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The mediating role of open innovation in enhancing the Saudi food industry's integration into the global value chain

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ABSTRACT

This study examines the integration of the Saudi food industry into the Global Value Chain (GVC) by assessing the influence of key external factors, including Trade Policy (TP), Digital Business (DB), Collaborative Partnerships (CP), Ethical Issues (EI), and Sustainability Environment (SE). Open Innovation (OI) is analyzed as a mediating factor linking these elements to GVC participation. Using structural equation modeling (SEM), data from 178 decision-makers in the Saudi food sector reveal that while external factors significantly impact GVC participation, their effect is primarily channeled through OI. OI facilitates knowledge sharing, technology adoption, and collaboration, serving as a critical enabler of GVC integration. These findings underscore the transformative role of OI in leveraging external factors to enhance industry competitiveness, aligning with Saudi Vision 2030's economic diversification objectives. The study emphasizes the need for policymakers and industry leaders to promote initiatives that strengthen the global positioning of the Saudi food industry.

1. Introduction

Global Value Chain (GVC) participation has emerged as a critical pathway for industries seeking enhanced global competitiveness and operational efficiency. For emerging markets like Saudi Arabia, integrating into GVCs enables industries to leverage international production and distribution networks, fostering growth and innovation (Gopalalan et al., 2022). In the food industry, where technological advancements and regulatory frameworks significantly influence market dynamics, understanding effective routes to GVC integration is crucial (Golgeci et al., 2021; Epede and Wang, 2022).

As a vital contributor to Saudi Arabia's Vision 2030 economic diversification agenda, the food industry faces challenges such as dependency on imports, fluctuating global market conditions, and stringent international standards, which hinder its GVC integration (Horner, 2022; Lupak et al., 2021; Hussien et al., 2024). Addressing these challenges necessitates a thorough understanding of External Impact Elements (EIEs)—Trade Policy (TP), Digital Business (DB), Collaborative Partnerships (CP), Ethical Issues (EI), and Sustainability Environment (SE)—and their influence on GVC participation.

Open Innovation (OI), a paradigm that emphasizes collaboration and external knowledge utilization, has transformed traditional business practices, making it especially relevant to the food industry (Bacchetta et al., 2024). By facilitating the adoption of new technologies and optimizing supply chain management, OI enhances adaptability and competitive advantages in global markets. It also acts as a critical mediator, amplifying the impact of EIEs on GVC participation in environments marked by rapid technological changes and complex regulatory requirements.

Despite the transformative potential of OI, the Saudi food industry remains constrained by reliance on imports, vulnerability to supply chain disruptions, and stringent compliance demands. Moreover, limited empirical research explores how OI mediates the relationship between EIEs and GVC participation in this regional context. This study addresses these gaps by examining the role of OI in the Saudi food industry, focusing on three objectives.

- Identifying key EIEs influencing GVC participation.
- Investigating OI's mediating role in connecting EIEs to GVC integration.
- Offering actionable recommendations to enhance GVC participation through OI.

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This research contributes to understanding the dynamics of EIEs and their implications for the Saudi food sector's global competitiveness. By leveraging global networks and fostering innovative practices, the industry can achieve sustainable growth and resilience, aligning with Vision 2030's economic goals. Furthermore, the findings aim to provide policymakers and industry leaders with strategic insights to advance innovation, promote global cooperation, and position Saudi Arabia as a competitive player in the global economy. While studies on OI's impact on business performance are extensive, their application to GVC participation in the Middle Eastern food industry remains underexplored. This study bridges that gap, enriching the literature and addressing a critical regional economic priority.

2. Literature review and hypothesis development

This segment aims to critically examine the extant literature concerning GVC participation, open innovation, and the EIEs that influence the Saudi food sector. Further, the analysis will assess the implications of the COVID-19 pandemic on these aspects, emphasizing the food industry in Saudi Arabia.

2.1. GVC participation in the food industry

GVC participation in the food industry is shaped by a complex interplay of economic, environmental, and social factors, varying across regions and market dynamics. Economically, GVCs enhance competitiveness, innovation, and productivity by integrating local producers into global markets (Fernandes et al., 2022). However, technological and infrastructural disparities often hinder developing countries' ability to fully leverage these benefits (Wang et al., 2021). Digital tools, such as blockchain, and frameworks like open innovation have emerged as key enablers, enhancing supply chain transparency, resilience, and efficiency (Lotfi et al., 2024; Wolfert et al., 2023).

Environmentally, GVC participation drives adherence to regulatory frameworks, encouraging green technological innovations (Hu et al., 2021). However, profitability pressures may lead to harmful practices in regions with lax environmental regulations (Wang et al., 2021). Adopting circular economic principles through open innovation offers a pathway to mitigate these risks and promote sustainable supply chains (Perotti et al., 2024; Lippolis et al., 2023; Moreau and Aligishiev, 2024).

Socially, GVCs create opportunities for local employment but may also exacerbate inequalities and undermine labor rights, depending on the local context (Fernandes et al., 2022). The uneven social impacts highlight the importance of tailoring GVC strategies to regional dynamics (Qu et al., 2020). The COVID-19 pandemic underscored the need for resilient and equitable frameworks, with global institutions like the WTO playing a pivotal role in addressing these challenges (Bacchetta et al., 2024).

2.2. Open innovation in the food industry

Open innovation has emerged as a transformative strategy in the Saudi food industry, driving advancements in research and development (R&D), product innovation, and participation in global value chains (GVCs). By fostering knowledge sharing and collaboration, open innovation enhances R&D efforts, enabling solutions tailored to local market needs and elevating the industry's diversity and quality. In product development, open innovation allows Saudi food manufacturers to integrate external ideas and technologies, creating products that align with evolving consumer preferences. Akkas and Altiparmak (2023) emphasized that this approach supports economic diversification, enabling the food sector to adapt to global trends while preserving local relevance. Moreover, open innovation significantly influences Saudi participation in GVCs. Collaborative engagements with international partners improve operational efficiency and market access. Studies by Yanikkaya and Altun (2020) highlighted the importance of such participation for sectoral growth and productivity, while Razzaq et al. (2024) and Zhang and Sun (2023) demonstrated its positive impact on sustainable economic growth in agriculture. Thus, open innovation is vital for enhancing the Saudi food industry's resilience and competitiveness in global markets.

2.3. EIEs affecting GVC participation

Several EIEs critically influence the food industry's participation in GVCs. These include trade policy, digital business, collaboration partnerships, ethical issues, and sustainability.

2.3.1. Trade policy

Trade policies significantly shape Saudi Arabia's GVC participation in the food industry, given its reliance on food imports. Greenville et al. (2019) noted that dynamic changes in agro-food GVCs are affected by national policies, which can either facilitate or impede access to international markets. While regional trade agreements offer market opportunities, they may also introduce pricing barriers (Fusacchia et al., 2022). Strengthening local production capacities is essential to better integrate into global supply chains and reduce dependence on imports (Olaopa and Alsuhaibany, 2023). Strategic policy reforms are crucial to optimizing trade dynamics and enhancing GVC participation.

2.3.2. Digital business

Digital business significantly enhances GVC participation by improving efficiency, fostering

collaboration, and boosting competitiveness in a globalized economy. Technologies such as blockchain and the Internet of Things (IoT) enhance transparency, traceability, and decision-making within GVCs (Egwuonwu et al., 2022; Ha, 2024). Digital platforms also streamline operations, reduce costs, promote resource sharing, creating adaptive and resilient supply chains (Meng and Zhao, 2022; Loonam and O'Regan, 2022). These advancements collectively drive productivity and competitiveness in global markets (Kliestik et al., 2023).

2.3.3. Collaboration partnerships

Collaboration partnerships are instrumental in fostering innovation and sustainability in the food industry. Strategic alliances enable advancements that enhance productivity and align with sustainable development goals. Digital innovation ecosystems, for example, integrate design principles that promote cooperation among stakeholders. However, challenges such as misaligned objectives and expectations can hinder the success of these partnerships. Despite these barriers, leveraging collaborative strategies can yield substantial financial benefits and support entrepreneurial growth (Krishnan et al., 2023; Mutambik, 2024; Luongo et al., 2023).

2.3.4. Ethical issues

Ethical considerations, including Corporate Social Responsibility (CSR), labor rights, and environmental sustainability, profoundly influence GVC participation. CSR frameworks encourage alignment with ethical standards, promoting sustainable practices (Ucaryilmaz Deibel, 2022). Labor rights compliance enhances workplace conditions and community well-being (Dahan et al., 2023), while trade agreements increasingly incorporate ecological responsibility to mitigate environmental harm (Harrison, 2023). Collaborative approaches to CSR, as emphasized by Asmussen et al. (2023), were essential to improving the ethical integrity of GVCs, benefiting both businesses and communities.

2.3.5. Sustainability environment

Sustainability plays a pivotal role in shaping GVCs, particularly in ecological food production practices that align with consumer demand and ethical expectations. The COVID-19 pandemic underscored the importance of sustainable supply chains, driving a shift toward circular economies that enhance value chain efficiency and resilience (Kumar et al., 2023; Hofstetter et al., 2021). While challenges remain in creating flexible value chains that meet sustainable development goals, circular food supply chains offer opportunities to add value and ensure safety, meeting evolving market demands (Dwivedi et al., 2021; Lavelli, 2021).

2.4 Impact of COVID-19 on GVC participation

The COVID-19 pandemic profoundly affected the Saudi food industry's participation in global value chains (GVCs), leading to significant disruptions, adaptive innovations, and an increased reliance on open innovation to foster resilience.

The pandemic initially caused substantial supply chain interruptions, resulting in shortages of essential goods and exposing vulnerabilities linked to the industry's reliance on imported assets (Strange, 2020; Bacchetta et al., 2024). These disruptions underscored the need for adaptive measures to mitigate dependency and strengthen supply chain stability.

In response, innovation became a pivotal tool for adaptation. The crisis accelerated the adoption of digital platforms, enabling local producers to implement direct-to-consumer models and diversify distribution channels. Additionally, economic shifts in agriculture and livestock trade highlighted opportunities for boosting domestic production and enhancing food security (Mtimet et al., 2021).

Open innovation played a critical role in fostering resilience during this period. Collaborative efforts between the public and private sectors drove the rapid development of strategies and technologies to address pandemic-related challenges. This cooperative approach not only mitigated risks but also positioned the Saudi food industry for sustainable growth and enhanced GVC integration in the post-pandemic era (Bacchetta et al., 2024).

Fig. 1 serves to portray the research schema relevant to our inquiry, which investigates how OI mediates the link between EIEs—specifically TP, DB, CP, EI, and SE—and engagement in GVC in the Saudi food sector. This model synthesizes insights derived from the literature review to scrutinize how these external determinants, via the mechanism of open innovation, either facilitate or obstruct successful engagement in global value chains.

The current study examines the impact of EIEs on GVC participation in the food industry in Saudi Arabia, focusing on the following main hypotheses:

H1: CP influences GVC Participation in the food industry in KSA.
H2: DB influences GVC Participation in the food industry in KSA.
H3: EI influence GVC Participation in the food industry in KSA.
H4: OI influences GVC Participation in the food industry in KSA
H5: SE influences GVC Participation in the food industry in KSA.
H6: TP influences GVC Participation in the food industry in KSA.

This study also explores the mediating role of OI in the relationship between EIEs and GVC participation in the food industry in Saudi Arabia, as reflected in the following mediation hypotheses:

H7: OI mediates the relationship between CP and GVC Participation in the KSA food industry.
H8: OI mediates the relationship between DB and GVC Participation in the KSA food industry.
H9: OI mediates the relationship between EI and GVC Participation in the KSA food industry.
H10: OI mediates the relationship between SE and GVC Participation in the KSA food industry.
H11: OI mediates the relationship between TP and GVC Participation in the KSA food industry.

3. Materials and methods

3.1. Subjects

The study targeted companies and organizations in Saudi Arabia actively engaged in or aiming to enhance their participation in the GVC. These entities span diverse sectors, including manufacturing, services, and agriculture, with a strong focus on collaboration partnerships, digital technologies, and sustainable practices. The sample consisted of 178 key decision-makers and leaders who influence strategic innovation and global market integration within their organizations. Participants were selected using purposive sampling to ensure the inclusion of individuals with relevant expertise and insights into GVC dynamics.

3.2. Survey

Data were collected through a structured questionnaire designed to examine key variables: CP, DB, EI, OI, SE, TP, and GVC Participation. The questionnaire utilized a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) and comprised multiple segments tailored to capture the study's core constructs. The survey was distributed via an online platform, ensuring accessibility and broader reach across various sectors in Saudi Arabia. Before full deployment, the instrument underwent pre-testing with a small sample to confirm clarity, reliability, and alignment with research objectives. Adjustments were made based on participant feedback during this phase.

3.3. Data analysis

The collected data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) to explore relationships among constructs and test the research hypotheses. Descriptive statistics summarized the sample's demographic characteristics, while confirmatory factor analysis (CFA) validated the measurement model's reliability and validity. Path coefficients, T-statistics, and P-values were used to assess relationships between independent variables (CP, DB, EI, OI, SE, TP) and the dependent variable (GVC). Robustness checks were conducted to ensure the reliability of results:

- Bootstrapping: Conducted with 10,000 resamples to verify the stability of path coefficients.
- Multi-Group Analysis (MGA): Identified variations in structural relationships across subgroups.
- Collinearity Diagnostics: Variance Inflation Factor (VIF) values confirmed no multicollinearity.
- Model Invariance Testing: Ensured consistent measurements across subsamples.
- Sensitivity Analysis: Alternative estimation techniques, such as Maximum Likelihood Estimation (MLE), were used to validate findings.

Construct reliability and validity were confirmed through composite reliability and Cronbach's alpha. Discriminant validity was assessed using the HTMT ratio and the Fornell-Larcker criterion. Model performance was evaluated with R-square values to measure explanatory power and f-square metrics to determine effect sizes. These steps ensured a robust analysis of the data.

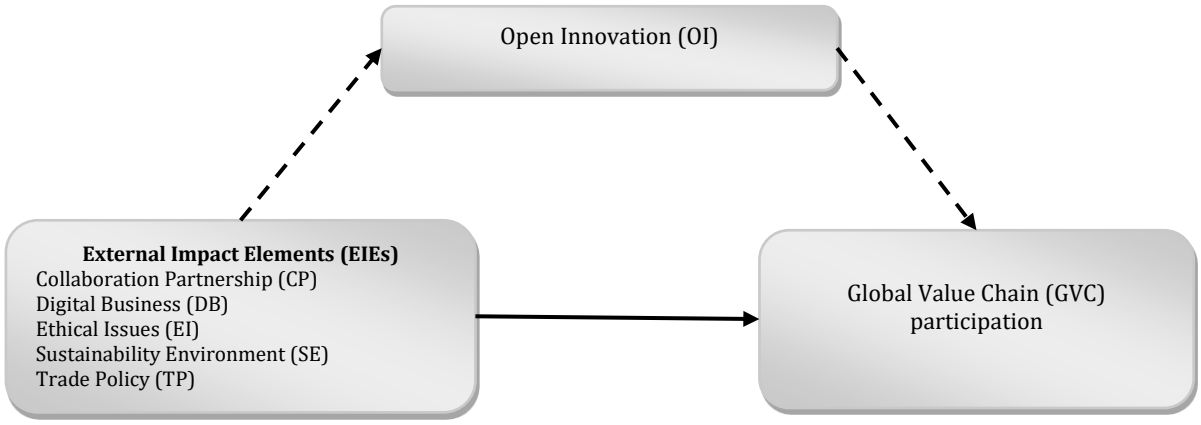

Fig. 1: Research framework

4. Results

Fig. 2 presented the measurement framework of our study, depicting how External Impact Elements such as TP, DB, CP, EI, and SE interact with OI to influence GVC in the food industry in Saudi Arabia. This framework highlights the structural relationships and path coefficients between the constructs, illustrating the direct and mediated impacts on GVC participation.

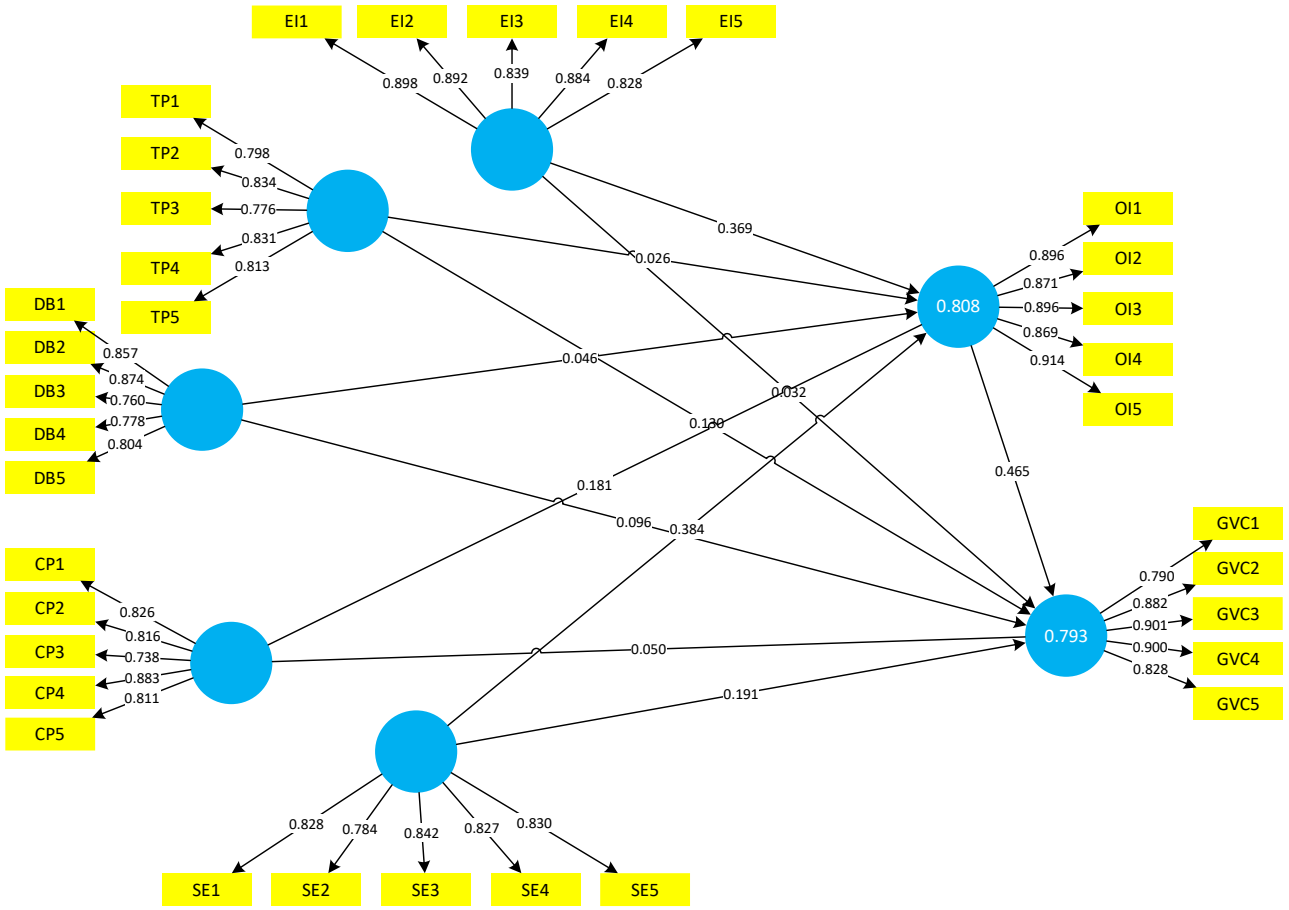

Fig. 2: Measurement framework

To achieve better clarity of the themes investigated in the examination, look at Table 1, which accentuates their validity and trust, featuring CP, DB, EI, OI, SE, TP, and GVC. The outer loadings for all constructs surpass the 0.7 thresholds, thereby affirming that the indicators exhibit a robust correlation with their respective constructs. For instance, the outer loadings for CP range from 0.738 to 0.883, exemplifying the strength of the association between each indicator and the foundational construct. Also, the VIF measures are persistently under 5, which mitigates fears regarding multicollinearity within the model.

The constructs' trustworthiness is also supported by Cronbach's alpha and composite reliability metrics, which align with the advised threshold of 0.7. To demonstrate, Open Innovation indicates a Cronbach's alpha of 0.934 together with a composite reliability of 0.935, highlighting a significant degree of internal consistency. Every construct features an Average Variance Extracted (AVE) that goes beyond 0.5, demonstrating that the indicators reveal a noteworthy amount of the variance present in each construct. EI, for example, possess an AVE of 0.755, which, as articulated by Hair et al. (2017), implies sufficient convergent validity. Collectively, the metrics substantiate that the constructions employed in the research are both reliable and valid, thereby facilitating a substantive interpretation of the findings.

Table 2 interprets discriminant validity through the Heterotrait-Monotrait (HTMT) ratio, marking acceptable values below the 0.85 threshold. This threshold is a widely accepted standard in the field, indicating that constructions with HTMT ratios below this value are distinct. The HTMT ratios observed between the various constructs in our model consistently fall beneath this specified limit, affirming the constructs' empirical distinction. For example, the HTMT ratio observed between CP and DB is recorded at 0.788, significantly lower than the 0.85 threshold, corroborating that these two constructs indicate disparate concepts. Similarly, the value recorded between GVC and EI stands at 0.773, further substantiating these constructs' distinctiveness.

The comprehensive HTMT analysis provides compelling evidence that discriminant validity is successfully achieved throughout the model. As Henseler et al. (2015) emphasized, an HTMT ratio below the 0.85 benchmark is a strong indicator of discriminant validity, ensuring that the constructions represent unique phenomena and are not excessively correlated.

The Fornell-Larcker criterion in Table 3 serves the purpose of assessing discriminant validity by comparing the square root of the AVE values for each construct to the correlations between constructs. In Table 3, the square root of the AVE for each construct (the bold diagonal values) exceeds its correlations with other constructs, indicating discriminant validity. For example, the square root of the AVE for CP is 0.816, which is greater than its correlation with Digital Business (0.776) and Ethical

Issues (0.832), showing that CP shares more variance with its items than with other constructs.

Using an analogous technique, the square root of the AVE tied to GVC Participation is computed at 0.861, outshining its correlation coefficients with both Sustainability Environment (0.831) and Open Innovation (0.863). As posited by Fornell and Larcker (1981), the criterion for discriminant validity is satisfied when the square root of the AVE exceeds the correlations with other constructs, thereby affirming the empirical distinctiveness of each construction. The robust findings presented in Table 3 provide strong support for the presence of discriminant validity, thereby affirming that each construction is designed to assess a distinct dimension of the overarching model.

Table 1: Construct reliability and validity metrics

Constructs	Item	Outer loading	VIF	Cronbach's alpha	Composite reliability (rho_a)	AVE
CP	CP1	0.826	3.092	0.874	0.8	0.666
	CP2	0.816	2.978			
	CP3	0.738	1.786			
	CP4	0.883	3.061			
	CP5	0.811	2.138			
DB	DB1	0.857	2.795	0.874	0.884	0.665
	DB2	0.874	3.120			
	DB3	0.760	1.818			
	DB4	0.778	2.877			
	DB5	0.804	3.071			
EI	EI1	0.898	3.247	0.918	0.920	0.755
	EI2	0.892	3.166			
	EI3	0.839	2.488			
	EI4	0.884	2.965			
	EI5	0.828	2.329			
OI	OI1	0.896	3.506	0.934	0.935	0.791
	OI2	0.871	3.056			
	OI3	0.896	3.322			
	OI4	0.869	3.042			
	OI5	0.914	4.037			
SE	SE1	0.828	2.090	0.881	0.889	0.676
	SE2	0.784	1.898			
	SE3	0.842	2.509			
	SE4	0.827	2.258			
	SE5	0.830	1.971			
TP	TP1	0.798	2.016	0.870	0.877	0.657
	TP2	0.834	2.346			
	TP3	0.776	1.817			
	TP4	0.831	2.050			
	TP5	0.813	1.976			
GVC	GVC1	0.790	1.832	0.912	0.914	0.742
	GVC2	0.882	3.185			
	GVC3	0.901	3.688			
	GVC4	0.900	3.465			
	GVC5	0.828	2.315			

Table 2: Discriminate validity (HTMT ratio)

Constructs	CP	DB	EI	OI	SE	TP	GVC
CP							
DB	0.788						
EI	0.721	0.633					
OI	0.795	0.724	0.722				
SE	0.715	0.709	0.718	0.731			
TP	0.739	0.785	0.738	0.786	0.661		
GVC	0.667	0.747	0.773	0.731	0.715	0.728	

An HTMT Ratio < 0.85 is considered valid

Table 3: Discriminant validity (Fornell-Larcker criterion)

	CP	DB	EI	OI	SE	TP	GVC
CP	**0.816**						
DB	0.776	**0.816**					
EI	0.832	0.750	**0.869**				
OI	0.817	0.750	0.855	**0.889**			
SE	0.809	0.799	0.831	0.855	**0.822**		
TP	0.739	0.780	0.755	0.715	0.759	**0.811**	
GVC	0.782	0.762	0.801	0.863	0.831	0.742	**0.861**

Following the Fornell-Larcker criterion, the bold value is accepted when it exceeds its row and column values

Table 4 highlights the model's strong explanatory power, as evidenced by the high R-square values. An R-square of 0.808 for OI indicates that 80.8% of the differences in OI are explained by the model's predictors. Similarly, the R-square value of 0.793 for GVC suggests that the model clarifies 79.3% of the differences in GVC. These high R-square values underscore the model's ability to clarify the differences in OI and GVC, demonstrating its strong explanatory power.

The Q^2 Predict values for OI (0.632) and GVC (0.547) demonstrate the predictive relevance of the model, as values above 0 indicate. Regarding the effect sizes, EI has an f-square of 0.158, reflecting a

medium effect size on Open Innovation. In contrast, Open Innovation has a very large effect on global value chain participation, with an f-square of 2.923. This not only shows the predictive power of Open Innovation but also underscores its importance as a mediating factor in the model, making the audience realize the significance of its role.

Table 4: R-square and f-square metrics for constructs

Constructs	R-square	R-square adjusted	Q2 predict *	f-square	
				OI	GVC
OI	0.808	0.805	0.632	/	/
GVC	0.793	0.789	0.547	/	/
CP	/	/		0.041	/
DB	/	/		0.123	/
EI	/	/		0.158	/
OI	/	/		/	2.923
SE	/	/		0.170	/
TP	/	/		0.119	/
GVC	/	/		/	/

*: PLS_SEM ver. 4.1 Q2 CVPAT prediction

The results of our hypothesis testing, presented in Table 5, reveal some key findings. Firstly, H1 (Collaboration Partnership → GVC) is rejected, indicating that collaboration partnerships do not significantly impact GVC participation. Similarly, H2 (Digital Business → GVC) is also rejected, suggesting that digital business does not significantly influence GVC participation. While ethical Issues (H3) are found to have no significant direct effect on GVC participation, H4 (Open Innovation → GVC) stands out with strong support. The highly significant P-value of 0.000 and a path coefficient of 0.465 demonstrate that open innovation has a powerful and direct positive effect on global value chain participation, highlighting the crucial role of innovation in driving global competitiveness. Reiterating the key findings, H5 (Sustainability Environment → GVC) is also supported, with a path coefficient of 0.191 and a P-value of 0.005, indicating that sustainability efforts positively influence GVC participation. Additionally, H6 (Trade Policy → GVC) is supported with a P-value of 0.024, showing that trade policies significantly affect GVC participation, although the effect size is moderate. In summary, Table 5 demonstrates that while collaboration partnerships, digital business, and ethical issues do not directly influence GVC participation, open innovation, sustainability, and trade policy are key factors that drive a firm's ability to integrate into global value chains.

Table 5: Direct hypotheses testing

Hypothesis	Path coefficients	O	SD	T-statistics (|O/SD|)	P-values	Results
H1	CP -> GVC	0.050	0.071	0.703	0.482*	rejected
H2	DB -> GVC	0.096	0.060	1.602	0.109*	rejected
H3	EI -> GVC	0.032	0.075	0.430	0.667*	rejected
H4	OI -> GVC	0.465	0.076	6.154	0.000**	supported
HP5	SE -> GVC	0.191	0.067	2.835	0.005**	supported
HP6	TP -> GVC	0.130	0.058	2.258	0.024*	supported

Significant at P** =< 0.01, p*<0.05; O: Original sample; SD: Standard deviation;

Table 6 underscores the indispensable role of open innovation in the relationship between several independent variables and GVC Participation. H7 (Collaboration Partnership → Open Innovation → GVC) is validated, with a path coefficient of 0.157 and a P-value of 0.003, signifying complete mediation. This implies that while collaboration partnerships do not directly influence GVC participation, they exert a significant indirect effect through open innovation. In essence, collaboration partnerships only augment GVC participation when firms actively employ open innovation strategies.

In contrast, H8 (Digital Business → Open Innovation → GVC) is rejected, with a P-value of 0.453, showing no mediation effect. This suggests that even when combined with open innovation, digital business does not significantly influence GVC participation in this context. On the other hand, H9 (Ethical Issues → Open Innovation → GVC) is strongly supported, with a path coefficient of 0.318 and a P-value of 0.000. This full mediation effect indicates that ethical issues significantly impact GVC participation, but only when mediated by open innovation. Firms that address ethical issues while engaging in open innovation are more likely to succeed in global value chains.

H10 (Sustainability Environment → Open Innovation → GVC) is supported with partial mediation, as the path coefficient is 0.331 and the P-value is 0.000. This partial mediation indicates that sustainability efforts, directly and indirectly, influence GVC participation through open innovation. Finally, H11 (Trade Policy → Open Innovation → GVC) is rejected, with a P-value of 0.691, suggesting that trade policy does not have a significant indirect effect on GVC participation via open innovation. In conclusion, Table 6 underscores the pivotal role of open innovation in mediating the effects of collaboration partnerships, ethical issues, and sustainability on global value chain participation. These findings strongly suggest that firms must embrace open innovation strategies to fully harness the benefits of these external factors for successful global market integration.

Table 6: Specific indirect effects

Hypothesis	Path coefficients	O	SD	T-statistics (|O/SD|)	P-values	Results	Decision
H7	CP -> OI -> GVC	0.157	0.053	2.939	0.003	Supported	Full mediation
H8	DB -> OI -> GVC	0.039	0.052	0.751	0.453	Rejected	No mediation
H9	EI -> OI -> GVC	0.318	0.051	6.259	0.000	Supported	Full mediation
H10	SE -> OI -> GVC	0.331	0.049	6.825	0.000	Supported	Partial mediation
H11	TP -> OI -> GVC	-0.021	0.052	0.397	0.691	Rejected	No mediation

Significant at P** =< 0.01, p*<0.05

5. Discussion

The findings of this study align with and expand existing literature, highlighting the dynamic interactions among EIEs and their collective influence on GVC participation. Central to these findings is the pivotal role of OI as a mediating factor, which enhances competitiveness and adaptability within global markets (Fernandes et al., 2022; Wang et al., 2021).

Support for hypothesis H4 (OI → GVC) underscores OI's significant influence on GVC participation (path coefficient: 0.465, P-value: 0.000), affirming its transformative potential in fostering integration and resilience (Nasser and Ouerghi, 2022). However, the rejection of H1, H2, and H3 indicates that collaboration partnerships, digital business practices, and ethical considerations require OI as a conduit to significantly impact GVC participation. This finding aligns with challenges identified in developing regions, where the absence of cohesive innovation strategies hinders GVC adoption (Wang et al., 2021).

The mediating role of OI (H7–H11) demonstrates its capacity to strategically integrate collaboration, sustainability, and ethical practices to enhance GVC participation. Supported hypotheses—H7 (CP → OI → GVC), H9 (EI → OI → GVC), and H10 (SE → OI → GVC)—emphasize the importance of cohesive innovation strategies. In contrast, the non-significance of H8 and H11 suggests gaps in aligning digital and trade policies with OI, identifying areas for further research and policy refinement.

The study findings extend beyond the Saudi context and show some global applicability. However, there are challenges that policymakers need to address, such as building collaborative ecosystems, embedding sustainability, and facilitating digital transformation to strengthen GVC participation. Vital measures include:

- Promoting public-private partnerships to support OI initiatives.
- Adopting international standards (e.g., WTO and FAO frameworks) to facilitate market entry.
- Implementing policies encouraging regional collaborations to strengthen global integration.

Globally, food industries must balance innovation, sustainability, and adaptability to thrive in GVCs. For example, Southeast Asia's textile sector could utilize digital innovation to manage market fluctuations, while Africa's electronics industry might align sustainability principles with international standards to improve GVC participation. By addressing regional disparities and leveraging tailored OI frameworks, industries can enhance their global competitiveness.

This study highlights that while EIEs are critical to GVC integration, their effectiveness depends on their integration with OI strategies. By adopting an integrated approach, industries can achieve sustainable and equitable global participation, navigating the complexities of modern GVCs. This model offers actionable insights for industries worldwide, emphasizing the importance of innovation-driven frameworks in ensuring resilience and global competitiveness.

6. Limitations and future research

This study provides valuable insights into the Saudi food industry's integration into the GVC through EIEs and OI. However, several limitations warrant consideration:

- Geographic Scope: The study focuses exclusively on Saudi Arabia, which limits the generalizability of the findings. Future research could extend the analysis to other regions or conduct cross-country comparisons to provide broader insights.
- Data Sources: Reliance on secondary data may not fully capture the nuances of current industry dynamics. Incorporating primary data, such as qualitative interviews or case studies, could enrich the understanding of GVC participation.
- Additional Mediators: Other mediating factors, such as economic stability, cultural elements, or government policy reforms, were not explored. Investigating these factors could provide a more comprehensive view of GVC integration.
- Temporal Considerations: The study's snapshot approach limits its ability to capture the evolving impact of COVID-19 and ongoing market changes. Longitudinal studies are recommended to assess long-term trends, recovery strategies, and the enduring role of OI in shaping GVC participation.

7. Conclusion and recommendations

The study underscores the significant role of OI as a mediator in enhancing GVC participation within the Saudi food industry. While some EIEs lack direct influence on GVC integration, their impact through OI is substantial, highlighting the importance of innovation in fostering adaptability and competitiveness in global markets.

To strengthen GVC participation, policymakers should incentivize R&D, foster public-private collaborations, and invest in digital infrastructure to

enhance operational efficiency. Encouraging sustainable and ethical practices is also crucial to meeting consumer demands and boosting global market credibility. Businesses must remain adaptive, leveraging OI to navigate market complexities and sustain growth.

List of abbreviations

AVE	Average variance extracted
CP	Collaboration partnership
CSR	Corporate social responsibility
DB	Digital business
EIEs	External impact elements
EI	Ethical issues
FAO	Food and Agriculture Organization
GVC	Global value chain
IoT	Internet of Things
KSA	Kingdom of Saudi Arabia
MLE	Maximum likelihood estimation
MGA	Multi-group analysis
OI	Open innovation
PLS-SEM	Partial least squares structural equation modeling
R&D	Research and development
SE	Sustainability environment
SEM	Structural equation modeling
TP	Trade policy
VIF	Variance inflation factor
WTO	World Trade Organization

Compliance with ethical standards

Ethical considerations

All participants provided informed consent, and their data were kept confidential. Participation was voluntary, and no personally identifiable information was collected.

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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