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The impact of innovation on employment and earnings in Ukrainian industry

Abstract: The innovative activity of industrial enterprises is one of the essential prerequisites for national socio-economic development. Innovations contribute to the growth of labour productivity, added value and profit, and, as a result, to an increase in earnings. Accordingly, the study of patterns of the impact of product innovation (expressed as an indicator of the share of innovative products in the volume of industrial products sold) on employment and earnings in the industrial sector of the economy has significant scientific and applied importance. In the article, using the example of Ukraine, a strong direct relationship between the innovativeness of products and industry share in employment is empirically proven (using correlation-regression methods). Using Almon's method, a distribution-lag model (with a lag of three years) has been created, which reflects the high direct dependence of the average monthly earnings of a full-time employee in the Ukrainian industry on growth in product innovation. A deterministic economic-mathematical model of optimising the technological structure of existing industrial and innovative products in the manufacturing industry has been developed according to the criterion of increasing innovativeness. The modelling results give a scientific basis for strategic planning, as they allow the choice of such a target optimisation (level of product innovation) at which earnings in the manufacturing industry will reach the desired value.

Keywords: earnings; employment; industry; innovative products; optimisation of industrial products

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Introduction

Innovation is an indicator and, at the same time, a prerequisite for economic efficiency in industry. On the one hand, the scale and development of innovations are formed under the influence of many direct and indirect factors. On the other hand, it affects several socio-economic indicators, particularly employment and earnings. In Ukraine, one of the critical problems of industrial development is enterprises' relatively low level of innovative activity.

At the same time, there is room for discussion in the Ukrainian expert environment on the impact of product innovations on employment and earnings. To answer this question, a study was conducted to confirm or refute a hypothesis about the positive impact of innovative product growth on employment in the Ukrainian industry.

Scientists from different countries still do not have a standard view about the direction (positive/negative) or presence of the impact of innovation on employment and earnings in industry. Thus, Meriküll (2010) substantiates that innovations positively affect employment in Estonia's medium- and low-tech enterprises. However, at the whole industry level, such influence is absent. A study in Italy (Evangelista, Savona, 2002) shows that the impact of innovation on employment differs in different industrial sectors. A positive effect is present in small enterprises and the service sector, while a negative effect is observed in large firms, capital-intensive industries, and all finance-related sectors. It was also concluded that the impact of innovations on employment depends on the qualifications of workers and the specialisation of the national economy. An inverse correlation between innovation and employment in the financial sector using the examples of South Korea, the UK and Ukraine is discussed in Palekhova and Kramarenko (2020). In Latin American countries, the impact of innovation on employment in manufacturing enterprises is positive (Crespi, Tacsir, 2011), but in China, it is negative (Su et al., 2022). The research results prove that the impact of innovations on employment is multifaceted and under debate. Different research results from different countries and continents may result from using diverse methodological approaches and data. They may also depend on the characteristics of the economy, the level of technology of the studied sectors, and many other factors.

The impact of innovations on earnings is no less debatable. From one point of view, if innovations can cause a decrease in employment, then, accordingly, they can have a negative effect on earnings. On the other hand, if innovations contribute to the growth of more qualified workers, then the earnings of the latter should increase. At the same time, a significant number of qualified workers intensifies competition in the labour market. As a result, only certain employees of specific segments of the economy or industry receive higher earnings. That is, even from the standpoint of analytical logic, there is no unequivocal answer to this question. Research results confirm this conclusion. In China, higher earnings have a positive effect on innovation. However, this impact differs for each economic sector (Gao et al., 2023). In Brazil, earnings growth in innovative enterprises was found (Cirera, Martins-Neto, 2023). In addition, it was established that an earnings increase occurs from the start of innovative activity and lasts for three years.

In contrast, a study based on data from France, Italy, Germany, the Netherlands, Portugal, Spain, and the UK found that earnings were falling in sectors with a high proportion of workers with only secondary education due to the spread of new technologies. Greater earnings polarisation is found in industries with innovative, solid products and a high proportion of university-educated workers (Croci Angelini et al., 2009). The results of these studies are a justification for the relevance of further study on the relationship between innovation and employment and earnings.

The study aims to substantiate and characterise the relationships between innovation and employment and between innovation and earnings in industry.

The following tasks were performed to achieve this goal:

1. Confirmation or refutation of the hypothesis that there is a high direct correlation between innovation and employment in industry at the national level. In other words, this means that innovation has a strong direct effect on employment in industry, and *vice versa*.

2. Confirmation or refutation of the hypothesis that there is a high direct correlation between a change in innovation rate and a change in earnings in a country's industry. In other words, this means that changes in innovation rates have a strong direct impact on changes in earnings in a country's industry, and *vice versa*.
3. Development of a deterministic economic-mathematical model of optimisation of the technological level of existing industrial products and innovative ones in the manufacturing industry, according to the criterion of increasing innovativeness.

Methods and data

Industry in Ukraine was chosen as the object of research. Statistical data from the State Statistics Service of Ukraine (SSSU, 2023) for 2005–2020 served as the research information base.

The research was conducted in three stages. In the first stage, an assessment of the relationship between innovation and employment in industry was carried out. At this research stage, an indicator of the share of innovative products from sales was used to reflect innovations. Employment was reflected as an indicator of industry share in the national economy.

In the second stage, an analysis of the relationship between innovations and earnings in industry was carried out. At the same time, attention was paid to the relationship between changes in innovation rates and earnings. An indicator of the share of innovative products in sales volume was used to reflect changes in innovation. The change in earnings was reflected in the average monthly earnings of a full-time worker.

To calculate this index, the average monthly earnings of full-time workers were converted from Ukrainian hryvnias (UAH) to US dollars (USD). Then, the index was calculated from changes to the average monthly earnings of full-time workers in US dollars. It was done to determine the change in value, which is closest to real, not nominal, earnings, in which the inflationary component takes a significant part. In other words, at the second stage of the study, the relationship between the change in the share of innovative products in terms of sales and the change in the actual average monthly earnings of full-time workers in Ukrainian industry was calculated.

In the third stage, the technological level of existing industrial and innovative products was optimised in the manufacturing industry according to increasing innovativeness.

General scientific methods of economic analysis (comparison, dynamics, structures, and others) were used to assess trends in innovation, employment and earnings. The correlation-regression analysis was used to confirm or refute the existence of a correlation between innovation and employment and between innovation and earnings. In particular, the correlation coefficient was calculated, and one-factor regression models were set up. Thus, using these methods, a one-factor regression model was created that reflects the magnitude of the impact of innovations on employment in Ukrainian industry. Determination of the impact of changes in innovation rates on changes in earnings was carried out using a one-factor regression model, followed by a distributional-lag model using the Almon method with a lag of three years. Almon's method was chosen to avoid multicollinearity, which is possible when constructing lag models. The correlation-regression analysis was applied since only a stochastic relationship between the analysed indicators is possible. These methods are traditionally used in economic analysis.

In order to optimise the technological level of both existing industrial products and innovative ones in the Ukrainian manufacturing industry, the author's method was applied according to the criterion of increasing innovativeness (Ishchuk et al., 2021). The deterministic optimisation model constructed by linear programming was modified according to Ukrainian statistical data. A deterministic model was chosen because there is a functional dependence between the share of innovative products in the manufacturing industry and both innovative and existing industrial products in the manufacturing industry (when one indicator changes, the other changes). The linear programming method was chosen because it provides the most objective results when constructing optimisation models. The Statistica software package was used to perform correlation-regression analysis.

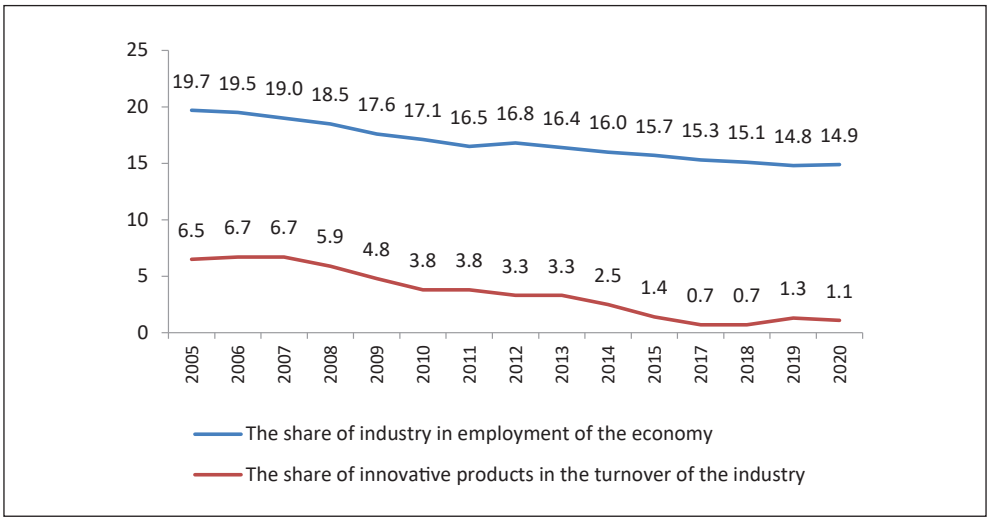
Results

Impact of innovation on employment in industry

The results of the analytical research indicate a decrease in the share of innovative products in sales from the Ukrainian industry in 2008–2018 by 6.0 percentage points (pp) (from 6.7% to 0.7%; Figure 1). As a result, according to the value of this indicator in 2018, Ukraine was inferior to, for example, Poland by more than 14 times (Ishchuk et al., 2021).

The negative change in the indicator of the share of innovative products in the sales of industrial products in Ukraine in this period was primarily determined by the influence of several global factors, among which the key ones were the global financial crisis of 2008 and the strengthening of economic globalisation, specialisation, offshoring processes, and the increasing role of TNCs in world trade and economy (Ishchuk, Sozanskyy, 2022). In addition, the decrease in the innovativeness of products in Ukrainian industry

Figure 1. The share of industry in employment in the economy and the share of innovative products in sales from Ukrainian industry, by %



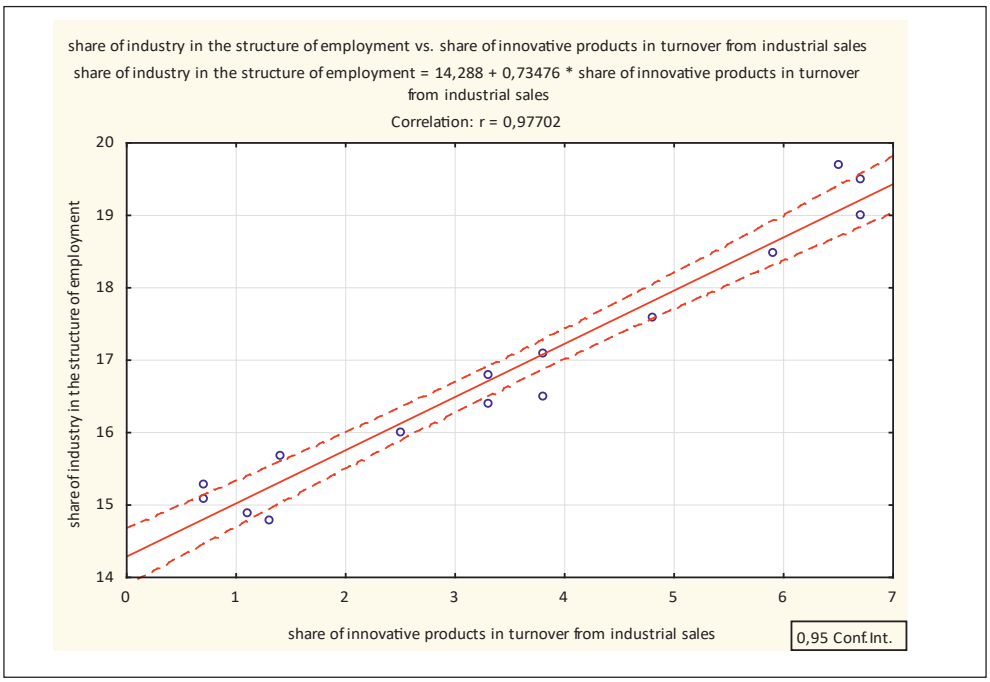
Source: authors' calculations based on SSSU (2023) and Eurostat (2023) data

may indirectly be a consequence of high import dependence on medium to high-tech industries, primarily machine-building (Ishchuk et al., 2023), the Russian armed aggression that began in 2014, a slow reorientation to new sales markets, weak statesmanship when concluding international economic agreements (WTO, FTA with the EU), and the lack of an effective strategy for the innovative economic development of the country.

Along with the decrease in the share of innovative products in the studied period, there was also a decrease in industrial employment in Ukraine from 19.69% in 2005 to 14.85% in 2020 (see Figure 1). The share of those employed in Ukraine was significantly lower than in Poland. Thus, in 2018, employment in the Ukrainian industry was 15.11% compared to 27.39% in Poland. Let us emphasise that there is also a trend of decreasing employment in Poland. However, in 2008–2018, in the Ukrainian industry, the value of this indicator decreased by 3.35 pp, while in Poland, by only 1.91 pp (Eurostat, 2023).

The relatively low and declining employment in industry in Ukraine may be due to the structural transformation of the national economy towards agrarianisation, as well as the lack of effective strategies for the country's industrial development. In addition, the decrease in employment in Ukrainian industry may be associated with a decrease in innovative industrial products. The substantiation of this thesis and, at the same time, of the hypothesis (H1) that innovations affect employment is found in the graphical and analytical proof of a very high, direct correlation between employment and the share of innovative products in Ukrainian industry (Figure 2). The correlation coefficient

Figure 2. Correlation and the share of innovative products in industrial sales and the share of industrial employment in Ukraine, calculated for 2005–2020



Source: authors' calculations based on SSSU data (2023)

between these indicators is 0.98 (Table 1). It is almost a deterministic (functional) connection. Note that in Poland, the value of this indicator was 0.78 (Ishchuk et al., 2021). The coefficient of determination (R2) proves that the share of industry in employment in Ukraine is 96%, explained by the share of innovative products in sales. In comparison, in Poland, it is 57% (Ishchuk et al., 2021).

Table 1. Statistical characteristics of the linear one-factor regression equation showing the influence of the share of innovative products from sales on the share of industrial employment in Ukraine calculated for 2005–2020

Regression Summary for the Dependent Variable: share of industry in employment in the economy (Spreadsheet1 (Recovered)) R= 0.98164706 R^2=0.96363096 Adjusted R^2= 0.96083334 F(1.13)=344.45 p						
	b*	Std.Err. – of b*	b	Std.Err. – of b	t(13)	p-value
Intercept			14.15935	0.168005	84.27934	0.000000
share of innovative products in turnover from industrial sales	0.981647	0.052893	0.75971	0.040934	18.55928	0.000000

Source: authors' calculations based on SSSU data (2023)

According to the data in Table 1, the influence of the share of innovative products on the share of industrial employment in Ukraine is reflected in the regression equation:

$$Y = 0.75971x + 14.1593 \quad (1)$$

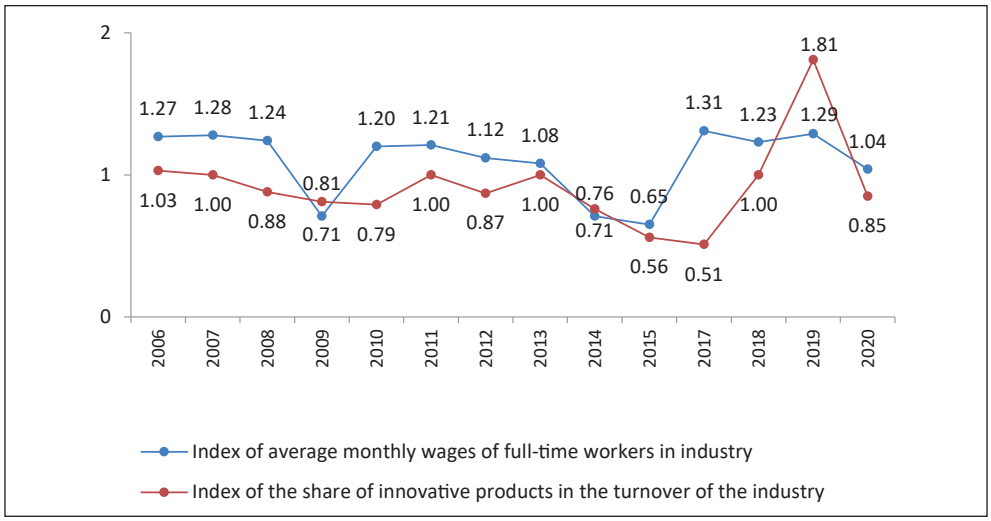
where:
Y – share of the manufacturing industry in employment in Ukraine,
x – share of innovative products in industrial sales.

According to its statistical characteristics, the regression equation (f1) has a very high significance level. In particular, the correlation coefficient (R) is 0.98, and the coefficient of determination (R2) is 0.96. The results of the interpretation of this equation showed an accuracy level of 99%. Thus, with an increase in the share of innovative products from sales by one pp, the share of industry in employment in Ukraine will increase by 0.76 pp. In Poland, the value of a similar indicator was 0.27 pp (Ishchuk et al., 2021).

The impact of changes in innovation rates on changes in earnings in industry

The trends of the values of the share of innovation in industrial sales and the index of real earnings of full-time employees in Ukrainian industry during 2006–2020 were approximately identical (Figure 3). Thus, the most significant decrease in the actual earnings of full-time workers occurred during the global financial crisis (2008–2009), the beginning of the Russian-Ukrainian war (2014–2017) and the spread of the COVID-19 pandemic (2020). In the first of the two periods, there was a significant devaluation of the Ukrainian hryvnia (UAH) and, as a result, a sharp drop in the real earnings of full-time industrial workers. The high devaluation of the national currency indirectly affected a decrease in the technological efficiency of Ukrainian industry and the decrease in raw material exports. As a result, these and other interconnected social and economic factors at national and global levels caused a fall in innovation. In 2020, the decline in innovation

Figure 3. The index of the share of innovations in industrial sales and the index of the actual earnings of a full-time employee in Ukrainian industry



Source: authors' calculations

and earnings was directly influenced by disruption, suspension of the functioning of global value chains, and a decrease in business activity.

According to the results of the correlation-regression analysis, there is an average direct correlation between the index of the share of product innovation in sales and the index of the average monthly earnings of full-time workers. It is confirmed by the correlation coefficient value (R=0.42) (Table 2).

Table 2. Statistical characteristics of the linear regression equation of the influence of the share of innovative products in industrial sales on the average monthly earnings of full-time workers in Ukraine

Regression Summary for the Dependent Variable: Y (Spreadsheet8) R= 0.41811969 R2=0.17482408 Adjusted R2= 0.10605942 F(1.12)=2.5424 p						
	b*	Std.Err. – of b*	b	Std.Err. – of b	t(12)	p-value
Intercept			0.799816	0.194677	4.108419	0.001450
x	0.418120	0.262230	0.321661	0.201735	1.594476	0.136814

Source: authors' calculations based on SSSU data (2023)

The assessment of the impact of changes in innovation rates on changes to the average monthly earnings of a full-time employee is reflected by the regression equation:

$$I_m = 0.799816 + 0.321661\ I_{inn} \quad (2)$$

where:

I_m – the index of the average monthly earning of a full-time industrial worker in Ukraine (earnings),

I_{inn} – the index of the share of innovative products in industrial sales in Ukraine (innovations).

The statistical characteristics of the regression equation are significant. The interpretation of the regression equation (f2) allows us to state that with the growth of the share of innovative products in industrial sales by one pp, there will be an increase in the average monthly earnings of a full-time industrial worker by 0.32 pp. Thus, the correlation-regression analysis results justify a direct correlation between innovation and the average earnings of an employee in the Ukrainian industry.

At the same time, it should be noted that according to the values of the coefficient of determination (R2) (see Table 2) in the regression equation (f2), the change in the index of the average monthly earnings of a full-time employee is explained by the change in the share of innovative products in industrial sales by only 17.5% (against 53% in Poland) (Ishchuk et al., 2021). The remaining 82.5% depends on other factors.

The relatively smaller influence of the share of innovative products in industrial sales on the average monthly earnings of a full-time employee can be explained by the fact that in Ukraine, the level of earnings is influenced by many factors, including non-economic and political ones, in particular, tariffs, the established level of minimum and average earnings, competition in the labour market, and strategic priorities of state and industrial enterprises. It is also essential to consider that the share of innovative products, compared to Poland, is very low (Ishchuk et al., 2021), so its immediate (year-by-year) impact on financial results and, thus, earnings is comparatively lower. Accordingly, it was assumed that the impact of an increase in innovation on earnings in industry might be reflected, however, with an inevitable delay (or time lag), that is, not immediately but after a year or two. It is caused by the length of operating cycles, the motivational policy of employers, the inertia of economic processes, and other factors already mentioned.

Given the delayed effect of innovation in Ukraine, a correlation-regression analysis was conducted to obtain more accurate research results, considering time lags. It made it possible to establish that there are time lags of one, two or three years between the index of the share of innovative products and the index of average monthly earnings. In particular, the statistical characteristics and interpretation of the distribution-lag model, according to Almon's method, with a lag of three years, showed that with the growth of the share of innovative products by one pp, the index of the average monthly earnings of full-time employees will increase by 1.19 pp over the next three years (0.577+0.031+0.024+0.557):

$$I_m = 0.577 + 0.031 I_{inn}^{t-1} + 0.024\, I_{inn}^{t-2} + 0.557\, I_{inn}^{t-3} \quad (3)$$

The coefficient of determination (R2 = 0.9521) shows that in the model (f3) change in the average monthly earnings of a full-time employee is explained by change in the share of innovative products. Statistical characteristics given in Table 3 confirm the significance of the model (f3).

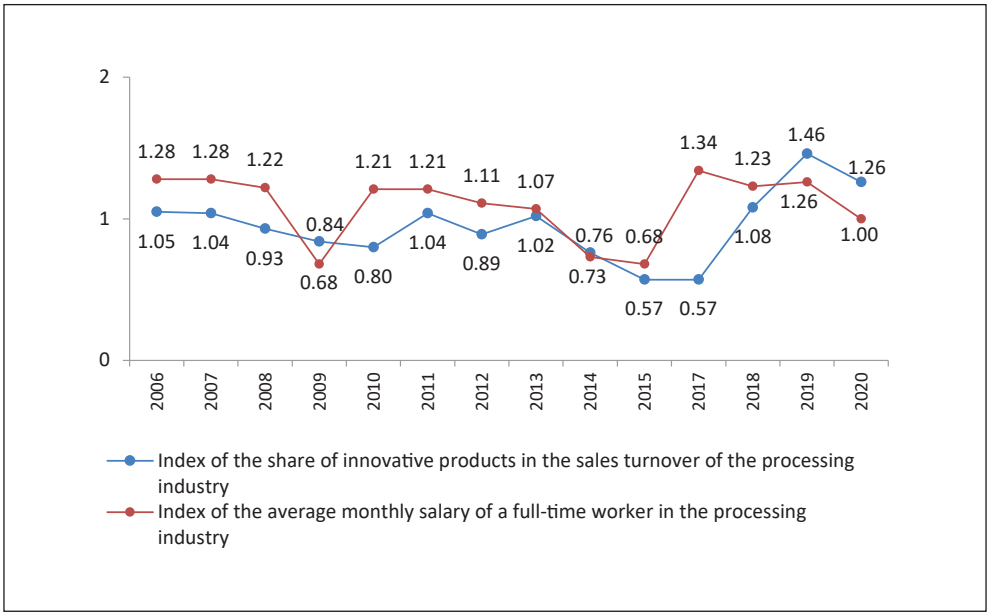
Further research made it possible to state that hypothesis (H2) that change in innovation has a high direct impact on change in earnings applies not only to the industrial sector of Ukraine in general, but to manufacturing industry in particular. Thus, based on the input data, a distribution-lag model (Figure 4) was created, which proved the presence of one, two or three years between change in the share of innovative products and change in the average monthly earnings of a full-time employee.

Table 3. Statistical characteristics of the lag regression equation showing the influence of the share of innovative products industrial sales on the average monthly earnings of a full-time employee of Ukrainian industry

Almon Polyn. Distr.Lags; Regression Coefficients (Spreadsheet247) Indep: VAR2 Dep: VAR1 Lag: 3 Polyn. order: 2 R = .9758 R^2 = .9521 N: 11				
	Regressn – Coeff.	Standard – Error	t(7)	p-value
0	0.577478654955	0.198577655083	2.908074701127	0.022722811091
1	0.031394558738	0.164133047661	0.191275061208	0.853739839682
2	0.024470357011	0.150236765461	0.162878619864	0.875216408536
3	0.556706049776	0.245859478478	2.264326163966	0.057960408748

Source: authors' calculations based on SSSU data (2023)

Figure 4. The index of the share of innovative products in industrial sales and the index of the real earnings of a full-time employee



Source: authors' calculations based on SSSU data (2023)

$$I_m = 0.916 - 0.29I_{inn}^{t-1} - 0.0317I_{inn}^{t-2} + 0.835I_{inn}^{t-3} \quad (4)$$

According to the values of the regression coefficients of the model, it can be stated that with the growth of the share of innovative products in industrial sales by one pp, the average monthly earnings of full-time employees in Ukrainian manufacturing industry will increase by 1.14 pp for three years (0.916+0.290+0.317+0.837).

The coefficient of determination (R2 = 0.9674) (Table 4) confirms the statistical significance of the model and that the change in the share of innovative products in industrial sales explains the change in average monthly earnings.

Table 4. Statistical characteristics of the lag regression equation show the influence of innovative product share in industrial sales on the average monthly earnings of a full-time employee

Almon Polyn. Distr.Lags; Regression Coefficients (Spreadsheet21) Indep: Index of the share of innovative products on industrial sales Dep: Index of the average monthly earning of a full-time worker Lag: 3 Polyn. order: 2 R= .9836 R2 = .9674 N: 11				
	Regressn – Coeff.	Standard – Error	t(7)	p-value
0	0.912080419813	0.231425306042	3.94114384210	0.005595133802
1	–0.287894560594	0.195315198306	–1.47399978645	0.183975867000
2	–0.313866579722	0.194089708495	–1.61712118667	0.149885433816
3	0.834164362428	0.245056693567	3.40396481437	0.011380894377

Source: authors' calculations based on SSSU data (2023)

Optimization of manufacturing industry in ukraine according to the criterion of increasing product innovativeness

As the author's previous studies proved, in Ukraine, as well as in Poland, one of the important reasons for the relatively low innovativeness of industrial products is its irrational structure. This made it necessary to optimise the structure of innovative products in Ukraine's manufacturing industry, following the example of Poland (Ishchuk et al., 2021). For this, the deterministic model (f5) was applied:

$$\frac{I_m}{P_m} = \frac{I_m\left(\frac{I_m}{I_m}\right)\left(\frac{I_{m_1}}{I_m} + \frac{I_{m_2}}{I_m} + \ldots + \frac{I_{m_{22}}}{I_m}\right)}{P_m\left(\frac{P_m}{P_m}\right)\left(\frac{P_{m_1}}{P_m} + \frac{P_{m_2}}{P_m} + \ldots + \frac{P_{m_{23}}}{P_m}\right)} \rightarrow \text{opt}, \qquad (5)$$

I_m – innovative products in the manufacturing industry,

$I_{m_1}, I_{m_2}, I_{m_{23}}$ – innovative products from the 22 manufacturing industry sectors,

P_m – manufacturing industry products sold,

$P_{m_1}, P_{m_2}, P_{m_{23}}$ – products sold from the 22 manufacturing industry sectors.

The target functionality of the model was to achieve such a level of product innovation that the average monthly earnings of a full-time employee in Ukraine would approach the figure in Poland. Using the interpretation of the model (f4), it was found that in order for the average monthly earning of an average worker to reach the level of Poland, i.e. to increase by 3.2 times (from USD 426.3 to USD 1346.2), the innovativeness rate of products of the Ukrainian manufacturing should be 23.7%. Therefore, this indicator was the target function for optimising innovative products in Ukrainian manufacturing. The results of such optimisation are given in Table 5.

It follows from the optimisation results that in order to increase the innovativeness of products from manufacturing in Ukraine to 23.7% and, thus, to reach the level at which the average monthly earnings of a full-time employee will equal the indicator in Poland (increase by 3.2 times), significant structural changes must take place. First, it is about

Table 5. Results of optimisation of the technological level of both innovative and existing industrial products in Ukrainian manufacturing industry according to the innovativeness criterion

Production	Actual data (2020)			Optimised data			Deviation (+/–)		
	The structure of the implementation innovative products,%	The structure of sold industrial products,%	The share of innovative products in the volume of sold industrial products, %	The structure of the implementation innovative products, %	The structure of sold industrial products, %	The share of innovative products in the amount of existing industrial products, %	The structure of the implementation innovative products,%	The structure of sold industrial products, %	The share of innovative products in the volume of sales of industrial products, %
Manufacturing	100.0	100.0	2.4	100.0	100.0	23.7	x	x	21.3
Manufacture of food products	15.2	32.5	1.1	7.4	20.1	8.7	–7.9	–12.4	7.6
Manufacture of beverages	2.6	3.9	1.6	2.9	2.9	24.1	0.3	–1.0	22.5
Manufacture of textiles	0.4	0.6	1.4	1.0	0.9	25.2	0.6	0.3	23.8
Manufacture of wearing apparel	0.4	0.7	1.3	0.7	0.7	24.0	0.3	0.0	22.7
Manufacture of leather and related products	0.0	0.3	0.2	0.3	0.3	22.8	0.3	0.0	22.6
Wood manufacturing and manufacture of wood and cork products, except furniture; production of products from straw and plant materials for weaving	1.3	2.2	1.4	2.5	3.1	18.7	1.1	1.0	17.3
Manufacture of paper and paper products	0.6	2.1	0.7	1.0	0.8	29.7	0.3	–1.4	29.0

Printing and reproduction of recorded media	0.2	0.6	0.6	0.7	0.9	19.5	0.5	0.2	18.9
Manufacture of chemicals and chemical products	2.6	4.2	1.5	4.6	7.8	14.0	2.0	3.6	12.6
Manufacture of pharmaceutical products	3.7	2.4	3.6	5.3	3.9	32.2	1.6	1.5	28.6
Manufacture of rubber and plastic products	1.5	3.1	1.2	2.6	3.1	19.7	1.1	0.0	18.6
Manufacture of other non-metallic mineral products	3.5	6.2	1.3	4.5	6.0	18.0	1.0	–0.2	16.6
Manufacture of basic metals	35.6	22.0	3.8	18.6	12.8	34.5	–16.9	–9.2	30.7
Manufacture of metal products	2.3	2.9	1.8	3.7	3.4	26.0	1.4	0.5	24.1
Manufacture of computer. electronic and optical products	3.7	0.9	9.3	4.9	4.0	28.8	1.2	3.1	19.5
Manufacture of electrical equipment	6.2	2.2	6.8	8.3	5.6	35.0	2.0	3.4	28.2
Manufacture of machinery and equipment	9.6	4.2	5.4	10.6	8.6	29.2	1.0	4.4	23.8
Manufacture of motor vehicles, trailers and semi-trailers	3.8	1.8	5.1	9.6	4.6	49.7	5.8	2.8	44.6
Manufacture of other transport equipment	5.2	2.7	4.5	8.4	6.9	28.7	3.2	4.2	24.2
Manufacture of furniture	0.8	1.5	1.3	1.2	2.7	10.4	0.4	1.2	9.1
Other manufacturing	0.4	0.4	2.4	0.7	0.6	28.8	0.3	0.2	26.4
Repair and installation of machinery and equipment	0.3	2.6	0.3	0.6	0.4	35.2	0.3	–2.2	34.9

Source: authors' calculations

increasing the share of high and medium high-tech industries (engineering, chemical and pharmaceutical) in terms of innovative and existing products. At the same time, the innovativeness of the products of each manufacturing industry sector of Ukraine must increase significantly. These processes (structural transformation and increasing the innovativeness level) are interrelated and are based on strengthening intersectoral ties in the economy.

Conclusions

As a result of the research, the following analytical and fundamental conclusions can be drawn.

The level of both innovation and employment in Ukrainian industry has significantly decreased. This trend was provoked by global crisis processes and internal economic and non-economic (primarily socio-political) factors. In addition, real earnings and innovations in industry and manufacturing in Ukraine have been changing rapidly, too.

The results of the statistical and correlation-regression analysis confirmed two under debate hypotheses: 1) an increase in the level of product innovation contributes to an increase in employment in industry; 2) an increase in the share of innovative products in the total volume sold contributes to an increase in earnings in industry. Thus, the impact of product innovation (the share of innovative products in the volume of industrial products sold) on employment and earnings in the industrial sector of the economy has been revealed.

It has been empirically proven that there is a high direct relationship between the innovativeness of products and the share of industrial employment in the economy. A regression model has been created with the help of which it is possible to determine how employment in Ukrainian industry will change when innovations increase by one pp. Using Almon's method, a distributional-lag model (with a three-year lag) was constructed, which reflects the high direct dependence of the average monthly earnings of a full-time industrial worker on growth in product innovation.

A deterministic economic-mathematical model of optimising the technological level of both existing industrial products and innovative ones in each manufacturing industry sector has been developed according to the criterion of increasing innovativeness. The modelling results form a scientific basis for strategic planning, as they allow the choice of a target optimisation (level of product innovation) at which earnings in the manufacturing industry will reach a desired value.

The fundamental and applied results can serve as scientific-methodological and analytical bases for planning and forecasting economic processes in industry, as well as a theoretical basis for conducting new research. Prospects for further research can be seen in modelling the impact of innovations on other economic indicators, particularly those of profitability and business activity.

References

Cirera, X., Martins-Neto, A. (2023). Do innovative firms pay higher wages? *Micro-level evidence from Brazil. Research Policy*, *52*, 104645. doi: https://doi.org/10.1016/j.respol.2022.104645

Crespi, G., Tacsir, E. (2011). *Effects of innovation on employment in Latin America*, 1–11. doi: https://doi.org/10.1109/ACSIP.2011.6064465

Croci Angelini, E., Farina, F., Pianta, M. (2009). Innovation and wage polarisation in Europe. *International Review of Applied Economics*, *23*, 309–325. doi: https://doi.org/10.1080/02692170902811736

Eurostat. (2023). Retrieved from. https://appsso.eurostat.ec.europa.eu/ (accessed: 3.07.2023).

Evangelista, R., Savona, M. (2002). The Impact of Innovation on Employment in Services: Evidence from Italy. *International Review of Applied Economics*, *16*, 309–318. doi: https://doi.org/10.1080/02692170210136136

Gao, Z., Wang, Z., Zhou, M. (2023). Is China's Urbanization Inclusive? Comparative Research Based on Machine Learning Algorithms. *Sustainability*, *15*(4), 3490.

Ishchuk, S., Sozanskyy, L., Kniaziev, S. (2023). Problematic issues of localization-based development of mechanical engineeringin Ukraine. *Science and innovation*, *19*(1), 20–35. doi: https://doi.org/10.15407/scine19.01.020

Ishchuk, S., Sozanskyy, L., Pukała, R. (2021). Optimisation of structural parameters of the industry by the criterion of product innovation. *Engineering Management in Production and Services*, *13*(3), 7–24. doi: https://doi.org/10.2478/emj-2021-0018

Ishchuk, S., Sozanskyy, L. (2022). National Mechanical Engineering in Conditions of Economic Globalization. *Management and Production Engineering Review*, *13*(4), 107–125. doi: https://doi.org/10.24425/mper.2022.142399

Meriküll, J. (2010). The Impact of Innovation on Employment. *Eastern European Economics*, *48*(2), 25–38. doi: https://doi.org/10.2753/EEE0012-8775480202

Palekhova, V., Kramarenko, O. (2020). The impact of technological innovations on employment in the financial sector. *Technology audit and production reserves*, *6*, 45–49. doi: https://doi.org/10.15587/2706–5448.2020.220290

State Statistics Service of Ukraine. (2023). Retrieved from: https://ukrstat.gov.ua/ (accessed: 3.07.2023).

Su, C.-W., Yuan, X., Umar, M., Lobonţ, O.-R. (2022). Does technological innovation bring destruction or creation to the labor market? *Technology in Society*, *68*(C). doi: https://doi.org/10.1016/j.techsoc.2022.101905

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