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ORIGINAL ARTICLE

Empirical Analysis of the Readiness of Kazakhstan's Labor Resources Transformation to a "Green" Economy

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Abstract
In Kazakhstan, the transition to a green economy remains insufficiently empirically researched, despite the availability of strategic documents on innovative development. The aim of the study is to assess the readiness of Kazakhstan's workforce for the transition to a "green" economy based on an analysis of factors affecting the number of people employed in "green" jobs.The methodological base of the study includes correlation analysis and the method of statistical equations of dependencies, which identify the stability of relationships in conditions of multicollinearity of factors and a limited length of time series. The empirical study is based on official statistical data from the Bureau of National Statistics for the period 2020-2024. The results of the correlation analysis showed a high degree of correlation between the dynamics of "green" employment and a number of factors (10 out of 19), including GDP per capita, investment in fixed assets, R&D expenditures, and financing of "green" economy projects. However, the application of the method of statistical equations of dependencies revealed the absence of stable functional relationships between the number of people employed in "green" jobs and most of the analyzed factors. The only variable for which a stable statistical relationship was recorded (stability coefficient $K > 0.7$) was the unemployment rate. The prospects for further research include analyzing institutional mechanisms that shape demand for "green" competencies, expanding the time series of data, and conducting a comparative analysis with practices in EU countries.

KEYWORDS
Economy, Green Economy, Green Job, Labor Market, Labor Resource, Human Capital, Unemployment, Demography

1 | INTRODUCTION

The global shift toward a green economy has emerged as a central paradigm of contemporary economic development, driven by the growing urgency of climate change, environmental degradation, and resource constraints. This transition extends beyond technological modernization and environmental regulation; it entails big structural changes in production systems, consumption patterns, and, critically, labor markets. As economies reorient toward sustainability goals, the capacity of labor resources to adapt to new requirements becomes a decisive factor shaping the effectiveness and pace of the green transition.

In advanced economies, the transition to a green economy has been accompanied by the systematic formation of green employment as a distinct and increasingly stable segment of the labor market. Countries of the European Union provide a clear example of this process, where environmental objectives are embedded within broader economic and social policies. Regulatory frameworks, targeted investment instruments, labor market policies, and education systems are aligned to support the creation of environmentally oriented jobs and the development of relevant skills. As a result, employment in green sectors in these countries demonstrates predictable and statistically observable relationships with macroeconomic indicators, investment in renewable energy and environmental technologies, innovation activity, and human capital development. Green employment thus functions not as a residual or declarative category, but as an integrated component of economic growth and labor market dynamics. In contrast, the situation in economies undergoing structural transformation requires a more cautious and empirically grounded assessment. In the Republic of Kazakhstan, the transition to a green economy is articulated in a range of strategic documents addressing sustainable development, environmental modernization, and decarbonization. These policy frameworks outline ambitious targets related to energy efficiency, renewable energy, and environmental protection. However, the structural characteristics of the national economy - most notably its resource-oriented model, significant role of the state, and limited diversification - raise questions about the extent to which these strategic objectives are reflected in actual labor market transformations.

In this context, employment in green jobs is a particularly informative indicator of labor resource transformation. Unlike investment volumes or policy commitments, employment outcomes capture the realized interaction between economic demand, institutional conditions, and workforce capabilities. Analyzing the number of individuals employed in green jobs allows for an assessment of whether the green transition in Kazakhstan is generating tangible labor market effects or remains largely confined to the level of strategic intentions.

Despite the expanding body of international research on green employment, empirical evidence for Kazakhstan remains fragmented. Existing studies often proceed from the assumption that the drivers of green employment observed in developed economies - such as environmental investment, innovation intensity, education levels, and overall economic growth - are universally applicable. However, such assumptions may not hold in transitional economies, where market mechanisms are intertwined with administrative regulation and policy-driven resource allocation. This necessitates empirical verification rather than theoretical extrapolation. The present study aims to contribute to this gap by examining the readiness of Kazakhstan's labor resources for the transition to a green economy through an analysis of the factors influencing employment in green jobs. Using official statistical data, the study investigates the relationship between the number of people employed in green jobs and a broad set of socio-economic, investment, innovation, and educational indicators. The central research hypothesis posits that, under current conditions, growth in green employment in Kazakhstan is not consistently and significantly dependent on these

factors and is shaped predominantly by institutional and political decisions rather than by market-based drivers.

The scientific contribution of this research lies in its methodological and conceptual approach. Rather than treating the absence of stable dependencies as a limitation, the study interprets it as a meaningful empirical result that reflects the actual state of labor market transformation. By demonstrating that parallel movements of indicators do not necessarily imply causal linkages, the research challenges conventional expectations regarding green employment dynamics. The findings suggest that the development of green jobs in Kazakhstan remains largely adaptive and policy-driven, highlighting a gap between strategic declarations and structural labor-market change. This underscores the need to transition from declarative environmental objectives to coherent policies that stimulate genuine demand for green competencies and sustainable employment. Thus, the study aims to assess the readiness of Kazakhstan's workforce for the transition to a "green" economy based on an analysis of factors affecting the number of people employed in "green" jobs.

2 | LITERATURE REVIEW

The transition to a green economy and its implications for labor markets have become central themes in contemporary economic research, driven by the global climate agenda, the energy transition, and the restructuring of production systems. In the international literature, this process is predominantly examined through the lens of employment restructuring, the creation of green jobs, shifts in skill requirements, and the role of public policy in facilitating labor market adaptation to new development trajectories.

A substantial body of empirical research focuses on the employment effects of environmental regulation and energy transition. Early studies primarily emphasized the potential costs of environmental policies, including job losses and higher production costs (Berman & Bui, 2001; Bezdek et al., 2008). More recent contributions, however, increasingly highlight compensatory mechanisms through job creation in environmentally oriented sectors, suggesting that the net employment effect of environmental regulation depends critically on institutional conditions, sectoral structure, and the degree of economic diversification (Barra & Ruggiero, 2019). Within this strand of literature, renewable energy development is widely identified as a key driver of green job creation. Empirical evidence from Germany, the Netherlands, and other OECD countries demonstrates that employment growth in renewable energy industries is closely linked to consistent government support, long-term investment strategies, and well-functioning labor market institutions (Lehr et al., 2008; Bulavskaya & Reynès, 2018; Destek et al., 2020). At the same time, these studies emphasize that the employment effects of green technologies are not automatic and depend on the economy's capacity to reallocate labor across sectors.

Research focusing on European Union countries further reveals relatively stable relationships between green employment, sustainable development indicators, and innovation dynamics. Swain et al. (2022) showed that green job growth in the EU is particularly pronounced in regions with advanced innovation systems, strong educational infrastructure, and supportive institutional environments. Using micro-level data, Bluedorn et al. (2023) provided additional evidence that the green transition reshapes labor demand and generates new skill requirements, reinforcing the structural nature of employment changes in advanced economies.

A growing literature also addresses the skill-biased effects of the green transition. Empirical findings suggest that environmental policies and energy transformation tend to increase demand for highly skilled labor, while simultaneously raising adjustment risks for

low-skilled workers (Briggs et al., 2022; Černý et al., 2024; Javed & Usman, 2025). Consequently, the green transition is increasingly framed not only as an environmental challenge, but also as a socio-economic one, requiring targeted education and retraining policies.

Another important stream of research examines the role of environmental innovation and green technologies. Firm-level studies indicate that innovation activity can mitigate the potentially negative employment effects of environmental regulation and contribute to job creation (Cainelli et al., 2011; Huang et al., 2023). However, the positive labor market impact of innovation appears to be significantly stronger in countries with mature institutional frameworks and well-developed mechanisms for supporting technological change.

In contrast, empirical evidence for developing and transition economies remains relatively limited. Studies focusing on China and other economies with a strong state role reveal heterogeneous and often indirect employment effects of environmental policies, largely shaped by institutional reforms and governance models (Li & Li, 2024; Liu et al., 2023). Similar conclusions are drawn in analyses of resource-oriented economies, where green transformation is frequently constrained by structural rigidities and institutional bottlenecks (Côté, 2018; Osorio-Aravena et al., 2025).

Overall, existing research suggests that in economies with well-developed institutions and coherent green policies, green employment tends to exhibit stable statistical relationships with investment, innovation, and educational indicators (Ram et al., 2020; Ma & Wang, 2025). By contrast, in economies at an early stage of green transformation, such relationships are often weak, unstable, or entirely absent.

Despite the growing literature, an important methodological gap persists regarding countries in which the green economy has been institutionally declared but has not yet been embedded in labor market structures. In particular, limited attention has been paid to whether the absence of stable statistical relationships between green employment and commonly cited determinants may itself constitute a meaningful empirical finding, reflecting the immaturity and fragmentation of transformation processes. This gap motivates the present study and informs its methodological approach. To capture both the presence and absence of stable relationships under conditions of limited data availability and high interdependence among factors, the study employs correlation analysis and the statistical dependency equation method, as discussed in the following section.

3 | RESEARCH METHODS

The objective of this study is to examine the readiness of labor resources for transformation during the transition to a green economy. Given the early stage of green labor market formation in the Republic of Kazakhstan and the limited availability of long and consistent statistical time series on green employment, the research design prioritizes methodological robustness and interpretability over the mechanical application of standard econometric techniques. Accordingly, a stepwise empirical strategy is employed, combining exploratory correlation analysis with the method of statistical dependency equations. This combination enables an initial diagnostic assessment of co-movements among variables, followed by a more structured evaluation of the stability and direction of pairwise dependencies under conditions of multicollinearity and institutional regulation.

The empirical analysis relies exclusively on official statistical data obtained from the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan. The use of a single official data source ensures methodological consistency, comparability of indicators, and uniform data-collection procedures throughout the observation period.

The dependent (result) variable is defined as the number of persons employed in "green jobs". This indicator is selected because it reflects the actual scale of environmentally oriented employment and captures labor market outcomes rather than declarative policy intentions. As such, it serves as a quantitative proxy for the extent of labor resource transformation within the green economy framework.

Independent variables were selected from several conceptual blocks, including macroeconomic development, investment activity, innovation performance, education and human capital, environmental expenditures, and labor market conditions. The selection of indicators was guided by theoretical considerations from labor economics and the green growth literature, as well as by practical constraints on statistical availability. In total, nineteen explanatory variables were included in the initial analytical set. In the first stage of the empirical analysis, pairwise correlation coefficients were calculated to assess the direction and strength of the co-movements between green employment and the selected independent variables. The purpose of this stage was not to establish causal relationships, but to conduct an exploratory diagnostic assessment of whether changes in green employment evolve alongside changes in key socio-economic, investment, and innovation indicators.

Correlation analysis is interpreted in this study strictly as a descriptive tool. The presence of moderate or relatively high correlation coefficients is not considered sufficient evidence of structural or causal dependence. In institutionally regulated processes - such as the transition to a green economy - parallel movements of indicators may reflect common policy impulses, macroeconomic conditions, or external shocks rather than direct functional relationships.

The results of the correlation analysis indicate that most factors exhibit moderate correlations with green employment. However, these findings also demonstrate that similarity in temporal dynamics does not necessarily imply a stable linkage between explanatory variables and the expansion of green jobs. This limitation motivated the application of a more appropriate analytical method at the next stage of the study.

Classical regression analysis was not employed as the primary analytical tool for several methodological reasons. First, a high degree of multicollinearity was identified among many explanatory variables, particularly those related to investment, innovation, and macroeconomic performance. Such interdependencies undermine the stability and interpretability of regression coefficients. It should be noted that according to econometric theory, multicollinearity of factors occurs when the correlation between two independent variables is higher than the correlation of each independent factor with the dependent (result) variable.

Second, the time span of available data for several indicators relevant to the green economy remains relatively short, which significantly constrains the reliability of multivariate econometric estimations. Third, the process under investigation is largely shaped by institutional and policy-driven mechanisms, including state programs, regulatory decisions, and targeted financing instruments. These influences are not adequately captured through conventional regression-based models and may lead to distorted inference. Given these constraints, the method of statistical equations of dependencies was adopted as the principal analytical tool. This method is particularly suitable for analyzing socio-economic transformation processes under conditions of limited data availability and strong interdependence among explanatory variables (Kaliyeva et al., 2025).

The method focuses on analyzing paired dependencies between the dependent variable and individual independent variables without imposing rigid assumptions about functional form. It minimizes distortions caused by multicollinearity and enables the identification of directional and structural features of transformation processes. In this study, linear

dependency equations were constructed according to formulas (1) and (2), which are applied depending on whether the relationship between the independent variable and green employment is assumed to be increasing or decreasing:

$$y_x = y_{\min}\left(1 + b \cdot d_{(x_i/x_{\min}-1)}\right) \tag{1}$$

$$y_x = y_{\min}\left(1 + b \cdot d_{(1-x_i/x_{\max})}\right) \tag{2}$$

where:
y_x – result variable;
$y_{\min}$ – minimum value of the result variable;
b – ratio of the sum of deviations from the unit of the calculated coefficients of comparison of the result and independent factors;
d_{x_i} – comparison coefficient of the independent factor as a whole;
$d_{x(\min)}$ – comparison coefficient to the minimum value of the independent factor;
$d_{x(\max)}$ – comparison coefficient to the maximum value of the independent factor.

To verify the adequacy of the estimated dependency equations, additional calculations were conducted to evaluate the strength and stability of the relationships between the dependent (result) variable and each explanatory (independent) factor considered separately. The stability assessment focused on those variables for which the pairwise correlation coefficient exceeded the threshold value of 0.7.

For these factors, stable dependence coefficients were calculated and required to meet a minimum threshold of 0.7. The concurrence of high correlation and stable dependence coefficients was interpreted as evidence that the estimated equations capture persistent relationships rather than coincidental co-movements. This verification procedure provides additional support for the methodological validity and internal consistency of the analytical results.

4 | RESULTS

This section presents the study's empirical findings, focusing on a quantitative assessment of the extent to which Kazakhstan's labor force is prepared for structural adjustment during the transition to a green economy. The dependent (result) variable (Y) is defined as the number of individuals employed in "green jobs", interpreted as an integrated measure reflecting the degree of labor market participation in environmentally oriented and technologically sustainable economic activities. This indicator allows for an assessment of the actual involvement of labor resources in the emerging green segment of the economy.

In order to identify potential determinants of changes in green employment, a system of nineteen explanatory variables was constructed, encompassing socio-economic conditions, investment activity, environmental expenditures, innovation dynamics, and educational characteristics. All statistical indicators were sourced from the Bureau of National Statistics of the Republic of Kazakhstan, which guarantees uniformity in data collection methods and ensures temporal and methodological comparability across variables. The independent factors considered in the present research are given in Table 1.

The selection of explanatory (independent) factors was grounded in established theoretical frameworks in labor economics and green growth, as well as in empirical evidence from the international research literature. Particular attention was given to factors commonly identified as drivers of green job creation in developed economies, thereby enabling a structured evaluation of their relevance within Kazakhstan's institutional and economic

Table 1 Independent variables used in the empirical analysis

No.	Variable	Indicator	Unit
1	X1	GDP per capita	tenge
2	X2	Investment in fixed capital	tenge
3	X3	Unemployment rate	%
4	X4	Gross enrollment ratio in higher education	%
5	X5	Gross enrollment ratio in secondary education	%
6	X6	Graduates in environmental specialties	persons
7	X7	Domestic R&D expenditure	tenge
8	X9	Enterprises with environmental innovations	units
9	X10	Share of environmental innovations	%
10	X11	Non-energy resource productivity	international dollars
11	X12	Number of licenses issued in the field of environmental protection	units
12	X13	Number of patents issued	units
14	X14	Volume of greenhouse gas emissions trading transactions	tons of CO_2
15	X15	Profitability (loss) of water supply and sanitation enterprises	%
16	X16	Official development assistance	thousand tenge
17	X17	Environmental taxes	thousand tenge
18	X18	Investments aimed at environmental protection	thousand tenge
19	X19	Amount of funds allocated to finance scientific and scientific-technical projects on the “green economy”	thousand tenge

Note: compiled by the authors.

context. In the first stage of the study, correlation analysis was applied to examine the direction and magnitude of the association between the dependent (result) variable and the selected explanatory factors (independent factors). Given the limited length of the time series, correlation analysis is used exclusively as a diagnostic tool rather than as evidence of causal relationships. The results of the correlation analysis, summarized in Table 2, indicate that 10 of the 19 variables analyzed exhibit high correlations with the result indicator, with correlation coefficients exceeding the threshold of 0.7.

Table 2 Correlation matrix of green employment and explanatory variables

	Y	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19
Y	1																			
X1	0,79	1																		
X2	0,82	1	1																	
X3	−0,96	−0,88	−0,91	1																
X4	−0,94	−0,84	−0,86	0,88	1															
X5	0,10	0,32	0,33	−0,36	0,10	1														
X6	0,78	0,97	0,97	−0,92	−0,75	0,54	1													
X7	0,63	0,83	0,81	−0,61	−0,84	−0,23	0,66	1												
X8	0,87	0,72	0,77	−0,94	−0,69	0,57	0,84	0,31	1											
X9	0,65	0,97	0,95	−0,74	−0,78	0,18	0,88	0,91	0,52	1										
X10	−0,99	−0,69	−0,73	0,92	0,91	−0,06	−0,69	−0,54	−0,85	−0,54	1									
X11	0,79	0,99	0,99	−0,91	−0,80	0,44	0,99	0,75	0,79	0,93	−0,70	1								
X12	−0,13	−0,15	−0,18	0,34	−0,15	−0,95	−0,40	0,42	−0,61	0,04	0,13	−0,29	1							
X13	−0,21	−0,01	0,00	−0,04	0,43	0,94	0,22	−0,52	0,31	−0,13	0,23	0,12	−0,93	1						
X14	0,93	0,53	0,57	−0,79	−0,87	−0,17	0,50	0,49	0,71	0,19	−0,97	0,51	0,05	−0,42	1					
X15	−0,18	−0,72	−0,69	0,43	0,24	−0,64	−0,75	−0,47	−0,36	−0,76	0,05	−0,75	0,38	−0,46	0,19	1				
X16	0,54	0,07	0,09	−0,28	−0,59	−0,72	−0,06	0,35	0,14	0,03	−0,62	−0,01	0,56	−0,82	0,79	0,63				
X17	0,62	0,87	0,85	−0,63	−0,82	−0,14	0,71	1	0,34	0,95	−0,52	0,79	0,35	−0,44	0,45	−0,55	0,26	1		
X18	0,45	−0,15	−0,11	−0,19	−0,39	−0,57	−0,20	0,01	0,18	−0,26	−0,57	−0,18	0,32	−0,60	0,75	0,79	0,93	−0,07	1	
X19	0,93	0,92	0,94	−1	−0,86	0,41	0,95	0,63	0,93	0,79	−0,88	0,94	−0,36	0,09	0,73	−0,52	0,19	0,66	0,10	1

Values $|r| \geq 0.7$ indicate high correlation

Note: compiled by the authors.

The group of highly correlated factors comprises indicators reflecting public and private environmental expenditures, investment activity, innovation intensity, macroeconomic development, and labor market conditions. The strongest correlations with green employment were observed for GDP per capita, investment in fixed capital, the unemployment

rate, the gross enrollment ratio in higher education, domestic R&D expenditure, the number of graduates in environmental specialties, the share of environmental innovations in total innovation activity, non-energy natural resource productivity, the volume of greenhouse gas emissions trading transactions, and the amount of public funding allocated to scientific and scientific-technical projects in the field of the green economy. The strong correlations among these indicators suggest that their dynamics parallel changes in the number of people employed in green jobs. This finding does not imply a causal relationship. However, it provides a basis for reducing the initial set of explanatory variables and selecting factors for subsequent analysis using statistical dependency equations.

However, the identification of a strong correlation does not imply a causal relationship, particularly given the limited length of the time series and the high interdependence among the factors. In this regard, the next stage of the study involved using statistical dependence equations to assess the stability of the relationship between the outcome and the influencing factors, without constructing multidimensional regression models that are sensitive to multicollinearity.

Calculations performed using statistical equations for 10 selected factors revealed that the vast majority do not form a stable, statistically significant relationship with the number of people employed in "green jobs". Despite high correlation coefficients, the resulting equations did not support the existence of a stable functional relationship between the dependent variable and independent variables such as environmental investment volume, R&D expenditures, enterprises' innovative activity, the share of environmentally friendly products, human capital indicators, and macroeconomic development.

The only factor for which a stable statistical dependence was identified (stable dependence coefficient (K) > 0.7) was the unemployment rate, with the relationship being inverse: an increase in unemployment is accompanied by a decrease in the number of people employed in "green jobs." This result indicates that employment in the green economy in Kazakhstan does not currently serve a compensatory function in the labor market and does not drive labor redistribution amid a deteriorating overall economic situation.

For clarity, Table 3 presents calculations of the parameters and stability of the relationship between the number of people employed in "green jobs" (Y) and the unemployment rate (X3).

Table 3 Results of the statistical dependency analysis between green employment and the unemployment rate

Year	Y	X3	d_y	d_x	bd_x	Estimated Y*	$d_x \cdot d_y$	d_x^2	d_y^2	$\frac{d_y - bd_x}{bd_x}$
2020	48453	4.9	0.00807	0	0	48065	0	0	0.00006	0.00807
2021	48065	4.9	0	0	0	48065	0	0	0	0
2022	48895	4.9	0.01726	0	0	48065	0	0	0.00029	0.01726
2023	57135	4.7	0.18870	0.04081	0.17070	56270	0.00770	0.00167	0.03560	0.01799
2024	54187	4.7	0.12736	0.04081	0.17070	56270	0.00519	0.00167	0.01622	0.04333
$b =$	4,1823052	r	0,00017	0,97826		K		0,746130408		

Note: compiled by the authors.

The results indicate a stable inverse relationship between the unemployment rate and the number of people employed in green jobs, confirming the importance of this factor in statistical analyses of dependencies. Calculations show that, with a decrease in the unemployment rate from 4.9% in 2020-2022 to 4.7% in 2023-2024, employment in green jobs increased from 48,065 to 57,135, as reflected by positive relative deviations of the

effective indicator.

Similar calculations were performed with other factors, for which the coefficient of stable dependence ranged from 0.29 to 0.67. For example, Table 4 presents the parameter estimates and the stability of the dependence of the number of people employed in "green jobs" (Y) on Investments in fixed assets (X2).

Table 4 Results of the statistical dependency analysis between green employment and the investments in fixed assets

Year	Y	X2	d_y	d_x	bd_x	Estimated Y*	$d_x \cdot d_y$	d_x^2	d_y^2	$\frac{d_y - bd_x}{bd_x}$
2020	48453	12270.1	0.00807	0	0	48065	0	0	6.51637	0.00807
2021	48065	13242.2	0	0.79225	0.02008	49030.42	0	0.00627	0	0.02008
2022	48895	15251.1	0.01726	0.24294	0.06159	51025.53	0.00419	0.05902	0.00029	0.04432
2023	57135	17649.3	0.18870	0.43839	0.11114	53407.25	0.08272	0.19219	0.03560	0.07755
2024	54187	19461.3	0.12736	0.58607	0.14858	55206.80	0.07464	0.34348	0.01622	0.02121
$b =$	0.2535278	r	0.03137	0.91225		K		0,498385162		

Note: compiled by the authors.

The results indicate that the calculated stability coefficient between green employment and investments in fixed assets equals 0.49, which remains below the threshold value adopted in this study for identifying stable dependencies. This finding implies that the observed high correlation does not translate into a structurally stable relationship. In other words, although green employment and fixed-asset investment exhibit parallel trends over time, statistical dependency analysis indicates that changes in investment levels cannot be interpreted as a consistent or reliable driver of green employment growth.

From a methodological perspective, this result reinforces the distinction between correlation-based evidence and stability-based dependency analysis. Particularly in institutionally driven transformation processes such as the transition toward a green economy, high correlation may reflect common macroeconomic or policy-related influences rather than direct functional dependence between variables.

Table 5 presents calculations in which the coefficient of stable dependence between the number of people employed in "green jobs" (Y) and the amount of funds allocated to finance scientific and scientific-technical projects on the "green economy" within the framework of grant- and program-targeted financing (X19) was 0.67.

It should be noted that this value does not meet the threshold for stable dependence but is very close to it, which helps interpret the identified relationship as emerging or quasi-stable. The presence of a borderline stability coefficient indicates the potential impact of scientific and technical funding on the formation of "green" employment, which, at the current stage, is not yet systematic but shows a tendency to strengthen.

Since a high stability coefficient for the number of people employed in green jobs was identified only with respect to the unemployment rate, further analysis was limited to this factor. The estimated stability coefficient exceeded the threshold value (K = 0.746 > 0.7), indicating a stable inverse relationship between green employment and the unemployment rate. The strength of this relationship is supported by a high correlation coefficient (r = 0.978). At the same time, the estimated sensitivity parameter (b = 4.18) suggests a pronounced response of green employment to changes in labor market conditions.

The absence of stable dependencies between the number of people employed in "green jobs" and most of the factors analyzed indicates that the process of transforming labor resources as part of the transition to a "green" economy is incomplete and fragmented.

Table 5 Results of the statistical dependency analysis between green employment and the amount of funds allocated to finance scientific and scientific-technical projects on the "green economy"

Year	Y	X19	d_y	d_x	bd_x	Estimated Y*	$d_x \cdot d_y$	d_x^2	d_y^2	$\frac{d_y - bd_x}{bd_x}$
2020	48453	163998.4	0.00807	0	0	48065	0	0	6.51637	0.00807
2021	48065	175215.8	0	0.06839	0.00124	48124.8302	0	0.00467	0	0.00124
2022	48895	221931.8	0.01726	0.35325	0.00642	48373.9993	0.00610	0.12478	0.00029	0.01083
2023	57135	1566782.9	0.18870	8.55364	0.15566	55547.0295	1.61409	73.1648	0.03560	0.03303
2024	54187	1768727.5	0.12736	9.78502	0.17807	56624.1412	1.24631	95.7467	0.01622	0.0507
$b =$	0.018198	r	8.82310	0.96503		K		0,67567687		

Note: compiled by the authors.

The coincidence of trends across multiple indicators is more likely to reflect economic or programmatic factors. It does not reflect the formation of stable demand mechanisms for green labor.

The results obtained indicate that, in Kazakhstan, the development of employment in the green economy is largely determined by institutional and political decisions rather than by market, investment, or innovation factors. Unlike in developed countries, where green jobs are created through systematic government policy, regulatory measures, and targeted incentives to stimulate demand for environmental skills, this process is not yet structural in Kazakhstan. Thus, the absence of stable statistical dependencies should be viewed not as a limitation of the study but as empirical confirmation of the labor market's insufficient readiness for the green transition, thereby justifying a review of public policy approaches to employment and human capital development.

5 | DISCUSSION

The results obtained in the course of the study confirm the hypothesis that, in the Republic of Kazakhstan, employment in the green economy does not exhibit a stable dependence on socio-economic, investment, innovation, and educational factors. Despite high correlations between the performance indicator and several factors, the application of the statistical equation method revealed the absence of stable functional relationships across virtually all areas of analysis. The only exception was the unemployment rate, which showed a stable inverse dependence.

This result fundamentally distinguishes the situation in Kazakhstan from that in developed countries, such as those in the European Union, where employment in the green economy is shaped by targeted government policy and integrated into the overall labor market architecture. In EU countries, the number of people employed in environmentally oriented sectors shows a stable dependence on the volume of green investments, expenditure on research and development, the development of renewable energy, the level of environmental innovation, and institutional support for green skills. Thus, European economies are seeing a clear translation of public policy into real changes in the structure of employment.

In Kazakhstan, however, the correlation between individual indicators and the number of people employed in "green jobs" is mainly macroeconomic in nature and does not reflect the formation of sustainable demand for environmentally oriented labor. The absence of stable dependencies indicates that "green" employment is not yet an independent segment of the labor market, but is developing in a fragmented manner, within the framework of

individual programs and projects that do not have a systemic effect.

Particularly significant is the inverse dependence between the level of unemployment and the number of people employed in "green jobs." In EU countries, the development of a "green" economy is often regarded as a means of mitigating the effects of structural unemployment associated with decarbonization and digital transformation. In contrast, in Kazakhstan, rising unemployment is accompanied by a decline in employment in green sectors, indicating their vulnerability and dependence on the overall state of the economy. This suggests that the green economy does not yet play a stabilizing role in the labor market and cannot compensate for negative employment shocks. A comparative analysis suggests that the key factor distinguishing Kazakhstan from EU countries is the institutional component. In European countries, the development of green jobs is based on strict environmental regulations, a system of financial incentives, green competency standards, and active policies in the field of education and retraining. In Kazakhstan, however, the transition to a green economy is largely programmatic and declarative in nature. It has not yet been accompanied by a transformation of the mechanisms that shape labor demand.

Thus, the study's results confirm the hypothesis that, in Kazakhstan, the transformation of labor resources during the transition to a green economy is primarily driven by political and institutional decisions rather than by market or economic factors. The absence of stable statistical dependencies between the number of people employed in "green jobs" and most of the indicators analyzed (independent variables) should be interpreted as an indicator of the immaturity of the relevant labor market segment. The conclusions underscore the need to borrow and adapt the experience of EU countries, in which green employment is the result of comprehensive policies rather than a byproduct of economic growth. Without the creation of institutional conditions that ensure long-term demand for green jobs, quantitative growth in employment in environmentally oriented sectors in Kazakhstan will remain unstable and weakly linked to key economic development indicators.

6 | CONCLUSION

The shift toward a green economy is increasingly recognized as a structural trajectory of long-term socio-economic development, with implications that extend well beyond technological change and energy systems to encompass the organization and functioning of labor markets. Against this background, the present study set out to examine the extent to which the Republic of Kazakhstan's labor resources are positioned to adapt to this transition and whether the foundations for sustainable green employment are already emerging within the national economy.

The empirical results demonstrate that, despite the formal advancement of environmental priorities at the strategic and policy levels, measurable changes in employment in environmentally oriented sectors remain weakly linked to most socioeconomic, investment, and innovation indicators. The analysis incorporated a broad spectrum of factors characterizing labor market conditions, economic performance, capital formation, research and development activity, and environmental expenditures. Nevertheless, the findings indicate that these variables do not yet translate into stable statistical relationships with the number of workers employed in green jobs.

A persistent and statistically meaningful association was identified only with the unemployment rate. This outcome suggests that the observed expansion of green employment in Kazakhstan is currently driven primarily by general labor-market adjustment processes rather than by a structurally embedded green-growth model. In this context, green jobs appear to function as an adaptive employment segment absorbing labor during periods of

macroeconomic adjustment, rather than as an autonomous engine of workforce transformation grounded in environmental innovation and long-term investment.

Importantly, the absence of stable dependencies between green employment and most explanatory factors should not be interpreted as a methodological shortcoming. On the contrary, this result constitutes a substantive empirical finding, reflecting the early and fragmented nature of labor market transformation in the green economy. In contrast to European Union countries, where green employment dynamics are underpinned by coherent regulatory frameworks, sustained public investment, and the systematic incorporation of green competencies into education and training systems, Kazakhstan's transition remains largely uncoordinated.

Comparative insights drawn from European experience reveal a pronounced gap between the declared objectives of green development and the practical mechanisms that generate demand for green labor. Limited alignment between environmental investment and employment outcomes, insufficient incentives for private-sector participation, and weak integration of green skills into human capital development constrain the development of a stable green labor market.

Overall, the findings support the research hypothesis that, under current conditions, the transformation of labor resources in Kazakhstan is shaped less by market-driven economic and innovation factors than by the scope, consistency, and orientation of public policy. The establishment of a sustainable green employment framework requires a shift from fragmented initiatives toward a comprehensive institutional strategy aimed at long-term restructuring of employment patterns and skill formation. These conclusions contribute to the broader understanding of green labor market development in economies in the early stages of environmental transition and underscore the importance of further research into the institutional and policy determinants of green employment.

AUTHOR CONTRIBUTION

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CONFLICT OF INTEREST

No conflict of interest/competing interest is reported by the authors.

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