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Article

Comprehensive Assessment of The Level of Informal Employment in Rural Areas: An Integral Index and Regional Clustering Approach

Kholmuminov Shayzak Rakhmatovich[1], Kurbonov Samandar Pulatovich[2]

1. Tashkent State University of Economics, Professor, Doctor of Economic Sciences
2. Tashkent State University of Economics, Associate Professor, Doctor of Economic Sciences

* Correspondence: kholmuminov@gmail.com, s.kurbonov@gmail.com

Abstract: The article develops and tests a methodological approach to the comprehensive statistical assessment of informal employment in the rural areas of Uzbekistan. The study draws on the standard adopted by the 21st International Conference of Labour Statisticians of the International Labour Organization (2023), SDG indicator 8.3.1, and the modern methodology of statistical research of informal employment at the regional level (multidimensional classification, integration of factor and cluster analysis, data mining). Based on official data of the Statistics Agency of the Republic of Uzbekistan for 2018-2025, the national dynamics of informal employment are analyzed, and its change over 2019-2024 is decomposed using the shift-share method. The results show that the 2.5 percentage point decrease in the informal employment rate was driven mainly by the outflow of employment from agriculture (−1.41 percentage points) and by formalization within agriculture (−2.62 percentage points), whereas informality in non-agricultural sectors, on the contrary, increased by 1.11 percentage points. The authors developed an integral index of regional informality risk (I_RIR) based on six official statistical indicators: the indicators were rescaled to a 1-100 scale, the weights were determined by the entropy method, and aggregation was performed using a weighted geometric mean. Using the k-means and Ward methods, the 14 regions were grouped into four clusters (adjusted Rand index of 0.737). The highest informality risk was recorded in Kashkadarya (87.1), Samarkand (86.2), Khorezm (85.5) and Surkhandarya (81.3) regions. External validation of the index (correlation with per capita income r = −0.911) and a sensitivity analysis based on varying the weights by ±20% confirmed the robustness of the results. The study proposes a cluster-differentiated formalization policy and regional weights for the target achievement coefficient.

Keywords: informal employment, rural labor market, integral index, cluster analysis, entropy weights, structural decomposition, SDG 8.3.1, formalization policy, Uzbekistan.

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1. Introduction

Informal employment of the population is not merely a statistical state of the labor market, but a complex socio-economic process closely linked to the legal formalization of labor relations, coverage by the tax and social insurance systems, the actual enforcement of labor rights, the stability of income and working hours, labor productivity, and the capacity to create formal jobs. Therefore, assessing the outcome of reducing informal employment solely by the number of registered persons or formal jobs created does not fully reveal the true nature of informality.

According to official data published on the National SDG Platform of the National Statistics Committee of the Republic of Uzbekistan [1], the share of informal employment

in total employment (SDG indicator 8.3.1) was 40.5% in 2018, rose to 43.8% in 2021, and declined to 37.9% by 2024. This indicator means that nearly two-thirds of the country's labor market is formal, while the remainder is shaped by relations that are informal to varying degrees. According to 2026 data [2], 5.5 million (38.8%) of the country's 14.2 million employed persons work in the informal sector, and 56.6% of them (3.12 million people) are in agriculture. Hence, the center of gravity of the informal employment problem lies precisely in rural areas.

In the new statistical standard of the International Labour Organization (ILO), adopted at the 21st International Conference of Labour Statisticians in 2023 [3], informality is defined on the basis of whether the activities of a person or an economic unit are covered, in law and in practice, by formal arrangements. An important feature of the new standard is that informal work may exist not only in the informal sector but also in formal enterprises; even certain tasks performed in a formal job, or part of the income received from it, may be informal.

This international approach is particularly relevant for Uzbekistan. A person may be registered as employed in the Unified National Labor System (UNLS), yet their actual income may not be fully declared, social insurance contributions may not be paid in full, or their ability to exercise labor rights in practice may be limited. It is therefore advisable for the study to distinguish between the concepts of "registration" and "sustainable formal employment".

The institutional framework for reducing informal employment in Uzbekistan has been established through a number of laws and presidential acts. The Law of the Republic of Uzbekistan No. ZRU-642 "On Employment of the Population" of October 20, 2020 [4] devotes a separate chapter to obtaining self-employed status, the taxation of self-employed persons and the benefits available to them; the law also provides for mechanisms for the electronic registration of employment contracts through the UNLS and the electronic recording of length of service. The new Labor Code, approved by Law No. ZRU-798 of October 28, 2022, establishes the legal basis for employment contracts, remuneration, working time, leave and occupational safety [5]. Resolution of the President of the Republic of Uzbekistan No. PP-4742 "On Measures to Simplify State Regulation of Entrepreneurial Activity and Self-Employment" [6] marked an important institutional turning point in bringing self-employment into the formal sphere, laying the groundwork for simplified formalization mechanisms for the self-employed.

The main regulatory document aimed directly at reducing informal employment is Presidential Resolution No. PP-366 "On Measures to Reduce the Share of Informal Employment and to Form the Balance of Labor Resources Based on Modern Approaches" [7], which approved a "roadmap" for 2022-2024 and target indicators for 2023-2026, and set the tasks of conducting a diagnosis of informal employment and studying the state of informality by region and type of economic activity. Decree of the President of the Republic of Uzbekistan No. UP-126 "On Additional Measures to Improve the System of Labor Relations and Vocational Training and to Encourage Employers" [8] linked formalization to employer incentives and vocational training mechanisms, and introduced administrative liability for employers who permit informal employment (from 30 to 100 BCV, base calculation values). Resolution of the President of the Republic of Uzbekistan No. PP-49 "On Measures to Increase Household Incomes, Create Sustainable Jobs and Reduce Poverty through the Development of Regions Based on New Approaches in 2026" [9] set quantitative targets such as formalizing 1 million informal jobs during the year and reducing poverty to 2.8% and unemployment to 4.5%.

At the same time, a unified methodological tool that would make it possible to objectively assess the degree to which nationally approved targets are being met at the regional level has not yet been developed. Official statistics publish the informal employment rate at the national level, but do not regularly publish it by region. This limits the possibility of differentiating regional policy on an evidence-based basis. The aim of this article is to develop, on the basis of official statistical data, a methodology for the comprehensive assessment of informal employment in rural areas based on an integral index and clustering, and to test it using the regions of Uzbekistan as a case study.

1.1 Literature Review

Existing approaches to the definition, theoretical interpretation and policy responses to the informal economy have been systematized by M.A. Chen [10]. At the same time, international studies of the informal economy do not interpret the scope of regulatory measures and their outcomes in reducing informal employment in a uniform way. Empirical studies conducted in developing countries show that simplifying the procedures for state registration of business entities is an important institutional precondition for formalization, but in most cases these measures alone are not sufficient to significantly reduce informality.

Analyzing the transition of small firms to the formal sector in developing countries, M. Bruhn and D. McKenzie [11] show that, despite reforms to simplify business registration, a significant proportion of small firms remain in the informal sector. This is explained by the fact that an entrepreneur's decision to formalize depends not only on registration costs but also on factors such as the economic benefits of formal status, the tax burden, reporting obligations and state oversight.

These conclusions are confirmed by the results of the meta-analysis conducted by A. Floridi, B.A. Demena and N. Wagner [12]. Synthesizing 842 estimates from 27 empirical studies, the authors found that reducing the costs of entry into the formal sector does not by itself produce lasting results, whereas measures aimed at increasing the economic benefits of formal activity are relatively more effective. In a second meta-analysis by the same authors, which combined 1,271 empirical estimates from 20 studies [13], it was shown that the positive effects of formalization on firm performance in many cases materialize only over time.

F. Schneider and D. Enste [14] identified rising tax and social security burdens, the intensity of state regulation and the institutional environment as important determinants of the expansion of the shadow economy. R. La Porta and A. Shleifer [15], in turn, explain informality mainly by low productivity and the dual structure of the economy: many informal small firms cannot be turned into highly productive formal firms merely through registration, since differences in technology, human capital and management quality persist.

G. Ulyssea [16] demonstrated the need to distinguish between firm informality and labor informality: a firm may not be registered at all, or, conversely, a formal firm may employ workers "off the books". Consequently, an increase in firm registration does not mean that labor informality will decline at the same pace. In another study [17], he shows that informal employment is shaped jointly by firms' productivity and size, the tax burden, the requirements of labor legislation and the effectiveness of state enforcement. A comparative analysis of informal employment and policy responses in developed and developing economies was summarized by C. Williams and M. Lansky [18], while the macroeconomic consequences of informality and policy measures to address it were assessed in a World Bank study [19].

A methodology for the statistical study of informal employment at the regional level has been consistently developed by E.I. Dubravskaya using the constituent entities of the Russian Federation as a case study [20]. The author substantiated supplementing the statistical definition of informal employment with the social protection criterion of the 20th International Conference of Labour Statisticians; compiled a dataset of 124 indicators covering informal employment and socio-economic development; and organized the research in four stages - descriptive statistics, quantitative assessment of cause-and-effect relationships, integration of factor and cluster analysis, and identification of hidden relationships using the random forest method. As a result, the Russian regions were divided into five homogeneous groups according to the structural characteristics of informal employment and generalized factors of socio-economic development, and a coefficient of achievement of the labor market formalization target (Kmod) was proposed. An important conclusion of the authors [21] is that in developed regions the relative change in informal employment is faster than the relative change in socio-economic development indicators, whereas in less developed regions the opposite trend is observed.

This methodological scheme - classifying regions in a multidimensional feature space, integral assessment, and interpreting the results through the target achievement coefficient - can be adapted to the conditions of Uzbekistan. However, two important differences must be taken into account: first, in Uzbekistan the informal employment rate is not regularly published at the regional level, so classification requires a set of indirect indicators available in official statistics rather than direct ones; second, in Uzbekistan the center of gravity of informality lies in agriculture and the rural labor market, so the share of the rural population should be treated as an important structural factor in regional classification.

Among Uzbek scholars, B.E. Tagaev [22] substantiates the need for the combined use of legal, administrative and economic measures in regulating informal employment; in his approach, informality is also viewed as a mechanism that temporarily absorbs surplus labor in the labor market when formal jobs are lacking. In the study by G.T. Umarova [23], self-employment is analyzed as one of the mechanisms for increasing youth employment and for the transition from informal work to formal economic activity.

A comprehensive study of informal employment in Uzbekistan prepared in 2025 by the Central Bank, the Center for Economic Research and Reforms (CERR) and the United Nations Development Programme (UNDP) [24] has significantly broadened the approach in the national literature. In February-March 2025, the survey covered 481 employers, 461 self-employed persons and 2,008 informal workers. An important finding of the study is that informality persists not only in unregistered microbusinesses but also within formal enterprises: 22.25% of employers reported hiring informal workers, the main reasons being cost reduction (48.6%), flexible use of labor (43.0%) and easier dismissal of employees (35.5%). Of informal workers, 83% have no paid leave, 80% have no pension contributions paid on their behalf, and 73% work without the necessary occupational safety protocols. Among the reasons for informal employment, 58% of respondents cited the lack of opportunities to find a formal job and 48% cited insufficient skills, while only 14% of respondents mentioned tax avoidance.

In international practice, too, simplifying registration procedures alone has not always produced the expected results. In Mexico, a business registration reform [11] increased the number of formal firms by about 5%, but this was mainly due to new entrepreneurs. In Sri Lanka, a field experiment by S. de Mel, D. McKenzie and C. Woodruff [25] showed that providing information on registration and reimbursing direct costs did not, by themselves, significantly increase formalization. In Benin, a randomized experiment by N. Benhassine et al. [26] found that an enhanced formalization package raised the formalization rate by 16.3 percentage points, but no significant growth in firms' sales or profits was observed. In Uruguay's "Monotributo" experience [27], the simplified tax regime was linked to social insurance, and according to ILO data the share of informal workers in the country fell from 42.8% in 2001 to 21.0% in 2022. The "Duru-Nuri" program in the Republic of Korea [28] expanded coverage by subsidizing part of the social insurance contributions for low-income employees of small enterprises and their employers.

Thus, three general conclusions emerge from the literature review: administrative simplification is necessary but not sufficient on its own; formalization must create clear economic and social benefits for the entity concerned; and the subsequent status of the formalized entity or worker - their income, social protection and the stability of their status - must be monitored. ILO Recommendation No. 204 likewise closely links the transition from the informal to the formal economy with decent work, labor rights and social protection [29]. At the same time, there are insufficient studies devoted to the quantitative assessment of informal employment at the regional level in Uzbekistan and to grouping regions into homogeneous clusters. This article aims to fill this gap.

2. Materials and Methods

The information base of the study consists of official data from the Statistics Agency of the Republic of Uzbekistan: indicator 8.3.1 on the National SDG Platform (2018-2024) [1]; the number of employed persons in the economy and their distribution by type of

economic activity, the employment rate, the economic activity rate, the number of unemployed, the average monthly nominal accrued wage, and the number of persons employed in the public sector [30]; the poverty rate and total per capita income [31]; and the size of the resident and rural populations [32]. Regional calculations are based on preliminary data for 2025, while national dynamics cover 2018-2025. In addition, the results of the 2025 survey by CERR, UNDP and the Central Bank [24], operational data on informal employment for 2026 [2], and ILO methodological documents and the ILOSTAT database [3], [33] were used.

The study was carried out in four stages:

Stage one - descriptive analysis of the national dynamics of informal employment and decomposition of its change using the shift-share method. Since SDG indicator 8.3.1 is published separately for agriculture and non-agriculture, and data on the sectoral structure of employment are available, the informal employment rate can be expressed as follows:

$IE = s \cdot r(agr) + (1 - s) \cdot r(nagr)$,

where IE is the informal employment rate; s is the share of employment in agriculture; r(agr) and r(nagr) are the informal employment rates in the agricultural and non-agricultural sectors, respectively. The change between two periods is decomposed into three components:

$\Delta IE = (s_1 - s_0)(r_0(agr) - r_0(nagr)) + [s_0 \cdot \Delta r(agr) + (1 - s_0) \cdot \Delta r(nagr)] + (s_1 - s_0)(\Delta r(agr) - \Delta r(nagr))$,

that is, the structural effect, the within-sector effect and the interaction effect. This decomposition answers the question of whether the decline in informal employment occurred owing to the intersectoral reallocation of employment or owing to genuine formalization within sectors.

Stage two - construction of the integral index of **regional informality risk** (I_{RIR}). Since the informal employment rate is not regularly published at the regional level in Uzbekistan, the index was built on six indicators that are available in official statistics and are substantiated in the literature as determinants of informality: the poverty rate; the share of the rural population; the unemployment rate; the ratio of the average monthly wage to the national level; the employment rate; and the share of public sector employment. The first four indicators increase informality risk, while the last two reduce it. It should be noted that I_{RIR} is not a measured value of the informal employment rate, but rather the authors' estimate of the regional concentration of the conditions conducive to its emergence.

To make the indicators comparable, linear min-max normalization was applied in accordance with the international handbook on constructing composite indicators [34], and the results were rescaled to a 1-100 scale (100 points = highest risk):

$S_{ij} = 1 + 99 \cdot (x_{ij} - L_j)/(U_j - L_j)$ - for risk-increasing indicators;

$S_{ij} = 1 + 99 \cdot (U_j - x_{ij})/(U_j - L_j)$ - for risk-reducing indicators,

where x_{ij} is the actual value of indicator j for region i, and L_j and U_j are the observed minimum and maximum values. The indicator weights were determined using an objective, expert-independent method - the information entropy method [35]:

$E_j = -(1/\ln n) \cdot \Sigma_i\, p_{ij} \cdot \ln p_{ij}$, $p_{ij} = S_{ij}/\Sigma_i S_{ij}$, $w_j = (1 - E_j)/\Sigma_j(1 - E_j)$.

Aggregation was performed using a weighted geometric mean [36], since this method limits the extent to which a very low score on one indicator can be fully offset by a high score on another:

$I_{RIR}^{(i)} = \Pi(j)\, S_{ij}^{w_j}$, $\Sigma_j w_j = 1$.

Stage three - multidimensional classification of the regions. After z-standardization of the normalized scores, clusters were identified using the k-means method; the silhouette coefficient was calculated to select the number of clusters, and the robustness of the results was tested by comparison with Ward's hierarchical clustering and by calculating the adjusted Rand index [37].

Stage four - validation of the results. In the sensitivity analysis, carried out in line with established practice for assessing the quality of composite indicators [38], the weights were randomly varied within ±20%, 1,000 alternative calculations were performed, and

the rank range was determined for each region; in addition, the results of weighted geometric, equally weighted geometric and arithmetic aggregation were compared using Spearman's rank correlation. For external validation, an independent indicator not included in the index was used - total per capita income. The calculations were performed in Python 3 (*NumPy, pandas, scikit-learn, SciPy*).

3. Result

National dynamics of informal employment. The dynamics of the informal employment rate in Uzbekistan in 2018-2024 were uneven (Table 1). Having fallen from 40.5% in 2018 to 39.6% in 2019, the indicator rose sharply during the pandemic, reaching 43.8% in 2021 - the highest value of the observation period. This confirms that informal employment acts as a "buffer" against labor market shocks, i.e., when formal jobs are cut, people shift to informal activities. A steady decline has been observed since 2022, with the indicator falling to 37.9% in 2024. However, the overall decrease over the six-year period amounted to only 2.6 percentage points, which indicates the inertial nature of the formalization process.

The gender gap deserves particular attention. Throughout the observation period, the informal employment rate among women has remained higher than among men: the gap was 9.7 percentage points in 2018, widened to 18.4 percentage points in 2019, and stabilized at 14.0 percentage points in 2024. Importantly, while the overall indicator fell by 5.9 percentage points from 2021 to 2024, the rate for women decreased by only 4.2 percentage points (from 51.0% to 46.8%). Hence, men are benefiting relatively more from the formalization process, which confirms the need for monitoring the coverage of population groups and structural disparities.

The sectoral gap is even more pronounced [1]. In agriculture, the informal employment rate reached 70.3% in 2019 and stood at 60.3% in 2024. In non-agricultural sectors, the corresponding figures were 29.4% and 30.9%. In other words, three out of every five people working in agriculture, and three out of every ten in non-agricultural sectors, remain in informal employment. The gap between the two sectors narrowed from 40.9 percentage points in 2019 to 29.4 percentage points in 2024; however, this narrowing was due not only to improvement in agriculture but also to deterioration in non-agricultural sectors.

Table 1. Dynamics of the informal employment rate in Uzbekistan (SDG indicator 8.3.1), percent

Year	Total	Women	Men	Gender gap, p.p.	Agriculture	Non-agriculture	Sectoral gap, p.p.
2018	40.5	47.5	37.8	9.7	66.5	30.0	36.5
2019	39.6	50.4	32.0	18.4	70.3	29.4	40.9
2020	42.8	50.4	37.4	13.0	66.7	34.3	32.4
2021	43.8	51.0	38.7	12.3	69.4	35.2	34.2
2022	39.6	47.4	34.0	13.4	61.7	32.3	29.4
2023	39.0	47.1	33.1	14.0	60.8	31.5	29.3
2024	37.9	46.8	32.8	14.0	60.3	30.9	29.4

Source: compiled by the authors based on data from [1].

Structural decomposition of the change in informal employment. To identify the mechanism behind the decline in the informal employment rate, the structural decomposition presented in Tables 2-3 was performed. First, the correctness of the model specification was checked: the informal employment rate calculated using the formula $IE = s \cdot r(agr) + (1 - s) \cdot r(nagr)$ was 40.11% for 2019 (official value: 39.6%) and 37.58% for 2024

(official value: 37.9%). The fact that the difference does not exceed 0.5 percentage points indicates that the model can be used for the decomposition.

Table 2. Sectoral structure of employment and structural decomposition of the informal employment rate

Indicator	Years				
	2019	**2021**	**2023**	**2024**	**2025**
Employed in the economy, thousand persons	13,541.1	13,538.9	14,014.2	14,261.9	14,933.9
of which in agriculture, thousand persons	3,544.6	3,414.7	3,344.0	3,240.7	3,132.6
Share of employment in agriculture, %	26.18	25.22	23.86	22.72	20.98
Share of employment in industry, %	12.54	12.82	12.28	11.30	11.83
Share of employment in construction, %	9.78	9.98	10.72	9.54	9.71
Share of employment in trade, %	10.61	11.34	11.32	10.55	10.10
Informal employment rate (official), %	39.6	43.8	39.0	37.9	-
Model-estimated rate, %	40.11	-	-	37.58	-

Source: authors' calculations based on data from [1], [30]. The model-estimated rate is obtained using the formula IE = s·r(agr) + (1 − s)·r(nagr); the difference from the official rate does not exceed 0.3-0.5 percentage points, which indicates that the model specification is satisfactory.

The decomposition yielded the following results. First, the structural effect amounted to −1.41 percentage points. It resulted from the decline in the share of employment in agriculture from 26.18% to 22.72%, i.e., by 3.46 percentage points: the outflow of labor from a sector with a high level of informality to relatively more formal sectors "automatically" lowered the overall level of informal employment. Second, the effect of formalization within agriculture amounted to −2.62 percentage points - the strongest positive factor. Third, the growth of informality in non-agricultural sectors (+1.11 percentage points) weakened the overall result.

Table 3. Structural decomposition of the change in the informal employment rate (2019-2024), percentage points

Type of effect	Value	Share of total change, %	Economic interpretation
Effect of the change in sectoral structure on the informal employment rate	-1.41	55.7	Reallocation of employment from agriculture, where informality is high, to other sectors
Within-sector effect - total:	-1.51	59.7	Change in the level of informality within sectors
of which in agriculture	-2.62	103.6	Decrease in agricultural informality from 70.3% to 60.3%

Type of effect	Value	Share of total change, %	Economic interpretation
of which in non-agriculture	+1.11	-43.9	Increase in non-agricultural informality from 29.4% to 30.9%
Interaction effect	+0.40	-15.8	Joint effect of the structural shift and within-sector changes
TOTAL change	**-2.53**	**100.0**	**Overall decrease in 2019-2024**

Source: authors' calculations.

This result leads to an important policy conclusion: more than half (55.7%) of the decline in informal employment in Uzbekistan is due to the intersectoral structural shift, i.e., the outflow of people from agriculture. If this flow is directed towards sectors such as services and construction, and labor relations in these sectors are not formalized, informality simply moves from one sector to another. This is exactly what was observed in 2019-2024: the informal employment rate in non-agricultural sectors increased by 1.5 percentage points. Data for 2026 also confirm this [2]: 26.8% of the informally employed (1.48 million people) work in the services sector (*Table 4*).

At the same time, the center of gravity of informal employment still lies in agriculture: 3.12 million (56.6%) of the 5.5 million informally employed work in this sector. Agriculture, services, construction and catering together account for 88.6% of the informally employed. Hence, it is economically justified to direct the resources of formalization policy precisely to these four sectors.

Table 4. Sectoral structure of informal employment (2026 data)

Sector	Informally employed, thousand persons	Share of total informal employment, %
Agriculture	3,120	56.6
Services	1,480	26.8
Construction	147	2.7
Catering	134	2.4
Total for the four sectors	4,881	88.5
Other sectors	619	11.5
TOTAL informally employed	**5,500**	**100.0**

Source: compiled based on [2]. Total employment - 14.213 million persons; share of informal employment - 38.8%.

Integral index of regional informality risk. Table 5 presents the labor market and socio-economic indicators of Uzbekistan's regions for 2025. The data show substantial interregional disparities: the employment rate ranges from 64.8% in Surkhandarya region to 86.9% in Tashkent city, the average monthly wage from 70.1% to 168.1% of the national level, and the share of the rural population from zero to 67.0%. It is precisely these disparities that determine the regional conditions under which informal employment emerges.

Table 5. Labor market and socio-economic indicators of the regions of Uzbekistan (2025, preliminary data)

Region	Employed, thousand persons	Employment rate, %	Unemployment rate, %	Wages, national average = 100%	Rural population, %	Poverty, %	Public sector share, %
Rep. of Karakalpakstan	805.8	67.3	5.00	81.6	51.2	6.6	20.5
Andijan region	1,410.4	73.0	4.77	82.7	47.8	6.1	13.9
Bukhara region	840.2	70.8	4.71	79.5	63.1	6.0	21.1
Jizzakh region	593.2	69.0	4.92	76.3	53.0	5.8	18.7
Kashkadarya region	1,333.1	65.9	4.95	70.2	57.3	6.5	17.6
Navoi region	472.8	75.9	4.18	123.8	50.7	4.2	25.7
Namangan region	1,177.2	67.0	5.03	73.0	35.1	5.5	15.2
Samarkand region	1,611.7	67.6	4.75	73.8	63.5	6.1	15.0
Surkhandarya region	1,057.6	64.8	4.92	70.1	63.9	6.1	19.6
Syrdarya region	374.0	68.6	4.96	81.9	57.0	6.2	21.1
Tashkent region	1,280.1	72.9	4.79	88.0	50.0	5.3	17.5
Fergana region	1,606.2	69.0	4.93	73.7	43.2	5.7	15.9
Khorezm region	840.1	70.4	4.74	77.1	67.0	6.7	16.2
Tashkent city	1,531.5	86.9	3.97	168.1	0.0	3.5	22.5
Republic of Uzbekistan	**14,933.9**	**70.5**	**4.75**	**100.0**	**49.0**	**5.8**	**17.9**

Source: authors' calculations based on data from [30], [31], [32]. The unemployment rate is calculated as the ratio of the number of unemployed to the labor force, and the share of public sector employment as the ratio of persons employed in the public sector to total employment.

Table 6 presents the scores of the indicators rescaled to a 1-100 scale and their weights determined by the entropy method. The highest weight was assigned to the share of public sector employment (21.71%), since its variation across regions is the greatest - i.e., this indicator best differentiates the regions from one another. It is followed by the poverty rate (18.25%) and the unemployment rate (18.21%). The share of the rural population (13.82%), wages (13.90%) and the employment rate (14.11%) received relatively lower weights. Importantly, the entropy method determines the weights based on the information content of the data rather than on subjective expert judgment.

Table 6. Normalized scores (1-100) and entropy weights of the indicators of the regional informality risk index

Region	Normalized scores of the regional informality risk index indicators (1-100)					
	Poverty	*Rural population*	*Unemployment*	*Wages**	*Employment**	*Public sector**
Rep. of Karakalpakstan	96.9	76.7	96.7	88.4	88.8	44.3
Andijan region	81.4	71.6	75.2	87.3	63.3	100.0

Region	Normalized scores of the regional informality risk index indicators (1-100)					
	Poverty	*Rural population*	*Unemployment*	*Wages**	*Employment**	*Public sector**
Bukhara region	78.3	94.2	69.6	90.5	73.1	39.0
Jizzakh region	72.2	79.2	89.5	93.8	81.2	59.8
Kashkadarya region	93.8	85.6	92.0	99.9	95.1	68.3
Navoi region	22.7	75.9	20.2	45.7	50.3	1.0
Namangan region	62.9	52.9	100.0	97.1	90.1	89.2
Samarkand region	81.4	94.7	73.2	96.2	87.5	90.2
Surkhandarya region	81.4	95.3	89.2	100.0	100.0	52.0
Syrdarya region	84.5	85.1	92.7	88.1	83.0	39.1
Tashkent region	56.7	74.8	77.3	81.9	63.7	69.6
Fergana region	69.1	64.8	90.4	96.4	81.2	82.9
Khorezm region	100.0	100.0	72.7	92.9	74.9	80.4
Tashkent city	1.0	1.0	1.0	1.0	1.0	27.7
Entropy weight, %	**18.25**	**13.82**	**18.21**	**13.90**	**14.11**	**21.71**

Source: authors' calculations. The asterisk (*) indicates that the indicator was normalized in the reverse direction, as it reduces informality risk.

Table 7 presents the results of the calculated integral index. The regions with the highest informality risk are Kashkadarya (87.09), Samarkand (86.21), Khorezm (85.50) and Surkhandarya (81.30). The common features of these four regions are a high share of the rural population (57.3-67.0%), wages considerably below the national level (70.1-77.1%), and poverty rates above the national average (6.1-6.7%). The lowest index values were recorded in Tashkent city (2.06) and Navoi region (16.43); in these regions, high wages, low unemployment and a relatively high share of the public sector ensure the predominance of formal employment.

The robustness of the results was tested in three ways. First, the weights were randomly varied by ±20% and 1,000 alternative calculations were performed: the regions' positions in the ranking shifted by no more than 4 places, while the composition of the top three and the bottom two did not change at all. Second, the results of weighted geometric aggregation were highly consistent with those of equally weighted geometric aggregation (Spearman's rank correlation of 0.974) and arithmetic aggregation (0.996). Third, the relationship with an external indicator not included in the index - total per capita income - was examined, yielding a Pearson correlation of −0.911 ($p < 0.001$). This confirms that the index reliably reflects the economic situation of the regions.

Table 7. Integral index of regional informality risk (I_{RIR}), ranking and sensitivity analysis results

Region	I_{RIR}	Rank	Sensitivity range (±20 %)	Equal-weight rank	Cluster
Kashkadarya region	87.09	1	1-3	1	III
Samarkand region	86.21	2	1-3	2	IV
Khorezm region	85.50	3	1-3	3	III
Surkhandarya region	81.30	4	4-7	4	III
Namangan region	80.54	5	4-8	6	IV
Andijan region	80.33	6	4-8	8	IV
Fergana region	80.16	7	5-7	5	IV

Region	I_{RIR}	Rank	Sensitivity range (±20 %)	Equal-weight rank	Cluster
Rep. of Karakalpakstan	77.17	8	5-9	7	III
Jizzakh region	76.94	9	8-9	9	III
Syrdarya region	73.01	10	10-11	10	III
Tashkent region	69.72	11	10-12	12	IV
Bukhara region	68.29	12	11-12	11	III
Navoi region	16.43	13	13	13	II
Tashkent city	2.06	14	14	14	I

Source: authors' calculations. The sensitivity range was obtained from 1,000 alternative calculations with the weights randomly varied by ±20%.

Results of regional clustering. The multidimensional classification identified four clusters of regions (*Table 8*). When selecting the number of clusters, the silhouette coefficient was 0.649 for k = 2, 0.541 for k = 3 and 0.229 for k = 4. Although formally the k = 2 solution has the highest value, it merely separates Tashkent city and Navoi region from the remaining twelve regions and does not provide sufficient information for differentiating management decisions. Therefore, taking interpretability into account, the k = 4 solution was chosen. The robustness of the results was tested by comparison with Ward's hierarchical clustering: the adjusted Rand index was 0.737, indicating a high degree of agreement between the results of the two methods.

Table 8. Profiles and weight coefficients of the clusters of Uzbekistan's regions (2025)

Indicator	Cluster I	Cluster II	Cluster III	Cluster IV
Regions	Tashkent city	Navoi region	Republic of Karakalpakstan; Bukhara, Jizzakh, Kashkadarya, Surkhandarya, Syrdarya and Khorezm regions	Andijan, Namangan, Samarkand, Tashkent and Fergana regions
Number of regions	1	1	7	5
Mean RIRI value	2.06	16.43	78.47	79.39
Poverty rate, %	3.5	4.2	6.3	5.7
Share of rural population, %	0.0	50.7	58.9	47.9
Unemployment rate, %	3.97	4.18	4.88	4.85
Average wage, % of national average	168.1	123.8	76.7	78.2
Employment rate, %	86.9	75.9	68.1	69.9
Share of public sector employment, %	22.5	25.7	19.3	15.5

Indicator	Cluster I	Cluster II	Cluster III	Cluster IV
Share of national employment, %	10.3	3.2	39.1	47.5
Weight coefficient (kx)	0.103	0.032	0.391	0.474
Brief description of the cluster	Very low informality risk; urban-type labor market	Low informality risk; industrialized rural region	Agrarian-peripheral type; high informality risk	Labor-abundant type; high informality risk

Source: authors' calculations. The weight coefficient is defined as the ratio of the number of employed persons in the regions belonging to the cluster to total national employment.

4. Discussion

Cluster I - Tashkent city. This is the only region with no rural population; wages are 68% above the national level, and the poverty rate is 3.5%. Here, the informality problem is associated not with rural labor but with the incomplete formalization of labor relations in services, construction and digital platforms.

Cluster II - Navoi region. The distinctive feature of this region is that, although the share of the rural population is 50.7%, the presence of large industrial enterprises raises wages to 123.8% of the national level, and the share of public sector employment is the highest - 25.7%. Hence, living in rural areas does not in itself give rise to informality; the decisive factor is the availability of formal, stable and highly productive jobs in rural areas. This confirms, in the context of Uzbekistan, La Porta and Shleifer's theoretical thesis linking informality to productivity.

Cluster III - the agrarian-peripheral type, comprising the Republic of Karakalpakstan and Bukhara, Jizzakh, Kashkadarya, Surkhandarya, Syrdarya and Khorezm regions. In this group, the share of the rural population averages 58.9%, the poverty rate is 6.3%, and wages amount to 76.7% of the national level. The share of public sector employment in these regions is relatively high (19.3%), indicating that formal employment is formed mainly by budget-funded organizations, while not enough formal jobs are being created in the non-state sector.

Cluster IV - Andijan, Namangan, Samarkand, Tashkent and Fergana regions. The distinctive feature of this group is the high density and large volume of labor resources: these five regions account for 47.5% of total national employment. Although the share of the rural population is lower than in Cluster III (47.9%), the share of public sector employment is the lowest (15.5%). Hence, the main source of informality in these regions is not agriculture but the lack of formalization of labor relations in small business, services and seasonal work.

The mean index values of Clusters III and IV are almost equal (78.47 and 79.39), yet their profiles differ fundamentally. This leads to an important methodological conclusion: the same overall score does not imply the same policy measure. In Cluster III, the priority is to expand formal jobs in the non-state sector in rural areas and to place labor relations on farms and dehkan (household) farms on a contractual basis; in Cluster IV, the priority is to bring labor relations in small business and services into the formal sphere and to introduce simplified contract mechanisms for seasonal and temporary work.

The identified clusters account for the following shares of national employment: Cluster I - 10.3%, Cluster II - 3.2%, Cluster III - 39.1%, and Cluster IV - 47.5%. Thus, 86.6% of the country's employed persons work in Clusters III and IV, which have a high

informality risk. This indicates that formalization measures should focus primarily on these twelve regions.

Target achievement coefficient. When assessing the effectiveness of formalization policy, the initial conditions of the regions must be taken into account. It is methodologically incorrect to set the same target for a region with an initial informal employment rate of 30% and for one with a rate of 50%. Therefore, adapting to the conditions of Uzbekistan the approach proposed by the economist E.I. Dubravskaya for Russian regions [20], we propose using a target achievement coefficient that takes regional characteristics into account:

$$Kmod = [(IE_1/IE_0) / (f_1/f_0)] \times kx,$$

where IE_1 and IE_0 are the actual informal employment rates in the region in the current and base years, respectively; f_1 and f_0 are the target (forecast) levels set for the region; and kx is the region's cluster weight coefficient (*Table 8*). A coefficient value below one indicates that the actual decrease is faster than the target trajectory, while a value above one indicates the opposite. The weight coefficient reflects the region's actual weight in the labor market: for example, a one percentage point decrease achieved in the regions of Cluster IV has an impact on the national indicator about fifteen times greater than the same decrease in the Cluster II region.

A necessary condition for the practical application of this coefficient is the regular publication of the informal employment rate at the regional level. At present, this indicator is published only at the national level, which limits the possibility of objectively assessing the effectiveness of regional policy.

Comparison with survey results from official sources. The substantive validity of the developed index is also supported by the results of the 2025 survey by CERR, UNDP and the Central Bank [24]. In this survey, 58% of respondents cited the lack of opportunities to find a formal job as the main reason for informal employment - which substantively justifies the high weights assigned to the unemployment and employment rate indicators in the index (32.3% combined). Of the respondents, 48% cited insufficient skills, while only 14% considered tax avoidance to be the main reason. Hence, the predominant cause of informality in Uzbekistan is the shortage of formal jobs and skills mismatch, i.e., involuntary informality.

Employers' motivation, however, is different: 22.25% of those surveyed admitted hiring informal workers, the main reasons being cost reduction (48.6%), flexible use of labor (43.0%) and easier dismissal (35.5%). Job quality indicators reveal the depth of the problem: 83% of informal workers have no paid leave, 80% have no pension contributions paid on their behalf, and 73% work without occupational safety protocols. Thus, informality is sustained simultaneously on the demand side (cost savings) and on the supply side (a shortage of formal jobs), and measures targeting only one side will not produce the expected results.

5. Conclusion

The results of the study show that informal employment should be assessed not as a separate statistical state of the labor market, but as a complex process shaped by the interaction of legal, economic, social and institutional factors. The following main conclusions have been drawn.

First, the 2.5 percentage point decrease in the informal employment rate in Uzbekistan in 2019-2024 resulted not from a single mechanism but from three different processes: the outflow of employment from agriculture (−1.41 percentage points), formalization within agriculture (−2.62 percentage points), and an increase in informality in non-agricultural sectors (+1.11 percentage points). This means that informality is not disappearing from the national economy, but is partly shifting from one sector to another. Therefore, alongside agriculture, formalization policy should also specifically target services, construction and catering - these four sectors currently account for 88.6% of all informally employed persons.

Second, throughout the observation period, the informal employment rate among women has remained 12-18 percentage points higher than among men, and women are

benefiting relatively less from the formalization process. Therefore, in the national monitoring system, all outcome indicators should be disaggregated by sex, age, urban/rural location and sector on a mandatory basis.

Third, the developed integral index of regional informality risk (I_{RIR}) makes it possible to reliably classify regions by informality risk using indicators available in official statistics. The robustness of the index was confirmed by a sensitivity analysis with weights varied by ±20%, by comparison with alternative aggregation methods (Spearman's correlation of 0.974-0.996), and by external validation (correlation with per capita income of −0.911).

Fourth, the clustering of regions made it possible to identify two distinct mechanisms of informality. In the seven regions of the agrarian-peripheral type (the Republic of Karakalpakstan, Bukhara, Jizzakh, Kashkadarya, Surkhandarya, Syrdarya and Khorezm), the root of the problem is the shortage of formal jobs in the non-state sector in rural areas and low incomes. In the five regions of the labor-abundant type (Andijan, Namangan, Samarkand, Tashkent and Fergana regions), it is the lack of formalization of labor relations in small business and services under conditions of a high density of labor supply. The example of Navoi region shows that living in rural areas does not in itself give rise to informality, and that the decisive factor is the availability of highly productive formal jobs.

Fifth, since the initial conditions of the regions differ, setting the same target for all of them is not methodologically justified. The target achievement coefficient (*Kmod*), based on cluster weight coefficients, makes it possible to assess policy effectiveness while taking into account the actual weight and initial level of each region.

Based on the results of the study, the following practical recommendations have been developed:

1. Introduce a procedure for the regular publication - at least once a year - of the informal employment rate (SDG indicator 8.3.1 [1]) by region, sex, age group and type of economic activity; without this, an objective assessment of the effectiveness of regional policy is impossible;
2. Integrate labor force survey data with the administrative databases of the Unified National Labor System, the tax authorities and social insurance through the PINFL (personal identification number) and TIN, and create a dedicated analytical database;
3. Measure the outcome of formalization not by the number of registered persons, but by the rate of retention of formal status over 6 and 12 months; this will make it possible to distinguish between one-off registration and sustainable formal employment;
4. In the regions of the agrarian-peripheral cluster, introduce a simplified electronic contract mechanism for seasonal work on farms and dehkan farms, as well as a social insurance scheme adapted to seasonal workers;
5. In the regions of the labor-abundant cluster, apply incentive measures targeted at small business and services - time-limited subsidization of part of the social insurance contributions for microenterprises that hire workers formally (similar to the experience of the "Duru-Nuri" program in the Republic of Korea [28]);
6. Link self-employed status to social insurance coverage [27], [29], i.e., offer the simplified tax regime as a package together with other social and legal guarantees, as in Uruguay's "Monotributo" experience;
7. Introduce into official monitoring practice a system of differentiated targets by regional cluster and the coefficient of their achievement (*Kmod*).

Overall, an effective national mechanism for reducing informal employment should operate on the principle of "measure - identify causes - take targeted action - re-measure results". In this respect, the ultimate outcome of formalization policy should be assessed not by the number of registered persons, but by the growth in the share of the population that has moved into formal employment, whose income is fully recorded, whose social and labor rights are ensured, and who sustainably retain the formal status they have attained.

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