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# SHADOW ECONOMY: FORMATION OF AN OBSERVATION MATRIX

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**Sierova I. A.**

**Shadow Economy: Formation of an Observation Matrix**

*The aim of the article is to form a matrix of observations of shadow processes in the economy as a tool ensuring the completeness of assessment and comparability of macroeconomic indicators. The relationship between the SNA and accounting as one of the conditions for consistency and quality of macro- and micro-level data is described. The basic moments concerning the complexity of interpreting indicators rapidly changing in time are generalized. Emphasis is placed on the specifics of the accuracy of economic measurements and the uncontrollability of the error of observation. There revealed the nature of the shadow economy through determining the degree of concealment from the available observation and the probability of the results obtained from the calculations. The basic approaches that make it possible to increase the analytical value of the calculations carried out and ensure the comparability of aggregated indicators are considered. There determined the feasibility of identifying homogeneous groups in which the values of the analyzed parameters are within the same limits, in order to track the stability of their positions by selected groups over time. Based on the fact that the reliability of the data is measured by the convergence of the results, the order of analytical techniques is determined, which allows to take into account the possible limits of variation of economic indicators and their comparability.*

***Keywords:*** *shadow economy, observation, completeness and specificity of assessment of an economic indicator, possible limits of the indicator variation, comparability of results, clustering.*

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***Sierova Iryna A.*** *– Candidate of Sciences (Economics), Associate Professor of the Department of Economic Theory, Statistics and Forecasting, Simon Kuznets Kharkiv National University of Economics (9a Nauky Ave., Kharkiv, 61166, Ukraine)*

***E-mail:*** *irina.cevaro@gmail.com*

***ORCID:*** *0000-0001-7178-9609*

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***Сєрова І. А. Тіньова економіка: формування матриці спостережень***

*Метою статті є формування матриці спостереження тіньових процесів в економіці як інструменту, що забезпечує повноту та зіставлення макроекономічних показників. Визначено взаємозв'язок СНР і бухгалтерського обліку як одну з умов узгодженості та якості макро- та мікрорівневих даних. Узагальнено базові моменти складності інтерпретації показників, що швидко змінюються у часі. Зроблено акцент на специфіці точності економічних вимірів й неконтрольованості похибки спостереження. Визначено характер тіньової економіки через ступінь приховання від доступного спостереження та ймовірність результатів, котрі отримані за підсумком проведених розрахунків. Розглянуто базові підходи, що дозволяють підвищити аналітичну цінність здійснених розрахунків і забезпечити зіставлення агрегованих показників. Визначено доцільність утворення однорідних груп, де значення параметрів, що аналізуються, знаходяться в однакових межах з метою відстеження стійкості їх позицій за виокремленими групами в динаміці. Виходячи з того, що достовірність даних визначається збіжністю результатів, визначено порядок аналітичних прийомів, які дозволяють врахувати можливі межі варіації економічних показників та їх зіставлення.*

***Ключові слова:*** *тіньова економіка, спостереження, повнота та специфіка оцінки економічного показника, можливі межі варіації показника, зіставлення результатів, кластеризація.*

***Рис.:*** *1.* ***Табл.:*** *3.* ***Бібл.:*** *18.*

***Сєрова Ірина Анатоліївна*** *– кандидат економічних наук, доцент кафедри економічної теорії, статистики та прогнозування, Харківський національний економічний університет ім. С. Кузнеця (просп. Науки, 9а, Харків, 61166, Україна)*

***E-mail:*** *irina.cevaro@gmail.com*

***ORCID:*** *0000-0001-7178-9609*

*UDC 311:33*
*JEL Classification: O17*

***Серова И. А. Теневая экономика: формирование матрицы наблюдения***

*Целью статьи является формирование матрицы наблюдения теневых процессов в экономике как инструмента, обеспечивающего полноту оценки и сопоставимость макроэкономических показателей. Определена взаимосвязь СНС и бухгалтерского учета как одно из условий согласованности и качества макро- и микроуровневых данных. Обобщены базовые моменты сложности интерпретации быстро меняющихся во времени показателей. Сделан акцент на специфике точности экономических измерений и неконтролируемости погрешности наблюдения. Определен характер теневой экономики через степень сокрытия от доступного наблюдения и вероятность результатов, полученных по итогам проведенных расчетов. Рассмотрены базовые подходы, позволяющие повысить аналитическую ценность проводимых расчетов и обеспечить сопоставимость агрегированных показателей. Определена целесообразность выделения однородных групп, в которых значения их анализируемых параметров находится в одинаковых пределах с целью отслеживания устойчивости их позиций по выделенным группам в динамике. Основываясь на том, что достоверность данных определяется сходимостью результатов, определен порядок аналитических приемов, позволяющий учесть возможные границы вариации экономических показателей и их сопоставимость.*

***Ключевые слова:*** *теневая экономика, наблюдение, полнота и специфика оценки экономического показателя, возможные границы вариации показателя, сопоставимость результатов, кластеризация.*

***Рис.:*** *1.* ***Табл.:*** *3.* ***Библ.:*** *18.*

***Серова Ирина Анатольевна*** *– кандидат экономических наук, доцент кафедры экономической теории, статистики и прогнозирования, Харьковский национальный экономический университет им. С. Кузнеца (просп. Науки, 9а, Харьков, 61166, Украина)*

***E-mail:*** *irina.cevaro@gmail.com*

***ORCID:*** *0000-0001-7178-9609*

**Introduction**. The modern level of society development is determined by the system of economic relations of various countries and regions based on the international division of labor. Today, the world economy represents a new level of internationalization of production. Countries and regions of the world are interconnected by commodity and financial flows, international business, information technologies, scientific and cultural cooperation, etc. The competitive mechanism is inherent in a market economy. Therefore, the existing integration processes are aimed not only at the development of international cooperation but also at determining the level of economic development of countries and regions.

The aggravation of competition among countries increases the interest in international comparisons and ways to implement them. The basis for such comparisons is the presence of unambiguous and, at the same time, correct for all countries methods, as well as completeness and quality of information ensuring the implementation of the latter.

Developing a unified methodology for comparing the levels of economic development of countries is a desirable but very difficult task. Many international organizations have been working on solving it for more than a decade [8, 10, 14, 18 ]. The results of their work are as follows:

- consistency of the methods for collecting and primary systematization of data of national economies with the international standards;
- maximum possible unambiguity in the content of calculated indicators with a view to their further aggregation.

Based on the earlier achieved results in the field of international comparisons, it is possible to assess the ability of a country's economy, maintain its steady state for certain periods of time, probably, using a system of indicators. The indicators characterize a specific property of an object, system or process, perform a specific analytical function, and reflect certain economic ties. The accuracy of determining these indicators is characterized by the degree of approximation of the calculation results to the actual value of the indicator being studied.

In the evaluation of economic indicators, chaotically acting factors cause random errors in production activity, and factors that persist over time serve as a source of significant systematic errors. If the measurement result is found with the highest accuracy and its error is estimated, then the measurement can be considered complete. Therefore, the method for calculating economic indicators should guarantee with a sufficient probability correctness of the result obtained within acceptable limits.

For a more complete description of expanded reproduction and, reflection of the restructuring of all spheres of economy under market conditions, a system of national accounts (SNA) is used. The SNA 2008 introduces an interpretation of new aspects of economic development [10]. Changes in the SNA are aimed at the most accurate calculation of GDP and its components across countries as well as a consistency of GDP estimates.

At present, GDP remains the basic indicator in assessing the level of economic development of a country. The SNA 2008 provides the reconciliation of three estimates of GDP but focuses on the fact that any error in the data source and inconsistency of data sources across countries lead to different results of the estimates of GDP.

Primary use of the SNA occurs in the form of time series. This makes it possible to assess the development of the economy taking into account the time factor. However, there is a contradiction between the timeliness and accuracy of the information provided. Covering more data requires more time to process them, and the speed of obtaining information is correlated with its subsequent revision.

According to the existing concept of building the SNA, to reflect the long-term changes in the economy, time series should be calculated over years. This gives an opportunity to study changes in the basic structure of the economy through changes in the composition of macroeconomic indicators in current prices. In the short-term assessments, the main role is played by data of national accounts, which are the intermediate indicators between the short-term indicators and data by years.

Long time series are of a particular interest. According to the requirements of the SNA, if the data are not revised for a long period of time, it is not advisable to use them for a comparative analysis. However, it is necessary to take into account that the interpretation of rapidly changing indicators that make up a time series is very complex. The complexity of interpretation can be reduced to the following basic points:

- political changes move the economic consequences to the background,
- data sources are changing and improving constantly.

Therefore, when applying even very complex methods for data collection, there are the discrepancies between calculations because of the differences in coverage, estimation, recording time and data sources. These discrepancies become even more significant if a comparative analysis of the level of economic development of countries is made. A change in the source of data leads to a discontinuity in the time series of the estimated indicators and, as a result, to mistakes in analytical conclusions. Thus, the presence of economic problems in any country and the issues of tracking and measuring these problems for different periods of time affect not only the assessment of the level of national economic development but the possibility of conducting a comparative analysis across countries as well. The topicality of these issues is beyond the influence of the time factor, which has determined the choice of the research topic.

**The aim of the article** is to form a matrix of observations of shadow processes in the economy as a tool that ensures the completeness of assessment and comparability of macroeconomic indicators.

**Presentation of basic material of the research**. Based on the fact that the SNA is a macro-statistical model of a market economy that reflects the economic behavior of participants in economic activities, their relations and results of these activities within the national economy, the primary task of the SNA 2008 is to ensure the accuracy and completeness of estimates of GDP in the national accounting system. Solving this problem requires the organization of systematic monitoring of both the size and behavior of volume measures.

Under modern conditions of development of market relations, no economy of the world is fully regulated and covered

by the statistical observation. Governments' attempts to restrict the freedom of the market and private entrepreneurship are provoked by the expansion of the shadow economy. The nature of the shadow economy is determined by the degree of concealment from the available observation and the probability of the calculation results. The ambiguity of socio-economic nature of the shadow economy, lack of a unified approach to the interpretation of its essence as well as to its measurement and evaluation, all these determine the differences in the levels of the shadow economy, regardless of their calculation in the same space-time framework.

The SNA2008 [10] identifies the following approaches to the accounting of unregulated activities:

- ensuring the measurement of all activities;
- measurement of activities of economic units that can be considered as informal ones. The first approach reflects the non-observed economy and the second one – the informal sector of the economy. These approaches overlap, but they are not parts of each other. Indeed, in the economic practice of any country, there is an activity that is not covered by statistical observation and is carried out informally. In addition, there is an activity that is not observed but is not informal, and there is also an activity that is informal but is observed.

Therefore, recording shadow processes in the economy is one of the basic problems of both national accounting and assessing the level of economic development of the country [16, 17].

At the level of national economies, the main source of information is accounting data. In any country, its development is influenced by the information needs of financial information users and the priority of both macro- or micro-economic interests of the state. Accounting data is the source of information for billing the SNA, i.e., accounting data is a reflection of micro-level processes in a country, and SNA data are macro-level information that allows to make a comparative assessments across countries and regions.

Both in collecting information on business entities for carrying out comparisons at the national and international level it is imperative that the accounting unit be defined. However, if in accounting a unit of account is a business transaction, in the SNA it is an economic operation that is broader in scope, since it includes institutional units. Therefore, having the same object of research, these accounting systems differ in terms of the unity of form and content. SNA in accounting practice determines the priority of content over form, whereas in accounting, to some extent, the procedure for determining indicators for financial statements is regulated.

In order to ensure the comparability of information across countries and the possibility of conducting a comparative analysis, a unified set of standards applicable in any situation and in any country is required. The document disclosing the requirements for the content of accounting information and the methodology for obtaining the most important accounting characteristics based on the harmonization of national standards is the International Financial Reporting Standards (IFRS) [10].

These standards envisage the implementation of accounting operations on an accrual basis and the continuity of business structures. It is not always possible to adhere to these assumptions at the national level of accounting because of the following aspects:

- many accounting operations are built on the reflection of real not accrued amounts;
- tracking the continuity of economic structures with an unstable level of economic development requires a constant review of the time series of the studied indicators and their closure.

Thus, if all countries of the world use an accounting method built on the principle of a double entry, but they explain and apply this method differently, a quantitative assessment of the operation of any economy will also have a different interpretation due to its volumetric and structural characteristics.

The correctness of data from the point of view of the completeness of their economic content and their availability for observation in analytical practice is determined by the composition of methods for assessing the shadow economy. If questions of the completeness of the economic content of data can be reduced to determining the causes of the under-received revenue in the form of tax revenues and actions to return them, the availability of observation will allow to correct and reduce the risk of an error in calculating indicators.

Based on the fact that the database for economic research consists of accounting data and, for the most part, the official statistics, the problem of economic measurements is rightly an issue of accounting and statistics. According to the International Association of Chartered Certified Accountants (ACCA), the use of different methods in assessing the scale of the shadow economy leads to different results [14], and consequently, to inaccuracies in calculating GDP.

Since there are no ideal methods for calculating and measuring indicators, and the consideration of behavior of these indicators under unstable development of economies determines their variation, let us consider the basic approaches to improve the analytical value of calculations and ensure the consistency of macroeconomic indicators.

An effective way to identify differences in accounting and reporting systems, as well as their general description is their classification. When making international comparisons, many experts group these systems by their essential features using cluster analysis [2].

Consideration of clustering as a stage of data analysis to form an analytical output determines its value. There is no single universal clustering algorithm. Therefore, we use the hierarchical method to select the optimal number of clusters and the k-means method to implement a visual representation of quality of a group.

Based on the fact that measuring the volume of the shadow economy makes it possible to get more accurate value of GDP and its derived indicators, and measuring the share of the shadow economy in GDP allows to judge the prevalence of this phenomenon and the degree of its control, we use these indicators to determine the possible limits of GDP variation.

In order to ensure consistency of data of international organizations with those on the economy of Ukraine as an independent state, we take 1991 as the base of comparison and trace the grouping of countries according to the above-mentioned indicators.

**Table 1**

**Trends in the distribution of countries with consideration for characteristics of clusters**

| Cluster characteristic | Distribution of countries in clusters | | | Characteristics of trends | |
|---|---|---|---|---|---|
| | 1991 (abridged version) | 2015 (abridged version) | 2015 (full version) | Average | Average growth rate |
| Low share of the shadow economy in GDP and high level of GDP per capita | Australia , Canada, GBR, Hong Kong, Ireland, *Italy*, Japan, USA, Singapore | Australia, Canada, GBR, Hong Kong, Ireland, Japan, Singapore, USA | Australia, Canada, GBR, Hong Kong, Ireland, Japan, Singapore, USA | Australia, Canada, GBR , USA, Hong Kong, Ireland, *Italy*, Japan, Singapore, | |
| Medium share of the shadow economy in GDP and medium level of GDP per capita | *Brazil*, Bulgaria, China, India, Indonesia, *Kenya*, Malaysia, *Pakistan*, Poland, *Russia*, *South Africa*, Turkey | Bulgaria, China, India, Indonesia, *Italy*, Malaysia, Poland, *South Africa*, Turkey | Bulgaria, China, Estonia, India, Indonesia, *Italy*, Latvia, Lithuania, Malaysia, Poland, Turkey | Bulgaria, China, Estonia, India, Indonesia, *Kenya*, Latvia, Lithuania, Malaysia, *Pakistan*, Poland, *South Africa*, Turkey | |
| High share of the shadow economy in GDP and low level of GDP per capita | Azerbaijan, Nigeria, Sri Lanka | Azerbaijan, Nigeria, Sri Lanka, *Brazil*, *Kenya*, *Pakistan*, *Russia* | Azerbaijan, Nigeria, Sri Lanka, *Brazil*, *Kenya*, *Pakistan*, *Russia*, *South Africa*, Sri Lanka, *Ukraine* | Azerbaijan, Nigeria, Sri Lanka, *Brazil*, *Ukraine*, *Russia* | |

*Source:* developed by the author based on [14; 15; 18]

The result of the clustering is the distribution of countries into 3 groups. To ensure consistency of the indicators under consideration in terms of time and content, we will cluster the countries in the year of 1991 and 2015 both for the reduced number of countries – excluding Ukraine, Latvia, Lithuania, Estonia, and including these countries.

The analysis shows that the redistribution of the countries among the clusters occurred in 2015. In 2015, when Brazil, Kenya, Pakistan, Russia, South Africa, Ukraine entered the cluster with a high share of the shadow economy and low GDP per capita, Italy moved from the cluster with a low share of the shadow economy and high GDP per capita to the cluster with medium values of these indicators.

These countries worsened their positions in terms of the indicators under consideration. The use of the full list of countries in 2015 shows that when Ukraine was in the cluster with a high share of the shadow economy and low GDP per capita, Latvia, Lithuania, Estonia were in the cluster with a medium value of the indicators under consideration. This clustering option basically did not change the position of countries in the selected groups. Only South Africa deteriorated its position, moving to a group with a high share of the shadow economy.

The basic tool for assessing time series is to obtain their characteristics. The analysis of Table 1 shows that the clustering of the countries both in terms of the average level of the share of the shadow economy in GDP and in terms of the average annual growth rate have a similar distribution. This indicates the possibility of their equivalent use for the implementation of analytical calculations within a cluster.

In order to determine the degree of homogeneity of the data used, the coefficient of variation across countries is calculated and they are clustered in terms of the variation of the share of the informal sector in GDP.

The result of clustering is the formation of the following groups (Tbl. 2)

**Table 2**

**Distribution of countries with regard to variation of the share of the shadow economy in GDP, %**

| Classification criteria | Weak variation | The variation is close to the upper limit of weak variation. | Medium variation | The variation is close to the upper limit of medium variation |
|---|---|---|---|---|
| Country | Brazil , Italy, Japan, Kenya, Nigeria, Pakistan, GBR | Australia, Canada, Indonesia, USA Malaysia, Singapore, Sri Lanka, Turkey, | Azerbaijan, Estonia, Hong Kong, Ireland, Russia, South Africa, Ukraine | Bulgaria, China, India, Latvia, Lithuania, Poland |
| The average coefficient of variation for the group | 5.7 % | 9.9 % | 13.26 % | 17.1 7% |

*Source:* developed by the author based on [14; 15; 18]

The data in Table 2 indicate that for all countries information on the indicator of the share of the shadow economy in GDP meets the criterion of homogeneity.

Therefore, it can be used for further analytical calculations, since, during the study period, significant fluctuations of this indicator relative to its average value are not observed.

Taking into account the fact that the considered indicators can have the same center of grouping and the same limits of variation of a criterion but differ in the nature of distribution of population units, we calculate the structural asymmetry coefficient across countries and implement their clustering. The result of clustering is as follows:

- negative asymmetry (more than above average): Azerbaijan, Bulgaria, China, Estonia, Hong Kong, Sri Lanka, Turkey;
- positive asymmetry (often lower than average values): Australia, Canada, Indonesia, Ireland, Lithuania, Latvia, Malaysia, Ukraine, GBR, the USA, Russia.

The significant obliquity of the distribution of the indicator, the share of the shadow economy in GDP is observed in Brazil (clearly defined right-sided asymmetry) and Nigeria (significant left-sided asymmetry). This situation may indicate ambiguously abrupt changes in the ratio of formal and informal sectors of economy as well as the observed and non-observed economies.

To assess the degree of materiality of the asymmetry, the mean square error of the asymmetry coefficient is calculated. The significance of asymmetry is confirmed only for Brazil and Nigeria $|As|$: $\sigma_{As} > 3$.

Based on the fact that ACCA conducts an assessment of the development of the shadow economy of countries until 2025, we will calculate the rate of change of this indicator for the period of 2016 to 2025 and will group the countries. Since 2016, according to ACCA, is taken as the base of comparison in the assessment of indicators, we will conduct a comparative analysis of the initial data [ ] with the calculated values of the studied indicator for this year.

The comparative analysis reveals the non-comparable information. The indicators of the share of shadow economy in GDP in the studied countries for 2016 differ from the predicted values obtained by the calculation. The analysis of deviations between the predicted and official value of the share of the shadow economy in GDP for 2016 shows that the largest absolute deviation towards overstatement of the official data is observed in Azerbaijan (-23.26 %); Russia (-16.28 %); Estonia (-14.12 %). The predicted values are higher than the official ones in absolute values obtained for such countries as Indonesia (5.37 %) and Malaysia (6.70 %).

-For other countries, the variability of the absolute deviations is less significant. The relative deviations in the considered situation demonstrate different results. For Australia, Azerbaijan, Bulgaria, Indonesia the predicted value is lower than the original one by more than 30 %; Canada, Hong Kong, Ireland, Latvia, Lithuania, Poland, Singapore – 20–30 %; Italy, Japan, South Africa, GBR – 10–20 %. Whereas for Indonesia and Malaysia the predicted value is higher than the original by 32.5 % and 28.8 %, respectively, and for the USA and Sri Lanka this deviation is the lowest – 2.4 % and 2.1 %, respectively. The presence of the deviations confirms that the reliability of data sources and their completeness determines the convergence of the results.

We can forecast the share of the shadow economy in GDP for the countries based on the data obtained as a result of the calculations. The prediction values are determined using time series decomposition models. The selection of the additive model in each case is made based on the result of analyzing the graphical representation of the available retrospective data. The behavior of this indicator in Ukraine is presented in Figure 1.

The average absolute percentage error less than 10 % as well as the values of the coefficients of multiple correlation and determination being more than 0.7 for each of the countries indicate the high accuracy of the predicted values obtained for the period of 2016 to 2025

Using the data obtained, we can cluster the countries in terms of the relative change in the share of the shadow economy in GDP.

The analysis of Table 3 clearly demonstrates the fact that Pakistan, Singapore, South Africa will be able to increase the share of the shadow economy in the GDP by 2025.

**Conclusion.** The basis for the formation of an observation matrix of shadow processes in the economy is a reflection of their adequacy and possibility of subsequent adjustment. The correctness of analytical procedures is ensured by a high degree of development of economic regulations along with a system of collecting and preprocessing information. The completeness of this relationship is determined by the consistency of actions in accounting practice of a national economy with the operations that are reflected in the SNA. The heterogeneity of economic

**Table 3**

**Distribution of countries by growth in the forecast values of the share of the shadow economy in GDP, %**

| Indicator | The growth in the forecast values of the share of the shadow economy in GDP | | | |
|---|---|---|---|---|
| Country | Australia, India, Japan, Latvia, Turkey | Azerbaijan, GBR, Estonia, SA ,Ireland, Malaysia, Poland, Sri Lanka | Brazil, Bulgaria, Canada, China, Hong Kong, Indonesia, Italy, Kenya, Lithuania, Nigeria, Russia, Ukraine | Pakistan, Singapore, South Africa |
| Average value of the indicator for the group | 0.806 | 0.91 | 0.98 | 1. 08 |

*Source:* developed by the author based on [14; 15; 18]

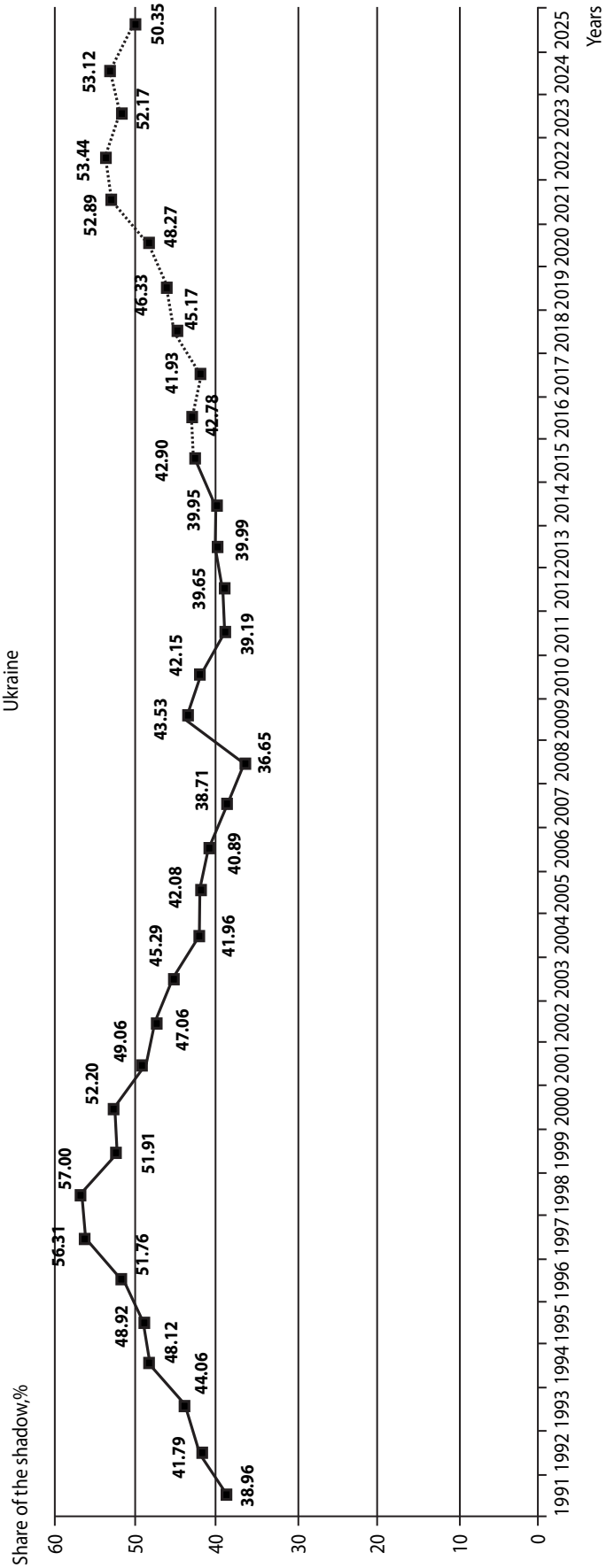


Fig. 1. Changes in of the share of the shadow economy in GDP, %

activity across countries leads to the change in the classification indicators taken into account in the system of indicators and the need to make adjustments to the time series being formed in order to make them comparable. It is possible to improve the quality of the formed databases and ensure their reliability for the analysis and forecasting through the development of algorithms that will ensure the transition from micro-level indicators to their macro-level analogs.

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