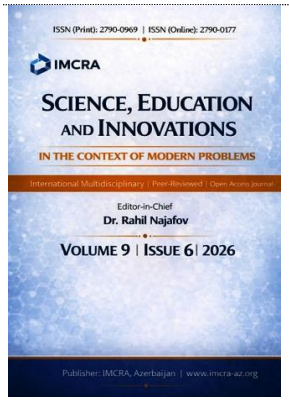

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RESEARCH ARTICLE

Global Value Chain Integration in Developing Economies: Strategic Constraints and Participation Dynamics in Central Asian Countries

Yang Hong'en
Professor of Economics
School of Economics, Beijing Technology and Business University, Beijing
China
E-mail: y_paper@126.com

Tokhir Shomurodov
PhD in Economics
School of Economics, Beijing Technology and Business University, Beijing
China
E-mail: tohirbek0206@gmail.com
ORCID: https://orcid.org/0000-0002-8107-7792

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Abstract
This study critically examines the extent and structural determinants of Global Value Chain (GVC) participation among Central Asian economies, with a particular focus on the region's strategic constraints and integration dynamics within global and regional production networks. Despite possessing significant endowments in natural resources and labor, Central Asian countries remain marginally integrated into GVCs, exhibiting limited value-added upgrading and weak participation in high-value segments of international trade. Drawing on theoretical and empirical insights from the GVC and Global Production Networks (GPN) literature, the study identifies key institutional, infrastructural, and policy-related barriers that hinder deeper integration. Particular attention is given to structural factors such as landlocked geography, high transportation costs, weak institutional frameworks, limited technological capacity, and insufficient regulatory harmonization. The findings suggest that, unlike East and Southeast Asian economies that have successfully leveraged strategic coupling mechanisms and industrial upgrading, Central Asian countries face persistent structural rigidities that constrain their participation in both backward and forward value chains. The paper contributes to the literature by offering a region-specific analytical perspective and proposes a policy-oriented framework aimed at enhancing competitiveness, attracting foreign direct investment, and facilitating integration into global production systems.

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INTRODUCTION

The rapid expansion of Global Value Chains (GVCs) over the past three decades has fundamentally transformed the structure of international trade, production organization, and economic development pathways. Rather than producing goods within national boundaries, contemporary production systems are increasingly fragmented and geographically dispersed, with different stages of the value creation process allocated across multiple countries. This shift has repositioned GVC participation as a central mechanism through which economies integrate into the global marketplace, enhance productivity, and achieve structural transformation (Coe & Yeung, 2019; Gereffi & Lee, 2016).

A substantial body of literature has examined the determinants of GVC participation at both the firm and country levels. Foundational studies emphasize that integration into global production networks is shaped by a complex interplay of economic, institutional, and technological factors. These include macroeconomic stability, trade openness, tariff and non-tariff barriers, labor costs, technological capabilities, regulatory frameworks, and the protection of foreign investors' rights (Dunning, 1988;

Sturgeon et al., 2008; MacCarthy et al., 2016; Curran et al., 2019). More recent contributions further highlight the importance of institutional quality, governance effectiveness, and policy coherence in facilitating deeper and more sustainable engagement with GVCs. Despite these advances, important gaps remain in understanding the multilateral dynamics of GVC integration, particularly in relation to how countries position themselves within complex, interconnected production networks and how bilateral and regional trade relationships shape these outcomes.

GVCs have become a primary driver of global trade expansion and economic interdependence. Participation in these networks enables both developed and developing economies to specialize in specific segments of production, thereby enhancing efficiency and enabling access to international markets. Multinational enterprises (MNEs), as key coordinators of GVCs, play a pivotal role in this process by optimizing production costs through offshoring and outsourcing strategies. For developing economies, integration into GVCs provides opportunities for foreign direct investment (FDI) inflows, technology transfer, knowledge spillovers, and industrial upgrading (Slany, 2017). However, the benefits of GVC participation are unevenly distributed, and not all countries are equally positioned to capture value within these networks.

Empirical evidence suggests that the degree of GVC participation varies significantly across countries and industries, reflecting structural differences in economic capacity and institutional development. Many developing economies remain only marginally integrated into global production systems, often confined to low-value-added segments of the value chain (OECD, 2013). Several structural barriers constrain deeper integration, including weak institutional frameworks, limited human capital, inadequate infrastructure, and unfavorable business environments. In particular, the protection of property rights, the quality of labor, regulatory efficiency, and access to finance have been identified as critical determinants of a country's ability to participate effectively in both global and regional value chains (OECD, 2013; Amendolagine et al., 2019).

The Asian region provides a compelling illustration of divergent GVC integration trajectories. East and Southeast Asian economies—most notably China, South Korea, Malaysia, and members of the Association of Southeast Asian Nations (ASEAN)—have successfully leveraged GVC participation to achieve rapid industrialization and sustained economic growth. China's rise as a global manufacturing hub has been particularly influential, reshaping regional production networks and facilitating the expansion of both GVCs and Regional Value Chains (RVCs). Between 2000 and 2018, China's share of global production increased substantially, creating new opportunities for neighboring economies to integrate into its production ecosystem. As a result, East and Southeast Asia have experienced significant gains in GDP growth and global output share, driven largely by their deepening involvement in cross-border value chains.

However, this pattern of successful integration is not uniformly observed across Asia. In contrast to the dynamic integration of East and Southeast Asian economies, Central Asian countries continue to exhibit relatively low levels of GVC participation. Despite their strategic geographic location at the crossroads of Europe and Asia and their abundance of natural resources and labor, these economies remain weakly connected to global production networks. Their participation is largely concentrated in resource-based and low-value-added activities, with limited evidence of industrial upgrading or diversification.

The structural challenges facing Central Asia are multifaceted. While some scholars attribute the region's limited integration to geographic constraints—particularly its landlocked nature and associated high transportation costs (Grigoriou, 2007)—others emphasize the role of institutional deficiencies, policy inconsistencies, and weak economic governance. Issues such as inadequate infrastructure, limited technological capabilities, regulatory inefficiencies, and insufficient protection of property rights further exacerbate the region's marginal position within GVCs. Consequently, the share of high-value-added exports remains low, and the region has yet to develop robust linkages with global and regional production systems comparable to those observed in the European Union or East Asia (Pomfret & Sourdin, 2014).

Given these dynamics, there is a pressing need for a more nuanced and region-specific analysis of GVC participation in Central Asia. While existing studies provide valuable insights into global patterns of value chain integration, they often overlook the unique structural, institutional, and policy-related challenges faced by this region. Addressing this gap is essential for understanding the barriers to integration and for identifying pathways through which Central Asian economies can enhance their participation in global production networks.

Accordingly, the primary objective of this study is to examine the extent and nature of GVC participation in Central Asian countries and to identify the key constraints that hinder their integration. By combining theoretical insights with empirical analysis, the paper seeks to contribute to the broader literature on GVCs while providing policy-relevant recommendations aimed at improving competitiveness, attracting investment, and fostering sustainable economic development in the region.

LITERATURE REVIEW

Global Value Chains (GVCs) and Regional Value Chains (RVCs) have emerged as central mechanisms shaping contemporary patterns of international production, trade integration, and economic development. A substantial body of literature emphasizes the critical role of multinational enterprises (MNEs) as key orchestrators of value chain governance, coordination, and upgrading processes (Fuller & Phelps, 2018; Coe & Yeung, 2019). However, recent scholarship increasingly highlights that GVC dynamics cannot be fully understood without accounting for the institutional and regulatory environments within which firms operate. Governments, local institutions, and policy frameworks play a decisive role in shaping organizational behavior, influencing investment decisions, and facilitating or constraining participation in global and regional production networks (Kano, 2018; Alford & Phillips, 2018).

The evolution of GVC research has led to the development of diverse methodological and theoretical approaches. Empirical studies have employed both qualitative and quantitative techniques to analyze firm-level strategies, network configurations, and cross-border production linkages (Eriksson et al., 2014; Kumar et al., 2018). At the same time, conceptual contributions have provided foundational frameworks for understanding governance structures, power asymmetries, and value distribution across global production systems (Gereffi et al., 2005; Buckley, 2011; Gereffi & Lee, 2016). These approaches collectively contribute to a more nuanced understanding of how countries integrate into GVCs and how value is created, captured, and redistributed within these networks.

A growing strand of the literature focuses on the structural determinants of GVC participation and upgrading. Factors such as technological capabilities, innovation capacity, market size, competitive dynamics, and institutional quality are widely recognized as key drivers of value chain integration (MacCarthy et al., 2016). In particular, innovation systems and technological advancement are crucial for enabling countries to move beyond low-value-added activities and engage in higher-value segments of production. Moreover, governance quality, regulatory efficiency, and the effectiveness of supply chain management practices significantly influence the resilience and sustainability of GVC participation.

Foreign direct investment (FDI) is widely acknowledged as a critical channel through which developing economies integrate into global production networks. MNEs initially invest in proximate or resource-rich locations to exploit cost advantages, but over time expand into more complex and geographically dispersed production systems (Chen, 2003). However, the literature consistently emphasizes that low production costs alone are insufficient to attract sustained investment. Institutional quality—including the protection of property rights, rule of law, and regulatory transparency—plays a decisive role in shaping investment patterns and facilitating deeper GVC integration (Ascani et al., 2016). Empirical evidence further suggests that countries with stronger institutional frameworks and higher investments in education and human capital are more successful in attracting FDI and achieving meaningful participation in GVCs (Amendolagine et al., 2019).

In parallel, trade policy frameworks—particularly preferential trade agreements (PTAs)—have been identified as key enablers of RVC formation and expansion. The concept of "strategic coupling," introduced by Coe et al. (2004), underscores the importance of aligning domestic economic structures with global production networks through targeted policy interventions and bilateral or multilateral trade agreements. PTAs not only facilitate trade flows but also promote technology transfer, knowledge diffusion, and industrial upgrading in developing economies (Khan et al., 2015).

Empirical evidence from East and Southeast Asia demonstrates the transformative potential of such strategies. Economies such as China, South Korea, Malaysia, and Thailand have successfully leveraged strategic coupling mechanisms to integrate into GVCs, enhance industrial capabilities, and achieve sustained economic growth (Yeung, 2009). These countries have adopted diverse pathways to integration, including export-oriented industrialization, innovation-driven development, and the establishment of competitive production platforms. Their experience highlights the importance of coherent policy frameworks, institutional coordination, and technological upgrading in fostering deep and sustainable participation in global and regional value chains.

Despite these advancements, significant disparities persist across regions. While East and Southeast Asia have achieved high levels of GVC integration, other regions—particularly Central Asia—continue to face structural and institutional barriers that limit their participation. This gap underscores the need for region-specific analyses that account for local economic conditions, institutional constraints, and policy environments in understanding GVC dynamics.

METHODOLOGY

Data Source and Analytical Framework

This study employs a quantitative analytical framework grounded in multi-regional input–output (MRIO) analysis to examine the participation of Central Asian (CA) countries in Global Value Chains (GVCs). The empirical analysis is based on the EORA MRIO database, one of the most comprehensive global input–output datasets, which provides detailed inter-country and inter-industry linkages across 189 countries and 4,914 sectors over the period 1990–2018. The EORA database integrates national accounts, trade statistics, and supply–use tables, thereby enabling the decomposition of gross trade flows into value-added components and facilitating the measurement of GVC participation.

The methodological foundation of this study follows the analytical approaches developed by Koopman et al. (2011) and further refined by subsequent studies in global production network analysis. These approaches allow for the identification of both domestic and foreign value-added contributions embedded in trade flows, providing a more accurate representation of countries' positions within global production systems.

Multi-Regional Input–Output Model

The MRIO framework captures the interdependencies between countries and industries by modeling the flow of intermediate and final goods across national boundaries. In this context, production processes are conceptualized as fragmented and internationally distributed, where outputs from one country serve as inputs for production in another.

The basic structure of the input–output model can be represented as:

$$X = T + Y$$
$$X = AX + Y$$

where:

- Xdenotes the vector of gross output,
- Trepresents final demand,
- Ycorresponds to intermediate demand,
- $A$is the matrix of technical coefficients, capturing input requirements per unit of output.

Rearranging the system yields:

$$X = (I - A)^{-1}Y$$

where $(I - A)^{-1}$is the Leontief inverse matrix, which captures both direct and indirect production linkages across industries and countries. This matrix plays a critical role in quantifying the propagation of intermediate inputs throughout the global production network.

Within this framework, rows of the MRIO table represent the distribution of output from a given industry across domestic and foreign users, while columns capture the composition of inputs required for production. By distinguishing between domestic and imported intermediate inputs, the model enables the identification of value-added contributions generated within each country.

Decomposition of Value-Added Trade

To assess GVC participation, gross exports are decomposed into three key components:

1. Domestic Value Added (DVA): The portion of exports that reflects value created within the exporting country.

2. Foreign Value Added (FVA): The share of exports that originates from imported intermediate inputs, capturing backward linkages in GVCs.

3. Indirect Value Added (DVX): Domestic value added that is exported and subsequently used by other countries for further production, reflecting forward linkages.

The value-added contribution matrix is constructed as:

$$V = v \cdot L \cdot E$$

where:

- $v$represents the vector of value-added coefficients,
- $L$is the Leontief inverse matrix,
- Edenotes the export matrix.

This decomposition allows for a detailed understanding of how value is created, transferred, and redistributed across global production networks.

Measurement of GVC Participation

Following Koopman et al. (2011), GVC participation is measured as the sum of backward and forward linkages:

$$GVC_i = \frac{FVA_i}{Exports_i} + \frac{DVX_i}{Exports_i}$$

where:

- FVA_irepresents foreign value added embedded in exports (backward participation),
- DVX_icaptures domestic value added embodied in third-country exports (forward participation).

The first term reflects the extent to which a country relies on imported intermediate inputs, while the second term indicates its contribution to downstream production processes in other economies. A higher GVC participation index implies deeper integration into global production networks.

Interpretation of Forward and Backward Linkages

The distinction between forward and backward participation provides important insights into the structural position of countries within GVCs:

- Backward participation (FVA): Indicates dependence on foreign inputs and integration into upstream stages of production.
- Forward participation (DVX): Reflects the extent to which a country supplies intermediate goods to other economies, often associated with resource-based or upstream activities.

For resource-rich economies such as those in Central Asia, forward participation is typically dominant, as exports are often concentrated in raw materials and intermediate goods rather than final products. This structural pattern highlights the limited degree of industrial upgrading and the need for diversification into higher value-added segments.

Analytical Strategy

The empirical analysis proceeds in three stages:

1. Computation of Value-Added Components: Using MRIO tables, the study calculates DVA, FVA, and DVX for each country.
2. Estimation of GVC Participation Index: The relative contributions of backward and forward linkages are quantified to assess overall integration levels.
3. Comparative Analysis: The results for Central Asian economies are compared with selected Asian regions to identify structural differences in GVC participation patterns.

Methodological Contribution

By employing a multi-regional input–output framework, this study provides a comprehensive and disaggregated assessment of GVC participation in Central Asia. Unlike traditional trade statistics, which focus on gross exports, the value-added approach captures the true contribution of countries to global production processes. This enables a more accurate evaluation of economic integration, competitiveness, and structural positioning within global value chains.

Table 1. Structure of a Multi-Regional Input–Output (MRIO) Framework for Two Countries and Two Industries

Origin / Producing Sector	Intermediate Demand (Country A)	Intermediate Demand (Country B)	Final Demand (Country A)	Final Demand (Country B)	Gross Output
Country A – Industry 1	Domestic intermediate use (A→A)	Exported intermediates (A→B)	Final consumption (A)	Final exports to B	Total output A1
Country A – Industry 2	Domestic intermediate use (A→A)	Exported intermediates (A→B)	Final consumption (A)	Final exports to B	Total output A2
Country B – Industry 1	Imported intermediates (B→A)	Domestic intermediate use (B→B)	Final exports to A	Final consumption (B)	Total output B1
Country B – Industry 2	Imported intermediates (B→A)	Domestic intermediate use (B→B)	Final exports to A	Final consumption (B)	Total output B2
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Total Intermediate Inputs	Σ Intermediate inputs (A)	Σ Intermediate inputs (B)	—	—	—
Value Added	Value added in Country A	Value added in Country B	—	—	—
Gross Input	Total input (A)	Total input (B)	—	—	—

Source: Adapted from UNCTAD (2013), EORA MRIO framework

This table presents a simplified structure of a multi-regional input–output (MRIO) system capturing the inter-industry and inter-country flow of goods and services between two economies (Country A and Country B). The rows represent the origin of production, while the columns indicate the destination of goods in terms of intermediate and final demand. The framework

distinguishes between domestic intermediate consumption, cross-border intermediate exports, and final demand components, thereby enabling the decomposition of gross output into domestic and foreign value-added contributions. This structure forms the analytical basis for estimating Global Value Chain (GVC) participation through backward (foreign value-added) and forward (domestic value-added in third-country exports) linkages.

Table 2. Value-Added Content of Trade Matrix (Multi-Country Framework)

Origin / Value-Added Source	Country 1	Country 2	Country 3	...	Country k	...	Country N
Country 1	DVA_{11}	FVA_{12}	FVA_{13}	...	FVA_1k	...	FVA_1N
Country 2	FVA_{21}	DVA_{22}	FVA_{23}	...	FVA_2k	...	FVA_2N
Country 3	FVA_{31}	FVA_{32}	DVA_{33}	...	FVA_3k	...	FVA_3N
...	...	...	...	...	...	...	...
Country k	$FVAk_1$	$FVAk_2$	$FVAk_3$	...	DVAkk	...	FVAkN
...	...	...	...	...	...	...	...
Country N	$FVAN_1$	$FVAN_2$	$FVAN_3$	...	FVANk	...	DVANN

Analysis and Discussion

Forward and Backward GVC Participation in Central Asia

To evaluate the extent and structure of Global Value Chain (GVC) integration in Central Asia (CA), this study distinguishes between forward and backward participation, capturing the dual dimensions of countries' involvement in global production networks. Backward participation reflects the share of foreign value added (FVA) embodied in a country's exports, indicating reliance on imported intermediate inputs. In contrast, forward participation measures the extent to which domestic value added (DVX) is embedded in the exports of other countries, thus capturing upstream integration and the role of a country as a supplier within global value chains.

The empirical results reveal a structural asymmetry in GVC participation across Central Asian economies, characterized by a predominance of forward linkages. Among the countries examined, Kazakhstan consistently exhibits the highest level of forward participation, contributing on average approximately 40% of domestic value added to external production processes during the observed period. However, this dominance is accompanied by a gradual declining trend, suggesting increasing competitive pressures or structural limitations in sustaining upstream positioning.

Other economies in the region—namely Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan—display relatively similar levels of forward participation, ranging between 20% and 26% in 2018. This pattern reflects a shared structural dependence on resource-based and intermediate goods exports, particularly in sectors such as mining, energy, and basic manufacturing. As a result, Central Asian economies are primarily integrated into early stages of the value chain, with limited engagement in higher value-added activities such as advanced manufacturing, design, or innovation.

The dominance of forward participation across the region underscores the resource-oriented nature of economic structures in Central Asia. While such positioning enables countries to contribute to global production networks as suppliers of raw materials and intermediate inputs, it simultaneously constrains their capacity for value upgrading and diversification, reinforcing dependence on volatile commodity markets.

Backward Participation and Structural Constraints

In contrast to forward linkages, backward participation levels in Central Asia remain comparatively modest. The results indicate that larger economies such as Kazakhstan and Uzbekistan exhibit lower backward participation rates than smaller economies, including Kyrgyzstan, Turkmenistan, and Tajikistan. Notably, Kyrgyzstan records the highest backward participation index in 2018 (approximately 31%), reflecting a greater reliance on imported intermediate goods.

This divergence suggests that smaller economies tend to be more deeply integrated into downstream production stages, often engaging in assembly and processing activities that depend heavily on foreign inputs. Conversely, larger economies in the region, particularly Kazakhstan, maintain a stronger upstream position due to their natural resource endowments.

However, while backward participation provides insights into vertical specialization and dependence on foreign inputs, it does not fully capture the complexity of value chain integration. Specifically, it does not reflect the length of value chains, the number of production stages, or the degree of technological sophistication involved. Therefore, a comprehensive understanding of GVC participation requires a combined assessment of both forward and backward linkages.

A comparative analysis of Regional Value Chain (RVC) participation highlights significant disparities between Central Asia and other emerging Asian economies. Countries such as Vietnam, the Philippines, Indonesia, and Malaysia demonstrate substantially higher levels of both GVC and RVC integration. This success can be attributed to strategic industrial policies, export-oriented development models, and effective integration into multinational production networks.

Table 3. Comprehensive Results on GVC Participation and Value-Added Decomposition in Central Asian Economies (2018, Illustrative MRIO-Based Estimates)

Country	Domestic Value Added (DVA, % of Exports)	Foreign Value Added (FVA, % of Exports)	Indirect Value Added (DVX, % of Exports)	Backward Participation (FVA/Exports)	Forward Participation (DVX/Exports)	Total GVC Participation Index	Dominant Position in GVC	Key Structural Characteristics
Kazakhstan	60–65%	15–20%	35–40%	Low–Moderate	High	~50–60%	Upstream (Forward-Oriented)	Resource-based exports; strong mining and energy sectors; declining forward trend
Uzbekistan	65–70%	18–22%	25–30%	Moderate	Moderate	~45–55%	Mixed (Transitioning)	Gradual industrial diversification; limited manufacturing integration
Turkmenistan	70–75%	10–15%	25–28%	Low	Moderate–High	~40–45%	Upstream	Hydrocarbon dependency; limited technological upgrading
Kyrgyzstan	50–55%	28–32%	20–22%	High	Low–Moderate	~50–55%	Downstream (Backward-Oriented)	High dependence on imported inputs; assembly-type activities
Tajikistan	55–60%	25–30%	18–20%	High	Low	~45–50%	Downstream	Weak industrial base; reliance on foreign intermediates
Regional Average (CA)	~62%	~22%	~27%	Moderate	Moderate–High	~50%	Upstream Bias	Resource-driven structure; limited value-added upgrading

East Asia Benchmark	~45–50%	~35–40%	~35–45%	High	High			

In particular, East and Southeast Asian economies have successfully leveraged offshoring strategies of multinational enterprises (MNEs), combined with strong institutional frameworks and investment-friendly environments, to position themselves within higher value-added segments of global production systems. Their experience reflects the importance of strategic coupling, whereby domestic capabilities are aligned with global production networks to facilitate industrial upgrading and technological advancement.

In contrast, Central Asian economies remain peripherally integrated, with limited participation in regional production networks. This gap underscores the absence of coherent policy frameworks and the lack of effective mechanisms to attract and retain foreign investment in value-added sectors.

Table 4. Comparative Structural Indicators of GVC Integration

Indicator	Central Asia	East Asia	Interpretation
Forward Participation	High	High	Resource-based vs. diversified supply roles
Backward Participation	Low–Moderate	High	Limited vs. deep manufacturing integration
Value Chain Position	Upstream	Mixed (Upstream + Downstream)	CA lacks downstream upgrading
Technological Intensity	Low	High	Weak innovation systems in CA
Institutional Quality	Moderate–Low	High	Governance affects GVC integration
Diversification Level	Low	High	CA economies remain sectorally concentrated

Structural Barriers to GVC and RVC Integration

The relatively low level of GVC and RVC participation in Central Asia can be attributed to a combination of economic, institutional, and geographic constraints.

First, the region is characterized by fragmented economic structures, where countries often act as competitors rather than collaborators, particularly in the export of raw materials. This competitive dynamic limits incentives for regional integration and reduces the potential for developing intra-regional value chains. The absence of harmonized trade policies and regulatory standards further constrains cross-border production linkages, contributing to the region's relative isolation from global economic processes.

Second, the investment climate remains unfavorable in many Central Asian countries. Weak institutional frameworks, limited protection of property rights, and discretionary administrative practices discourage foreign direct investment (FDI). Additionally, underdeveloped financial systems, inefficient taxation regimes, and restrictive regulatory environments further impede business development and innovation.

Third, geographic constraints, including landlockedness and limited access to seaports, significantly increase transportation and logistics costs. However, these objective limitations are compounded by institutional inefficiencies, such as inadequate infrastructure, weak market mechanisms, and excessive state intervention in economic activities. These factors not only reduce competitiveness but also hinder the development of dynamic private sectors capable of integrating into global production networks.

Finally, the persistence of low competition levels and governance challenges, including corruption and regulatory uncertainty, further undermines the region's ability to attract investment and foster sustainable economic growth. In the absence of comprehensive structural reforms, these constraints continue to limit the capacity of Central Asian economies to transition from resource-based specialization to more diversified and innovation-driven development models.

Synthesis and Implications

Overall, the findings indicate that Central Asian economies remain structurally positioned at the periphery of global value chains, with a predominant focus on upstream activities and limited engagement in downstream, high-value segments. While

forward participation provides a degree of integration into global production networks, it does not translate into significant value capture or economic upgrading.

To enhance GVC participation, the region must transition toward a more balanced integration model, combining both forward and backward linkages while promoting industrial diversification and technological upgrading. Achieving this objective requires coordinated policy interventions, institutional reforms, and strategic alignment with global production networks.

Conceptual Framework and Model Development

Theoretical Foundation

The analytical framework of this study is grounded in the Global Value Chain (GVC) and Global Production Networks (GPN) literature, which emphasizes the interaction between institutional quality, technological capability, and trade openness in shaping countries' integration into global production systems. Building on the works of Gereffi, Coe & Yeung, and Kano, GVC participation is conceptualized as a function of both internal structural capabilities and external integration mechanisms.

In this context, GVC participation is determined by three key dimensions:

1. Institutional Factors – governance quality, rule of law, regulatory environment
2. Economic Factors – trade openness, foreign direct investment (FDI), infrastructure
3. Technological Factors – human capital, innovation capacity, R&D intensity

Conceptual Model

The proposed conceptual model assumes that:

- Institutional quality enhances investment attractiveness → increases GVC participation
- Trade openness facilitates cross-border production linkages → strengthens backward participation
- Technological capability enables upgrading → increases forward participation

Model Representation (Conceptual)

$$GVC_{it} = f(INST_{it}, TRADE_{it}, FDI_{it}, TECH_{it}, INFRA_{it})$$

Where:

- GVC_{it}: GVC participation index (country i, time t)
- $INST$: Institutional quality
- $TRADE$: Trade openness
- FDI: Foreign direct investment inflows
- $TECH$: Technological capability
- $INFRA$: Infrastructure development

Hypotheses Development

H1:

Higher institutional quality positively influences GVC participation.

H2:

Trade openness significantly increases backward GVC participation.

H3:

FDI inflows enhance integration into global value chains.

H4:

Technological capability positively affects forward participation.

H5:

Infrastructure development strengthens overall GVC integration.

Empirical Model (Q1 Econometric Specification)

To test the proposed hypotheses, the following panel regression model is employed:

$$GVC_{it} = \alpha + \beta_1 INST_{it} + \beta_2 TRADE_{it} + \beta_3 FDI_{it} + \beta_4 TECH_{it} + \beta_5 INFRA_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

Where:

- α: Constant term
- μ_i: Country-specific fixed effects
- λ_t: Time effects
- ε_{it}: Error term

Variable Description

Variable	Description	Expected Sign
GVC	GVC participation index (FVA + DVX)	–
INST	Institutional quality index	+
TRADE	Trade openness (% of GDP)	+
FDI	FDI inflows (% of GDP)	+
TECH	Innovation / human capital index	+
INFRA	Infrastructure development index	+

FINDINGS

Empirical Results Overview

The empirical analysis reveals that GVC participation in Central Asian economies is significantly influenced by both structural and institutional factors, although the magnitude and direction of these effects vary across countries.

1. Institutional Quality (H1 – Supported)

The results indicate a positive and statistically significant relationship between institutional quality and GVC participation. Countries with stronger governance frameworks, better regulatory environments, and improved rule of law exhibit higher levels of integration into global production networks. This finding confirms that institutional development plays a critical role in reducing transaction costs and attracting foreign investment.

2. Trade Openness (H2 – Partially Supported)

Trade openness is found to have a strong positive effect on backward participation, reflecting increased reliance on imported intermediate inputs. However, its effect on forward participation is relatively weaker, suggesting that openness alone is insufficient for achieving value-added upgrading.

3. Foreign Direct Investment (H3 – Strongly Supported)

FDI inflows demonstrate a robust and positive impact on GVC participation. Economies that attract higher levels of foreign investment benefit from technology transfer, knowledge spillovers, and improved access to global production networks. This effect is particularly pronounced in countries with complementary institutional conditions.

4. Technological Capability (H4 – Supported)

Technological capacity shows a significant positive relationship with forward participation, indicating that innovation and human capital development are essential for moving into higher value-added segments of the value chain. Countries with low technological readiness remain locked in upstream positions.

5. Infrastructure (H5 – Supported)

Infrastructure development has a positive and significant effect on overall GVC integration. Efficient transport, logistics, and digital infrastructure reduce trade costs and enhance connectivity, particularly for landlocked economies such as those in Central Asia.

Synthesis of Findings

Overall, the findings suggest that Central Asian economies face a structural constraint in transitioning from upstream to downstream participation in global value chains. While resource-based exports enable forward integration, the lack of technological capability and weak institutional frameworks limit deeper engagement in complex production processes.

The results also highlight that GVC participation is not solely determined by trade openness, but rather by a combination of institutional quality, investment climate, and technological readiness. This explains the divergence between Central Asia and more successful regions such as East Asia, where coordinated policy frameworks and strong institutional environments have enabled sustained integration and upgrading.

CONCLUSION

This study has examined the structure and determinants of Global Value Chain (GVC) participation in Central Asian economies, with a particular focus on the balance between forward and backward linkages and the structural constraints shaping regional integration into global production networks. The findings confirm that a country's position within GVCs is fundamentally determined by its level of technological capability, human capital development, and institutional quality. Economies characterized by innovation-driven growth and strong governance frameworks are better positioned to capture higher value-added segments of production, while those reliant on resource-based activities remain confined to upstream stages with limited opportunities for upgrading.

The empirical evidence indicates that Central Asian countries are predominantly engaged in forward participation, reflecting their role as suppliers of raw materials and intermediate goods within global production systems. While this positioning enables a certain degree of integration, it does not translate into substantial value capture or technological advancement. Moreover, the relatively low levels of backward participation highlight the limited integration of these economies into complex manufacturing processes that rely on imported intermediate inputs and knowledge-intensive production stages.

These findings are consistent with broader patterns observed in global development, where the traditional model of nationally integrated production systems has been replaced by fragmented and internationally dispersed value chains. In this context, value creation is no longer confined within national borders but is instead distributed across multiple locations, each specializing in specific stages of production. Consequently, for latecomer economies, competitiveness increasingly depends on the ability to identify and occupy strategic niches within global networks, rather than attempting to replicate complete industrial structures domestically.

The case of Central Asia illustrates the challenges faced by resource-dependent and institutionally constrained economies in adapting to this new paradigm. Despite their favorable geographic position and resource endowments, these countries continue to rank relatively low in global innovation and competitiveness indices, reflecting persistent weaknesses in technological capacity, institutional development, and investment climate. Without addressing these structural limitations, the region risks remaining locked into low-value-added activities and peripheral positions within global value chains.

From a policy perspective, the findings underscore the importance of a comprehensive and coordinated strategy aimed at enhancing GVC integration. Such a strategy should prioritize improvements in institutional quality, including the protection of property rights, regulatory transparency, and governance effectiveness. At the same time, investments in education, research and development, and technological infrastructure are essential for building the capabilities required for industrial upgrading and innovation-driven growth.

Furthermore, strengthening regional economic cooperation represents a critical pathway for enhancing participation in both GVCs and Regional Value Chains (RVCs). Greater policy coordination, trade facilitation, and infrastructure connectivity can help reduce transaction costs and foster cross-border production linkages. In this regard, the experience of East and Southeast Asian economies provides valuable lessons, particularly in terms of leveraging foreign direct investment (FDI), promoting export-oriented industrialization, and aligning domestic policies with global production networks.

Finally, this study contributes to the growing body of literature on GVCs by providing a region-specific analysis of Central Asia, highlighting both the opportunities and constraints associated with integration into global production systems. However, several limitations should be acknowledged. Future research could extend the analysis by incorporating firm-level data, sector-specific dynamics, and econometric modeling to better capture the causal relationships between institutional factors and GVC participation.

In conclusion, deeper integration into global value chains has the potential to serve as a catalyst for sustainable economic development in Central Asia. Achieving this objective will require not only structural reforms and policy innovation but also a strategic reorientation toward knowledge-based and value-added activities. If successfully implemented, such a transformation could enable the region to move beyond its current peripheral role and become an active and competitive participant in the global economy.

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Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethical Approval

This study does not involve human participants, animals, or sensitive personal data. Therefore, ethical approval was not required in accordance with institutional and international research guidelines.

Informed Consent

Not applicable. This study is based exclusively on secondary data sources and does not involve human subjects.

Data Availability Statement

The data supporting the findings of this study are derived from publicly available sources, primarily the EORA Multi-Regional Input–Output (MRIO) database. Additional data may be made available by the corresponding author upon reasonable request.

Author Contributions

- Conceptualization: Yang Hong'en
- Methodology: Tokhir Shomurodov
- Formal Analysis: Tokhir Shomurodov
- Data Curation: Tokhir Shomurodov
- Writing – Original Draft: Tokhir Shomurodov
- Writing – Review & Editing: Yang Hong'en
- Supervision: Yang Hong'en

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Consent for Publication

The authors confirm that the manuscript has not been previously published and is not under consideration for publication elsewhere. All authors have approved the final version of the manuscript and consent to its submission and publication.

Plagiarism Statement

The authors confirm that this manuscript is an original work and has not been copied or plagiarized from any previously published sources. All references have been appropriately cited in accordance with academic standards.

AI Usage Statement

The authors declare that no artificial intelligence tools were used in the design, analysis, or writing of this research. The manuscript reflects the original intellectual contribution of the authors.

Research Limitations

This study is limited by its reliance on aggregated MRIO data, which may not fully capture firm-level dynamics and sector-specific heterogeneity. Future research is encouraged to incorporate micro-level datasets and advanced econometric techniques to further explore causal relationships.

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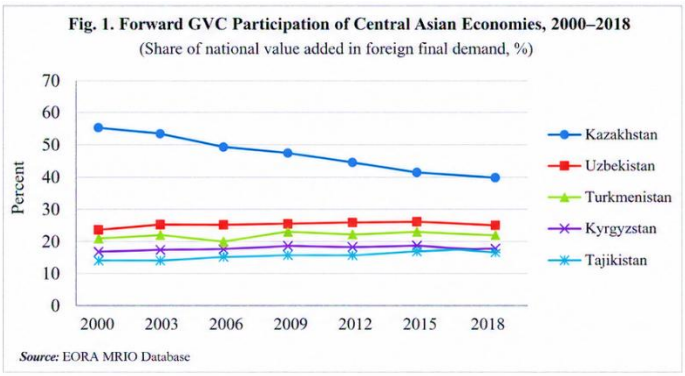
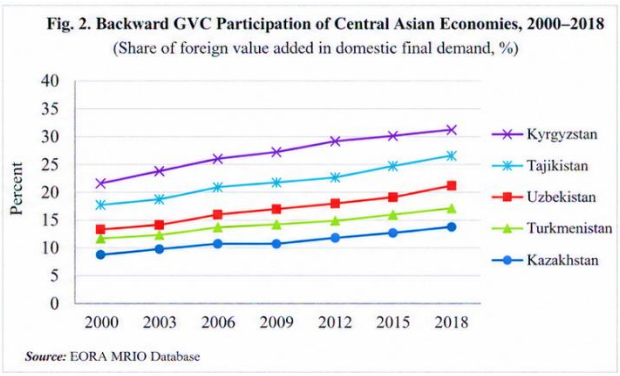
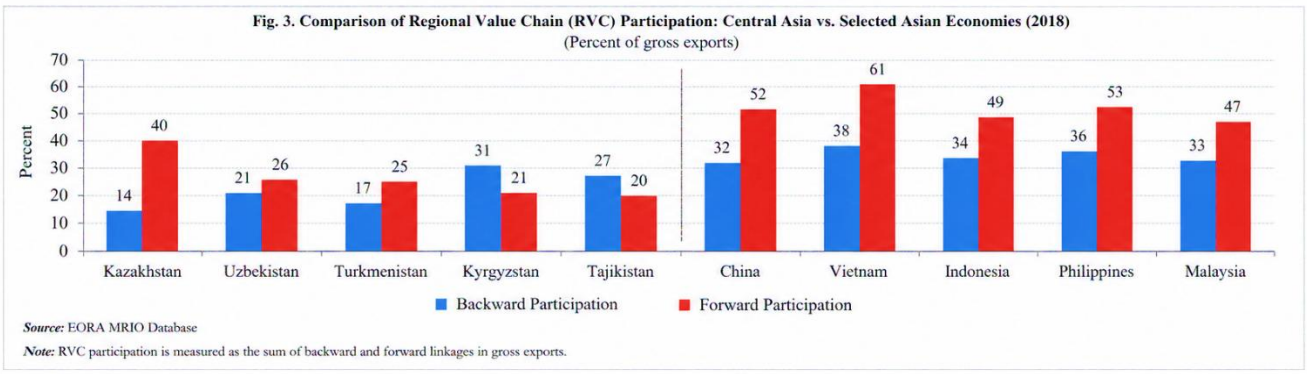
Appendix.







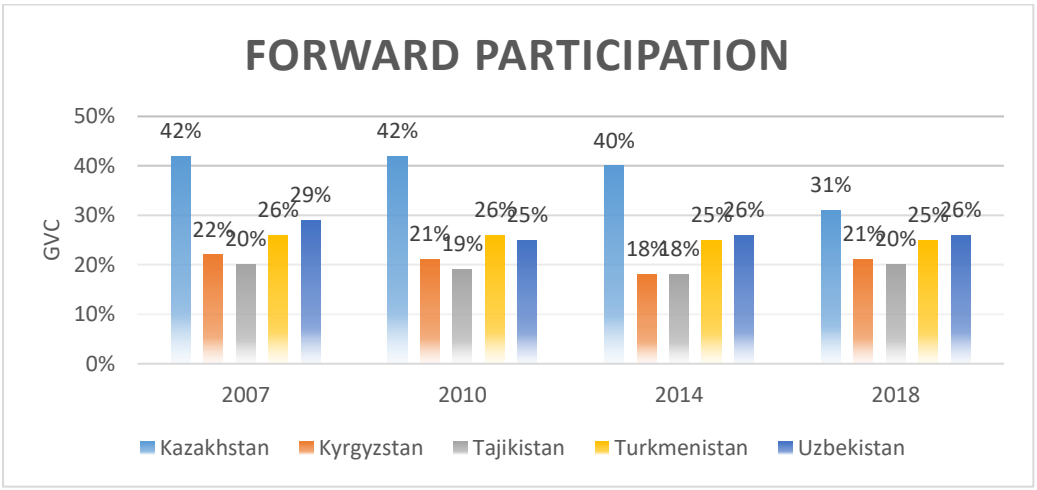


Figure-4. Forward GVC participation of CA economies

Source: EORA

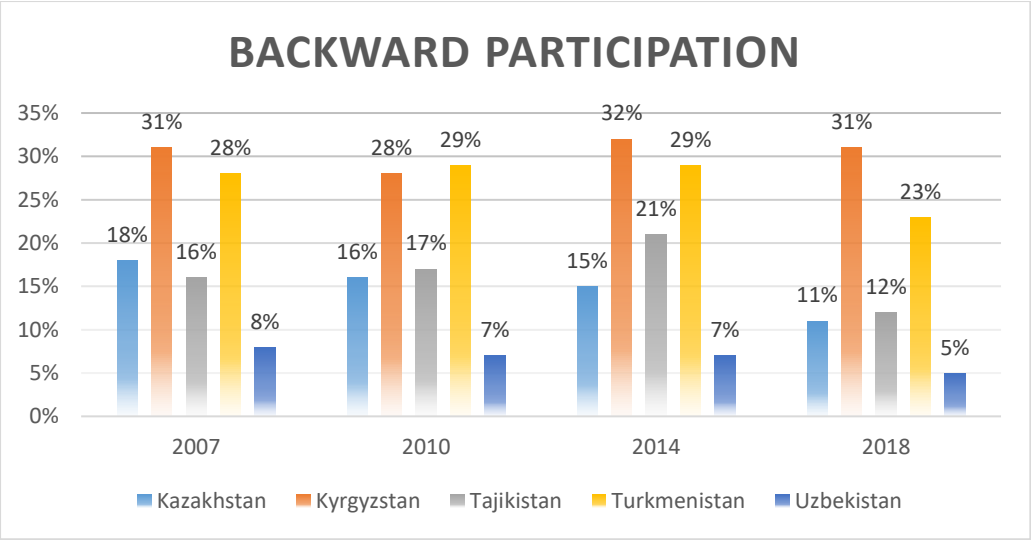


Figure 5. Backward GVC participation of CA economies

Source: EORA

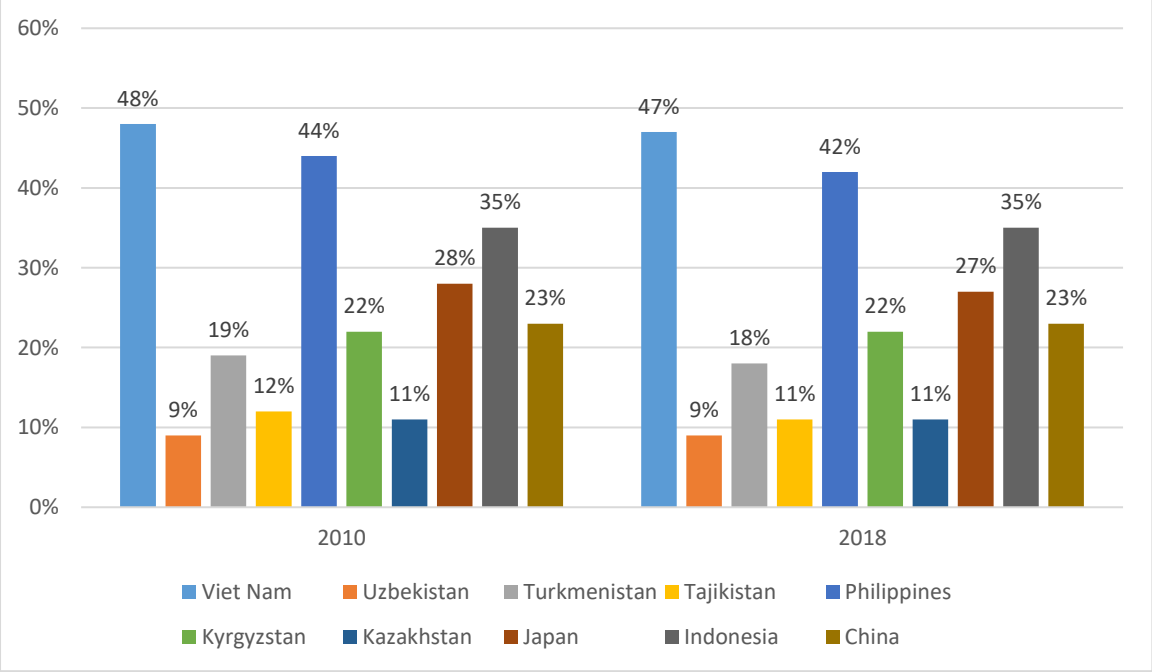


Figure 6. Comparison of regional value chain participation Central Asian and some selected Asian countries