

“Responsible production in Kazakhstan’s manufacturing sector: An empirical assessment of environmental, operational, and social drivers”

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RESPONSIBLE PRODUCTION IN KAZAKHSTAN'S MANUFACTURING SECTOR: AN EMPIRICAL ASSESSMENT OF ENVIRONMENTAL, OPERATIONAL, AND SOCIAL DRIVERS

Abstract

The study analyzes the implementation of responsible production practices in Kazakhstan's manufacturing sector, an area of growing importance for sustainable development in emerging economies. The aim is to examine how environmental, operational, and social factors influence production processes and community contributions. Data were collected through an online survey conducted between May and August 2024, using a voluntary response sampling method. To enhance the representativeness of the findings, the sectoral distribution of the responding enterprises was analyzed post-collection. The survey captured top, middle, and line management responses to comprehensively assess sustainability practices. Structural equation modeling (PLS-SEM) was employed to evaluate the relationships between ecological operational efficiency, environmental protection, resource efficiency, waste management, social factors, product manufacturing, and community contribution. The findings reveal that environmental protection, efficient resource use, and effective waste management significantly strengthen manufacturing performance and enhance companies' contributions to community development. In contrast, improvements in ecological operational efficiency and workplace social initiatives do not directly impact production outcomes. The study concludes that integrating sustainable environmental and resource management practices into production processes is crucial for enhancing both manufacturing performance and broader societal outcomes. The findings offer practical implications for industrial managers, policymakers, and stakeholders aiming to promote sustainability transitions in manufacturing sectors.

Keywords

responsible production, circular economy,
manufacturing sector, emerging economies, Kazakhstan

JEL Classification

Q56, L60, M14, O13

INTRODUCTION

Responsible production has gained critical importance in achieving sustainable development, particularly in emerging economies facing industrial expansion alongside environmental and social challenges. In line with Sustainable Development Goal 12, industries are increasingly required to adopt production practices that minimize environmental harm and promote positive societal outcomes (Huatuco & Ball, 2019; McNeill, 2020; Vázquez-Burguete et al., 2023). Traditional approaches have often focused on reducing emissions and resource consumption, yet the modern understanding of responsible production extends well beyond these initial frameworks by emphasizing socio-economic benefits and engagement with diverse stakeholders (Baranowski & Kopnina, 2022; Lebel & Lorek, 2008; Thanh et al., 2016; Camilleri, 2017; Rodríguez-Fernández et al., 2020).



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Globally, research on responsible production has expanded, reflecting the growing influence of environmental stewardship and corporate responsibility across industries. However, much of the empirical literature still centers on established economies, where corporate sustainability practices benefit from mature regulations and well-developed infrastructures (Arli & Lasmono, 2010; Ali et al., 2017; Boubakri et al., 2021; Zhidebekkyzy et al., 2024). These contexts differ significantly from emerging economies that may face resource limitations, inconsistent policy enforcement, or competing development priorities (Amos, 2018; Shakoor & Ahmed, 2023). Consequently, responsible production in these settings is less understood, and empirical evidence remains scarce. Within this context, Kazakhstan presents a relevant case.

As a resource-rich country undergoing rapid industrialization, Kazakhstan has prioritized sustainability in national strategies, yet adopting responsible production practices in its manufacturing sector remains under-researched (Colapinto et al., 2020; Zhidebekkyzy et al., 2022a). These research gaps include how environmental, operational, and social factors converge to influence production performance and contributions to local communities.

Existing studies on responsible production in Kazakhstan typically focus on isolated aspects such as corporate social responsibility or environmental compliance (Potluri et al., 2010; Orazayeva & Arslan, 2021; Baltabayeva et al., 2024; Kalmakova et al., 2023). However, integrated analyses examining how environmental protection, resource efficiency, waste management, ecological operational efficiency, and social factors collectively influence production outcomes and contributions to the community are largely absent. This gap limits the ability of policymakers, managers, and stakeholders to design effective sustainability initiatives tailored to the realities of emerging economies.

Therefore, the present study investigates the impact of environmental, operational, and social factors on product manufacturing and community contribution within Kazakhstan's manufacturing enterprises. By addressing this research gap, the study contributes to a deeper understanding of how responsible production can support sustainable development in industrial sectors of emerging markets.

1. LITERATURE REVIEW AND HYPOTHESES

The concept of responsible production is receiving growing attention as industries strive to balance economic performance with environmental sustainability and social responsibility. Many firms now recognize responsible production as a strategic priority, driven by regulatory frameworks, stakeholder expectations, and competitive advantages (Hussain et al., 2024; Nash, 2009).

Various frameworks and methodologies have been proposed to measure responsible production, integrating environmental, operational, and social factors. Veleva and Ellenbecker (2001) developed a comprehensive indicator framework for sustainable production, emphasizing core and supplemental indicators that evaluate companies' sustainability performance based on environmental impact, resource efficiency, and social contribu-

tions. Their methodology provides a systematic approach to tracking progress toward sustainability goals while allowing flexibility to adapt to industry-specific contexts.

Similarly, Liu et al. (2021) conducted a bibliometric review of responsible production and sustainability, identifying key attributes such as preventive initiatives, process management, and corporate responsibility. They highlight that responsible production is influenced by contextual factors, firm characteristics, and regulatory environments, ultimately affecting firm performance and stakeholder engagement. Their study underscores the need for an integrated assessment framework that accounts for sustainable production's financial and non-financial benefits.

Responsible production has been linked to long-term organizational sustainability and social benefits. Tsai et al. (2015) developed a green pro-

duction assessment framework, emphasizing the importance of reducing pollution, conserving resources, and extending corporate social responsibility (CSR) to environmental management. In a broader sustainability context, Jayashree et al. (2021) explored the moderating role of Industry 4.0 technologies in enhancing cleaner production and environmental management systems. Their findings suggest that digitalization and automation can significantly improve sustainability metrics, reducing waste and optimizing resource use. This aligns with Hens et al. (2018), who traced the evolution of cleaner production from a compliance-driven practice to a core business strategy that integrates environmental, social, and economic objectives.

Multiple studies have identified key drivers of responsible production, including environmental policies, market pressures, and corporate leadership. Guo et al. (2015) examined green corporate social responsibility (GCSR) in manufacturing firms, demonstrating how regulatory frameworks and green industry laws shape corporate sustainability strategies. Alayón et al. (2017) explored how companies implement sustainable production principles in practice, emphasizing that most sustainable manufacturing practices remain environmentally focused, particularly on energy efficiency, waste management, and emissions reduction. However, their study also highlighted that proactive sustainability measures, such as integrating social responsibility into production, remain underdeveloped. Similarly, Sáez-Martínez et al. (2016) analyzed the key drivers of the sustain-

able output, emphasizing eco-innovation, green chemistry, and regulatory pressures as central to sustainability transitions.

The Enterprise Survey, conducted by the World Bank, the European Bank for Reconstruction and Development, and the European Investment Bank, is used to develop a unique Corporate Environmental, Social, and Governance Responsibility composite indicator, covering small and medium-sized enterprises in over 40 emerging economies. The analysis reveals that these firms lag significantly in adopting sustainability and green growth practices, with significant gaps persisting in transitioning to a sustainable business environment (Ferrazzi & Tueske, 2022).

The literature highlights that responsible production is a multidimensional construct integrating ecological, operational, and social aspects. It reflects a transition from compliance-based to strategy-driven approaches, especially relevant in emerging markets where institutional environments and resource limitations shape sustainability practices. The following conceptual foundations can be used to structure the latent variables for a quantitative model (Table 1).

Current empirical research often focuses on direct relationships without addressing feedback loops and indirect pathways through which environmental and operational practices enhance social contributions. This gap is particularly pronounced in emerging economies where sustainability challenges require a holistic approach. Figure 1 pres-

Table 1. Latent variables and key indicators based on the literature

Latent Variable	Conceptual Basis	Key Indicators
Ecological Operational Efficiency (EOE)	Integration of sustainable methods into production to enhance operational efficiency and reduce environmental harm (Tsai et al., 2015; Alayón et al., 2017)	Energy efficiency, emission reduction, pollution control, automation, and digitalization
Environmental Protection (ENV)	Compliance with environmental regulations and adoption of eco-friendly technologies (Hens et al., 2018; Guo et al., 2015)	Pollution prevention, use of green materials, and adherence to environmental standards
Efficient Resource Use (EUR)	Maximizing resource productivity and minimizing raw material waste (Veleva & Ellenbecker, 2001; Jayashree et al., 2021)	Reduced material consumption, reuse of resources, and application of clean technologies
Waste Management (WM)	Adoption of circular economy principles for waste reduction and reuse (Zhidebekyzy et al., 2022b; Alayón et al., 2017)	Recycling rate, waste reduction, and process waste management
Social Factors (SF)	Stakeholder engagement, CSR practices, and social inclusion in operations (Spaargaren, 2011; Adae et al., 2021)	Worker participation, health and safety, and contribution to local communities
Production Processes (PRO)	Operationalization of responsible production through integrated practices (Liu et al., 2021; Amos, 2018)	Adoption of sustainable techniques in core business operations
Social Contribution (SOC)	Social impact and value creation driven by responsible production (Cezarino et al., 2022; Stahl et al., 2016)	Contribution to SDGs, social trust, and long-term community development

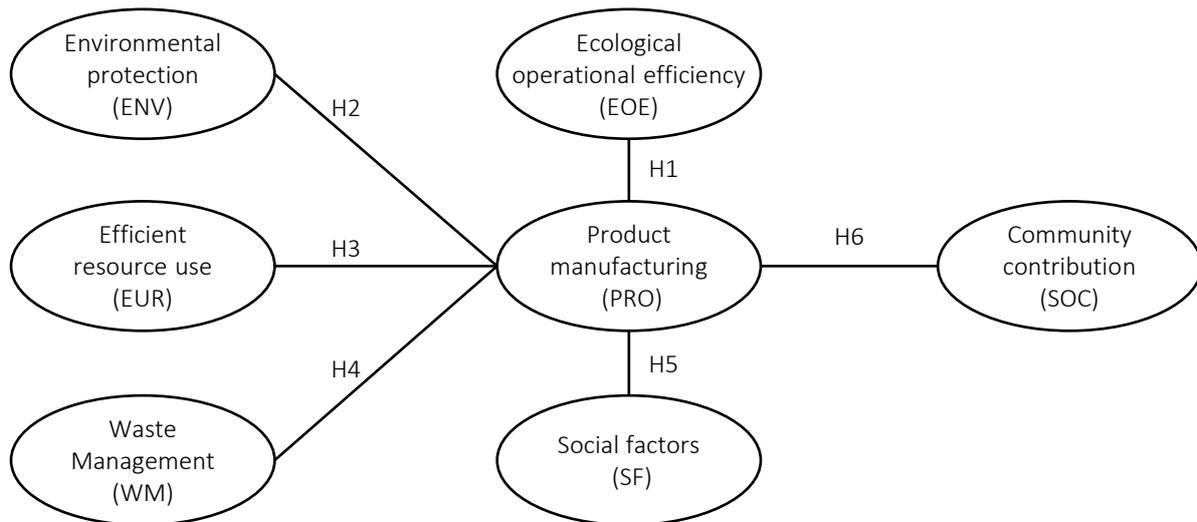


Figure 1. Conceptual model

ents the conceptual model that illustrates the relationships between environmental, operational, and social factors that affect organizational sustainability.

The following hypotheses were developed based on the conceptual model:

- H1: Ecological operational efficiency has a significantly positive impact on product manufacturing.*
- H2: Environmental protection positively influences product manufacturing.*
- H3: Resource efficiency positively and significantly impacts product manufacturing.*
- H4: Waste management has a strong positive effect on product manufacturing.*
- H5: Social factors do not significantly influence product manufacturing.*
- H6: Product manufacturing positively impacts contribution to the community.*

This study addresses the existing research gap by empirically testing a comprehensive conceptual model that integrates environmental, operational, and social factors. By analyzing their mutual influence and the mediating role of production processes, the study offers practical insights into

optimizing responsible production to achieve organizational sustainability and long-term social benefits.

2. METHODS

This study employs a quantitative research design, utilizing a survey administered to managerial personnel in Kazakhstan’s industrial sector. Surveying top management provides a comprehensive assessment of the level of development of responsible production within enterprises (Awan et al., 2021; Puma-Flores & Rosa-Díaz, 2024; Sánchez-García et al., 2025). This quantitative approach identifies the current state of responsible production and aids in formulating future research questions for case studies or in-depth interviews. The questionnaire was developed using an extensive literature review to ensure its relevance and construct validity.

The survey questionnaire assessed various dimensions of sustainable practices within companies, emphasizing environmental and resource efficiency, product development, waste management, and social contributions. The questionnaire consisted of seven sections, each representing key sustainability factors, with Likert-scale items (1 to 5) measuring the extent of agreement, where 1 signifies strong disagreement and 5 represents strong agreement. The detailed structure of the questionnaire is shown in Appendix A, and descriptive statistics are presented in Appendix B.

The study sample included 100 enterprises from the manufacturing sector selected to reflect the distribution and diversity of the industry in Kazakhstan. Based on information from the “Enterprises of Kazakhstan” section available on the official portal, an initial database of 478 industrial enterprises covering all major industrial sectors was created. A voluntary response sampling approach was employed, with survey invitations distributed to all listed enterprises. Participation in the survey was voluntary, and responses were collected anonymously to ensure participant confidentiality. After data collection, the sample composition was evaluated to ensure adequate sectoral representation.

The online survey method was chosen for its cost-effectiveness, rapid response time, and convenience in reaching geographically dispersed enterprises across Kazakhstan. Data were collected throughout Kazakhstan in May-August 2024. A total of 107 responses were received, corresponding to a response rate of 22.4%. After excluding incomplete and duplicate submissions, a final dataset of 100 valid questionnaires was prepared for analysis. The selected enterprises represented various subsectors, including metallurgy, machinery, food production, and chemical manufacturing. The selection criteria ensured representative distribution based on sub-sector significance and enterprise size. The inclusion of enterprises from different industries and sizes ensured a comprehensive and representative assessment of responsible production practices across Kazakhstan’s manufacturing sector.

Respondents were strategically selected to provide insights into sustainability practices and operational performance. They included individuals from the top management (CEOs, directors, operational, financial, and technical managers, and board members), middle management (department heads, production managers, and workshop supervisors), and line management (section heads, shift supervisors, team leaders, and production engineers). Enterprises range from small firms with 1-50 employees to large organizations with over 1,000 employees, ensuring balanced representation across enterprise size categories. This ensured that the results captured insights from various organizational contexts within the manufacturing sector.

The data were analyzed using SmartPLS 4 software to assess the relationships between the key factors and test the research hypotheses. Partial least squares structural equation modeling (PLS-SEM) was employed because of its effectiveness in handling complex models and small sample sizes. The PLS-SEM approach enabled the evaluation of measurement and structural models (Hair et al., 2021). The measurement model assessed the reliability and validity of the constructs, while the structural model tested the hypothesized relationships between the factors, including direct, indirect, and overall effects. This technique is particularly suitable for analyzing the mutual influence of factors related to sustainability, operational performance, and organizational practices, ensuring robust results for hypothesis testing.

The reliability of the constructs in the conceptual model was assessed using Cronbach’s alpha, with all values exceeding the threshold of 0.7, indicating strong internal consistency. The results demonstrated that ecological operational efficiency achieved a Cronbach’s alpha of 0.888, environmental protection of 0.729, and efficient resource use of 0.759. Similarly, production processes and waste management showed high reliability, with alpha values of 0.910 and 0.912, respectively. Social factors had an alpha value of 0.890 and a social contribution of 0.915. The overall Cronbach’s alpha of 0.952 confirms that the survey instrument is reliable, ensuring an accurate measurement of the variables related to responsible production and organizational sustainability.

3. RESULTS

3.1. Company profile

This study included respondents from different company sizes, managerial positions, and regions within Kazakhstan (Table 2). The industrial breakdown is led by metallurgical production (35%), mechanical engineering (13%), food production (10%), and light industry (9%). Sectors such as the production of oil and oil products, gas, and coal (8%), and the production of building materials (8%) also contribute significantly. Other industries, including chemical products (3%), rubber and plastic products (1%), and electricity production (6%), demonstrate a variety of manufacturing activities.

In terms of company size, large enterprises with more than 1,000 employees accounted for 38%, while companies with 201-500 employees (20%) and 51-200 employees (19%) formed a significant portion. Smaller enterprises with 1-50 employees comprise 16% of the total, and 7% of companies fall within the 501-1,000 employee range.

Respondents' roles in their organizations included top management (36%), middle management (31%), and line management (20%). Top managers, such as CEOs, directors, and senior executives, provide strategic insights, while middle managers, including department and workshop heads, provide operational perspectives. Line managers and others (13%) offered insights from daily operations and execution.

The regional distribution indicates that 36% of respondents are from the Karagandy region, followed by Zhetysu (23%) and Mangistau (11%). Additional contributions came from regions such as Pavlodar (5%), Kostanay (4%), Astana (4%), and Almaty (4%), with 13% from other regions. The dominance of key regions, such as Karagandy and Zhetysu, is justified by the high concentration of industrial enterprises, including metallurgy, machinery, and energy production sectors, which play a central role in Kazakhstan's overall industrial output. Including enterprises from these regions ensures that the data reflects the country's primary industrial hubs, providing a comprehensive understanding of responsible production practices.

Table 2. Companies' characteristics

Category	Percent
Company size	
1-50	16
51-200	19
201-500	20
501-1,000	7
More than 1,000	38
Position	
Top management (CEO, head/director of the organization, operational/financial/technical director, member of the board of directors, etc.)	36
Middle manager (head of department/division, workshop/management manager, etc.)	31
Line manager (site supervisor, team leader, shift supervisor, production engineer, etc.)	20
Other	13

Category	Percent
Region	
Karagandy region	36
Zhetysu region	23
Mangistau region	11
Pavlodar region	5
Kostana region	4
Astana city	4
Almaty city	4
Other regions	13
Total	100

3.2. Model measurement

The reliability and validity analyses of the responsibility dimensions revealed high internal consistency and strong composite reliability. All dimensions demonstrated strong internal consistency, as evidenced by Cronbach's alpha values exceeding 0.7 for all constructs (Table 3). The highest internal consistency was observed for contribution to the community and waste management, with alpha values greater than 0.91. Composite reliability (ρ_c) was robust across all dimensions, with values above 0.8, further confirming the reliability of the constructs. Product manufacturing and waste management exhibited the highest composite reliability values (0.944), suggesting that these dimensions are well represented by their indicators. The average variance extracted (AVE) values were above the acceptable threshold of 0.5, indicating that the constructs explained a significant portion of the variance. Product manufacturing and waste management stand out, with AVE values of 0.848 and 0.849, respectively, reflecting excellent convergent validity. The constructs demonstrate overall reliability and validity, with product manufacturing, waste management, and contribution to the community exhibiting the most substantial results across all metrics. Meanwhile, although reliable, environmental protection shows comparatively lower values, indicating potential areas for improvement in measurement or representation.

The R -squared values for product manufacturing and contribution to the community indicate the explanatory power of each model. The product manufacturing model has a high R -squared of 0.722, meaning that the independent variables explain 72.2% of the variance in the dependent variable. The adjusted R -squared was slightly

Table 3. Reliability and validity measures

Variable	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
ENV	0.737	0.751	0.833	0.555
EOE	0.890	0.898	0.924	0.752
EUR	0.758	0.778	0.847	0.582
PRO	0.911	0.913	0.944	0.848
SF	0.891	0.910	0.932	0.820
SOC	0.919	0.929	0.943	0.805
WM	0.912	0.924	0.944	0.849

Note: EOE = Ecological Operational Efficiency; ENV = Environmental Protection; EUR = Efficient Resource Use; WM = Waste Management; SF = Social Factors; PRO = Production Processes; SOC = Social Contribution.

lower at 0.707, accounting for the number of predictors in the model. In contrast, the contribution to the community model had a lower *R*-squared of 0.346, indicating that 34.6% of the variance was explained by the independent variables, with an adjusted *R*-squared of 0.339, reflecting a minimal adjustment for the number of predictors. This suggests that the product manufacturing model is much more robust in explaining variability compared to the contribution to the community model.

These correlations show strong relationships between certain variables (Table 4). For example, product manufacturing is highly correlated with waste management (0.850) and resource efficiency (0.802), suggesting a close relationship between efficient manufacturing, resource use, and waste management practices. On the other hand, contribution to the community shows moderate correlations with other dimensions like resource use (0.709) and product manufacturing (0.637), indicating that companies contributing to the community also prioritize resource efficiency and product manufacturing.

Table 4. Correlation matrix of constructs

Variable	ENV	EOE	EUR	PRO	SF	SOC	WM
ENV	–	–	–	–	–	–	–
EOE	0.885	–	–	–	–	–	–
EUR	0.858	0.806	–	–	–	–	–
PRO	0.859	0.591	0.802	–	–	–	–
SF	0.782	0.549	0.570	0.518	–	–	–
SOC	0.675	0.513	0.709	0.637	0.630	–	–
WM	0.773	0.645	0.783	0.850	0.456	0.684	–

Note: EOE = Ecological Operational Efficiency; ENV = Environmental Protection; EUR = Efficient Resource Use; WM = Waste Management; SF = Social Factors; PRO = Production Processes; SOC = Social Contribution.

3.3. Path analysis

Path analysis revealed key relationships between sustainability dimensions and their effects on product manufacturing and contribution to the community (Table 5). Environmental protection (path coefficient = 0.392, *T*-statistic = 3.296, *P*-value = 0.001) has a substantial and statistically significant positive effect on product manufacturing. Similarly, resource efficiency (path coefficient = 0.222, *T*-statistic = 2.475, *P*-value = 0.013) and waste management (path coefficient = 0.470, *T*-statistic = 5.815, *P*-value = 0.000) were significant drivers, highlighting their critical roles in enhancing sustainable production processes. Conversely, ecological operational efficiency (path coefficient = –0.160, *T*-statistic = 1.512, *P*-value = 0.130) and social factors (path coefficient = 0.007, *T*-statistic = 0.090, *P*-value = 0.928) did not have a significant impact on product manufacturing within this model. Additionally, product manufacturing significantly influences the contribution to the community (path coefficient = 0.588, *T*-statistic = 8.222, *P*-value = 0.000), indicating that improvements in production processes directly contribute to broader social benefits. In summary, environmental protection, resource efficiency, and waste management are key determinants of sustainable production, whereas product manufacturing plays a central role in driving positive community outcomes.

The structural equation model (SEM) illustrates the interconnections among sustainability constructs, highlighting how key factors influence production processes and a company's contribution to the community (Figure 2). Resource efficiency, waste management, and environmental

Table 5. Path coefficients and significance testing

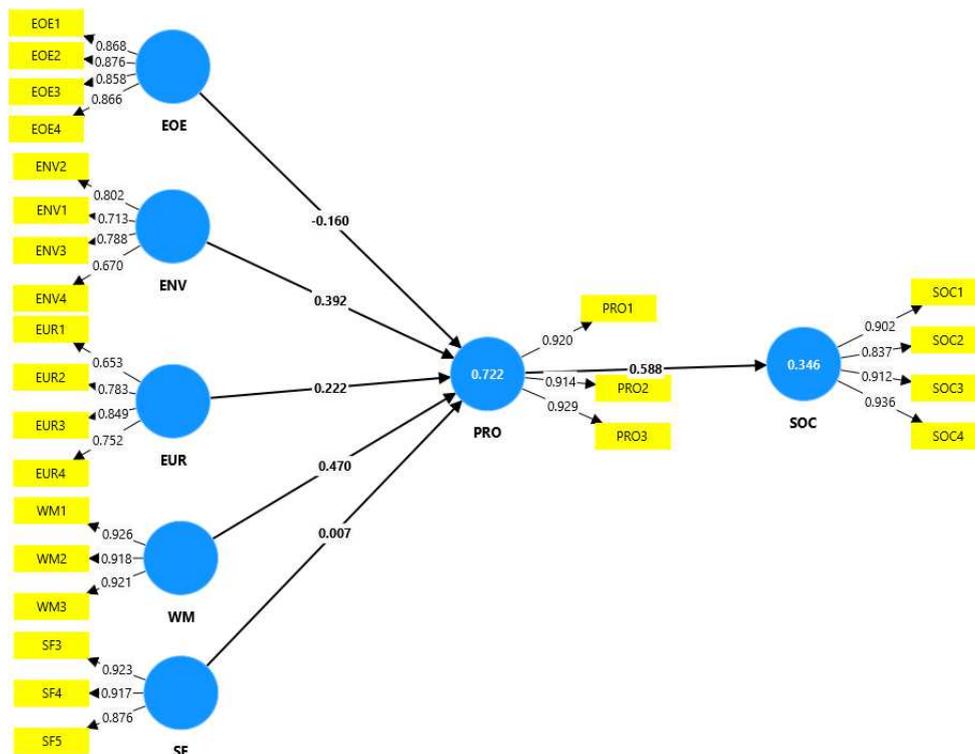
Path	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (O/STDEV)	P values
ENV → PRO	0.392	0.392	0.119	3.296	0.001
EOE → PRO	-0.160	-0.153	0.106	1.512	0.130
EUR → PRO	0.222	0.231	0.090	2.475	0.013
PRO → SOC	0.588	0.593	0.072	8.222	0.000
SF → PRO	0.007	0.004	0.079	0.090	0.928
WM → PRO	0.470	0.461	0.081	5.815	0.000

Note: EOE = Ecological Operational Efficiency; ENV = Environmental Protection; EUR = Efficient Resource Use; WM = Waste Management; SF = Social Factors; PRO = Production Processes; SOC = Social Contribution.

protection play a significant role in sustainable manufacturing, emphasizing the importance of eco-friendly practices. Specifically, ecological protection enhances production sustainability, while resource optimization and waste management are critical for improving efficiency. In contrast, ecological operational efficiency and social factors did not show a significant impact, suggesting the need for further analysis. Ultimately, improvements in production processes positively affect corporate social contributions, confirming that sustainable manufacturing practices drive broader community benefits.

3.4. Hypotheses testing

The hypotheses testing reveals key insights into the relationships among sustainability dimensions and their effects on product manufacturing and contribution to the community. Environmental protection (H2), resource efficiency (H3), and waste management (H4) are significant drivers of product manufacturing, with positive and statistically substantial path coefficients of 0.392, 0.222, and 0.470, respectively (Table 6). This highlights the critical role of sustainable environmental and resource management practices in enhanc-



Note: EOE = Ecological Operational Efficiency; ENV = Environmental Protection; EUR = Efficient Resource Use; WM = Waste Management; SF = Social Factors; PRO = Production Processes; SOC = Social Contribution.

Figure 2. Structural model and path coefficients

Table 6. Hypotheses testing

Hypothesis	Path	Path Coefficient (O)	T Statistic	P Value	Conclusion
H1: Ecological operational efficiency (EOE) has a significantly positive impact on product manufacturing (PRO)	EOE → PRO	-0.160	1.512	0.130	Not Supported: Negative and insignificant effect
H2: Environmental protection (ENV) positively influences product manufacturing (PRO)	ENV → PRO	0.392	3.296	0.001	Supported: Significant positive effect
H3: Resource efficiency (EUR) positively and significantly impacts product manufacturing (PRO)	EUR → PRO	0.222	2.475	0.013	Supported: Significant positive effect
H4: Waste management (WM) has a strong positive effect on product manufacturing (PRO)	WM → PRO	0.470	5.815	0.000	Supported: Strong positive effect
H5: Social factors (SF) do not significantly influence product manufacturing (PRO)	SF → PRO	0.007	0.090	0.928	Supported: Insignificant effect
H6: Product manufacturing (PRO) positively impacts contribution to the community (SOC)	PRO → SOC	0.588	8.222	0.000	Supported: Strong positive effect

ing production processes. Conversely, ecological operational efficiency (*H1*) shows a negative but statistically insignificant impact on product manufacturing (path coefficient = -0.160), and social factors (*H5*) do not have a significant influence (path coefficient = 0.007). These results suggest that improvements in green operational efficiency and social factors alone may not directly enhance production performance within this model. Furthermore, product manufacturing (*H6*) strongly and significantly impacts contribution to the community (path coefficient = 0.588), indicating that optimized production processes are crucial in driving positive community outcomes. Overall, the findings emphasize integrating environmental protection, resource efficiency, and waste management into production strategies to achieve organizational and societal sustainability.

3.5. Indirect and direct effects

The analysis revealed that environmental protection, resource efficiency, and waste management positively and significantly influence contribu-

tions to the community through product manufacturing, with path coefficients of 0.230, 0.131, and 0.276, respectively (Table 7). These results highlight the importance of environmental investment, efficient resource utilization, and effective waste management in driving community benefits. By contrast, ecological operational efficiency and social factors exhibit no significant indirect effects, suggesting that their contributions to community outcomes through the manufacturing process are minimal in this model.

Environmental protection, resource efficiency, and waste management play critical roles in positively and significantly influencing product manufacturing and community contributions, emphasizing the importance of sustainable practices. In contrast, ecological operational efficiency and social factors did not significantly affect product manufacturing or community contributions. Product manufacturing has a substantial direct impact on contribution to the community, underscoring its pivotal role in fostering community engagement through enhanced production performance (Table 8).

Table 7. Indirect effects

Path	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (O/STDEV)	P values
ENV → PRO → SOC	0.230	0.230	0.067	3.425	0.001
EOE → PRO → SOC	-0.094	-0.089	0.061	1.537	0.124
EUR → PRO → SOC	0.131	0.137	0.057	2.281	0.023
SF → PRO → SOC	0.004	0.003	0.047	0.089	0.929
WM → PRO → SOC	0.276	0.275	0.062	4.421	0.000

Note: EOE = Ecological Operational Efficiency; ENV = Environmental Protection; EUR = Efficient Resource Use; WM = Waste Management; SF = Social Factors; PRO = Production Processes; SOC = Social Contribution.

Table 8. Direct effects

Path	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (O/STDEV)	P values
ENV → PRO	0.392	0.392	0.119	3.296	0.001
ENV → SOC	0.230	0.230	0.067	3.425	0.001
EOE → PRO	-0.160	-0.153	0.106	1.512	0.130
EOE → SOC	-0.094	-0.089	0.061	1.537	0.124
EUR → PRO	0.222	0.231	0.090	2.475	0.013
EUR → SOC	0.131	0.137	0.057	2.281	0.023
PRO → SOC	0.588	0.593	0.072	8.222	0.000
SF → PRO	0.007	0.004	0.079	0.090	0.928
SF → SOC	0.004	0.003	0.047	0.089	0.929
WM → PRO	0.470	0.461	0.081	5.815	0.000
WM → SOC	0.276	0.275	0.062	4.421	0.000

Note: EOE = Ecological Operational Efficiency; ENV = Environmental Protection; EUR = Efficient Resource Use; WM = Waste Management; SF = Social Factors; PRO = Production Processes; SOC = Social Contribution.

Overall, the empirical results confirm that environmental protection, resource efficiency, and waste management are key enablers of sustainable product manufacturing, which in turn significantly enhances a company's contribution to the community. These findings highlight the central mediating role of production performance in linking operational sustainability practices with broader social outcomes. Conversely, ecological operational efficiency and social factors did not show a significant direct or indirect impact in this model, suggesting that their effects may be more context-dependent, indirect, or require longer timeframes to materialize. These insights provide a robust empirical foundation for the subsequent discussion on the implications for industrial policy and corporate strategy in emerging economies.

4. DISCUSSION

Responsible production practices in emerging markets are increasingly important for achieving sustainable development goals (SDGs) and gaining legitimacy in global markets (Gomez-Trujillo et al., 2021). While developed economies have established regulatory frameworks, technological advancements, and financial incentives to support sustainability initiatives, emerging economies often face unique challenges, including limited regulatory enforcement, financial constraints, and competing economic priorities (Spaargaren, 2011).

This study assessed how environmental, operational, and social dimensions influence responsible production outcomes in Kazakhstan's man-

ufacturing sector. The results revealed that environmental protection, resource efficiency, and waste management significantly enhance product manufacturing, contributing to community development. These findings affirm the central role of tangible and actionable sustainability practices in driving industrial and social outcomes. In contrast, ecological operational efficiency and social factors did not demonstrate significant effects in this model, suggesting that internal efficiency improvements and CSR activities may not yet be sufficiently embedded in firms' strategic operations or institutional environments.

These results align with the literature on emerging markets, where sustainability often focuses on external compliance rather than internal transformation. As Stahl et al. (2016) argue, fostering responsible leadership in these contexts requires accommodating diverse stakeholder needs while adapting to local capacities and constraints. The limited influence of social factors may reflect the predominance of symbolic or externally oriented CSR, rather than deeply integrated stakeholder engagement (Cezarino et al., 2022; Mishchuk et al., 2023).

In emerging economies, responsible production is typically supported by three pillars: corporate social responsibility, green business, and sustainability management. Policy support is critical to accelerate this transition (Ade et al., 2021; Kontautienė et al., 2024). Practical strategies include reducing material inputs, recycling, and deploying technology to monitor and control processes. However, as

the current study shows, the most effective drivers are those directly related to environmental performance and operational outcomes. This suggests that responsible production in Kazakhstan is still evolving from narrow compliance-based actions toward more strategic integration.

Manufacturing enterprises, in particular, face the dual challenge of maintaining competitiveness while meeting sustainability expectations (Amos, 2018). While multinational corporations operating in these regions are often subject to global sustainability standards, domestic manufacturers may lack the resources, expertise, or regulatory oversight to implement responsible production practices effectively.

Nonetheless, Kazakhstan has begun transitioning from linear to circular production models, which aligns with broader international trends. Emphasis is growing on waste reduction, resource reuse, and industrial symbiosis (Zhidebekkyzy et

al., 2022b; Sabden et al., 2020; Zhaksybayeva et al., 2024). The findings support this direction by showing that resource efficiency and waste management significantly contribute not only to internal production outcomes but also to societal value creation.

In summary, the results answer the research question by showing that responsible production in Kazakhstan is driven primarily by environmental and resource-focused strategies. At the same time, internal operational and social dimensions remain underdeveloped. Theoretically, this supports prior observations that context-specific constraints shape responsible production in emerging markets and tend to emphasize measurable practices. Practically, the study implies that managers and policymakers should prioritize investments in environmental technologies and resource efficiency, while also building institutional capacity to support more integrated social and operational strategies.

CONCLUSION

This study empirically assessed how environmental, operational, and social dimensions influence responsible production outcomes in Kazakhstan's manufacturing sector. Using a structural equation modeling approach, the analysis demonstrated that environmental protection, efficient resource use, and waste management significantly enhance product manufacturing, which in turn contributes to stronger community engagement.

These findings indicate that companies that integrate environmental strategies and resource optimization into their core operations are more likely to achieve economic and societal benefits in an emerging economy. However, the lack of significant influence from ecological operational efficiency and social factors suggests that these areas require further attention, whether through policy incentives, internal capacity-building, or improved measurement frameworks. Notably, the manufacturing performance acts as a bridge – companies with improved sustainable production processes are better positioned to give back to their communities, highlighting how internal operational improvements translate into external social benefits. This points to an encouraging implication for emerging economies like Kazakhstan: pursuing sustainability in core operations can go hand-in-hand with industrial growth, creating a mutually reinforcing economic and social progress cycle.

Overall, the research fills a significant gap in understanding how integrated sustainability practices impact manufacturing success and societal well-being in emerging markets. Moreover, this study provides first-time empirical evidence of responsible production drivers in Kazakhstan's manufacturing sector. As responsible production becomes a strategic imperative for industrial development, these insights offer practical guidance for business leaders and policymakers aiming to align industrial growth with sustainability goals. Future research should explore the dynamic evolution of these relationships over time, examine cross-sectoral differences, and assess the role of regulatory and institutional mechanisms in enabling responsible production practices.

AUTHOR CONTRIBUTIONS

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APPENDIX A

Table A1. Questionnaire elements

No.	Factor Name	Statements
1	Ecological Operational Efficiency (EOE)	Our company effectively manages electricity consumption (EOE1)
		Our company optimizes water usage efficiently (EOE2)
		Our company maintains a low waste ratio relative to production volume (EOE3)
		Over the past 5 years, our company has reduced waste per production unit (EOE4)
2	Environmental Protection (ENV)	Our company invests in eco-friendly equipment (ENV1)
		Our company consistently meets air and water emission standards (ENV2)
		Our company has obtained or is in the process of obtaining environmental certifications (ENV3)
		Our company has minimal or no environmental violations (ENV4)
3	Efficient Resource Use (EUR)	Our company effectively uses primary raw materials (EUR1)
		Our company efficiently utilizes recycled wastewater (EUR2)
		Our company prioritizes renewable energy sources (EUR3)
		Our company carefully selects suppliers based on sustainability practices (EUR4)
4	Product Manufacturing (PRO)	Our company conducts product lifecycle assessments to minimize environmental impacts (PRO1)
		Our company applies eco-design principles to minimize environmental impacts (PRO2)
		Our company uses monitoring systems for sustainability performance (PRO3)
5	Waste Management (WM)	Our company has implemented comprehensive recycling programs (WM1)
		Our company initiates waste reduction measures across all operations (WM2)
		Our company operates an effective return management system (WM3)
6	Social Factors (SF)	Our company prioritizes workplace health and safety (SF3)
		Our company respects labor agreements and guarantees rights (SF4)
		Our company provides safe, healthy, and positive working conditions (SF5)
7	Community Contribution (SOC)	Our company actively participates in community work (SOC1)
		Our company donates to community causes (SOC2)
		Our company maintains a friendly and open community communication (SOC3)
		Our company supports community improvements and environmental projects (SOC4)

APPENDIX B

Table B1. Descriptive statistics

Variable	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
EOE1	100	1	5	3.82	1.077	-.574	.241	-.333	.478
EOE2	100	1	5	3.81	1.107	-.752	.241	-.100	.478
EOE3	100	1	5	3.81	1.228	-.696	.241	-.485	.478
EOE4	100	1	5	3.70	1.251	-.609	.241	-.621	.478
ENV1	100	1	5	3.53	1.389	-.514	.241	-1.003	.478
ENV2	100	1	5	4.10	1.176	-1.185	.241	.340	.478
ENV3	100	1	5	3.74	1.508	-.861	.241	-.758	.478
ENV4	100	1	5	4.03	1.283	-1.229	.241	.428	.478
EUR1	100	1	5	4.31	1.002	-1.705	.241	2.584	.478
EUR2	100	1	5	3.37	1.522	-.440	.241	-1.293	.478
EUR3	100	1	5	3.00	1.557	.000	.241	-1.515	.478
EUR4	100	1	5	3.98	1.155	-.885	.241	-.259	.478
PRO1	100	1	5	3.77	1.309	-.664	.241	-.771	.478
PRO2	100	1	5	3.38	1.376	-.432	.241	-1.049	.478
PRO3	100	1	5	3.77	1.278	-.860	.241	-.281	.478
WM1	100	1	5	3.35	1.410	-.360	.241	-1.213	.478
WM2	100	1	5	3.63	1.323	-.621	.241	-.725	.478
WM3	100	1	5	3.41	1.326	-.398	.241	-.915	.478
SF3	100	1	5	4.44	.935	-2.051	.241	4.310	.478
SF4	100	1	5	4.44	.914	-1.887	.241	3.498	.478
SF5	100	1	5	4.57	.807	-2.466	.241	7.108	.478
SOC1	100	1	5	4.29	.998	-1.423	.241	1.449	.478
SOC2	100	1	5	4.00	1.239	-1.073	.241	.057	.478
SOC3	100	1	5	4.18	1.104	-1.238	.241	.635	.478
SOC4	100	1	5	4.30	1.059	-1.516	.241	1.558	.478
Valid N (listwise)	100								