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Labour economics and social policy in the context of European integration

Abstract. Strengthening of international competitiveness is one of the priorities of economic development of both the leading countries in the world and growing economies. The issue of an effective policy for regulating social and labour relations under modern economic and demographic challenges is gaining priority as an integral component of a long-term growth strategy. The article is devoted to a comparative analysis of social policy and social and labour relations in Ukraine and European countries. The set of EU members was supplemented with Iceland, Norway and Switzerland. Shares of compensation of employees and government social expenditures in GDP were chosen as initial indicators. The study covered the period of 2021-2023. Empirical analysis did not reveal a significant correlation between initial indicators. In view of this, a non-parametric approach was used. According to it, a data convex hull was built for the data of every year. Unlike existing studies, the proposed article covered all parts of the hull. It was split into two pairs of mutually opposite international frontiers, each of which had its virtual extremum. The point of the maximum of both studied indicators was interpreted as the final state of simultaneous growth in total income of a population. The point of maximum compensation of employees and minimum government social expenditures was considered to be virtual maximum of the substitution of government social assistance with the employees' own incomes. Initial data were normalised using three methods. Two of them were classic ones - normalisation by half-differences of extreme values of initial indicators and normalisation by standard deviations from half-amounts of their extrema. The third method was new and consisted in normalisation by half-amounts of standard deviations from the extrema of initial indicators. The international position of countries in the field of social and labour relations was characterised by the difference in distances to opposite virtual extreme states. The dynamics of changes in the country's international position was analysed using two coefficients of the development efficiency in

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relevant directions. These coefficients were calculated as an increment of the difference in the country's distances to opposite virtual extrema, divided by the length of the path travelled by it during this period. For Ukraine in 2021-2022, both coefficients were positive, and in the next period they became negative. The comparison of distances calculated in three coordinate systems has confirmed the previous supposition that Z-standardisation should give estimates that are the largest by modulus, and the other two methods are quite close. Based on the proposed approach, it is possible to analyse the data averaged over several years, as well as other macroeconomic indicators. Such analysis can contribute to the optimisation of government socio-economic policy

Keywords: international comparative research, compensation of employees, social protection, methods of data normalisation, DEA modelling, efficiency of socio-economic development, consequences of Russian aggression

Introduction

The accumulation of interstate contradictions during the period of accelerated globalisation causes the search for new sources of global competitiveness of countries and regions. With the increase in manufacturability of the world economy, the key factor of economic growth - innovative, productive human capital - retains its leadership. Its conservation and multiplication forms the agenda of economic policy of both leading countries and growing economies. The radical change in the foreign policy of the world's largest economy - the United States - in 2025 added uncertainty to both global commodity, financial markets and labour market. With the reorientation of international business to alternative countries and regions, the importance of appropriate working conditions and social and labour relations in them is increasing.

European countries as a traditional world migration centre are getting new opportunities to attract new investments and talents. However, the European labour market has long suffered from structural deficiencies, excessive government regulation and lagging behind in digitalisation. According to the largest business association of Europe - Business Europe, a forecast of a reduction in the working-age EU population by 2100 is by 50 million. The situation is complicated by the lag in labour productivity in the EU - 75% of the US level as of 2022. The definition of European employment and social policy as necessary condition for improving Europe's competitiveness and labour productivity is the response to new challenges of global fragmentation, which intensify interstate and interregional competition.

Literature review

The problems of social policy, labour economics, and social and labour relations under modern conditions are actively studied in Ukrainian and foreign scientific literature. Thus, in the work of I. Kravets (2021), the role of social partnership as a necessary condition for regulating employment, developing human capital, and ensuring economic growth is determined. M. M. Duchenko and A. V. Zhuk (2023) analysed theoretical aspects of social partnership and directions for its improvement based on the experience of developed countries. The research conducted by these authors can be the basis for maximising the benefits for all participants in the process - employees, employers and the government.

The features of social and labour relations and social policy of Ukraine under martial law are determined in the work of the team of authors (T. Kostyshyna *et al*., 2023). The authors substantiated the emergence of a new type of labour relations - platform employment. The use of Internet services as an element of the labour market infrastructure, where the customer and the service provider interact, is its key characteristic.

The analysis of the accumulation of crisis phenomena in social policy of European countries in 2008-2011 was carried out by V. Glassner and M. Keune (2012). The authors focus on

significant differences in social policy and social and labour relations in various European countries, the growing role of collective agreements, the expansion of the practice of using flexible forms of employment and accounting for working hours. As the authors have shown, in contrast to the public sector, the private sector demonstrates greater opportunities and flexibility in social and labour relations. G. Sirot, U. Unal and R. Maialeh (2025) conducted an in-depth study on the interdependence of inflation and labour market activity in the Czech Republic. The Czech labour market, in contrast to traditional cases, is characterised by relatively low dynamics of compensation of employees and a consistently tight labour market situation. This is due, among others, to the relatively high level of production specialisation of the economy. Under such conditions, the efficiency of government employment policy is higher in the short term, when inflationary processes are kept at acceptable levels. However, when planning long-term government economic policy, it is also necessary to take into account non-standard situations in the labour market (Sirot *et al*., 2025).

European integration has contradictory consequences for member states in matters of social policy and general well-being, as noted by T. Tobera and M. R. Busemeyerb (2020). Restrictions on the fiscal freedom of EU countries reduce the possibilities of social compensations. Fiscal austerity measures increase the differentiation of the dynamics of compensation of employees and unemployment in EU member states. Thus, the results of their study record contradictory effects of European integration. The continuation of these negative trends may lead to a significant divergence in the needs, objectives and opportunities of individual countries' social policies.

Materials and methods

The sphere of labour relations and social policy can be characterised by various indicators. However, official statistical databases significantly limit their scope. In view of this, two indicators, for which the necessary data are available on the websites of Eurostat and the Ministry of Finance of Ukraine for 2021-2023, were selected. The first of them - “Compensation of employees” - reflects total remuneration paid by the employer to employees in cash or in kind. The second indicator - “Social protection” - reflects corresponding General government expenditures. Both values were measured as shares in the gross domestic product of the country.

International states of countries were analysed based on the data convex hull approach (DEA - Data Envelopment Analysis). Unlike existing studies based on this approach, in the proposed article a full data convex hull, which is split into two pairs of mutually opposite international frontiers, is constructed for each year. The upper right part of the hull characterises the maximum of one indicator for a certain value of the other and, accordingly, vice versa. This part is logically considered an international frontier of maximum simultaneous growth of total income of the population. The lower right part of the data hull characterises the maximum of compensation of employees for a certain level of social protection and the minimum of social protection for a certain level of compensation of employees. This part of the hull is interpreted as an international frontier of maximum replacement of government social assistance with the population's own labour income. Opposite parts of the hull are interpreted as international frontiers of the minimum total income of the population and the minimum independence of employees from the government social protection system. Opposite vertices of a rectangle circumscribed around the data hull are characterised in a similar way. Since these points are located outside the data hull, they are considered as virtual extrema of two alternative courses of countries' social development - towards higher total income of the population and towards its greater independence from the government social protection system. Along the positively sloping diagonal of the rectangle, there is a complementary change in compensation of employees and government social expenditures. Along the negatively sloping diagonal, there

is a substitution of one type of income of the population with another. A geometric interpretation of the proposed approach is presented in Figure 1.

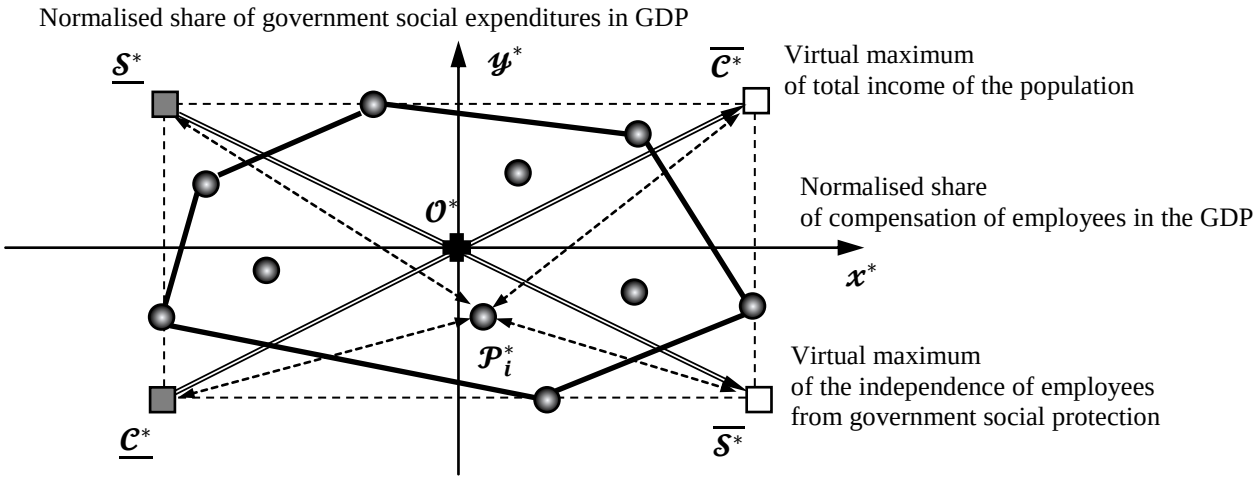

Figure 1. DEA model of alternative directions of social development of countries in a normalised coordinate system

Source: I. Zagoruyiko's model

Correct comparisons of international states of countries require preliminary normalisation of initial indicators. Each of possible normalisation methods has certain advantages and disadvantages, therefore, in the proposed study three methods that complement each other have been used. In all these methods, the origin of coordinates is transferred to the point of half-amounts of extreme values of the studied indicators - $O^*\left((x_{\min} + x_{\max})/2\,;(y_{\min} + y_{\max})/2\right)$, where x - the share of compensation of employees in the GDP of the country, and y - the similar share of government social expenditures. Further, depending on the normalisation method, the deviations of initial indicators from these coordinates are divided into certain values.

In the case of linear normalisation, half-differences of extreme values serve as the basis for comparison:

$$x^* = \frac{x - (x_{\min} + x_{\max})/2}{(x_{\max} - x_{\min})/2} \qquad y^* = \frac{y - (y_{\min} + y_{\max})/2}{(y_{\max} - y_{\min})/2} \tag{1), (2}$$

In this coordinate system, both indicators vary in the range –1, +1.

Z-standardisation is the second classic method used in this study. According to this method, the deviations of initial indicators are divided into standard deviations from new origin of coordinates:

$$\sigma_{stand}\,(x) = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(x_i - \frac{x_{\min} + x_{\max}}{2}\right)^2} \tag{3}$$

$$\sigma_{stand}\,(y) = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(y_i - \frac{y_{\min} + y_{\max}}{2}\right)^2} \tag{4}$$

where N - the number of countries studied.

In the presented study, a new normalisation method - by half-amounts of standard deviations from the extrema of initial indicators - is additionally used:

$$\sigma_{extr}(x) = \frac{1}{2}\left(\sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_{\max} - x_i)^2} + \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - x_{\min})^2}\right) \quad (5)$$

$$\sigma_{extr}(y) = \frac{1}{2}\left(\sqrt{\frac{1}{N}\sum_{i=1}^{N}(y_{\max} - y_i)^2} + \sqrt{\frac{1}{N}\sum_{i=1}^{N}(y_i - y_{\min})^2}\right) \quad (6)$$

Compared to the classic Z-standardisation method, the third method should give smaller values of calculated quantities. This is due to the fact that for a particular country, the function of the half-amount of squares of the deviation from the extrema is located higher than the similar Z-standardisation function:

$$f_3(x) = (x_{\max} - x)^2/2 + (x - x_{\min})^2/2 \;>\; f_2(x) = \left(x - \frac{x_{\min} + x_{\max}}{2}\right)^2 \quad (7)$$

This inequality also holds for square roots of these functions.

As for the $f_1(x) = (x_{\max} - x_{\min})/2$ graph, then under the $x_{\max} - x_{\min} > 2$ condition it will be located below the $f_3(x)$ graph. However, due to the fact that in the third method the square root is obtained, and the first one is linear, their normalisation bases converge.

The international state of the $\mathcal{P}_i$ country in the field of social and labour relations is characterised by the difference of Euclidean distances to the opposite virtual extreme states:

$$\delta\left(\underline{\mathcal{C}^*}; \mathcal{P}_i^*; \overline{\mathcal{C}^*}\right) = \rho\left(\underline{\mathcal{C}^*}; \mathcal{P}_i^*\right) - \rho\left(\mathcal{P}_i^*; \overline{\mathcal{C}^*}\right) \quad (8)$$

$$\delta\left(\underline{\mathcal{S}^*}; \mathcal{P}_i^*; \overline{\mathcal{S}^*}\right) = \rho\left(\underline{\mathcal{S}^*}; \mathcal{P}_i^*\right) - \rho\left(\mathcal{P}_i^*; \overline{\mathcal{S}^*}\right) \quad (9)$$

where $\underline{\mathcal{C}^*}(x_{\min}^*; y_{\min}^*)$, $\overline{\mathcal{C}^*}(x_{\max}^*; y_{\max}^*)$ - virtual extreme states on the diagonal of complementary changes in population income; and $\underline{\mathcal{S}^*}(x_{\min}^*; y_{\max}^*)$, $\overline{\mathcal{S}^*}(x_{\max}^*; y_{\min}^*)$ - virtual extreme states on the diagonal of substitution of government social assistance and private labour income.

To characterise the actual change in the international position of a country, two efficiency coefficients of socio-economic development are introduced. They are calculated as the increments of the difference in the country's distances to opposite virtual extrema, divided by the length of the path it has travelled:

$$\epsilon_{i,t}^{\mathcal{C}} = \left(\delta\left(\underline{\mathcal{C}_t^*}; \mathcal{P}_{i,t}^*; \overline{\mathcal{C}_t^*}\right) - \delta\left(\underline{\mathcal{C}_{t-1}^*}; \mathcal{P}_{i,t-1}^*; \overline{\mathcal{C}_{t-1}^*}\right)\right)/\rho\left(\mathcal{P}_{i,t}^*; \mathcal{P}_{i,t-1}^*\right) \quad (10)$$

$$\epsilon_{i,t}^{\mathcal{S}} = \left(\delta\left(\underline{\mathcal{S}_t^*}; \mathcal{P}_{i,t}^*; \overline{\mathcal{S}_t^*}\right) - \delta\left(\underline{\mathcal{S}_{t-1}^*}; \mathcal{P}_{i,t-1}^*; \overline{\mathcal{S}_{t-1}^*}\right)\right)/\rho\left(\mathcal{P}_{i,t}^*; \mathcal{P}_{i,t-1}^*\right) \quad (11)$$

The proposed approach makes it possible to compare the effectiveness of alternative directions of social development of the country. An elementary model of such a comparison consists in calculating the difference between two virtual coefficients - the coefficient of efficiency of reaching the $\overline{\mathcal{S}_t^*}$ state:

$$\varepsilon_{i,\text{virt}}^{\mathcal{S}} = \left(\rho\left(\underline{\mathcal{S}_t^*}; \overline{\mathcal{S}_t^*}\right) - \delta\left(\underline{\mathcal{S}_t^*}; \mathcal{P}_{i,t}^*; \overline{\mathcal{S}_t^*}\right)\right)/\rho\left(\mathcal{P}_{i,t}^*; \overline{\mathcal{S}_t^*}\right) \quad (12)$$

and the coefficient of efficiency of reaching the $\overline{\mathcal{C}_t^*}$ state:

$$\varepsilon_{i,\text{virt}}^{\mathcal{C}} = \left(\rho\left(\underline{\mathcal{C}_t^*}; \overline{\mathcal{C}_t^*}\right) - \delta\left(\underline{\mathcal{C}_t^*}; \mathcal{P}_{i,t}^*; \overline{\mathcal{C}_t^*}\right)\right) / \rho\left(\mathcal{P}_{i,t}^*; \overline{\mathcal{C}_t^*}\right) \quad (13)$$

Other things being equal, the country should move in the direction in which the virtual efficiency coefficient is higher. Since virtual coefficients are relative indicators, it should be expected that their values for one year in all coordinate systems will be very close.

Results and discussion

The absence of correlation between the studied indicators is an important condition for the feasibility of using non-parametric methods. To clarify this, the data for 2023 (see Appendix 3) were used, for which $y(x)$ econometric functions, where x - employers' expenditures for compensation of employees (as a percentage of GDP), and y - the level of general government expenditures on social protection of the population (also as a percentage of GDP), were constructed. The verification has shown that for all main econometric functions the R^2 determination coefficient does not exceed 0.13.

Thus, in the case of a linear function

$$y = 0{,}15446187x + 9{,}11932133 \quad (14)$$

$R^2 = 0{,}0505$;

- in the case of a quadratic parabolic function

$$y = -0{,}01990239x\text{^}2 + 1{,}89708637x - 28{,}18981956 \quad (15)$$

$R^2 = 0{,}1231$;

- in the case of a cubic parabolic function

$$y = -0{,}00038586x\text{^}3 + 0{,}03035049x\text{^}2 - 0{,}2346755x + 1{,}14467 \quad (16)$$

$R^2 = 0{,}1258$;

- in the case of a power function

$$y = 2{,}00648625x\text{^}0{,}53762378 \quad (17)$$

$R^2 = 0{,}0383$;

- in the case of an exponential function

$$y = 9{,}39603706 \times 1{,}01112979\text{^}x \quad (18)$$

$R^2 = 0{,}0255$;

- in the case of a logarithmic function

$$y = 7{,}38133251 \cdot \ln(x) - 11{,}9630146 \quad (19)$$

$R^2 = 0{,}064$.

Virtual extreme states were determined by the coordinates of the following countries:

– in 2021 - Ireland ($\min x$), Finland ($\max y$), Switzerland ($\max x$) and Ukraine ($\min y$);
– in 2022 - Ireland ($\min x$, $\min y$), France ($\max y$) and Switzerland ($\max x$);
– in 2023 - Ireland ($\min x$), Finland ($\max y$), Switzerland ($\max x$) and Ukraine ($\min y$) (see Appendices 1, 2, 3).

The frontier of minimum independence of employees from the government social protection system was formed by:

– in 2021 - Ireland, Italy and Finland;
– in 2022 - Ireland, Greece, Italy, Finland and France;
– in 2023 - Ireland, Greece, Italy and Finland.

The frontier of maximum independence of employees from the government social protection system was formed by:

– in 2021 and 2023 - Ukraine and Switzerland;
– in 2022 - Ireland, Ukraine and Switzerland.

In all years, the diagonal of population income substitution crossed the corresponding maximum frontier on the Ukraine-Switzerland section. As for the minimum frontier, in 2021 the point of its intersection with this diagonal was located on the Ireland-Italy section, in 2022 - on the Ireland-Greece section, and in 2023 - on the Greece-Italy section.

The frontier of minimum total income of employees was formed by:

– in 2021 and 2023 - Ireland and Ukraine;
– in 2022 - only one country - Ireland.

The frontier of maximum total income of employees was formed by:

– in 2021 and 2023 - Finland, France and Switzerland;
– in 2022 - France and Switzerland.

In all years, the diagonal of simultaneous change in all incomes of the population crossed the corresponding maximum frontier on the France-Switzerland section.

The results of the qualitative analysis of convex hulls are consistent with the indicators of countries' distances to opposite virtual extrema (see Appendices 1, 2, 3).

Thus, in all years and in all coordinate systems, Ukraine was closer to the maximum of independence from government social protection than to its minimum. In 2021 and 2023, our country was closer to the minimum of total income of the population than to its maximum. 2022, for which two coordinate systems show a smaller distance to the minimum of total income, and one coordinate system, on the contrary, shows a smaller distance to its maximum, was the exception. This discrepancy is explained by small (by modulus) values of the differences in distances to the extrema of total income.

A similar picture was also characteristic of Ireland. In all years and in all coordinate systems (except for one value in 2022), this country was located in the "red zone" by both indicators of distance differences. Switzerland, on the contrary, was always closer to virtual maxima in all coordinate systems. France, Italy and Finland in all years were relatively close to the maximum of total income of the population and relatively distant from the maximum of independence from the government social protection system.

Against this background, Greece was distinguished by certain specificity. In 2021, it was relatively closer to the minimum of independence from government support of the population and the maximum of its total income. In 2022, one of coordinate systems showed its approximation to the minimum of total income of the population. And already in 2023, the country was in the "red zone" by both indicators and in all coordinate systems.

It is worth focusing separately on the state of the European Union as a whole. Eurostat provides the data on the EU, which consists of 27 countries. According to the results of the presented study, in 2021 and 2022 the EU-27 was relatively close to the minimum of employees' independence from government support and to the maximum of total income of the population. However, relative proximity to the minimum of social independence was small, and relative proximity to the maximum of total income was, on the contrary, quite significant. For 2023, one of coordinate systems showed a closer approximation to the maximum of employees' economic independence. As in the case of Ukraine, such a discrepancy is explained by small deviations of this difference in distances from zero.

It is worth noting that, for the most part, normalisation by half-differences of the extrema of initial indicators (system I) and by half-amounts of standard deviations from these extrema (system III) give very close values, and Z-standardisation (system II) gives values that are significantly

larger by modulus (in many cases, by 2-3 times). This feature is reflected in the last six columns of Appendices 1, 2, 3 and in the first three columns of Appendices 4, 5. However, there were certain exceptions to this regularity. They concerned several countries with a negative difference in distances to the extrema of employees' economic independence. Thus, in 2021, the differences in distances to the extrema of independence of the European Union-27, Austria and Belgium were such exceptions (see Appendix 1). In 2022, the European Union-27 and Belgium, and in 2023, the European Union-27 and Austria were the exceptions (see Appendices 2, 3). All of them were located in the upper right part of the polygon formed by the convex hull.

As for the length of the path travelled by the country, for all countries and in both periods (2021-2022, 2022-2023), the system II showed significantly larger values than two other systems. In addition, in the vast majority of cases, the system I led to slightly larger estimates than the system III. In 2021-2022, the EU-27 and Italy, for which the path length turned out to be the same according to systems I and III, and Poland, for which this indicator was larger according to the system III than according to the system I, were the exceptions (see Appendix 4). For Finland, systems I and III showed the same path length for 2022-2023 (see Appendix 5).

According to the proposed methodology, the length of the path travelled by the country was the basis for determining the effectiveness of socio-economic development (see Appendices 4, 5). Compared to the differences in distances to opposite extrema discussed above, the path length was much smaller. For example, according to systems I and III, Poland almost did not change its international position during 2021-2022 - its path length was close to zero.

During this period, our country was radically different against the background of other countries. As a result of the full-scale Russian invasion, the length of the path travelled by Ukraine exceeded the corresponding values for the rest of the countries several times. Norway, whose path length was close to the Ukrainian one, was the exception (see the first three columns of Appendix 4). During 2022-2023, Norway became the leader by the length of the path travelled, while Ukraine was somewhat inferior to it in this regard. The dynamics of efficiency coefficients of both countries were opposite. In 2022, our country improved its position relative to the extrema of employees' economic independence and total income of the population - both efficiency coefficients were positive. For Norway, on the contrary, both of these coefficients were negative. In 2022-2023, already domestic coefficients became negative, and Norwegian ones became positive. At the same time, Norway became the leader by the efficiency of development in the direction of growth in total income of the population. It can be assumed that such progress of Norway was due to a sharp reduction in purchases of Russian gas by European countries. In addition to Norway, only Denmark and Estonia demonstrated positive dynamics of development by both criteria over these years (see Appendix 5).

The above-mentioned regularities in the ratios of quantities calculated according to different systems and exceptions to these regularities also affected actual efficiency coefficients. According to the authors, it is of fundamental importance that in the vast majority of cases, the coefficients of the same name for the same period had the same sign in all coordinate systems. For the period of 2021-2022, Austria, Belgium, Greece, Poland, Slovenia and Finland were the exceptions (see Appendix 4). For the period of 2022-2023, Ireland, Finland and Switzerland were the exceptions (see Appendix 5). However, firstly, in all of them, there were differences in signs only for one of two efficiency coefficients. Secondly, except for Belgium and Poland in 2021-2022, the signs of coefficients according to systems I and III coincided. Thirdly, in all these cases, the system II (Z-standardisation) gave an extreme value of the coefficient compared to other two systems. These features can be considered an argument in favour of the joint use of all three coordinate systems.

A comparative analysis of alternative directions of possible socio-economic development of countries in 2021-2023 was the last stage of empirical part of the study (see Appendix 6).

On the eve of the full-scale Russian invasion, our country was in a group of countries for which it would be more effective to move towards the highest total income of the population - an increase in both the share of compensation of employees in GDP and the share of government social expenditures. This seems quite natural, since during this period the share of domestic government social expenditures in GDP was already minimal (see Appendices 1 and 6). By the $\varepsilon^{\mathcal{S}}_{i,\text{virt}} - \varepsilon^{\mathcal{C}}_{i,\text{virt}}$ difference in virtual efficiency coefficients, Ukraine was between Germany and Austria. For Norway, and especially for Slovakia, both alternative directions were almost equally effective. As for countries with the opposite difference in efficiency coefficients, the advantage of the course to reduce government social expenditures for them was either small or moderate (see Appendix 6).

The full-scale Russian invasion had very little effect on virtual effectiveness of alternative directions of development in European countries. In 2022, the value of the $\varepsilon^{\mathcal{S}}_{i,\text{virt}} - \varepsilon^{\mathcal{C}}_{i,\text{virt}}$ difference for the vast majority of countries changed insignificantly, and its sign did not change at all. The formation of a group of countries with almost equal effectiveness of alternative directions of socio-economic development was the only notable feature of 2022-2023. In 2022, Bulgaria, the Netherlands and Slovakia became such countries. In 2023, they were joined by Cyprus, Norway, Poland and Portugal (see Appendix 6).

For our country, the situation changed radically - in 2022, the course to reduce the share of government social expenditures in GDP (to the Irish level) became significantly more effective (see Appendices 2 and 6). In 2023, Ukraine found itself at a virtual "crossroads". In one coordinate system, the course to increase the share of compensation of employees while maintaining a constant share of government social expenditures (which already became an international minimum) had a very slight advantage. In other two systems, the course to increase both the share of compensation of employees and the share of government social expenditures would be slightly more effective (see Appendices 3 and 6).

The data presented in Appendix 6 confirm the previous assumption that virtual efficiency coefficients of one year in all coordinate systems should be very close.

Prospects for further investigations

The research presented in this article is open for further development in several directions. Thus, if necessary, mean values for a certain period of time can be chosen as initial data. Depending on the method of constructing the chronological mean, various modifications of the proposed coordinate systems will be formed.

Using the inverse efficiency problem, the virtual state in which the country will find itself, provided that the data hull remains unchanged, can be determined. Thus, if the goal of the country is to move towards the maximum of the total income of the population, then the problem of determining its virtual state will have the form:

$$\begin{cases} \left(\delta\left(\underline{\mathcal{C}^*_t}; \mathcal{P}^*_{i,\text{virt}}; \overline{\mathcal{C}^*_t}\right) - \delta\left(\underline{\mathcal{C}^*_t}; \mathcal{P}^*_{i,t}; \overline{\mathcal{C}^*_t}\right)\right) / \rho\left(\mathcal{P}^*_{i,t}; \mathcal{P}^*_{i,virt}\right) = \varepsilon^{\mathcal{C}}_{i,\text{targ}} \\ \dfrac{y^*_{i,\text{virt}} - y^*_{i,t}}{x^*_{i,\text{virt}} - x^*_{i,t}} = \dfrac{y^*_{\max} - y^*_{i,t}}{x^*_{\max} - x^*_{i,t}} \end{cases} \quad (20)$$

where $\varepsilon^{\mathcal{C}}_{i,\text{targ}}$ - the target value of the efficiency coefficient.

In the case of choosing a movement towards maximum independence of employees from the government social protection system, this problem will have a similar form:

$$\begin{cases} \left(\delta\left(\underline{\mathcal{S}_t^*}; \mathcal{P}_{i,\text{virt}}^*; \overline{\mathcal{S}_t^*}\right) - \delta\left(\underline{\mathcal{S}_t^*}; \mathcal{P}_{i,t}^*; \overline{\mathcal{S}_t^*}\right)\right) / \rho\left(\mathcal{P}_{i,t}^*; \mathcal{P}_{i,virt}^*\right) = \varepsilon_{i,\text{targ}}^{\mathcal{S}} \\ \dfrac{\mathcal{Y}_{i,\text{virt}}^* - \mathcal{Y}_{i,t}^*}{x_{i,\text{virt}}^* - x_{i,t}^*} = \dfrac{\mathcal{Y}_{\min}^* - \mathcal{Y}_{i,t}^*}{x_{\max}^* - x_{i,t}^*} \end{cases} \quad (21)$$

where $\varepsilon_{i,\text{targ}}^{\mathcal{S}}$ - the target value of the efficiency coefficient.

Another direction for further study of the presented data may consist in the calculation of absolute and relative areas of convex hulls. The ratio of the area of the convex hull of the states of countries to the rectangle of extreme states can be used as a measure of its "extremeness". The ratio of the areas of the figures formed by the sides of the rectangle of extreme states and the convex hull will characterise the degree of its asymmetry in four directions.

Given that two of three normalisation methods used gave close distance values, in further studies it would be advisable to fill the "gap" between them and Z-standardisation. Tables 1-4 present all possible normalisation bases, which are linear or quadratic functions of a certain z indicator and its extreme values.

Table 1. Normalisation bases by deviations from the arithmetic mean and the mean square of extreme values

sequence of operations			difference, δ			
			variable		constant	
I	II	III	$z - \overline{z_{\text{extr}}}$	$z - \sqrt{\overline{z_{\text{extr}}^2}}$	$\sqrt{\overline{z^2}} - \overline{z_{\text{extr}}}$	$\sqrt{\overline{z^2}} - \sqrt{\overline{z_{\text{extr}}^2}}$
mean	modulus		$\sqrt{\overline{\delta}^2} = \lvert\overline{\delta}\rvert$	$\sqrt{\overline{\delta}^2} = \lvert\overline{\delta}\rvert$	$\sqrt{\overline{\delta}^2} =$ $\sqrt{\overline{\delta^2}} =$ $\overline{\sqrt{\delta^2}} = \lvert\delta\rvert$	$\sqrt{\overline{\delta}^2} =$ $\sqrt{\overline{\delta^2}} =$ $\overline{\sqrt{\delta^2}} = \lvert\delta\rvert$
square	mean	root	$\sqrt{\overline{\delta^2}} = \sigma_{\text{stand}}$	$\sqrt{\overline{\delta^2}}$		
modulus		mean	$\overline{\sqrt{\delta^2}} = \lvert\overline{\delta}\rvert$	$\overline{\sqrt{\delta^2}} = \lvert\overline{\delta}\rvert$		

Source: developed by I. Zagoruyko

Table 2. Normalisation bases by deviations from the mean square and the square of the mean of extreme values

sequence of operations			difference, δ			
			variable		constant	
I	II	III	$z^2 - \overline{z_{\text{extr}}^2}$	$z^2 - \overline{z_{\text{extr}}}^2$	$\overline{z}^2 - \overline{z_{\text{extr}}^2}$	$\overline{z}^2 - \overline{z_{\text{extr}}}^2$
mean	modulus	root	$\sqrt{\lvert\overline{\delta}\rvert}$	$\sqrt{\lvert\overline{\delta}\rvert}$	$\sqrt{\lvert\overline{\delta}\rvert} =$ $\sqrt{\lvert\overline{\delta}\rvert} =$ $\overline{\sqrt{\lvert\delta\rvert}} = \sqrt{\lvert\delta\rvert}$	$\sqrt{\lvert\overline{\delta}\rvert} =$ $\sqrt{\lvert\overline{\delta}\rvert} =$ $\overline{\sqrt{\lvert\delta\rvert}} = \sqrt{\lvert\delta\rvert}$
modulus	mean	root	$\sqrt{\lvert\overline{\delta}\rvert}$	$\sqrt{\lvert\overline{\delta}\rvert}$		
modulus	root	mean	$\overline{\sqrt{\lvert\delta\rvert}}$	$\overline{\sqrt{\lvert\delta\rvert}}$		

Source: developed by I. Zagoruyko

Table 3. Normalisation bases by deviations from linear quantities of extreme values

sequence of operations				arguments		base, ν
I	II	III	IV	$z, z_{\max}$	$z, z_{\min}$	
mean	difference, δ	modulus		$\overline{\lvert\delta_{\max}\rvert}$	$\overline{\lvert\delta_{\min}\rvert}$	$(z_{\max} - z_{\min})/2$
difference, δ	mean	modulus		$\overline{\lvert\delta_{\max}\rvert}$	$\overline{\lvert\delta_{\min}\rvert}$	
difference, δ	square	mean	root	$\sqrt{\overline{\delta_{\max}^2}}$	$\sqrt{\overline{\delta_{\min}^2}}$	$\big(f(\delta_{\max}) + f(\delta_{\min})\big)/2 = \sigma_{extr}$
difference, δ	modulus		mean	$\overline{\lvert\delta_{\max}\rvert}$	$\overline{\lvert\delta_{\min}\rvert}$	$(z_{\max} - z_{\min})/2$

Source: developed by I. Zagoruyko

Table 4. Normalisation bases by deviations from the squares of extreme values

sequence of operations				arguments		base, ν
I	II	III	IV	$z, z_{\max}$	$z, z_{\min}$	
mean	square	difference	root	$\sqrt{z_{\max}^2 - \overline{z}^2}$	$\sqrt{\overline{z}^2 - z_{\min}^2}$	$(f_{\max} + f_{\min})/2$
square	mean	difference	root	$\sqrt{z_{\max}^2 - \overline{z^2}}$	$\sqrt{\overline{z^2} - z_{\min}^2}$	$(f_{\max} + f_{\min})/2$
square	difference	mean	root			
square	difference	root	mean	$\overline{\sqrt{z_{\max}^2 - z^2}}$	$\overline{\sqrt{z^2 - z_{\min}^2}}$	$(f_{\max} + f_{\min})/2$

Source: developed by I. Zagoruyko

As follows from the above tables, a total of 21 normalisation methods, of which three have been used in this study, are possible.

Potential implementation of results

The proposed approach to the analysis of the international position of countries in the field of social and labour relations can be used in several aspects.

Firstly, the construction of a full data convex hull is appropriate in cases where maximum and minimum levels of the studied indicators may represent alternative goals of the government's socio-economic policy.

In the presented study, first of all, the level of social protection of the population at the expense of government expenditures has this property. Despite their importance for ensuring social stability, these expenditures can weaken incentives for labour activity, increase the level of taxation and public debt and, as a result, slow down economic growth. Thus, in Argentina, permanent populist policies have led to a long-term deterioration of its international economic position. In the case of Japan, the population aging ahead of the pace of technological progress has caused its economy to stagnate for several decades. On the other hand, neglecting to support vulnerable segments of the population contributes to the spread of protest sentiments that can be used by extremist movements and totalitarian countries. As for the share of compensation of employees in GDP, it also has its limits. The ratio of the shares of labour income and capital income in a certain sense reflects the choice of society between consumption and investment and therefore cannot lean excessively in one direction or the other.

In addition to social expenditures and compensation of employees, indicators such as the country's net international investment position and the net immigrant contingent have similar minimax properties. The international data hull by these indicators was analysed in detail in the previous work of the authors (Zagoruiko & Petkova, 2024).

Secondly, by analogy with the proposed efficiency coefficients of socio-economic development, efficiency coefficients of other changes in the international position of the country can be constructed. In doing so, it is not necessary that the indicators under study be alternative goals of economic policy or social development. The “unemployment rate - inflation rate” and “labour productivity - capital productivity” are examples of such pairs of indicators. In most cases, society is interested in reducing

both unemployment and inflation. As for the second pair of indicators, their increase is a source of not only economic, but also social (in a broad sense) progress. In the 21st century, the study of the world technological frontier began on the basis of the DEA approach.

Thirdly, the method of normalisation by half-amounts of standard deviations from extrema tested by the authors expands the set of tools for initial data processing. Together with two other classic normalisation methods - linear minimax and Z-standardisation, the proposed method can be used not only in international, but also in any other econometric studies. Its important feature is that it simultaneously makes it possible to estimate the degree of asymmetry of the studied set. The stability of the values of virtual efficiency coefficients with respect to the change in the coordinate system indicates the feasibility of their use for optimising the government socio-economic policy.

Conclusions

Empirical analysis of initial data makes it possible to draw certain conclusions.

Thus, the verification of six basic regression equations (linear, quadratic, cubic, power, exponential and logarithmic ones) has shown no correlation between initial indicators ($R^2_{2023} < 0{,}13$). This fact can be considered an important argument in favour of the feasibility of non-parametric methods.

In all years, virtual extreme states were determined by the coordinates of Ireland and Switzerland - respectively, the minimum and maximum of the share of compensation of employees in GDP. In 2021 and 2023, our country had minimum share of government social expenditures, and Finland - maximum one. In 2022, Ireland and France were such countries.

According to the proposed methodology, the convex hull of the states of countries was split into four parts - the frontiers of maximum and minimum independence of employees from the government social protection system and similar mutually opposite frontiers of the total incomes of the population. Ukraine, together with Switzerland, was at the frontier of maximum economic independence of employees in all years, and Italy and Finland were always at the opposite frontier. In all years, France and Switzerland were at the frontier of maximum total income of the population, and Ireland was always at the opposite frontier.

Qualitative analysis of these frontiers is consistent with indicators of countries' distances to opposite virtual extrema. Thus, in all years and in all coordinate systems, our country was closer to the maximum of economic independence of employees than to its minimum. The full-scale Russian invasion significantly affected the international situation of Ukraine. The length of the path travelled by our country in 2021-2022 exceeded the corresponding values for the rest of the countries several times. For the period of 2022-2023, the corresponding national indicator was not much lower than the maximum one (Norwegian). National coefficients of efficiency of socio-economic development responded to the aggression with a delay. In 2022, both of our coefficients were positive, but in 2023 they became negative.

The empirical part of the study confirmed theoretical assessment of discrepancies of the quantities of the same name in applied coordinate systems. With few exceptions, normalisation by half-differences of extrema of initial indicators (system I) and by half-amounts of standard deviations from these extrema (system III) gave very close values of distances and distance differences, and Z-standardisation (system II) - values that were significantly larger by modulus. Differences in estimates of these quantities in different coordinate systems affected the coefficients of actual efficiency of socio-economic development. It was important, however, that in the vast majority of cases, the coefficients of the same name for the same period had the same sign according to three normalisation methods. In addition, in all cases, the system II (Z-standardisation) gave an extreme value of the coefficient compared to other two systems. These empirical regularities indicate the expediency of sharing all three coordinate systems. The significant stability of the values of virtual efficiency coefficients with respect to the change in the coordinate system is a good reason for their use in macroeconomic modelling and forecasting.

The proposed approach to the comparative analysis of the states of countries can be developed in various directions. Firstly, it can be applied in the study of mean values of indicators over several years. Secondly, the tested methods of analysis can be supplemented by other methods based on the geometric approach. Thirdly, the proposed approach can be applied to other pairs of initial indicators, in particular those that reflect the areas of social policy and labour relations. A set of various efficiency coefficients of a country's relative development can be used to choose the optimal course of its socio-economic policy.

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Conflict of interest

None.

References

Duchenko, M. M., & Zhuk, A. V. (2023). Theoretical aspects of social partnership in the sphere of social and labor relations. *Business Inform*, *5*, 19–23. doi: 10.32983/2222-4459-2023-5-19-23

Eurostat (2025). *Compensation of employees* [tec00013]. doi: 10.2908/tec00013. Last updated: 15/05/2025.

Eurostat (2025). *General government expenditure by function (COFOG)* [gov_10a_exp$defaultview]. doi: 10.2908/gov_10a_exp. Last updated: 23/04/2025.

Glassner, V., & Keune, M. (2012). The crisis and social policy: The role of collective agreements. *International Labour Review*, *151*(4), 351–376. doi: 10.1111/j.1564-913X.2012.00153.x

Kostyshyna, T., Tuzhylkina, O., Kostyshyna, A., Golubets, V., & Krasiuk, R. (2023). Regulation of social and labor relations in the context of social policy implementation. *Modern Engineering and Innovative Technologies*, *2*(27–02), 85–91. doi: 10.30890/2567-5273.2023-27-02-038

Kravets, I. (2021). Social partnership in labour regulation. *University Scientific Notes*, *4*(82), 99–107. doi: 10.37491/UNZ.82.8

Ministry of Finance of Ukraine (2022). *Information on the status of implementation of the Consolidated and State Budgets of Ukraine for January-December 2020-2021 (according to the monthly report of the State Treasury Service of Ukraine dated January 25, 2022).* Retrieved from https://mof.gov.ua/uk/budget-process-projects-declaration

Ministry of Finance of Ukraine (2023). *Information from the Ministry of Finance of Ukraine on the implementation of the State Budget of Ukraine for 2022*. Retrieved from https://mof.gov.ua/uk/budget_2022-538

Ministry of Finance of Ukraine (2023). *Information on the status of implementation of the Consolidated and State Budgets of Ukraine for January-December 2021-2022 (according to the monthly report of the State Treasury Service of Ukraine dated January 25, 2023).* Retrieved from https://mof.gov.ua/uk/budget_2022-538

Ministry of Finance of Ukraine (2024). *Information from the Ministry of Finance of Ukraine on the implementation of the State Budget of Ukraine for 2023*. Retrieved from https://mof.gov.ua/uk/budget_2023-582

Ministry of Finance of Ukraine (2024). *Information on the status of implementation of the Consolidated and State Budgets of Ukraine for January-December 2022-2023 (according to the monthly report of the State Treasury Service of Ukraine dated January 25, 2024).* Retrieved from https://mof.gov.ua/uk/budget_2023-582

Ministry of Finance of Ukraine (2025). *Information from the Ministry of Finance of Ukraine on the implementation of the State Budget of Ukraine for 2024*. Retrieved from https://mof.gov.ua/uk/budget_of_2024-698

Sirot, G., Unal, U., & Maialeh, R. (2025, 7 Jan.). Inflationary dynamics of labour market activity: Evidence from the Czech Republic. *SSRN Electronic Journal*. doi: 10.2139/ssrn.5016487

Tobera, T., & Busemeyerb, M. R. (2020). Breaking the link? How European integration shapes social policy demand and supply. *Journal of European Public Policy*, *29*(2), 259–280. doi: 10.1080/13501763.2020.1824010

Zagoruiko, I., & Petkova, L. (2024). Asymmetry indices of international position of countries: Geometric approach. *Economic Bulletin of Cherkasy State Technological University*, *25*(1), 32–47. doi: https://doi.org/10.62660/ebcstu/1.2024.32

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Економіка праці та соціальна політика в умовах євроінтеграції

Анотація. Посилення міжнародної конкурентоспроможності є одним із пріоритетів економічного розвитку як провідних країн світу, так і зростаючих економік. Питання ефективної політики з регулювання соціально-трудових відносин за сучасних економічних, демографічних викликів набуває пріоритету як невід'ємна складова довгострокової стратегії зростання. Статтю присвячено порівняльному аналізу соціальної політики та соціально-трудових відносин в Україні та в європейських країнах. Сукупність країн-членів ЄС було доповнено Ісландією, Норвегією та Швейцарією. Як вихідні показники було обрано частки у ВВП оплати праці та державних соціальних видатків. Дослідження охоплювало період 2021–2023 рр. Емпіричний аналіз не виявив істотного кореляційного зв'язку між вихідними показниками. З огляду на це було використано непараметричний підхід. Відповідно до нього для даних кожного року була побудована опукла оболонка даних. На відміну від існуючих досліджень, у пропонованій статті були розглянуті усі частини оболонки. Вона була поділена на дві пари взаємно протилежних міжнародних рубежів, кожному з яких відповідав свій віртуальний екстремум. Точка максимуму обох досліджуваних показників інтерпретувалася як кінцевий стан одночасного збільшення сукупних доходів населення. Точка максимальної оплати праці та мінімальних державних соціальних видатків вважалася віртуальним максимумом заміщення державної соціальної допомоги власними доходами працівників. Вихідні дані нормалізувалися трьома методами. Два з них є класичними – нормалізація за напіврізницями екстремальних значень вихідних показників та нормалізація за середніми квадратичними відхиленнями від напівсум їхніх екстремумів. Третій метод є новим і полягав у нормалізації за напівсумами середніх квадратичних відхилень від екстремумів вихідних показників. Міжнародне положення країн у сфері соціально-трудових відносин характеризувалося за допомогою різниці відстаней до протилежних віртуальних екстремальних станів. Динаміку зміни міжнародного положення країни було проаналізовано за допомогою двох коефіцієнтів ефективності розвитку за відповідними напрямами. Ці коефіцієнти обчислювалися як приріст різниці відстаней країни до протилежних віртуальних екстремумів, поділений на довжину шляху, пройденого нею за цей період. Для України за 2021–2022 рр. обидва коефіцієнти були додатними, а в наступному періоді стали від'ємними. Порівняння відстаней, обчислених у трьох системах координат, підтвердило попереднє припущення, що Z-стандартизація має давати оцінки, найбільші за модулем, а два інші методи – досить близькі. На основі пропонованого підходу можна аналізувати дані, усереднені за декілька років, а також інші макроекономічні показники. Такий аналіз може сприяти оптимізації соціально-економічної політики держави

Ключові слова: міжнародні порівняльні дослідження, соціальна політика**,** оплата праці, соціальний захист, методи нормалізації даних, DEA-моделювання, ефективність соціально-економічного розвитку, наслідки російської агресії

Appendix 1

The state of the studied countries in 2021

Country	Compensation of employees (% of GDP), x	Social protection (% of GDP), y	Position relative to opposite virtual extrema, δ_{21} (distance to the lowest state minus distance to the highest state)					
			by levels of independence of employees from the government social protection system, δ^S			by levels of total income of the population, δ^C		
			systems of normalised coordinates					
			I	II	III	I	II	III
EU-27	47.5	20.2	– 0.181	–0.134	–0.129	1.146	2.436	1.044
Austria	49.6	21.9	–0.237	–0.177	–0.170	1.587	3.373	1.446
Belgium	48.5	20.8	–0.180	–0.099	–0.125	1.327	2.825	1.209
Bulgaria	43.9	12.9	0.612	1.253	0.550	–0.290	–0.483	–0.245
Croatia	45.6	13.9	0.611	1.325	0.560	0.008	0.161	0.027
Cyprus	44.4	13.3	0.596	1.245	0.540	–0.187	–0.263	–0.151
Czech Republic	44.6	13.2	0.629	1.317	0.570	–0.184	–0.250	–0.148
Denmark	49.8	20.3	–0.006	0.284	0.036	1.368	2.962	1.254
Estonia	47.9	13.3	0.906	1.991	0.834	0.113	0.454	0.133
Finland	47.5	25.0	–0.769	–1.300	–0.654	1.744	3.586	1.571
France	51.3	24.8	–0.448	–0.556	–0.353	2.103	4.436	1.911
Germany	53.4	20.5	0.239	0.873	0.269	1.704	3.759	1.571
Greece	38.0	20.3	–1.042	–2.180	–0.944	0.305	0.423	0.246
Hungary	40.7	13.0	0.311	0.539	0.266	–0.561	–1.138	–0.503
Iceland	53.5	13.2	1.377	3.123	1.282	0.533	1.458	0.531
Ireland	26.1	8.2	–0.171	–0.832	–0.221	–2.551	–5.574	–2.345
Italy	40.1	22.6	–1.157	–2.311	–1.033	0.790	1.447	0.687
Latvia	49.2	13.9	0.922	2.076	0.856	0.310	0.885	0.314
Lithuania	47.6	14.2	0.739	1.655	0.685	0.224	0.658	0.229
Luxembourg	47.8	18.4	0.105	0.434	0.125	0.897	1.970	0.826
Malta	41.5	10.1	0.790	1.497	0.694	–0.899	–1.757	–0.797
Netherlands	47.5	16.4	0.385	0.967	0.371	0.557	1.300	0.523
Norway	42.6	18.1	–0.301	–0.557	–0.262	0.390	0.771	0.347
Poland	38.7	17.1	–0.493	–1.095	–0.456	–0.106	–0.347	–0.113
Portugal	47.9	18.1	0.158	0.541	0.172	0.859	1.900	0.793
Romania	37.7	13.3	0.005	–0.172	–0.021	–0.783	–1.695	–0.717
Slovakia	42.6	15.9	0.036	0.092	0.035	0.052	0.121	0.049
Slovenia	52.7	17.9	0.565	1.499	0.556	1.218	2.784	1.137
Spain	48.9	20.1	–0.051	0.168	–0.008	1.258	2.711	1.151
Sweden	47.6	19.2	–0.030	0.165	0.005	1.004	2.167	0.919
Switzerland	58.1	14.1	1.519	3.524	1.425	0.966	2.425	0.932
Ukraine	40.9	6.7	1.129	2.142	0.992	–1.346	–2.652	–1.196
maximum	*58.1*	*25.0*	*1.519*	*3.524*	*1.425*	*2.103*	*4.436*	*1.911*
minimum	*26.1*	*6.7*	*–1.157*	*–2.311*	*–1.033*	*–2.551*	*–5.574*	*–2.345*

Notes: 1) the "Compensation of employees" indicator reflects the total remuneration paid by the employer to employees in cash or in kind; 2) the "Social protection" indicator reflects the corresponding General government expenditures; 3) virtual state of the lowest economic independence of employees is characterised by the lowest level of compensation of employees and the highest level of social protection, virtual state of the lowest total income of the population is characterised by the lowest level of compensation of employees and the lowest level of social protection; 4) to characterise the international position of the country, its distance to a certain highest state was subtracted from the distance to the opposite (lowest) state; 5) I - coordinate system normalised by half-differences of the extrema of initial indicators, II - coordinate system normalised by standard deviations from half-amounts of the extrema of initial indicators, III - coordinate system normalised by half-amounts of standard deviations from the extrema of initial indicators; in all normalised coordinate systems, the half-amount of the extrema of initial indicators was chosen as the origin; 6) when calculating mean squares in systems II and III, the data for the EU-27 were not taken into account

Source: compiled by the authors based on the data from the Eurostat website and the website of the Ministry of Finance of Ukraine

Appendix 2

The state of the studied countries in 2022

Country	Compensation of employees (% of GDP), x	Social protection (% of GDP), y	Position relative to opposite virtual extrema, δ_{22} (distance to the lowest state minus distance to the highest state)					
			by levels of independence of employees from the government social protection system, δ^S			by levels of total income of the population, δ^C		
			systems of normalised coordinates					
			I	II	III	I	II	III
EU-27	46.7	19.3	–0.154	–0.131	–0.106	1.094	2.246	0.990
Austria	48.5	21.6	–0.348	–0.463	–0.270	1.618	3.294	1.459
Belgium	47.7	20,0	–0,180	–0,157	–0,125	1,297	2,662	1,174
Bulgaria	41.8	13.2	0.452	0.875	0.400	–0.357	–0.660	–0.310
Croatia	45.0	13.0	0.763	1.565	0.690	–0.118	–0.110	–0.083
Cyprus	43.5	12.5	0.715	1.427	0.640	–0.325	–0.548	–0.273
Czech Republic	43.0	13.3	0.539	1.078	0.483	–0.238	–0.397	–0.199
Denmark	48.0	18.6	0.061	0.315	0.089	1.088	2.275	0.992
Estonia	47.0	12.6	1.002	2.083	0.912	–0.019	0.136	0.014
Finland	47.4	23.8	–0.713	–1.200	–0.598	1.787	3.582	1.601
France	51.9	23.9	–0.388	–0.479	–0.295	2.232	4.566	2.017
Germany	52.6	20.0	0.188	0.663	0.219	1.711	3.602	1.565
Greece	35.4	18.8	–1.045	–2.166	–0.949	0.043	–0.,093	0.006
Hungary	40.6	13.1	0.365	0.672	0.317	–0.477	–0.926	–0.422
Iceland	52.5	10.9	1.758	3.687	1.605	0.136	0.560	0.173
Ireland	24.7	7.3	0.000	–0.370	–0.066	–2.828	–5.886	–2.574
Italy	39.2	21.4	–1.110	–2.170	–0.985	0.748	1.361	0.646
Latvia	49.5	14.0	0.965	2.087	0.892	0.408	1.020	0.402
Lithuania	46.6	13.5	0.814	1.713	0.744	0.095	0.343	0.113
Luxembourg	49.2	19.1	0.076	0.372	0.107	1.275	2.669	1.163
Malta	41.8	9.8	0.976	1.869	0.859	–0.878	–1.652	–0.768
Netherlands	45.8	15.7	0.368	0.840	0.348	0.402	0.905	0.378
Norway	34.9	14.3	–0.310	–0.781	–0.306	–0.759	–1.638	–0.701
Poland	37.8	16.7	–0.482	–1.023	–0.442	–0.106	–0.308	–0.112
Portugal	46.6	17.5	0.129	0.407	0.142	0.780	1.648	0.714
Romania	37.3	13.4	0.036	–0.052	0.010	–0.712	–1.475	–0.647
Slovakia	42.5	15.6	0.107	0.242	0.101	0.107	0.242	0.101
Slovenia	51.9	17.8	0.486	1.226	0.481	1.257	2.712	1.161
Spain	47.7	18.4	0.070	0.324	0.095	1.028	2.153	0.938
Sweden	47.0	18.9	–0.066	0.044	–0.028	1.053	2.179	0.956
Switzerland	57.8	12.7	1.762	3.811	1.629	0.754	1.851	0.736
Ukraine	53.3	8.7	2.198	4.548	1.995	–0.115	0.082	–0.047
maximum	*57.8*	*23.9*	*2.198*	*4.548*	*1.995*	*2.232*	*4.566*	*2.017*
minimum	*24.7*	*7.3*	*–1.110*	*–2.170*	*–0.985*	*–2.828*	*–5.886*	*–2.574*

Note: see Appendix 1

Source: compiled by the authors based on the data from the Eurostat website and the website of the Ministry of Finance of Ukraine

Appendix 3

The state of the studied countries in 2023

Country	Compensation of employees (% of GDP), x	Social protection (% of GDP), y	Position relative to opposite virtual extrema, δ_{23} (distance to the lowest state minus distance to the highest state)					
			by levels of independence of employees from the government social protection system, δ^S			by levels of total income of the population, δ^C		
			systems of normalised coordinates					
			I	II	III	I	II	III
EU-27	47.0	19.2	–0.060	0.023	–0.039	0.712	1.555	0.650
Austria	49.6	21.4	–0.156	–0.077	–0.116	1.295	2.816	1.181
Belgium	49.1	20.1	–0.011	0.197	0.012	1.047	2.304	0.957
Bulgaria	43.7	13.8	0.483	0.966	0.432	–0.437	–0.854	–0.388
Croatia	46.2	13.0	0.838	1.770	0.759	–0.326	–0.537	–0.280
Cyprus	43.5	15.1	0.264	0.525	0.236	–0.255	–0.502	–0.227
Czech Republic	42.9	13.5	0.454	0.876	0.403	–0.556	–1.123	–0.498
Denmark	51.0	19.5	0.238	0.762	0.242	1.120	2.527	1.031
Estonia	49.7	13.5	1.085	2.406	0.994	0.055	0.350	0.073
Finland	48.5	25.7	–0.783	–1.386	–0.682	1.727	3.626	1.562
France	51.3	23.4	–0.281	–0.282	–0.223	1.750	3.785	1.594
Germany	53.1	19.7	0.376	1.104	0.372	1.331	3.027	1.227
Greece	34.4	18.5	–1.081	–2.505	–1.001	–0.513	–1.363	–0.493
Hungary	41.1	12.3	0.464	0.825	0.404	–0.903	–1.884	–0.816
Iceland	52.8	10.8	1.795	3.938	1.640	–0.071	0.187	–0.030
Ireland	28.0	8.1	–0.034	–0.524	–0.076	–2.771	–6.119	–2.537
Italy	38.6	21.1	–1.126	–2.429	–1.025	0.226	0.261	0.183
Latvia	52.5	13.5	1.331	3.006	1.225	0.284	0.901	0.288
Lithuania	48.5	14.0	0.897	1.983	0.821	0.026	0.252	0.044
Luxembourg	48.7	20.2	–0.061	0.085	–0.033	1.025	2.246	0.937
Malta	40.7	9.7	0.771	1.427	0.678	–1.292	–2.669	–1.164
Netherlands	45.9	16.2	0.311	0.716	0.288	0.137	0.371	0.132
Norway	42.2	17.5	–0.233	–0.513	–0.213	0.004	–0.044	–0.002
Poland	39.1	16.9	–0.418	–1.006	–0.391	–0.370	–0.911	–0.348
Portugal	47.1	16.6	0.356	0.854	0.332	0.308	0.759	0.290
Romania	37.7	12.8	0.091	–0.042	0.058	–1.150	–2.512	–1.050
Slovakia	41.7	17.6	–0.294	–0.655	–0.270	–0.026	–0.123	–0.030
Slovenia	51.2	17.0	0.646	1.589	0.608	0.727	1.751	0.680
Spain	47.8	18.5	0.118	0.410	0.123	0.674	1.514	0.620
Sweden	47.4	18.7	0.052	0.262	0.063	0.670	1.488	0.614
Switzerland	58.9	13.1	1.854	4.248	1.712	0.678	1.852	0.657
Ukraine	49.6	7.8	1.838	3.890	1.665	–0.691	–1.166	–0.596
maximum	*58.9*	*25.7*	*1.854*	*4.248*	*1.712*	*1.750*	*3.785*	*1.594*
minimum	*28.0*	*7.8*	*–1.126*	*–2.505*	*–1.025*	*–2.771*	*–6.119*	*–2.537*

Note: see Appendix 1

Source: compiled by the authors based on the data from the Eurostat website and the website of the Ministry of Finance of Ukraine

Appendix 4

The effectiveness of socio-economic development of the studied countries for 2021-2022

Country	The length of the travelled path (distance between old and new states), $\rho(\mathcal{P}^*_{21};\mathcal{P}^*_{22})$			The coefficient of efficiency of movement relative to the extrema of economic independence of employees, ϵ^S			The coefficient of efficiency of movement relative to the extrema of the total income of the population, ϵ^C		
	systems of normalised coordinates								
	I	II	III	I	II	III	I	II	III
EU-27	0.031	0.102	0.031	0.880	0.028	0.755	–1.705	–1.869	–1.743
Austria	0.069	0.147	0.060	–1.610	–1.942	–1.661	0.440	–0.537	0.225
Belgium	0.015	0.085	0.018	0.002	–0.682	–0.037	–1.987	–1.928	–1.984
Bulgaria	0.086	0.203	0.081	–1.854	–1.866	–1.870	–0.782	–0.875	–0.804
Croatia	0.100	0.187	0.088	1.513	1.279	1.471	–1.256	–1.449	–1.254
Cyprus	0.095	0.176	0.083	1.252	1.032	1.198	–1.458	–1.620	–1.461
Czech Republic	0.052	0.134	0.050	–1.724	–1.790	–1.760	–1.036	–1.102	–1.033
Denmark	0.145	0.348	0.135	0.468	0.088	0.396	–1.938	–1.973	–1.942
Estonia	0.084	0.166	0.074	1.148	0.551	1.044	–1.564	–1.913	–1.600
Finland	0.036	0.087	0.034	1.552	1.151	1.645	1.194	–0.052	0.899
France	0.072	0.085	0.061	0.836	0.908	0.953	1.796	1.534	1.746
Germany	0.030	0.125	0.029	–1.707	–1.686	–1.702	0.233	–1.258	–0.237
Greece	0.140	0.291	0.128	–0.020	0.046	–0.040	–1.873	–1.770	–1.869
Hungary	0.049	0.121	0.047	1.106	1.105	1.088	1.689	1.764	1.735
Iceland	0.279	0.555	0.248	1.364	1.017	1.302	–1.423	–1.620	–1.442
Ireland	0.164	0.301	0.142	1.041	1.532	1.096	–1.692	–1.035	–1.618
Italy	0.039	0.119	0.039	1.186	1.185	1.208	–1.092	–0.721	–1.057
Latvia	0.058	0.086	0.051	0.733	0.127	0.700	1.686	1.566	1.712
Lithuania	0.076	0.158	0.067	1.005	0.365	0.887	–1.696	–1.989	–1.730
Luxembourg	0.189	0.353	0.169	–0.153	–0.174	–0.105	1.995	1.977	1.995
Malta	0.100	0.190	0.088	1.866	1.962	1.870	0.208	0.552	0.332
Netherlands	0.079	0.200	0.074	–0.212	–0.634	–0.312	–1.958	–1.974	–1.955
Norway	0.578	1.216	0.528	–0.016	–0.184	–0.083	–1.987	–1.981	–1.987
Poland	0.006	0.036	0.007	1.998	1.988	2.000	–0.023	1.067	0.202
Portugal	0.043	0.135	0.042	–0.681	–0.998	–0.724	–1.844	–1.876	–1.857
Romania	0.039	0.118	0.038	0.803	1.015	0.816	1.822	1.864	1.847
Slovakia	0.045	0.093	0.041	1.575	1.611	1.593	1.229	1.292	1.261
Slovenia	0.045	0.135	0.042	–1.746	–2.024	–1.816	0.859	–0.530	0.583
Spain	0.132	0.305	0.122	0.914	0.511	0.846	–1.742	–1.832	–1.750
Sweden	0.032	0.052	0.026	–1.157	–2.302	–1.261	1.559	0.229	1.433
Switzerland	0.158	0.324	0.140	1.536	0.887	1.456	–1.343	–1.775	–1.395
Ukraine	0.821	1.795	0.761	1.303	1.340	1.319	1.499	1.523	1.510
maximum	*0.821*	*1.795*	*0.761*	*1.998*	*1.988*	*2.000*	*1.995*	*1.977*	*1.995*
minimum	*0.006*	*0.036*	*0.007*	*–1.854*	*–2.302*	*–1.870*	*–1.987*	*–1.989*	*–1.987*

Note: Efficiency coefficients were calculated as the increment of the difference in distances to opposite extreme states divided by the length of the path travelled by the country

Source: compiled by the authors based on calculations according to Appendices 1, 2

Appendix 5

The effectiveness of socio-economic development of the studied countries for 2022-2023

Country	The length of the travelled path (distance between old and new states), $\rho(\boldsymbol{\mathcal{P}}^*_{22};\boldsymbol{\mathcal{P}}^*_{23})$			The coefficient of efficiency of movement relative to the extrema of economic independence of employees, ϵ^S			The coefficient of efficiency of movement relative to the extrema of the total income of the population, ϵ^C		
	systems of normalised coordinates								
	I	II	III	I	II	III	I	II	III
EU-27	0.199	0.363	0.177	0.469	0.425	0.377	–1.922	–1.901	–1.923
Austria	0.207	0.352	0.180	0.924	1.094	0.855	–1.558	–1.359	–1.545
Belgium	0.158	0.271	0.137	1.071	1.305	1.000	–1.588	–1.319	–1.576
Bulgaria	0.044	0.119	0.042	0.702	0.765	0.758	–1.808	–1.623	–1.840
Croatia	0.116	0.265	0.108	0.644	0.776	0.633	–1.788	–1.610	–1.814
Cyprus	0.231	0.458	0.207	–1.951	–1.967	–1.947	0.305	0.100	0.221
Czech Republic	0.165	0.375	0.154	–0.516	–0.538	–0.521	–1.923	–1.936	–1.948
Denmark	0.097	0.257	0.088	1.819	1.737	1.745	0.335	0.979	0.444
Estonia	0.057	0.187	0.053	1.451	1.735	1.558	1.284	1.150	1.112
Finland	0.046	0.135	0.046	–1.514	–1.377	–1.810	–1.289	0.331	–0.857
France	0.290	0.488	0.255	0.367	0.404	0.280	–1.660	–1.602	–1.660
Germany	0.210	0.367	0.185	0.896	1.201	0.825	–1.815	–1.565	–1.826
Greece	0.300	0.689	0.273	–0.120	–0.492	–0.191	–1.851	–1.844	–1.829
Hungary	0.226	0.515	0.208	0.436	0.298	0.421	–1.884	–1.862	–1.889
Iceland	0.124	0.274	0.117	0.301	0.915	0.303	–1.678	–1.362	–1.736
Ireland	0.034	0.147	0.020	–1.008	–1.047	–0.520	1.704	–1.583	1.842
Italy	0.285	0.591	0.256	–0.056	–0.437	–0.155	–1.830	–1.864	–1.812
Latvia	0.191	0.465	0.176	1.915	1.978	1.898	–0.648	–0.256	–0.649
Lithuania	0.054	0.149	0.052	1.514	1.807	1.485	–1.270	–0.612	–1.333
Luxembourg	0.145	0.258	0.133	–0.939	–1.114	–1.055	–1.720	–1.635	–1.698
Malta	0.229	0.548	0.214	–0.895	–0.806	–0.847	–1.805	–1.856	–1.848
Netherlands	0.138	0.276	0.127	–0.415	–0.449	–0.478	–1.931	–1.938	–1.946
Norway	0.387	0.808	0.354	0.199	0.332	0.264	1.973	1.973	1.977
Poland	0.137	0.303	0.123	0.465	0.055	0.412	–1.932	–1.990	–1.914
Portugal	0.261	0.514	0.234	0.871	0.870	0.815	–1.811	–1.730	–1.813
Romania	0.221	0.523	0.204	0.246	0.021	0.237	–1.978	–1.981	–1.976
Slovakia	0.211	0.470	0.195	–1.898	–1.908	–1.903	–0.627	–0.776	–0.672
Slovenia	0.276	0.524	0.249	0.580	0.691	0.512	–1.917	–1.834	–1.930
Spain	0.178	0.326	0.160	0.273	0.264	0.176	–1.984	–1.960	–1.989
Sweden	0.202	0.372	0.180	0.587	0.586	0.503	–1.901	–1.855	–1.904
Switzerland	0.058	0.213	0.056	1.568	2.049	1.478	–1.297	0.009	–1.414
Ukraine	0.371	0.791	0.345	–0.971	–0.831	–0.955	–1.553	–1.578	–1.588
maximum	*0.387*	*0.808*	*0.354*	*1.915*	*2.049*	*1.898*	*1.973*	*1.973*	*1.977*
minimum	*0.034*	*0.119*	*0.020*	*–1.951*	*–1.967*	*–1.947*	*–1.984*	*–1.990*	*–1.989*

Note: see Appendix 4

Source: compiled by the authors based on calculations according to Appendices 2, 3

Appendix 6

Comparative effectiveness of alternative directions of socio-economic development of the studied countries in 2021-2023

Country	Difference in efficiency coefficients of virtual socio-economic development, $\varepsilon^S - \varepsilon^C$								
	2021			2022			2023		
	systems of normalised coordinates								
	I	II	III	I	II	III	I	II	III
EU-27	–0.130	–0.134	–0.131	–0.123	–0.125	–0.124	–0.059	–0.059	–0.059
Austria	–0.212	–0.221	–0.216	–0.180	–0.189	–0.184	–0.165	–0.170	–0.167
Belgium	–0.169	–0.174	–0.171	–0.162	–0.166	–0.164	–0.124	–0.127	–0.125
Bulgaria	0.027	0.028	0.028	0.003	0.004	0.004	–0.004	–0.003	–0.004
Croatia	0.045	0.046	0.045	0.064	0.065	0.064	0.054	0.055	0.054
Cyprus	0.035	0.035	0.035	0.037	0.037	0.037	–0.001	–0.001	–0.001
Czech Republic	0.039	0.040	0.040	0.024	0.024	0.024	–0.024	–0.022	–0.024
Denmark	–0.199	–0.206	–0.202	–0.135	–0.139	–0.137	–0.139	–0.144	–0.140
Estonia	0.097	0.099	0.098	0.114	0.117	0.115	0.134	0.138	0.136
Finland	0.070	0.026	0.055	0.041	0.007	0.027	0.075	0.035	0.065
France	–0.085	–0.131	–0.101	–0.089	–0.132	–0.107	–0.226	–0.238	–0.229
Germany	–0.277	–0.294	–0.283	–0.286	–0.299	–0.291	–0.174	–0.183	–0.176
Greece	0.130	0.122	0.127	0.126	0.121	0.124	0.090	0.087	0.089
Hungary	–0.033	–0.031	–0.033	–0.018	–0.017	–0.018	–0.094	–0.088	–0.093
Iceland	0.156	0.166	0.159	0.302	0.315	0.308	0.301	0.313	0.304
Ireland	–0.487	–0.461	–0.478	–0.586	–0.559	–0.575	–0.566	–0.536	–0.559
Italy	0.161	0.143	0.155	0.146	0.134	0.141	0.149	0.141	0.147
Latvia	0.091	0.095	0.092	0.090	0.094	0.092	0.185	0.194	0.187
Lithuania	0.062	0.063	0.062	0.079	0.081	0.080	0.094	0.096	0.095
Luxembourg	–0.095	–0.097	–0.096	–0.179	–0.185	–0.182	–0.117	–0.119	–0.117
Malta	–0.080	–0.071	–0.077	–0.067	–0.057	–0.063	–0.205	–0.186	–0.201
Netherlands	–0.021	–0.021	–0.021	–0.003	–0.003	–0.003	0.010	0.010	0.010
Norway	–0.004	–0.004	–0.004	–0.052	–0.051	–0.052	0.007	0.007	0.007
Poland	0.028	0.027	0.027	0.026	0.026	0.026	0.004	0.004	0.004
Portugal	–0.086	–0.089	–0.087	–0.072	–0.074	–0.073	0.004	0.004	0.004
Romania	–0.073	–0.070	–0.072	–0.061	–0.059	–0.061	–0.151	–0.144	–0.150
Slovakia	–0.000	–0.000	–0.000	0.000	0.000	0.000	0.011	0.010	0.011
Slovenia	–0.120	–0.128	–0.123	–0.141	–0.149	–0.144	–0.013	–0.014	–0.013
Spain	–0.169	–0.174	–0.171	–0.122	–0.125	–0.123	–0.054	–0.055	–0.055
Sweden	–0.114	–0.117	–0.115	–0.122	–0.125	–0.123	–0.054	–0.055	–0.055
Switzerland	0.056	0.054	0.055	0.102	0.100	0.101	0.119	0.116	0.118
Ukraine	–0.257	–0.220	–0.244	0.380	0.397	0.387	–0.040	0.002	–0.029
maximum	*0.161*	*0.166*	*0.159*	*0.380*	*0.397*	*0.387*	*0.301*	*0.313*	*0.304*
minimum	*–0.487*	*–0.461*	*–0.478*	*–0.586*	*–0.559*	*–0.575*	*–0.566*	*–0.536*	*–0.559*

Notes: 1) the length of the virtual path to a certain highest state is equal to the distance of the country to it; 2) at the points of the highest states, the difference in the distances of countries to the opposite extrema of the same name is equal to the length of the diagonal of the virtual rectangle; 3) to compare the effectiveness of alternative directions of socio-economic development, the coefficient of efficiency of achieving the state of the highest total income of the population was subtracted from the coefficient of efficiency of achieving the state of the highest economic independence of employees

Source: compiled by the authors based on calculations according to appendices 1, 2, 3