between the average number of employees and revenue in the groups of medium and the smallest enterprises of the formed sample for 2022

Source: Author's development based on data (*YouControl, 2024; Opendatabot, 2024*).

Thus, it was not possible to illustrate the truth of hypothesis 1 with the help of a regression model, which would predict a directly proportional dependence of revenue on the average number of employees for the formed sample of RTE.

4. Analysis of labor productivity

The indicator of revenue per employee, which is traditionally called labor productivity[*] in domestic sources of scientific and educational literature, characterizes the return of the economic labor resource and, according to hypothesis 2, due to the scale effect, should be greater in enterprises with higher revenue.

For the formed RTE sample, the labor productivity indicator is calculated as a share of the division of net income (revenue) from the sale of goods by the average number of employees according to financial reporting data. This approach is not entirely correct and implies a certain distortion of the result, since in the calculations it is necessary to use the indicator of the average accounting number of employees in the equivalent of full employment (Instruction on statistics of the number of employees, 2005), information about which is not publicly available for individual enterprises.

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[*] This title is controversial, because some scientists understand productivity as a broader concept that characterizes continuous efforts to adapt economic activity to constantly changing conditions, the application of new theories and methods (Yeremenko, 2000, p. 23).

According to hypothesis 2, the largest average value of the labor productivity indicator is observed in the group of the largest retail trade enterprises in the sample. However, contrary to hypothesis 2, this indicator for the group of the smallest enterprises exceeds the value for both groups of medium-sized enterprises – larger medium and smaller medium – according to the data in the *Table 6*.

Table 6

Labor productivity of a retail trade enterprise sample,
belonging to class 47.11 according to KVED-2010, in Ukraine for 2022

Indicators	Group of enterprises				Total
	largest	higher average	smaller average	smallest	
Number of enterprises with labor productivity in the range of: 1) up to UAH 1000 thousand per 1 employee	–	5	9	7	21
2) 1000 – 1500	2	11	9	13	35
3) 1500 – 2000	6	11	5	5	27
4) 2000 – 2500	4	7	3	3	17
5) 2500 – 3000	2	1	4	1	8
6) 3000 – 3500	3	3	1	2	9
7) 3500 – 4000	1	1	1	2	5
8) over UAH 4000 thousand per 1 employee	2	6	–	5	13
total number of enterprises in the sample	20	45	32	38	135
Average labor productivity, UAH thousand per employee	2 813	2 395	1 628	2 485	2 300
Standard deviation, UAH thousand per 1 employee	1 800	1 935	845	2 906	2 084
Coefficient of variation, %	64.0	80.8	51.9	116.9	90.6

Source: Author's development based on data (*YouControl, 2024; Opendatabot, 2024*).

Table 6 data demonstrate the lack of dependence of the coefficient of variation of labor productivity on the scale of enterprise activity. If the highest value of the coefficient of variation is quite naturally observed in the smallest enterprises, then the lowest value – in the group of smaller medium-sized enterprises against the background of the lowest value of average labor

productivity requires an additional in-depth study of the reasons that led to such a result (it is possible that this anomaly is somehow connected connected with the functioning of enterprises in the conditions of martial law, or is a coincidence).

The distribution of labor productivity values of the sample enterprises is illustrated by a histogram constructed using the Excel Data Analysis – Histogram procedure (*Figure 6*).
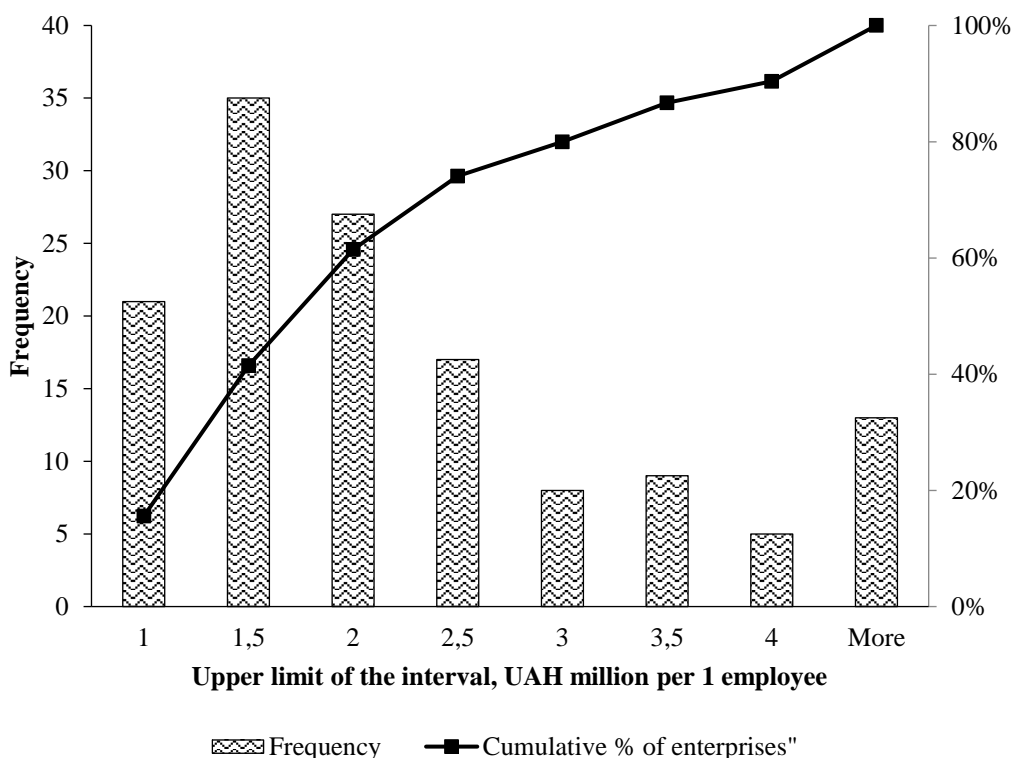

Figure 6. Histogram of labor productivity of enterprises
of the formed sample for 2022

Source: Author's development based on data (*YouControl, 2024; Opendatabot, 2024*).

Visually, the law of distribution of the random value of labor productivity in *Figure 6* is similar to lognormal. Verification of the statistical hypothesis H_0 about the lognormal distribution of labor productivity for retail enterprises belonging to class 47.11 according to KVED-2010 in Ukraine for 2022 using the criterion of consistency (agreement, agreement) Pearson's chi-square (χ^2) confirms the visual assumption: the calculated value $\chi^2 = 5.364$, which is calculated according to formula (5) (Motsny, 2018), is less than the critical value χ^2 (0.05) = 11.07[*], so the H_0 hypothesis does not contradict the observational data.

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[*] Calculated using the Excel function CHISQ.INV.RT for the significance level $\alpha=0.05$ and degrees of fluency $v = k - r - 1 = 5$, where r – is the number of unknown parameters of the distribution calculated from the sample data, or, which is the same as the number of superimposed connections, the number of indices of the empirical series connecting the empirical and theoretical frequencies (in our case – the average value and standard deviation; $r = 2$).

$$\chi^2 = \sum_{j=1}^{k} \frac{(n_j - np_j)^2}{np_j}, \tag{5}$$

where n_j – is the empirical frequency for the j-th grouping interval (variants) of a random variable (in our case, the labor productivity of retail enterprises belonging to class 47.11);

p_j – is the probability of a random variable falling into the j-th grouping interval, provided that this random variable is subject to a hypothetical (in our case – lognormal) distribution law;

n – sample volume (amount of observation data); the product np_j – is the theoretical frequency for the j-th grouping interval of a random variable;

k – is the number of grouping intervals (in our case, $k = 8$, see *Figure 6*).

It can also be asserted that the logarithmic values of labor productivity of retail trade enterprises of class 47.11, according to observation data in 2022, are subject to the normal distribution law, contrary to existing differences in trade and technological processes and labor organization at individual enterprises, which hypothetically could make any comparison and generalization for this random variable.

The discovery of the specified law of distribution can be considered an element of scientific novelty, but only on the condition that the formed sample, which includes enterprises of different groups in terms of revenue, is homogeneous in terms of labor productivity. To test the statistical hypothesis H0 about the homogeneity of the sample at the initial stage, the χ^2 Pearson homogeneity criterion was used, which involves the calculation of the calculated criterion indicator according to the following formula:

$$\chi^2 = \sum_{i=1}^{l} \sum_{j=1}^{k} \frac{(n_{ij} - \bar{n}_{ij})^2}{\bar{n}_{ij}}, \tag{6}$$

where l – is the number of subsamples (in our case – groups of enterprises depending on the amount of revenue in the formed sample; $l = 4$);

k – is the number of grouping intervals (in our case, $k = 8$, see *Figure 6*);

n_{ij} – is the actual number of elements of the i-th subsample that fell into the j-th grouping interval (these values can be seen in *Table 6*);

$\bar{n}_{ij}$ – is the mathematical expectation of the number of elements of the i-th sub-sample that fell into the j-th grouping interval, provided that the statistical hypothesis H0 about the homogeneity of the sub-samples is true.

According to the results of the verification, the calculated value $\chi^2 = 27.230$, which was calculated according to *formula (6)*, turned out to be less than the critical value $\chi^2(0.05) = 32.671^*$, therefore the H0 hypothesis about the homogeneity of labor productivity values in the formed sample of enterprises does not contradict the observed data.

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* Calculated using the Excel function CHISQ.INV.RT for the significance level $\alpha=0.05$ and degrees of fluency $v = (l-1)(k-1) = 21$.

But only one of these tests is not enough, given the dominance of the group of the largest enterprises in the sample and the results of the analysis of the statistical relationship between the number of employees and the revenue of enterprises in different groups – it is necessary to additionally perform a pairwise test of homogeneity using the more powerful Anderson homogeneity criterion. which involves the calculation of the calculated criterion indicator according to the formula:

$$a = \frac{1}{mn(m+n)}\left[m\sum_{i=1}^{m}(s_i - i)^2 + n\sum_{j=1}^{n}(r_j - j)^2\right] - \frac{4mn-1}{6(m+n)}, \qquad (7)$$

where a – is the estimated sample value of Anderson's criterion statistical indicator (statistics);

s_i and r_j – are the ordinal numbers of indicators x_i and y_j in the combined population of two groups (subsamples), sorted by growth; x_i and y_j – in our case, are indicators of labor productivity for enterprises of two groups by revenue in the formed sample of retail trade enterprises of class 47.11 (for example, groups of the largest and smallest enterprises);

i and j – serial numbers (ranks) of indicators xi and yj in their own (separate) groups ordered by growth;

m and n – are the number of observations (enterprises) in each of the two groups.

The results of calculating the indicator a according to formula (7) form a matrix (*Table 7*); the upper right half is symmetrical relative to the diagonal, so it is not shown) of values for six possible pairs of comparisons of the homogeneity of four groups of enterprises of the formed sample.

Table 7

The matrix of values of Anderson's calculated criterion statistical indicator for testing the homogeneity of data on labor productivity in groups of sample enterprises

Group	Largest	Larger average	Smaller average	Smallest
Largest	0			
Larger average	0.365	0		
Smaller average	**1.127**	**0.489**	0	
Smallest	**0.798**	0.288	0.121	0

Source: Author's development based on data from *(YouControl, 2024; (Opendatabot, 2024).*

In the *Table 7*, those calculated values of Anderson's criterion statistical indicator, which exceed the critical value for the significance level $\alpha=0.05$ – 0.461, are highlighted in bold. There are 3 out of 6 such values. Therefore, in half of the cases of pairwise comparisons, the hypothesis about the homogeneity of groups (subsamples) of enterprises within the formed

sample contradicts the observational data and should be rejected. In particular, this applies to pairwise comparisons of the following groups of enterprises:

• the largest and smallest;

• the largest and smallest averages (it is for this pair that heterogeneity is the greatest);

• higher averages and lower averages.

In view of the obtained results of a pairwise homogeneity check, for the purposes of labor productivity analysis, the formed sample needs to be divided into 2 parts: the largest and larger medium ones – the next *larger* enterprises; smaller, medium and smallest – further *smaller* enterprises.

For both of the specified parts of the sample, the statistical hypothesis H_0 about the lognormal distribution of labor productivity is confirmed using the χ^2 Pearson consistency criterion, as evidenced by the data in the *Table 8.*

Table 8

The results of testing the hypothesis about the lognormal law of the distribution of the random variable of labor productivity according to the χ^2 Pearson consistency criterion for larger and smaller enterprises of the sample

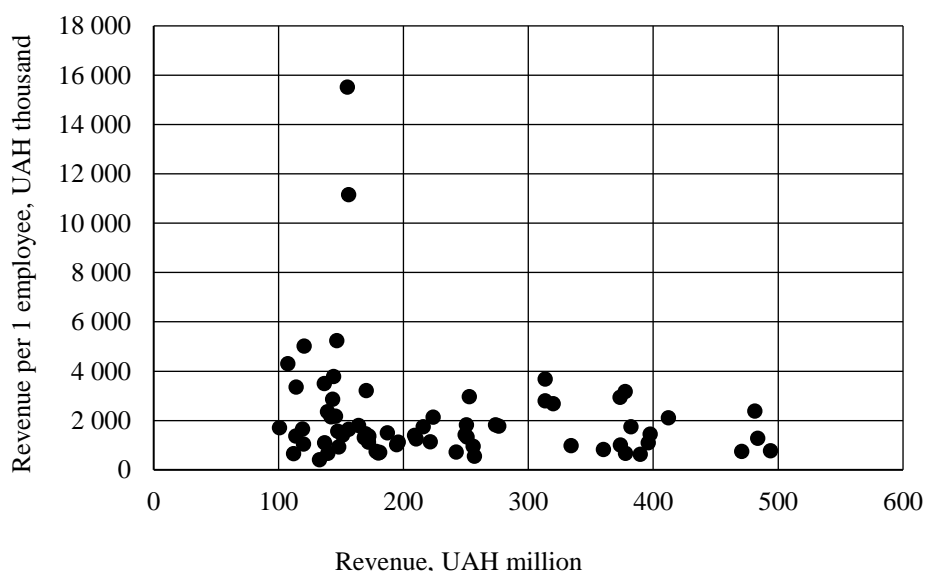| Indicators	Larger enterprises	Smaller enterprises

Distribution parameters, UAH thousand per 1 employee:
    mathematical expectation
    standard deviation
Criterion indicator χ^2:
    calculated value
    critical value
	2 524
	1 890
	
	1.126
	3.841
		2 093
		2 243
		
		3.279
		7.815

Conclusion about the hypothesis of the law of distribution	The hypothesis does not contradict the observation data	The hypothesis does not contradict the observation data

Source: Author's development based on data (*YouControl, 2024; Opendatabot, 2024*).

Just as for the aggregate sample, the random variable of labor productivity separately for larger and smaller enterprises has the same lognormal distribution law, but with different parameters according to the *Table 8*. Larger enterprises have a higher value of the mathematical expectation, which does not contradict the initial hypothesis 2, and a lower value of the standard deviation, which is also quite natural.

Contrary to hypothesis 2, an increase in labor productivity is not observed with an increase in the scale of the enterprise's activity, which is characterized by the indicator of the amount of revenue, as shown in *Figure 7*.
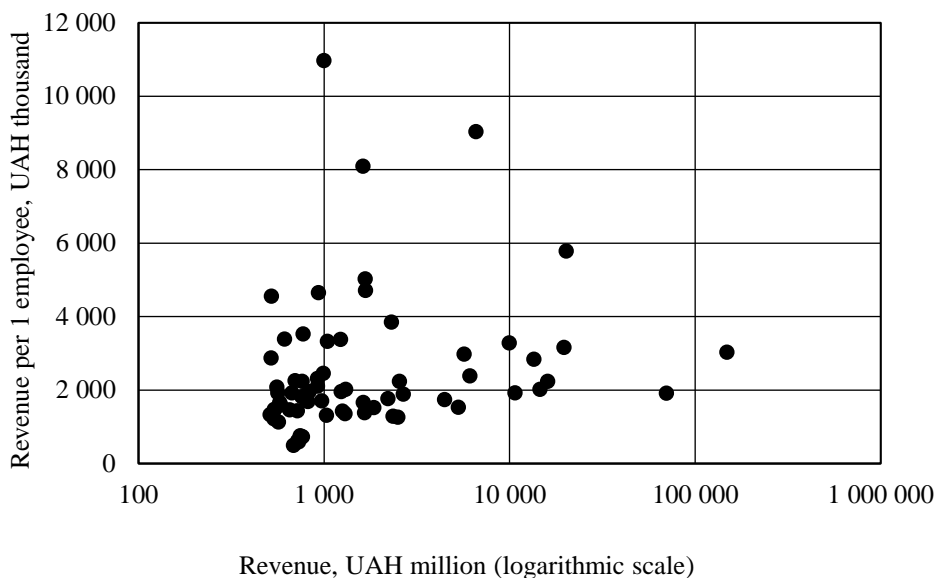
a

b

Figure 7. Statistical relationship between revenue and labor productivity
(the indicator of revenue per 1 employee) for the formed sample for 2022:
a) larger enterprises; b) smaller enterprises

Source: Author's development based on data (*YouControl, 2024; Opendatabot, 2024*).

On the scatter diagrams shown in *Figure 7*, it is visually observed that there is no directly proportional relationship between revenue and labor productivity for both larger retail enterprises of class 47.11 and smaller ones. Thus, it was not possible to illustrate the truth of hypothesis 2 and to find arguments for its confirmation based on the data of the formed sample.

Conclusions

The war has significantly limited the labor resources for all sectors of the economy, retail trade was no exception, and, as is known, the effectiveness of the enterprise depends on the level of supply of employees with the necessary qualifications and experience.

In view of the need for post-war reconstruction against the background of a shortage of labor resources, the goal is to verify the truth of the principles of the relationship between the scope of activities and the amount of resources used, formulated back in the days of neoclassical economics. According to the results of calculations based on empirical data for a group of retail enterprises of the same type, no confirmation of the formulated hypotheses was found.

Thus, for domestic retail enterprises that belong to class 47.11 according to KVED-2010, in the conditions of martial law, the regularity of the labor resource in accordance with the hypothesis, which states that the larger volume of operational activity of the enterprise, which is characterized by a larger volume of sales of products (goods, services) for a certain short-term unit of time, implies a greater amount of use of the economic resource of labor and capital, if there is no increase in labor intensity, development of technologies and innovations in business processes that allow to reduce the need for resources, it does not come true. Final confirmation of this assumption requires further in-depth research, including on the basis of empirical data from other samples of Ukrainian retail trade enterprises.

According to the results of the calculations, there is a reason to assume that the theoretical hypothesis that an increase in the volume of sales of products (goods, services) of the enterprise for a certain short-term unit of time strengthens the effect of scale and, as a result, increases the return (efficiency) of the economic resources used, including the resource of labor and capital, in the conditions of martial law has no practical significance, at least for RTE class 47.11. Perhaps due to the fact that enterprises with a larger scale of operations also experience greater losses in connection with a large-scale military invasion (thus the advantage of the scale of operations is neutralized by the scale of losses). The example of one of the leading enterprises of the formed sample, LLC "ATB-MARKET", in which, according to information from the interview of the general director and chairman of the board of directors of the ATB corporation Boris Markov, after the beginning of a large-scale invasion, 31 sales points were destroyed, and 79 remained in temporarily occupied territories (Mishchenko, 2023).

Therefore, further research will be aimed at the substantiation of other samples of Ukrainian retail trade enterprises and the search for inter-dependencies between their scope of activity and the amount of economic resources involved in the conditions of war and post-war recovery.

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