Adaptation of the UN's gender inequality index to Ukraine's regions

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This article analyses the application of the Human Development Index (HDI) and its derivative indices that take into account the gender factor. Currently, this index is used both for ranking countries based on their level of human development and for studying the situation in regions in the context of the indicators of this index. We proceed from the fact that, for countries for which sub-national regional indicators are very diverse in different spheres, it is expedient to adapt not only the index of human development, but also the indices of the development of human potential, taking into account the gender factor. This study suggests an adaptation of the Gender Inequality Index (GII) in the United Nations' (UN) basic methodology to the sub-national level. The method suggested by the authors enables the use of this adaptation for a revision of the system of indicators for which the index is determined. Our results allowed us to compare the indicators and the trends in the two methods for calculating the sub-national indices based on the corresponding indicators in the observed country from the previous 10 years. We concluded that the GII indicators based on an entire country and those derived by the UN's basic methodology do not reflect a wide sub-national disparity. The expansion of the base of the indicators for the determination of GII allowed the development of a new method for a sub-national GII adaptation. The aim was to adjust GII calculated according to the basic methodology and, therefore, to provide more objective political, economic, and social recommendations in the context of development of human potential, taking into account the gender factor.

Introduction

Since 1990, the United Nations Development Program (UNDP) has published the World Human Development Reports. The methods for calculating the various indices for measuring human development appear in the technical applications of these documents. These indices allow a comparative analysis of the progress of particular countries and regions of the world. Every year, the number of countries for which these indices are calculated increases. To date, more than 180 countries have been represented in the statistical annexes of these reports. Since 1994, most of these countries have been publishing the annual national human development reports (Kolesov 2008).

The method of calculating the HDI was published for the first time (UNDP 1990) in the 1990 UN experts' report 'The Concept and Measurement of Human Development'. In 1995, the method of calculating two human development indices – Gender Development Index (GDI) and Gender Empowerment Measure (GEM) (UNDP 1995) – started taking into account the gender factor. The idea embodied in these indices is based on the statement that gender inequality inhibits human development, and the average level of achievements in a particular country cannot be adequately evaluated without considering the inequality between men and women. In the formulation of 'The Concept and Measurement of Human Development', the idea was that development is a process in which the person is in the centre. Consequently, the main components of HDI at the UN level were health, education, and material well-being.

Currently, HDI is used both to rank countries in terms of human development and to examine the situation in different regions according to the indicators used in this index. Thus, the HDI can be adapted to the sub-national level. Since the statistical indicators for calculating HDI are available, it is natural to expand the set of indicators that characterize human development in a particular country with additional economic, educational, and health indicators.

For countries where the sub-national indicators vary across regions, it is advisable to adapt not only HDI, but also the human development indices with the gender factor. Moreover, the indicators of the GII in a single country can conceal serious sub-national imbalances and disparities. Therefore, this study proposes a method for adapting GII to the sub-national level.

Literature review

The indices that can be used to assess the gender parity in a country or region can be categorized as simple or complex. The main simple indices for estimating the gender inequality in demographic and social statistics are summarized in Akbash et al. (2018). Simple indices measure gender inequality based on a single indicator in a

particular area. Recently, much research has been devoted to the analysis of inequalities for various sub-national simple indicators. For example, sub-national health inequalities without a gender factor are considered in Egri (2017) and Uzzoli (2016).

For gender analysis that covers several areas of human activity simultaneously, complex indices are used. These indices are calculated at the country level and used to rank countries by the level of gender inequality in the context of human development.

Attempts have been made in some countries to assess the regional development of society. For example, an international methodology was used in Poland (NHDRP 2012) and China (CNHDR 2013). The indicators for achieving the UN's Millennium Development Goals (ESD 2009) were used as the basis for calculating regional HDI in the Russian Federation (RUNDP 2006),

In 2000, the National Academy of Sciences of Ukraine developed a national methodology for assessing human development (Libanova et al. 2002). This methodology was based on the use of 96 indicators, reflecting nine aspects of human development: living conditions, social environment, the state of the labour market, social financing, demographic development, health care, education, material well-being, and ecological status. Since 2001, the State Statistics Committee of Ukraine began the annual monitoring of the Regional Human Development Index. Further, in 2003, the first report on the level of human development in the regions of Ukraine was prepared by the Institute of Demography and Social Research of the National Academy of Sciences of Ukraine and the State Statistics Committee of Ukraine (HDU 2003). This approach to adapting the HDI is original, but it raises the logical question regarding the possible multicollinearity among the variables in the calculations – although Libanova et al. (2002) attempted to eliminate this problem by introducing weights.

Main research results

Description of the data and its sources

To adapt GII to the sub-national level (e.g. the Kirovohrad region in Ukraine), the GII's analysis period, and its trends during 2010–2017, we use the basic method for calculating the index from the technical annexes of the Human Development Report (UNDP 2018). GII characterizes, for the countries (areas) on which qualitative and quantitative data exist, the degree of the unfavourable position of one of the physiological sexes (in this case, females) in three dimensions: empowerment, economic activity, and reproductive health. Hence, GII shows the degree of the negative influence on human development due to the inequality in achievements between women and men in these dimensions.

Recall that GEM has been used since 1995 to demonstrate gender inequality, and, in 2010, it was replaced by GII. GEM reflected the inequalities between men and women in political and economic participation and decision-making positions, as well as positions in the management of economic resources. The structure of the dimensions and indicators of GEM is shown in Figure 1.

Figure 1

Calculating the GEM – graphical presentation

Gender Empowerment Measure
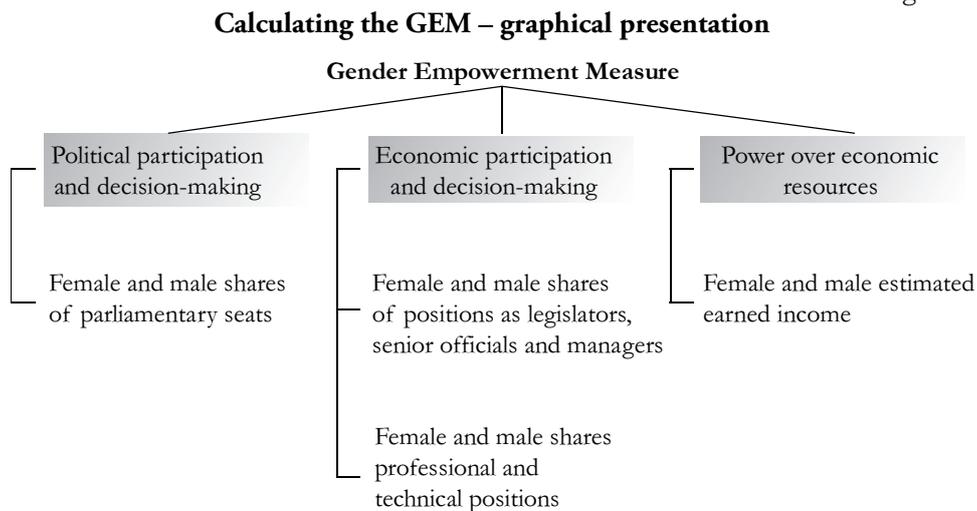
GII reflects not only the disadvantaged position of women in sharing political power, but also in reproductive health. It also displays inequality at the level of secondary education. The structure of the dimensions and indicators of GII is shown in Figure 2.

Figure 2

Calculating GII – graphical presentation
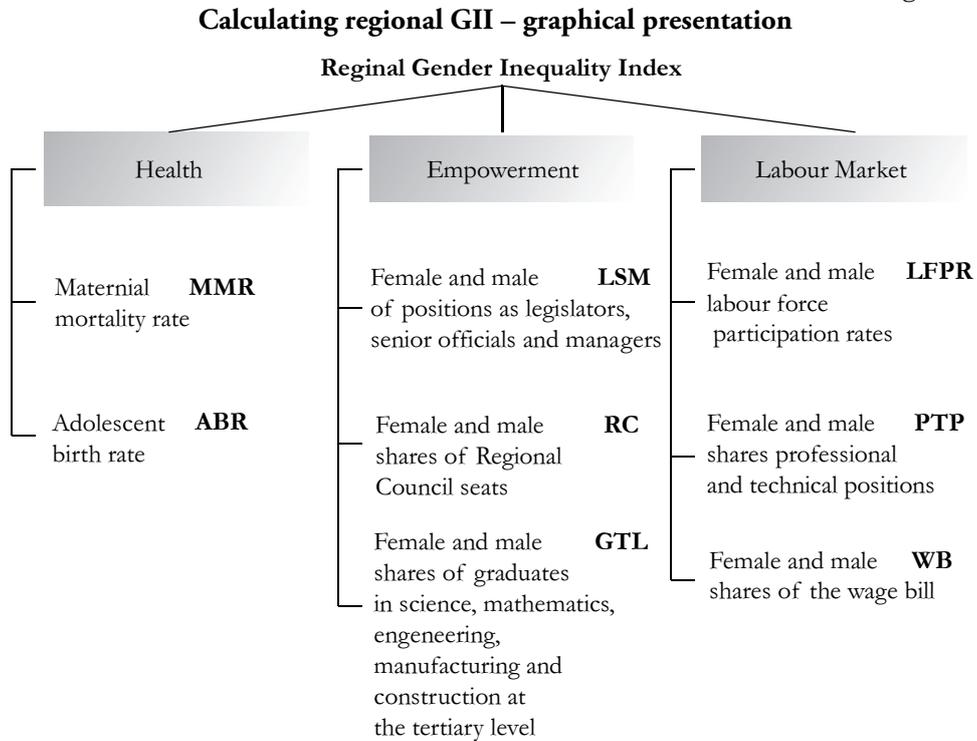
Gender Inequality Index
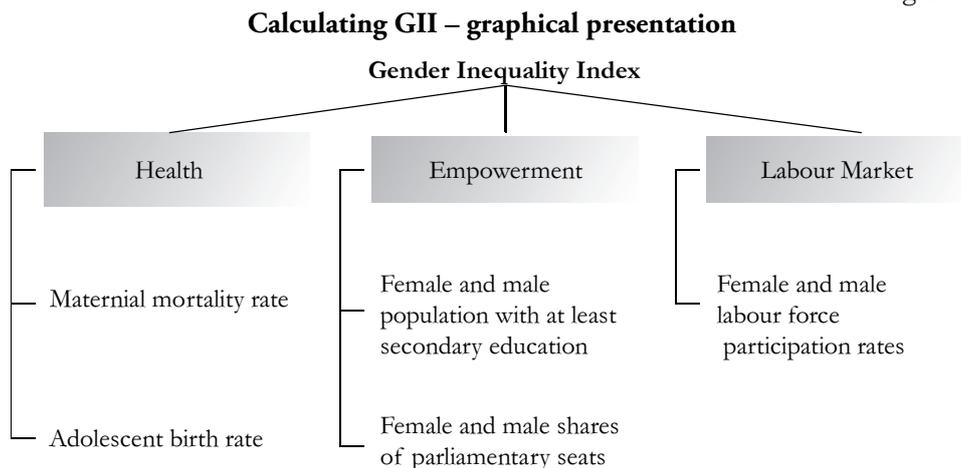
Later in this article, we will demonstrate the calculation of GII at the sub-national level using the basic UN methodology without changing the set of indicators, and also offer our own version of the GII sub-national adaptation with an expanded base of indicators that will be more sensitive to gender inequality in the key areas of human activity.

To construct a regional GII, we combined the GEM and GII indicators as follows:

- The dimension of Health in GII remains unchanged in structure.
- The dimension of empowerment has been modified. The 'Female and male shares of parliamentary seats' indicator was replaced by the corresponding 'Female and male shares of the Regional Council seats' indicator. The 'Female and male population with at least secondary education' indicator is not relevant at the level of Ukrainian regions, since secondary education is compulsory for all. Moreover, this figure has not been calculated since 2001 – since the last census in the country. Accordingly, this educational indicator – 'Female and male population with at least secondary education' – was replaced by the more relevant and more informative 'Female and male shares of graduates in science, mathematics, engineering, manufacturing, and construction at the tertiary level', selected from the Human Development Data in Dashboard 3: Women's empowerment (UNDP 2018). Additionally, the indicator 'Female and male shares of positions as legislators, senior officials, and managers' has been added to GII. Moreover, the indicator 'Female and male shares of positions as legislators, senior officials, and managers' has been added from set of indicators of GEM.
- The Labour market dimension has been expanded with two indicators from GEM. The indicator 'Female and male shares of professional and technical positions' has been added. Also included was the indicator 'Female and male shares of the wage bill', from which the indicator 'Female and male estimated earned income' was calculated. However, at the sub-national level of one country, there is no need to recalculate women and men's incomes into US dollars, so we settled on their shares of the wage bill. The indicator 'Female and male labour force participation rates' has been retained.

Figure 3 shows the structure of the adapted regional GII, as well as abbreviations of the GII indicators that will be used in the article.

Figure 3

Calculating regional GII – graphical presentation

Reginal Gender Inequality Index

Health	Empowerment	Labour Market

Maternial **MMR**
mortality rate

Adolescent **ABR**
birth rate

Female and male **LSM**
of positions as legislators,
senior officials and managers

Female and male **RC**
shares of Regional
Council seats

Female and male **GTL**
shares of graduates
in science, mathematics,
engeneering,
manufacturing and
construction at
the tertiary level

Female and male **LFPR**
labour force
participation rates

Female and male **PTP**
shares professional
and technical positions

Female and male **WB**
shares of the wage bill

This change in the method of calculating the regional GII for Kirovohrad allows us: a) to take into account the existing regional disparity in the characteristics of a possible existing gender inequality in a wider number of indicators; b) to investigate the dynamics of this change, not only in the general regional GII over a given period, but also the dynamics of their composite indicators; and, c) to provide objective political, economic, and social recommendations for a particular region in the context of human development with a gender perspective.

Calculation of regional GII according to basic UN methodology

Based on the UN methodology, we create Table 1, showing the definition and data sources for all composite GII indicators (UNDP 2018).

Table 1

Indicators and data sources for UN's regional GII

Indicator	Definition	Data source
	Health	
Maternal mortality ratio (MMR)	Number of deaths due to pregnancy-related causes per 100,000 live births.	Databank of the State Statistics Service of Ukraine (DSSSU 2017).
Adolescent birth rate (ABR)	Number of births to women ages 15–19 per 1,000 women ages 15–19.	State Statistics Service of Ukraine. Population Of Ukraine. Demographic Yearbook (SSSU 2017).
	Empowerment	
Share of seats in Regional Council (RC)	Proportion of seats held by women in the Regional Council, expressed as a percentage of total seats.	Kirovohrad Regional Council website: www.oblrada.kirovograd.ua
Population with at least some secondary education (SE)	Percentage of the population aged 25 and older who have reached (but not necessarily completed) a secondary level of education.	The data were obtained based on the results of Ukraine's last census in 2001 and have not been updated yet (DSSSU 2017).
	Labour market	
Labour force participation rate (LFPR)	Proportion of working-age population (ages 15 and older) engaging in the labour market, either by working or by actively looking for work, expressed as a percentage of the working-age population.	Main Department of Statistics in Kirovohrad Region (DSKR 2017).

Next, we present the main steps of the basic method of calculating GII in the form of Table 2 (UNDP 2018).

Table 2

Steps for calculating the UN's regional GII

№	Step	Calculation
1	Treating zeros and extreme values	Since a geometric mean cannot be computed from zero values, a minimum value of 0.1 percent is set for all component indicators.
2	Aggregating across the dimensions within each gender group using geometric means.	For women, the aggregation formula is $$G_F = \sqrt[3]{\left(\frac{10}{MMR} \cdot \frac{1}{ABR}\right)^{1/2} \cdot (RC_F \cdot SE_F)^{\frac{1}{2}} \cdot LFPR_F}$$ And, for men, the formula is $$G_M = \sqrt[3]{1 \cdot (RC_M \cdot SE_M)^{1/2} \cdot LFPR_M}$$
3	Aggregating across the gender groups using a harmonic mean.	$$HARM(G_F, G_M) = \left[\frac{(G_F)^{-1} + (G_M)^{-1}}{2}\right]^{-1}$$

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№	Step	Calculation
4	Calculating the geometric mean of the arithmetic means for each indicator	$\overline{health} = \dfrac{\left(\sqrt{\left(\frac{10}{MMR}\right)\cdot\left(\frac{1}{ABR}\right)}+1\right)}{2}$ $\overline{emp} = \left(\sqrt{RC_F \cdot SE_F} + \sqrt{RC_M \cdot SE_M}\right)\cdot {}^1\!/_2$ $\overline{LFPR} = \dfrac{LFPR_F + LFPR_M}{2}$ $G_{F,M} = \sqrt[3]{\overline{health}\cdot\overline{emp}\cdot\overline{LFPR}}$
5	Calculating GII	$GII = 1 - \dfrac{HARM(G_F, G_M)}{G_{F,M}}$

Implementation of GII calculation according to basic UN methodology

<u>Step 1.</u> Because a geometric mean cannot be computed in the presence of zero values, a minimum value of 0.1 percent is set for all component indicators. Further, as higher maternal mortality suggests poorer maternal health, for the maternal mortality ratio, the maximum value is truncated to 1,000 deaths per 100,000 births and the minimum value set at 10. The rationale is that countries where maternal mortality ratios exceed 1,000 do not differ in their inability to create conditions and ensure support for maternal health, that countries with 10 or fewer deaths are performing at essentially the same level, and that small differences are random. The representation of women in countries' (regions') parliaments (regional councils), fixed at a level of 0%, will be encoded as 0.1% because: a) the geometric mean cannot have zero values, and b) women in such countries (regions) still have some political influence.

In Tables 3 and 4, we present the data values that will be used to calculate, using UNDP methodology, the GII for Ukraine and the sub-national adaptation of GII (using the example of Kirovohrad Oblast) for the period 2010–2017.

Table 3

Composite indicators of the GII for Ukraine

Year	Health		Empowerment				Labour market	
	ABR	MMR	PR female	PR male	SE female	SE male	LFPR female	LFPR male
2010	28.3	18	8.2	91.8	91.5	96.1	62.3	72.6
2011	30.8	26	8.0	92.0	91.5	96.1	52.0	65.4
2012	28.0	25	8.0	92.0	91.5	96.1	47.5	63.9
2013	26.1	32	8.0	92.0	91.5	96.1	53.3	66.6
2014	25.7	32	9.4	90.6	91.5	96.1	53.0	66.6
2015	25.7	23	11.8	88.2	91.7	95.9	53.2	66.9
2016	24.1	24	12.1	87.9	94.3	96.0	52.2	67.4
2017	23.8	24	12.3	87.7	94.5	95.6	46.9	63.0

Table 4

Composite indicators of the GII for the Kirovohrad region

Year	Health		Empowerment				Labour market	
	ABR	MMR	RC female	RC male	SE female	SE male	LFPR female	LFPR male
2010	38.6	85.5	16.16	83.84	94.2	92.1	58.1	67.4
2011	39.6	28.4	16.16	83.84	94.2	92.1	57.8	69.6
2012	42.2	18.1	16.16	83.84	94.2	92.1	57.8	71.0
2013	39.5	0.0	16.16	83.84	94.2	92.1	56.0	69.0
2014	40.9	37.8	16.16	83.84	94.2	92.1	55.2	67.5
2015	41.5	10.6	14.75	85.25	94.2	92.1	54.4	68.5
2016	34.1	33.9	14.75	85.25	94.2	92.1	54.0	67.5
2017	29.5	0.0	14.75	85.25	94.2	92.1	54.5	67.7

Taking into account the extreme values in the calculations, we set the MMR values for the Kirovohrad region in 2013 and 2017 at 10.

Step 2. Aggregation is the first step towards making the GII available for interconnection (calculated using the formulas in row 2 of Table 2).

Step 3. The female and male indices are aggregated by the harmonic mean to create the equally distributed gender index, to generate an equally distributed gender index (calculated using formulas in row 3 of Table 2). Using the harmonic mean of within-group geometric means captures the inequality between women and men and adjusts for the associations among dimensions – that is, it accounts for the overlapping inequalities in the different dimensions.

Step 4. The reference standard for computing inequality is obtained by aggregating female and male indices using equal weights (thus treating genders equally) and then aggregating the indices across the dimensions (calculated using the formulas in row 4 of Table 2). $\overline{health}$ should not be interpreted as an average of the corresponding female and male indices, but rather, as half the distance from the norms established for the reproductive health indicators – fewer maternal deaths and fewer adolescent pregnancies.

Step 5. Comparing the equally distributed gender index to the reference standard yields GII. It ranges from 0 – where women and men fare equally – to 1 – where one gender fares as poorly as possible in all measured dimensions (calculated according to the formulas in row 5 of Table 2).

Analysis of the outcome of comparing the results of the GII calculation according to the basic methodology for a country and its region

The results of the calculation of GII according to the basic methodology and the dynamics across 2010–2017 in Ukraine and the Kirovohrad region are presented in Figure 4.

Figure 4

Dynamics of GII values (calculated according to the basic method)
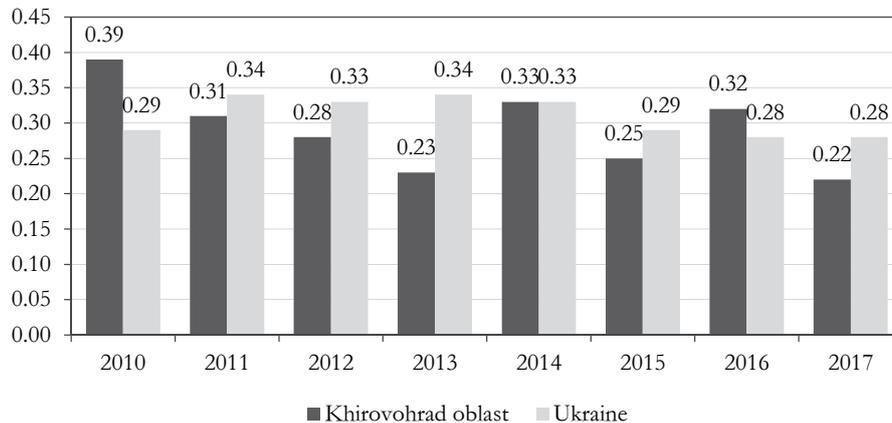
All index values are in the interval [0.216, 0.388], therefore, we can conclude that there are gender inequalities, but, compared to those in other countries, the values are not critically low (e.g. UNDP (2018)). However, the analysis of the dynamics in GII confirms the thesis that the overall GII of the country does not reveal the sub-national disparities. The variability of GII is within the limits of permissible values – in Ukraine, it does not exceed 9%, and, in the Kirovohrad region, it is 21%. However, there is no direct linear relationship between the dynamics of these indicators (the correlation coefficient is negative, namely, –0.156). Consequently, the indicator of the regional GII takes into account the peculiarities of the region, the trends of which do not coincide with (or deviate from) the characteristics of the country as a whole. Indeed, a statistical analysis of the data in Tables 3 and 4 allows us to draw the following conclusions: a) in the analysed region and in the country as a whole, there is a partial direct relationship between the dynamics of the ABR indicators (correlation coefficient 0.573) and the dynamics of the LFPR female indicators (correlation coefficient 0.323); b) there is a strong negative correlation between RC and PR dynamics (correlation coefficient –0.971), and there is also a partial feedback between the dynamics of MMR values (correlation coefficient –0.517) and dynamics of LFPR male indicators (correlation coefficient –0.484); c) there is no connection between the dynamics of the SE indicators for both women and men. Thus, using the example of adapting the calculation of GII according to the basic methodology, it is obvious that the indicators of GII for the entire country do not reflect the rather wide sub-national disparities. Consequently, it will be impossible to use the general (for the whole country) political, economic, and social recommendations in the context of human development, taking into account the gender factor, for a specific region. Therefore, the recommendations above should be adjusted for a particular region to reflect the results of the GII adaptation for the sub-national level.

Other factors are also relevant to women's well-being, such as the use of free time, access to assets, domestic violence, empowerment at the local level, the division of professions into 'female' and 'male' in the labour market, and the gender wage gap. It is obvious that if we take into account all these factors, GII would be calculated based on a larger number of indicators and, therefore, would be more objective. However, at the country level, it is not possible to collect some of the data. Nevertheless, for some indicators at the level of a country's regions, such an opportunity always exists.

Calculation of regional GII using an adapted methodology

Table 5 below presents the definitions and data sources for all the composite indicators of the adapted regional GII (UNDP 2018).

Table 5

Indicators and data sources for regional GII using an adapted methodology

Indicator	Definition	Data source
Health		
Maternal mortality ratio (MMR)	Number of deaths due to pregnancy-related causes per 100,000 live births.	Databank of the State Statistics Service of Ukraine (DSSSU 2017)
Adolescent birth rate (ABR)	Number of births to women aged 15–19 per 1,000 women aged 15–19.	State Statistics Service of Ukraine. Population Of Ukraine. Demographic Yearbook (SSSU 2017)
Empowerment		
Share of seats in Regional Council (RC)	Proportion of seats held by women in the Regional Council expressed as a percentage of total seats.	Kirovohrad Regional Council website: www.oblrada.kirovograd.ua
Female and male shares of graduates in science, mathematics, engineering, manufacturing, and construction at the tertiary level (GTL)	The female and male shares of graduates in science, mathematics, engineering, manufacturing, and construction at the tertiary level: Share of female tertiary graduates in 'Natural Sciences, Mathematics, and Statistics', 'Information and Communication Technologies', and 'Engineering, Manufacturing, and Construction' programs.	Main Department of Statistics in Kirovohrad Region (DSKR 2017)
Female and male shares of positions as legislators, senior officials, and managers (LSM)	Female and male shares of positions defined according to the International Standard Classification of Occupations (ISCO-88) to include legislators, senior government officials, traditional chiefs and heads of villages, senior officials of special-interest organizations, corporate managers, directors and chief executives, production and operations department managers, and other department and general managers.	

(Continuation.)

Indicator	Definition	Data source
	Labour market	
Labour force participation rate (LFPR)	Proportion of the working-age population (aged 15 and older) involved in the labour market, either by working or actively looking for work, expressed as a percentage of the working-age population.	
Female and male shares of professional and technical positions (PTP)	Female and male shares of positions defined according to the International Standard Classification of Occupations (ISCO-88) to include physical, mathematical, and engineering science professionals (and associate professionals), life science and health professionals (and associate professionals), teaching professionals (and associate professionals) and other professionals and associate professionals.	Main Department of Statistics in Kirovohrad Region (DSKR 2017)
Female and male shares of the wage bill (WB)	Female and male shares of the wage bill in non-agricultural sectors.	

We present the main steps of the method for calculating the adapted regional GII in the table form (Table 6).

Table 6

Steps to calculate the adapted regional GII

№	Steps	Calculating
1	Treating zeros and extreme values	Because a geometric mean cannot be computed in the presence of zero values, a minimum value of 0.1 percent is set for all component indicators.
2	Aggregating across the dimensions within each gender group using geometric means	For women, the aggregation formula is $$G_F = \sqrt[3]{\left(\frac{10}{MMR} \cdot \frac{1}{ABR}\right)^{1/2} \cdot (GTL_F \cdot RC_F \cdot LSM_F)^{\frac{1}{3}} \cdot (LFPR_F \cdot PTP_F \cdot WB_F)^{\frac{1}{3}}}$$ and, for men, the formula is $$G_M = \sqrt[3]{1 \cdot (GTL_M \cdot RC_M \cdot LSM_M)^{\frac{1}{3}} \cdot (LFPR_M \cdot PTP_M \cdot WB_M)^{\frac{1}{3}}}$$
3	Aggregating across gender groups using a harmonic mean	$$HARM(G_F, G_M) = \left[\frac{(G_F)^{-1} + (G_M)^{-1}}{2}\right]^{-1}$$
4	Calculating the geometric mean of the arithmetic means for each indicator	$$\overline{health} = \frac{\left(\sqrt{\left(\frac{10}{MMR}\right) \cdot \left(\frac{1}{ABR}\right)} + 1\right)}{2}$$ $$\overline{emp} = \left(\sqrt[3]{GTL_F \cdot RC_F \cdot LSM_F} + \sqrt[3]{GTL_M \cdot RC_M \cdot LSM_M}\right) \cdot {}^{1}/_{2}$$ $$\overline{LabourMarker} == \left(\sqrt[3]{PTP_F \cdot WB_F \cdot LFPR_F} + \sqrt[3]{PTP_M \cdot WB_M \cdot LFPR_M}\right) \cdot {}^{1}/_{2}$$ $$G_{F,M} = \sqrt[3]{\overline{health} \cdot \overline{emp} \cdot \overline{LabourMarker}}$$
5	Calculating GII	$$GII = 1 - \frac{HARM(G_F, G_M)}{G_{F,M}}$$

Implementation of the sub-national adaptation GII

The main stages of the implementation of the sub-national adaptation coincide with the stages of determining the GII according to the basic methodology. Therefore, we describe only the new features. Table 7 presents the values that will be used to determine the GII in the Kirovohrad region (with dynamics for the period 2010–2017) according to the methodology above.

Table 7

Composite indicators of the adapted GII for the Kirovohrad region

Year	Health		Empowerment						Labour market					
	ABR	MMR	RC female	RC male	GTL female	GTL male	LSM female	LSM male	PTP female	PTP male	LFPR female	LFPR male	WB female	WB male
2010	38.6	85.5	16.16	83.84	38.40	61.60	22.35	77.65	63.2	36.8	58.1	67.4	46.99	53.01
2011	39.6	28.4	16.16	83.84	26.86	73.14	21.15	78.85	64.6	35.4	57.8	69.6	45.16	54.84
2012	42.2	18.1	16.16	83.84	22.92	77.08	17.05	82.95	62.5	37.5	57.8	71.0	45.33	54.67
2013	39.5	0.0	16.16	83.84	22.01	77.99	17.32	82.68	61.8	38.2	56.0	69.0	45.33	54.67
2014	40.9	37.8	16.16	83.84	21.16	78.84	17.54	82.46	60.3	39.7	55.2	67.5	45.33	54.67
2015	41.5	10.6	14.75	85.25	20.54	79.46	25.9	74.1	58.5	41.5	54.4	68.5	43.21	56.79
2016	34.1	33.9	14.75	85.25	20.00	80.00	24.2	75.8	59.4	40.6	54.0	67.5	43.10	56.90
2017	29.5	0.0	14.75	85.25	19.80	80.20	24.8	75.2	60.2	39.8	54.5	67.7	43.04	56.96

Note that the calculation of women's and men's share of the total wage bill in the Kirovohrad region for the period in question was performed according to the traditional method (UNDP 2018). For example, for 2010, the calculation was as follows:

$$S_f = \frac{\frac{Wf}{Wm} \times EAf}{\frac{Wf}{Wm} \times EAf + EAm} \cdot 100\% = \frac{0,939 \times 48,56}{0,939 \times 48,56 + 51,44} \cdot 100\% = 46,99\%$$

where $\frac{Wf}{Wm}$ is the ratio of female to male wage, EAf is the female share of the economically active population, and EAm is the male share. The male share of the wage bill is calculated as $S_m = 1 - S_f$.

The calculation of women's and men's share of the total wage bill is shown in Table 8.

Table 8

Calculation of S_f and S_m in the Kirovohrad region

Year	Ratio of female to male wages in non-agricultural sectors $\dfrac{Wf}{Wm}$	Female share of the economically active population EAf	Male share of the economically active population EAm	Female share of the wage bill S_f	Male share of the wage bill S_m
2010	0.939	48.56	51.44	46.99	53.01
2011	0.875	48.48	51.52	45.16	54.84
2012	0.901	47.92	52.08	45.33	54.67
2013	0.901	47.92	52.08	45.33	54.67
2014	0.901	47.92	52.08	45.33	54.67
2015	0.851	47.20	52.80	43.21	56.79
2016	0.845	47.27	52.73	43.10	56.90
2017	0.842	47.30	52.70	43.04	56.96

We analyse the selected indicators at the mathematical level to substantiate their differences (Table 7). We are more interested in the correlation of gender differences among the indicators AFR, MMR, RC, LSM, GTL, PTP, WB, and LFPR than in the correlation among them. To measure the gender differences, we use Specific Gender Asymmetry Indices (GAI_RC, GAI_GTL, GAI_LSM, GAI_PTP, GAI_LFPR, and GAI_WB). The definition of the Specific Gender Asymmetry Index was introduced in Akbash et al. (2018). These factors will determine which indicators affect the overall GII the most.

Let us turn to the analysis of the Specific Gender Asymmetry Indices of indicators by year. We will analyse all indicators with the exception of those in the health dimension (the AFR and MMR health indicators at the level of the Kirovohrad region are not correlated; their correlation coefficient is 0.16), which only assesses the performance of women.

Table 9

**Specific Gender Asymmetry Indices of GII composite indicators for the Kirovohrad region**

Year	GAI_RC	GAI_GTL	GAI_LSM	GAI_PTP	GAI_LFPR	GAI_WB
2010	−0.68	−0.23	−0.55	0.26	−0.07	−0.06
2011	−0.68	−0.46	−0.58	0.29	−0.09	−0.10
2012	−0.68	−0.54	−0.66	0.25	−0.10	−0.09
2013	−0.68	−0.56	−0.65	0.24	−0.10	−0.09
2014	−0.68	−0.58	−0.65	0.21	−0.10	−0.09
2015	−0.71	−0.59	−0.48	0.17	−0.11	−0.14
2016	−0.71	−0.60	−0.52	0.19	−0.11	−0.14
2017	−0.71	−0.60	−0.50	0.20	−0.11	−0.14

At the Kirovohrad region level, we can say that all indicators, except for 'Female and male shares of professional and technical positions', are characterized by a gender asymmetry towards men, but the level of this asymmetry is completely different. Thus, we can establish the weight of the indicators' influence in GII at the level of the Kirovohrad region in the following order: RC, LSM, GTL, PTP, WB, and LFPR.

Figure 5 shows these differences for the absolute values of the Specific Gender Asymmetry Indices, since GII does not take into account the direction of gender asymmetry (towards women or men), but only adjusts its overall level.

Figure 5

**Specific Gender Asymmetry Indices for the Kirovohrad region:
GAI_{RC}, GAI_{GTL}, GAI_{LSM}, GAI_{PTP}, $GAIL_{FPR}$, and GAI_{WB}**
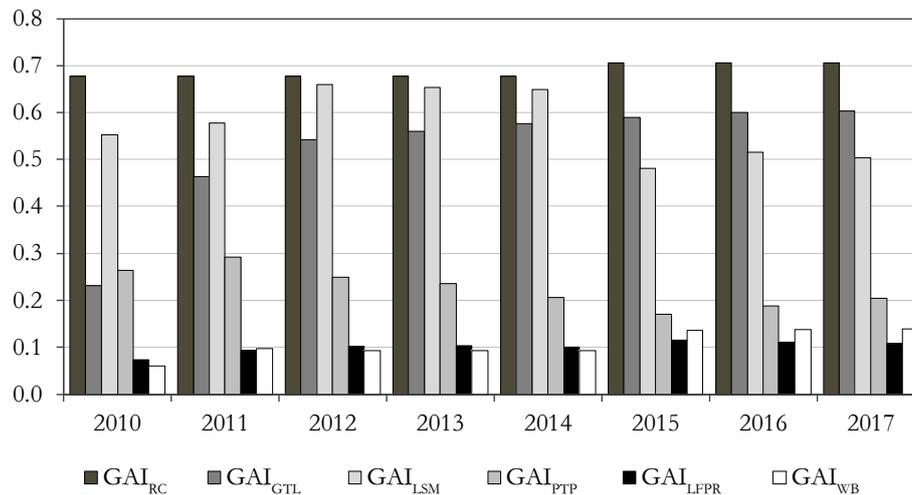
In Figure 5, the gender asymmetries of two dimensions – Empowerment (GAI_{RC}, GAI_{GTL}, GAI_{LSM}) and Labour market (GAI_{PTP}, GAI_{LFPR}, GAI_{WB}) – are clearly distinguished in separate groups. The asymmetry of the indicators in the Empowerment dimension is much higher than that of the indicators in the Labour market dimension.

Let us analyse the significance of the correlation of the coefficients in the groups of indicators, based on the absolute values of the coefficients in Table 9. We begin the analysis with the indicators of the Empowerment dimension group (RC, GTL, and LSM).

Table 10

Bivariate correlations among GAI$_{RC}$, GAI$_{GTL}$, and GAI$_{LSM}$

	Denomination	GAI$_{RC}$	GAI$_{GTL}$	GAI$_{LSM}$
GAI$_{RC}$	Pearson Correlation	1	0.504	−0.842**
	Sig. (1-tailed)		0.101	0.004
	N	8	8	8
GAI$_{GTL}$	Pearson Correlation	0.504	1	−0.014
	Sig. (1-tailed)	0.101		0.487
	N	8	8	8
GAI$_{LSM}$	Pearson Correlation	−0.842**	−0.014	1
	Sig. (1-tailed)	0.004	0.487	
	N	8	8	8

** Correlation is significant at the 0.01 level (1-tailed).

We see one significant correlation with feedback between the GAI$_{LSM}$ and GAI$_{RC}$ indicators, but, as the correlations are negative, we cannot remove one of the indicators, since they do not show the same thing.

Figure 6

Specific Gender Asymmetry Index GAI$_{RC}$ (Ukraine, from 2015 to 2017)
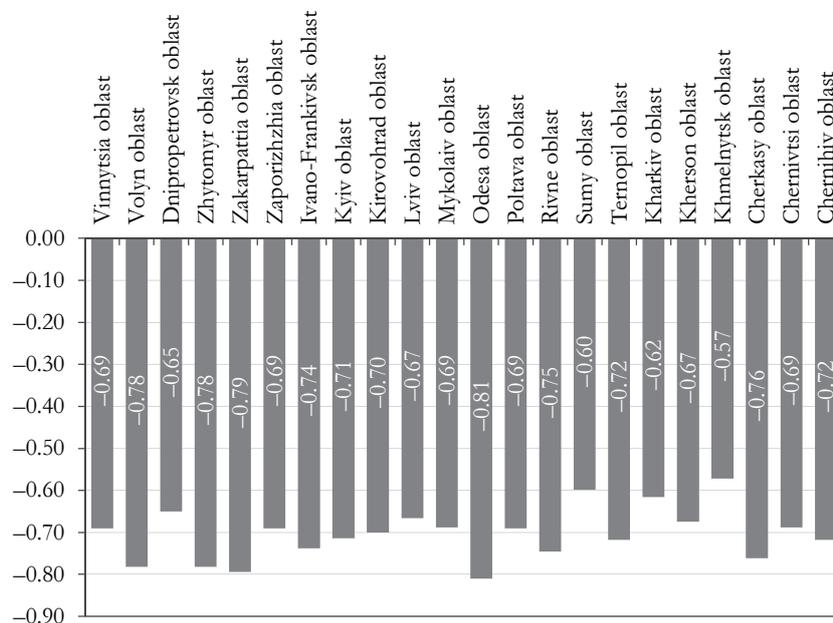
The greatest asymmetry at the regional level, in the indicator 'Share of seats in the Regional Council', is typical, and gender inequality has only increased over the years. This indicator, although it does not change every year, is very important in the formation of GII, since it is characterized by significant differentiation at the level of the sub-national regions. If we analyse this indicator in all of Ukraine's regions (with the exception of the Donetsk and Luhansk regions, for which data are unavailable), we will see a significant differentiation at the level of gender asymmetries (Figure 6).

Gender asymmetry for RC in Ukraine varies from –0.57 (Khmelnytsk oblast) to –0.81 (Odesa oblast).

Let us turn to the analysis of the indicators of the Labour market dimension group (PTP, WB, and LFPR).

Table 11

Bivariate correlations among GAI$_{PTP}$, GAI$_{LFPR}$, and GAI$_{WB}$

Denomination		GAI$_{PTP}$	GAI$_{LFPR}$	GAI$_{WB}$
GAI$_{PTP}$	Pearson Correlation	1	–0.741	–0.740
	Sig. (1-tailed)		0.018	0.018
	N	8	8	8
GAI$_{LFPR}$	Pearson Correlation	–0.741	1	0.859**
	Sig. (1-tailed)	0.018		0.003
	N	8	8	8
GAI$_{WB}$	Pearson Correlation	–0.740	0.859**	1
	Sig. (1-tailed)	0.018	0.003	
	N	8	8	8

** Correlation is significant at the 0.01 level (1-tailed).

We can see that only one correlation is significant – the one between the indicators GAI$_{LFPR}$ and GAI$_{WB}$ at the Kirovohrad region level. However, even with such a significant correlation in the Kirovograd region, we cannot conclude that one of these indicators should be excluded, since the situation in other sub-national regions may not be so explicit. Since all constituent indicators for calculating the WB and LFPR indicators are available for all of Ukraine's sub-national regions for 2017 on the State Statistics Service of Ukraine website, it is possible to analyse the correlation between the gender asymmetries in WB and LFPR for all sub-national regions. It is important to analyse both in the context of the region over the years and in the context of the structural components of GII by sub-national regions. Since all values for both indicators are negative, it is not necessary to analyse their absolute values.

Figure 7

Specific Gender Asymmetry Indices: GAI$_{LFPR}$ and GAI$_{WB}$ (Ukraine, 2017)
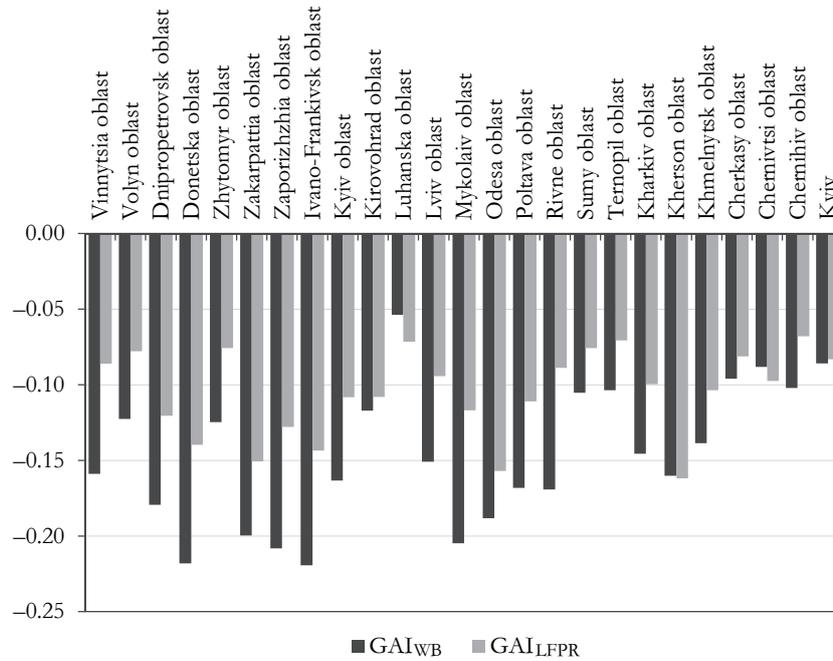
Interestingly, the correlation of 0.792 is also significant at the level of Ukraine's sub-national regions (Table 12).

Table 12

**Bivariate correlations between GAI$_{LFPR}$ and GAI$_{WB}$
for Ukraine's sub-national regions**

Denomination		GAI$_{WB}$	GAI$_{LFPR}$
GAI$_{WB}$	Pearson Correlation	1	−0.792**
	Sig. (1-tailed)		0.000
	N	25	25
GAI$_{LFPR}$	Pearson Correlation	0.792**	1
	Sig. (1-tailed)	0.000	
	N	25	25

** Correlation is significant at the 0.01 level (1-tailed).

However, there is a nuance to which attention should be paid: the lack of correlation between the indicators WB_{male} and $LFPR_{male}$ (the correlation coefficient is 0.187). In addition, the country GAI_{WB} values are at a much larger scale (0.17) than that of GAI_{LFPR} values (0.09).

Note that the multiple correlation coefficient (concordance) between absolute values of GAI_{RC}, GAI_{GTL}, GAI_{LSM}, GAI_{PTP}, GAI_{LFPR}, and GAI_{WB} is 0.14 and non-significant. This means that all the indices are independent among themselves.

Thus, the selected set of indicators (Table 5) is complete for a comparative analysis of the GII for Ukraine's sub-national regions.

The choice of indicators is also justified by the limited availability of gender data at the level of the sub-national regions of the country. Most dimensions of the Empowerment and Labour market are not included in the State Statistics Service of Ukraine. However, these data are available in the statistical collections of all of Ukraine's sub-national regions, which are published annually by the main departments of statistics of these regions by request and with the support of the 'Gender responsive budgeting' project (http://grbproject.org). Gender responsive budgeting is an internationally recognized tool that ensures the achievement of de-facto gender equality and contributes to effective allocation of public funds. However, the gender data set of these collections is very limited in terms of demographic indicators, health care, education, employment and unemployment, physical education, and sports. Therefore, at this stage of measuring gender data, it is too early to introduce the expansion of the base of GII indicators. It would be advisable for these collections to add another section with calculations of complex gender indices (e.g. GII), adapted for the sub-national regions of the country, that will allow ranking the sub-national regions of the country by the level of gender inequality and gender development.

Analysis of the results of sub-national adaptation of the GII according to the proposed methodology

The results of the calculation of GII for the Kirovohrad region and the study of its dynamics over 2010–2017 are presented in Figure 8. The values of GII are in the interval [0.60, 0.64] and are much higher than those calculated by the basic method (compare to the results in Figure 4). The obtained results confirm the existence of the pronounced sub-national characteristics, indicate the existence of sub-national disparity, and show the presence of specific sub-national problems in the context of the negative impact on human development due to the inequality of achievements of women and men as reflected in these measurements and their indicators.

Figure 8

**Dynamics of GII values (calculation according to the proposed method)
for the Kirovohrad region**
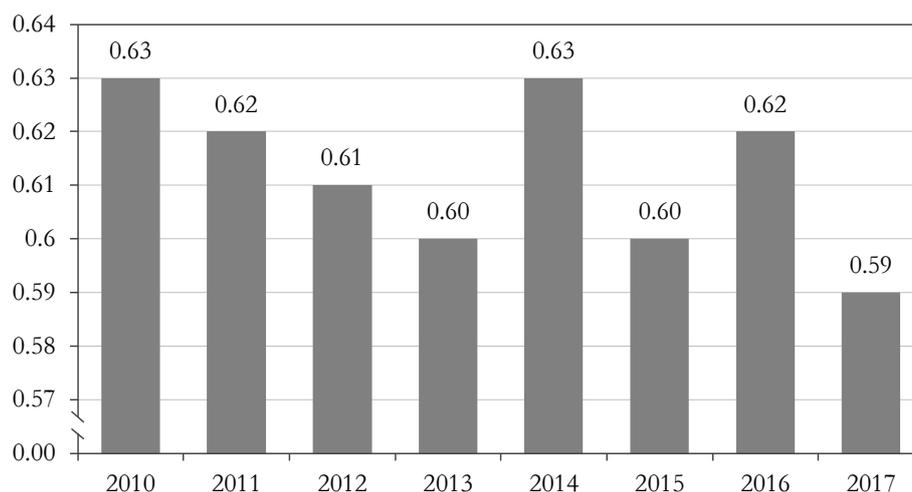
A meaningful analysis of the results of computing the regional GII according to the proposed methodology allows us to draw conclusions and offer recommendations. First, GII's high value indicates that it is too early to discuss gender equality in the Kirovohrad region.

Second, the indicators of the first dimension (MMR and ABR) and the indicators of the second dimension (LFPR, PTP, and WB) have a small effect on the 'deterioration' of the level of GII. This is because all indicators are close to parity, if we consider: (1) their values and tendency to decrease (in the case of the first dimension) and (2) the ratio of the value of 'Female and male shares of professional and technical positions', the ratio of 'Labour force participation rate', and the ratio of 'Female and male shares of the total wage bill' (in the case of the third dimension). However, it is obvious that appropriate recommendations in the field of economic activity and policies to support women's participation in a region's labour force will contribute to the successful formation of relations on equal terms.

Third, greatest impact on the decline GII was provided by second-dimension – women's empowerment – indicators, namely, participation and decision-making powers both in political (RC) and economic (LSM) areas, as well as the female share of graduates in science, mathematics, engineering, manufacturing, and construction at the tertiary level (GTL). Consequently, the main recommendations in the context of human development of the Kirovohrad region from a gender perspective should be related to ensuring women's high educational potential in the field of natural,

exact, and technical sciences, which will increase women's participation in political decision-making and will enhance economic management and the labour market.

Conclusions and prospects for further research in the field of study

The results of this study provide an opportunity for us to formulate the following conclusions:

1. The use of UNDP methodologies and the integration of regional indicators allow the sub-national adaptation of the human development indices from a gender perspective without the expansion of the base of indicators for calculating these indices. The results of this universalization of the sub-national adaptation allow the comparative analysis of the progress in the development of human potential both in individual country's sub-national regions and in regions of different countries worldwide.

2. The need for a sub-national adaptation of the human development indices with a gender factor (in our case, GII) is the existence of the objective danger that the indicators of GII on an entire country do not reflect rather wide sub-national disparities. As a result of the calculation of the overall country index, it becomes impossible to provide accurate political, economic, and social recommendations in the context of human development with a gender factor that would be effective and optimal for all the sub-national regions of the country. Therefore, the aforementioned recommendations for each sub-national region should be adjusted to reflect the results of the sub-national adaptation of GII.

3. The expansion of the base of indicators for the determination of GII allowed us to create a new methodology for the sub-national adaptation of GII. Testing this methodology on the example of the Kirovohrad region (Ukraine, study period 2010–2017) enabled us to refine the GII indicator compared to the baseline calculation and, therefore, to provide more objective political, economic, and social recommendations in the context of human development with a gender factor.

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