Research Article

Determinants of Participation in Global Value Chains: The Case of Türkiye

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Abstract: The aim of this paper is to identify the determinants of Türkiye's participation in Global Value Chains (GVCs) by using data for 34 manufacturing, mining, and service sectors over the period 2006 to 2020. To achieve this, Augmented Mean Group (AMG), System Generalized Method of Moments (System GMM), and Fixed Effects (FE) methods are employed in the estimations. Our estimation results indicate that Foreign Direct Investment (FDI) is one of the key determinants that enhances Türkiye's backward, forward, and total GVCs participation. An increase in the tariff rate reduces Türkiye's integration into GVCs by decreasing backward as well as total participation. On the other hand, an increase in labor costs in Türkiye leads to a rise in backward GVC participation while having a detrimental effect on both forward and total participation. Our estimation results also suggest that backward GVC participation is particularly prominent in capital-intensive sectors. On the other hand, although the importance of sectoral real exchange rates and skilled and unskilled labor varies across different indicators of GVC integration, these variables are not the primary determinants for Türkiye's total participation in GVCs.

Keywords: Global Value Chains, GVCs, Determinants of Participation in GVCs, Panel Data Analysis
Jel Codes: F14, F19, F60, L2

Türkiye Küresel Değer Zincirlerine Katılımın Belirleyicileri: Türkiye Örneği

Öz: Bu makalenin amacı, 2006-2020 döneminde üretim, madencilik ve hizmet olmak üzere 34 sektöre ait verileri kullanarak Türkiye'nin Küresel Değer Zincirlerine (KDZ) katılımının belirleyicilerini tespit etmektir. Bunu amaç doğrultusunda, tahminlerde Genişletilmiş Ortalama Grup (AMG), Sistem Genelleştirilmiş Momentler Yöntemi (Sistem GMM) ve Sabit Etkiler (FE) yöntemleri kullanılmıştır. Tahmin sonuçlarımız, Yabancı Doğrudan Yatırım'ın (FDI) Türkiye'nin geriye dönük, ileriye dönük ve toplam KDZ katılımını artıran temel belirleyicilerden biri olduğunu göstermektedir. Tarife oranındaki bir artış, geriye dönük ve toplam katılımı azaltarak Türkiye'nin KDZ'lere entegrasyonunu olumsuz etkilemektedir. Öte yandan, Türkiye'de işgücü maliyetlerindeki bir artış hem ileriye dönük hem de toplam katılım üzerinde olumsuz bir etkiye sahipken geriye dönük katılımda bir artışa yol açmaktadır. Tahmin sonuçlarımız ayrıca geriye dönük GVC katılımının özellikle sermaye yoğun sektörlerde belirgin olduğunu göstermektedir. Öte yandan, sektörel reel döviz kurunun, vasıflı ve vasıfsız işgücünün önemi, KDZ entegrasyonunu gösteren farklı göstergeler arasında değişiklik gösterse de bu değişkenler Türkiye'nin KDZ'lere toplam katılımının temel belirleyicileri değildir.

Anahtar Kelimeler: Küresel Değer Zinciri, KDZ, KDZ'nin Belirleyicileri, Panel Data Analizi
Jel Kodları: F14, F19, F60, L2

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1. Introduction and Review of Studies on the Determinants of GVC Participation

GVCs represent an international production system in which various stages of the production process design, manufacturing, assembly, marketing, and distribution, are carried out in different countries. This structure enhances efficiency and provides a competitive advantage by allowing specific production functions to be relocated of specific production functions to lower-cost economies or those with specialized capabilities. Developed countries tend to concentrate on technology and design, whereas developing countries primarily engage in processes such as assembly and the production of intermediate goods. A country's position within GVCs is determined by factors such as human capital, technological capacity, and infrastructure. Greater integration into GVCs allows countries to generate higher value, sustain long-term economic growth, and strengthen their competitiveness in global trade (Gereffi et al., 2005).

The most significant indicator of a country's integration into GVCs are its participation in both backward and forward activities. Backward GVC participation refers to the use of foreign inputs in the production of final and intermediate goods, whereas forward GVC participation indicates the use of domestically produced inputs in other countries' exports. Backward GVC participation increases import competition by directing local resources toward more competitive firms while also accelerating knowledge diffusion through suppliers and FDI. On the other hand, forward GVC participation strengthens the integration of local producers into global supply chains, enabling them to establish stronger connections with exporting countries. This, in turn, allows manufacturing firms to gain a greater competitive advantage in the global market while also promoting technology transfer and knowledge diffusion (World Bank, 2020).

The importance of GVCs have increased in line with the globalization of production processes. While conventional trade theories are based on the movement of final goods, GVCs organize production across several countries, allowing each country to focus on a part of the process. This fragmentation not only increases the production efficiency but also increases the economic interdependence between the countries. For the developing economies, the integration with the global production networks has facilitated industrialization and expanded market opportunities (Gereffi & Fernandez-Stark, 2016).

Türkiye has had a significant transformation with GVC participation since 1995. The process of globalization, trade liberalization, and the increase in FDI have contributed to the restructuring of Türkiye's production framework and industrial policies to align with GVCs. Türkiye's total GVC participation has increased from 20.5 percent in 1995 to 38.7 percent in 2020, while participation in the manufacturing sector rose from 19.3 percent to 40.1 percent (Trade in Value Added (TiVA)-2023). This upward trend has been particularly driven by Türkiye's export-oriented industrial policies, research and development incentives, international trade agreements, and investment support programs. Among the sectors that have experienced the highest levels of integration are "Motor Vehicles, Trailers, and Semi-Trailers" and "Computers, Electronics, and Optical Products" (TiVA-2023). Türkiye has achieved deeper GVC integration in the automotive, electrical, and optical product sectors due to increasing technology investments, digitalization efforts, robust supply chains, and expansion of production capacity.

In recent years, transformations in global trade dynamics have accelerated research on value-added trade and GVCs. The TiVA database, developed through a collaboration between the Organization for Economic Co-Operation and Development (OECD) and the World Trade Organization (WTO), and continuously updated since 1995, provides a more detailed analysis of the positions of countries and sectors within global production networks. Recent studies have examined the levels of GVC integration among countries (Johnson & Noguera, 2022), the effects of value-added trade on labor markets (Los et al., 2022), and the capacity of different sectors to generate value-added (Taglioni & Winkler, 2016). In particular, the transformation of developing countries within global production networks and the impact of trade policies on GVC integration have become central topics

in recent studies. In addition, the disruption in supply chains following COVID-19 and the effects of geopolitical developments are at the core of recent studies (Antras & Chor, 2021).

Within this framework, the number of studies focusing on the determinants of GVC participation has increased. These studies are accordingly categorized into three levels: country-level, sector-level, and firm-level.

Studies at the country level examine how factors like economic structure, trade policies, FDI, and logistics infrastructure affect GVC participation. Tinta (2017) investigated the effect of GVC participation on economic integration in the ECOWAS region and revealed that the higher the backward integration, the higher the trade openness. Soliman et al. (2021) found that FDI, innovation, and infrastructure quality are the main determinants of GVC participation for 15 MENA countries. Ateş et al. (2022) stated that FDI and research and development expenditures drive GVC participation for developed economies. Key determinants of GVC participation were identified by Kowalski et al. (2015) as market size, industrial structure, geographic location, trade policies, logistics performance, and infrastructure, and the authors argued that improvements in trade and investment policies could further promote integration with GVCs.

Studies at the sector level investigate the drivers of GVC participation by focusing on the role of sector-specific factors. Fernandes et al. (2020), covering more than 100 countries and four major sectors, investigated the roles of industrial capacity, trade policies, and FDI in GVC participation. Banerjee & Zeman (2020) found that technology-intensive manufacturing industries are more integrated with GVCs. The World Bank (2020) studied Vietnam's position in the electronics GVC, and the research showed that unskilled labor supports backward linkages, while natural resources lead to forward linkages. Yameogo & Jammeh (2019) stated that skilled labor is the key determinant of GVC participation in the manufacturing sector of Sub-Saharan African countries. Mehta (2018), after reviewing GVC participation in the manufacturing sector across the G7, the EU, and developing countries, argued that skilled labor, capital, and innovation are the most vital factors. Cheng et al. (2015) investigated the role of infrastructure, trade policies, and human capital in the low- and high-tech manufacturing sectors, and the researchers established that tariffs on intermediate goods are bad for GVC participation. Stehrer & Stöllinger (2015) and Buelens & Tirpák (2017) stated that FDI inflows are very important for the development of GVCs in the manufacturing sector. Moreover, Yanıkkaya et al. (2024) showed that tariff barriers are detrimental to cross-country sectoral participation in GVCs.

Firm-level studies investigate the impact of firm size, foreign ownership, labor productivity, financial access, quality certification, and innovation on GVC participation. Urata & Baek (2020) analyzed that labor productivity, foreign ownership, and quality certification improve the GVC participation for Small and Medium-sized Enterprises (SMEs). Kotturu & Mahanty (2017) showed that quality standards and price competitiveness are the main drivers in India's automotive sector. Orlic (2016) examined foreign ownership, international certifications, and access to bank credit as factors that enhance GVC integration. Cieślik et al. (2019) found that larger, more innovative, and internationally owned firms are more strongly linked to GVCs. These studies also noticed the importance of financial and technological capacity, firm scale, and quality standards in the determination of GVC participation.

Parallel to the prolific increase in studies focusing on the effects of GVCs, there has also been a notable increase in the number of studies on Türkiye as well. Existing studies primarily focus on assessing Türkiye's position within GVCs. Taymaz et al. (2011) assessed Türkiye's position within GVCs and examined the degree of the participation of five key sectors (automotive, textile and apparel, television, food, and machinery) in GVCs. Similarly, Özer et al. (2016) also investigated Türkiye's position in GVCs and its participation across sectors. This study also evaluated Türkiye's participation in GVCs for three sectors: automotive, textiles and apparel, and agri-food. Gündoğdu & Saraçoğlu

(2016) reviewed Türkiye's participation in GVCs with a particular focus on backward integration. Akkoyunlu Wigley et al. (2018) examined the degree of participation in GVCs for manufacturing industry sectors. Altun et al. (2023) analyzed the effects of backward and forward GVC participation on the productivity and profitability of Turkish firms.

To the best of our knowledge, there is no empirical study investigating the determinants of Türkiye's GVC participation at the sectoral level. Therefore, this study aims to contribute to the literature by examining the determinants of Türkiye's participation in GVCs at the sectoral level, focusing on the manufacturing, mining, and services sectors. To achieve this, equations for the various indicators of Türkiye's participation in GVCs will be estimated for 34 sectors between the years 2006 and 2020 by using panel data analysis.

The rest of the study is organized as follows: Section 2 introduces the model, dataset, and estimation methods. Section 3 presents the results of our empirical investigation. Finally, Section 4 concludes the study.

2. The Model, Data Set, and the Estimation Methods

2.1 The Model

For the quantitative analysis of the determinants of Türkiye's GVC participation, we investigate the determinants of GVC participation at three levels: backward GVC participation, forward GVC participation, and total GVC participation.

With that purpose, we estimate equations (1), (2), and (3). The analysis covers 34 subsectors of mining, manufacturing, and service sectors for the years 2006–2020.[1]

$$Backward_{it} = \beta_0 + \beta_1 FDI_{it} + \beta_2 TAX_{it} + \beta_3 REER_{it} + \beta_4 CI_{it} + \beta_5 UCL_{it} + \beta_6 UNSKILL_{it} + \varepsilon_{it} \quad (1)$$

$$Forward_{it} = \beta_0 + \beta_1 FDI_{it} + \beta_2 HHI_{it} + \beta_3 REER_{it} + \beta_4 CI_{it} + \beta_5 UCL_{it} + \beta_6 SKILL_{it} + \varepsilon_{it} \quad (2)$$

$$GVC\ Part_{it} = \beta_0 + \beta_1 FDI_{it} + \beta_2 TAX_{it} + \beta_3 REER_{it} + \beta_4 CI_{it} + \beta_5 UCL_{it} + \beta_6 TOTALLABOR_{it} + \varepsilon_{it} \quad (3)$$

In these equations, $Backward_{it}$ represents backward GVC participation for sector i in year t, $Forward_{it}$ represents forward GVC participation for sector i in year t, and $GVC\ Part_{it}$ represents the overall GVC participation for sector i in year t. Explanatory variables; FDI is the foreign direct investment, TAX is the average custom tax rate, $REER$ is the real exchange rate, CI is capital intensity, UCL is unit labor costs, $SKILL$ is skilled labor, $UNSKILL$ is unskilled labor, HHI is the Herfindahl Hirschman index, $TOTALLABOR$ is total of unskilled, semi-skilled and skilled labor and ε is the usual error term.

2.2 Data Set:

Dependent Variables:

Forward and backward GVC participation, as well as total GVC participation, calculated based on the OECD-TiVA database, are used in this study as dependent variables to measure the degree of GVC participation at the sectoral level.

Backward GVC Participation (Backward) is the share of foreign value-added in a sector's gross exports. It reflects the reliance on imported intermediate inputs in the production process. A higher backward GVC participation indicates stronger integration into upstream segments of GVCs (Koopman et al., 2014).

Forward GVC Participation (Forward) represents the share of domestic value-added that is exported to third economies. It refers to the domestic value-added embedded in intermediate goods or services exported to a partner economy, which then re-exports them to a third economy as part of other products (WTO & OECD, 2016). It measures the extent to which an industry contributes to downstream production processes. Sectors with high forward GVC participation tend to specialize in the supply of intermediate goods to other economies.

[1] Sectors 10-99 in Nomenclature generale des activites economiques dans les Communautes europeennes, (NACE) Rev.2. The list of the sectors can be found in Appendix A1

The GVC Participation (GVC part) is used as a dependent variable in addition to backward and forward GVC participation. This measure, proposed by Koopman et al. (2014), evaluates upstream and downstream linkages by holistically assessing an industry's participation in GVCs. The formula for calculating the index is given below:

$$Total\ GVC\ Participation = Backward\ Participation + Forward\ Participation \quad (4)$$

We have identified several independent variables based on the related literature.

Explanatory Variables:

Foreign Direct Investment (FDI) is one of the explanatory variables that were used in the analysis of the GVCs. It is the main driver of industries and firms' integration into production networks around the world, with technology, market access, and capital. In countries with low restrictions on FDI, multinational corporations relocate production functions and thereby involve local firms in GVCs (Cheng et al., 2015). FDI can improve backward GVC participation by increasing the country's dependence on imported intermediate inputs and thus its participation in the upstream segments of GVCs. Previous studies have found a positive relationship between FDI openness and backward GVC participation (Banerjee & Zeman, 2020; World Bank, 2020). Moreover, the FDI affects GVC participation by allowing domestic firms to create value-added inputs that can be exported back through the international production networks (Javorcik, 2004). Insofar as the GVC participation is concerned, Fernandes et al. (2020) argue that FDI is most important for developing economies because it fosters technology transfer, supply chain relationships, and domestic firm competitiveness in international markets. Similarly, Buelens et al. (2017) establish that countries with high FDI inflows have higher GVC participation rates since multinational enterprises involve local suppliers in their supply chains. The annual sectoral FDI data were collected from the CBRT (Central Bank of the Republic of Türkiye).

Custom Tax Rate (TAX): Customs duty is a tax that is levied by the economy of two or more countries during foreign trade and on the entry of services into the economy (Smith, 2015, p. 42). This is because import tariffs are a form of trade policy that can limit or discourage the entry of intermediate goods from upstream countries. As noted by Ignatenko et al. (2019), removing trade barriers and promoting favorable investment policies are essential for enhancing the development of backward GVCs in developing countries. Cheng et al. (2015) show that higher tariffs on intermediate goods suppress backward GVC participation in low-tech and high-tech manufacturing sectors. Similarly, Yanıkkaya et al. (2024) offer evidence that both applied and faced tariff rates adversely affect sectors' backward GVC participation. Their study also shows that more liberal trade policies and lower tariff barriers are associated with higher country integration into global production networks. The customs tax data we got was from the Ministry of Trade, and we used the data according to the Harmonized System 12. We placed the relevant data into the NACE Rev.2 classification system by using the OECD correspondence table.

Sectoral real exchange rate (REER): Another important determinant of the GVC participation is the sectoral real exchange rate. An increase in the value of a currency is expected to enhance backward GVC participation by decreasing import expenses and therefore promoting the import of intermediate products and materials. The effect of the real exchange rate on GVC participation is rather ambiguous in the available empirical studies. Fernandes et al. (2020) investigate the effects of real exchange rates on GVC participation at the sectoral and cross-country levels and fail to establish a clear-cut positive relationship between exchange rate appreciation and backward participation in GVCs. Similarly, Banerjee & Zeman (2020) assess the influence of real exchange rates on GVC indicators and identify country size and FDI openness as the key determinants of GVC participation, while exchange rate volatility may have divergent effects across sectors. However, this is because, in the forward position, currency appreciation is likely to hamper GVC participation by raising export prices and, therefore, reducing

international competitiveness. Taglioni & Winkler (2016) also claim that exchange rate appreciation may be detrimental to GVC participation since it hampers export market share.

To consider the industry-specific differences regarding trading partners, we employ the sectoral real exchange rate as a real exchange variable. With that purpose, the real exchange rate calculated by Dinçer (2021) for the manufacturing industry sectors has been extended to 2020, and the sectoral real exchange rate for the service and mining subsector was calculated. Accordingly, we obtained REER for 34 sectors between the years 2006-2020 annually. The following equation represents the real exchange rate:

$$RER_{TR} = NER_{TR}\left(\frac{P_F}{P_{TR}}\right) \tag{5}$$

In the equation (5) here, NER_{TR}, the nominal effective exchange rate is the foreign trade partner of Türkiye, P_F is the price level of the relevant foreign trade partner, and P_{TR} is the price level in Türkiye.

Trade weights (TW) are calculated based on the Goldberg (2004, p.4) method. Accordingly, the 20 largest trading partners were determined according to the sum of sectoral export and import volumes. The relevant formulas are presented below:

$$TW_{TR,i} = \frac{(X+M)}{\sum_{TR}(X+M)} \tag{6}$$

In the equation (6), TW denotes Türkiye's trade weights calculated as the sum of export and import for i sector. $(X + M)$ indicates the sector export and import volumes for the sector in each year. Based on this, the sectoral real exchange rate employed in the study is calculated as follows (Goldberg, 2004, p. 4);

$$REER_{TR,i} = \sum\nolimits_{TR}(TW_{TR,i} * RER_{TR}) \tag{7}$$

The consumer price index (CPI) and NER for Türkiye and its trading partners, are from the International Monetary Fund's International Financial Statistics database.[2] Sectoral exports and imports data were obtained from the Turkish Statistical Institute (TURKSTAT).

Sectoral Capital Intensity (CI): Capital intensity is one of the most important predictors of country and sectoral competitiveness in GVC participation. Higher capital intensity implies the use of more machinery and technology in the production functions, which enhances the international competitiveness of firms. This, in turn, allows sectors to move up the global market hierarchy to more value-added production. Fernandes et al. (2020) state that capital-intensive sectors are more integrated into GVCs because they require sophisticated production processes and technology-intensive inputs. In the same manner, Banerjee & Zeman (2020) point out that capital intensity is a key determinant of backward GVC participation, especially in high-tech manufacturing sectors. They explain that capital-intensive industries have the advantage of scale, which enhances the ability of firms to acquire sophisticated production technologies and thus get integrated into multinational production networks. This view is also supported by Cheng et al. (2015), who established that capital-intensive sectors are more likely to depend on imported intermediate goods and foreign technologies and therefore have higher levels of backward GVC participation. Regarding forward linkages, the effect of capital intensity on them is not clear. Van der Marel (2015) established a positive and significant relationship between capital intensity and forward linkages, while arguing that physical capital endowment improves a country's position in the global supply chains. However, Olczyk & Kordalska (2017) establish that capital intensity is a deterrent to GVC participation in the manufacturing sectors of Eastern Europe.

[2] Exchange rates of some countries that cannot be directly converted to Turkish Lira have been converted to US dollars using the cross-exchange rate method.

The sectoral capital intensity variable used in the estimation of equations is calculated using sectoral balance sheets obtained from the Entrepreneur Information System (EIS) database. Sectoral capital intensity is measured as the ratio of tangible assets to the total number of workers. Tangible assets are adjusted for inflation using the producer price index (PPI) specific to sectors within the manufacturing industry; meanwhile, for non-manufacturing sectors, the implicit Gross Domestic Product (GDP) deflator is computed using current price GDP data from TURKSTAT. Also, assets that are not directly linked to productivity, like land and real estate, are taken out of the calculation of this variable.

Sectoral Unit Cost of Labor (UCL): An increase in the cost of production is likely to have a positive impact on the backward GVC participation. According to Rodrik (2018), the rising labor costs make firms search for ways of cutting costs through the use of cheaper and more efficient imported intermediate goods. Likewise, Timmer et al. (2016) note that high labor costs lead firms to increase the effectiveness of their production and depend more on imported inputs, which in turn increases their backward GVC participation. They also claim that rising labor costs suppress firms' participation in global supply chains, especially in the labor-intensive sectors.

As for the forward GVC participation, Rodrik (2018) expresses that rising labor costs erode firms' competitive position in international markets and render it harder for them to export intermediate products. In the same vein, Timmer et al. (2016) argue that high labor costs decrease production capabilities and hence limit firms' participation in forward GVC linkages. Johnson & Noguera (2022) establish that countries with high unit labor costs have a lower share of domestic value addition in their exports, which in turn weakens their forward GVC linkages.

The sectoral unit labor cost is computed using the EIS database using the following formula[3]:

$$W_t^i = \frac{PC_t^i}{E_t^j} \; x \; L_t^i \tag{8}$$

$$ULC_t^i = \frac{W_t^i}{VA_t^i} \tag{9}$$

In the equations (8) and (9) $W_t^i$is the labor cost of sector i for year t, PC_t^j is the personnel cost in sector i for year t, E_t^i is the number of paid employees in sector i for year t, L_t^i is the number of employees in sector i for year t, VA_t^i is the value added at factor cost of sector i for year t, and ULC_t^i is the unit labor cost of sector i for year t. Unit labor costs for sections B, C, D, and E of NACE Rev.2 are deflated by using the CPI (2015=100) and unit labor costs for the other sectors is deflated by using the GDP deflator.

Herfindahl-Hirschman Index (HHI): From the findings of Cheng et al. (2015), sectors with higher market concentration gain advantages from economies of scale, as well as stronger supplier-buyer relationships within the GVCs. In more concentrated market structures, firms are more prone to establishing long-term contracts with international buyers and developing specialized capabilities that reinforce their position in the global supply networks. HHI is a metric that is used to determine the level of market share and competitive rivalry in a market. HHI is determined by aggregated squared market shares of firms in a particular market (Herfindahl, 1950; Hirschman, 1945). Hence, for this paper, we employ the sectoral HHI as a measure of market concentration, which is computed from the EIS database using the following formula:

$$HHI_i^t = \sum_{j=1}^{N} \left(\frac{Sector\ Net\ Sales_{\ i,t}}{Total\ Net\ Sales_{\ i,t}} \right)^2 \tag{10}$$

[3] Unit Cost of Labor Metadata: Access website link: https://gbs.sanayi.gov.tr

In the equation (10) HHI_i^t is Herfindahl-Hirschman Index for sector i in year t and N is total number of firms in the sector.

Skilled (SKILL), Semi-skilled, and Unskilled (UNSKILL) Labor: The contribution of human capital is fundamental to GVC participation. (Urata & Baek, 2020; Yameogo & Jammeh, 2019). Unskilled labor is an entry point to downstream assembly stages, which are associated with a high share of imported inputs in the country's exports as well as exports of final goods (Fernandes et al., 2020). However, GVC integration increasingly demands a highly skilled workforce, especially in the new economy and high-technology industries (Winkler, 2020). On the other hand, the World Bank (2020) states that while skilled labor is important, other factors such as innovation, infrastructure, and industrial capacity are also important. Therefore, it can be concluded that while skill is not the only factor that determines GVC participation, it is possible to argue that skill is not sufficient to influence GVC participation if other factors are not present. In this study, in line with Winkler (2020) and Fernandes et al. (2020), we use unskilled and skilled labor as explanatory variables in the backward and forward GVC participation equations, respectively. In addition, we also used total labor (the sum of the skilled, semi-skilled, and unskilled) as an explanatory variable in the total GVC participation.

We utilize the TURKSTAT data for the skill distribution of employment based on the classification of the International Labor Organization (ILO), according to the skill levels defined by the International Standard Classification of Education (ISCED) education levels. Individuals with less than a high school education are classified as unskilled, while those with a university degree or higher are considered skilled labor. Individuals with upper secondary education, such as high school or vocational high school graduates, are categorized as semi-skilled or medium-skilled labor. Although educational attainment is not an ideal measure of skill since it fails to consider informal training, work experience, or cognitive and non-cognitive abilities, the skill distribution of employment based on education levels is the only available indicator of human capital at the sectoral level. Despite this limitation, education-based skill classification is widely used in the empirical literature for data availability and comparability in cross-country comparisons.

2.3 Estimation Methods

We employ panel data estimation methods to analyze the determinants of sectoral GVC participation given in equations (1), (2), and (3). Panel data models offer several advantages, including controlling for time-series and cross-sectional variability, accounting for individual heterogeneity, reducing multicollinearity, and improving estimation efficiency (Baltagi, 2008). The Fixed Effects (FE), Random Effects (RE), Augmented Mean Group (AMG), and System Generalized Method of Moments (System GMM) methods were applied to address key econometric challenges such as heterogeneity, endogeneity, and cross-sectional dependence.

During the estimation process, the Hausman test was conducted to choose between the FE and the RE method. In the FE method, time dummies were also included. Considering the endogeneity problem and the influence of these variables on GVC participation variables may emerge with a delay, the explanatory variables have been introduced into the regressions with one-year lagged values.

Among the explanatory variables, FDI, unit labor cost, and skilled labor affect GVC participation, while changes in GVC participation also have the potential to affect these variables. To address the endogeneity issue caused by this reciprocal relationship, the System GMM estimation was utilized for dynamic panel data estimation (Arellano & Bover, 1995). System GMM reduces potential correlation between the lagged dependent variable and the error term, leading to more reliable and efficient coefficient estimates (Blundell & Bond, 1998). This method is particularly suitable for panel datasets with a large cross-section (N) but a short time dimension (T) and effectively handles endogeneity problems (Arellano & Bover, 1995). In Difference GMM methods, the instruments for lagged dependent variables may be weak, leading to biased estimates. However, System

GMM overcomes this issue by incorporating both level and difference equations, providing stronger instrument variables. The consistency of the method was examined using the Arellano-Bond autocorrelation test and the Hansen over-identification test. The AR (1) test detects first-order autocorrelation, while the AR (2) test determines whether second-order autocorrelation is present (Arellano & Bond, 1991). Additionally, the Hansen test was used to validate the instrumental variables; failure to reject the null hypothesis confirms that the instruments are correctly specified (Hansen, 1982). In this context, our System GMM estimation results used in this study provide consistent and efficient estimates for panel datasets with a large cross-section but a short time dimension.

To account for cross-sectional dependence and parameter heterogeneity, second-generation panel unit root tests were applied. The Cross-Sectionally Augmented Dickey-Fuller (CADF) test and Cross-Sectionally Augmented IPS (CIPS) test were used to analyze the stationarity levels of the variables. When the cross-sectional dimension (N) is greater than the time dimension (T), the cross-sectional dependency test is more valid (Pesaran, 2021). As part of panel data estimation techniques, the AMG estimator (Eberhardt & Teal, 2011) was employed. The AMG method was selected due to its ability to apprehend both cross-sectional dependence and parameter heterogeneity effectively.

All variables are measured in logs. All the calculations are performed using STATA 17.

3. Estimation Results

This section presents the estimation results on the determinants of GVC participation for equations (1), (2), and (3) by using three estimation methods, namely FE/RE, System GMM, and the AMG methods. The estimation results of the backward GVC participation (equation (1)) are presented in Table 1.

Table 1. Backward GVC Participation Estimation Results

	FE	Two-Step System GMM	AMG
Backward		0.67*** (0.00)	
lnFDI	0.27* (0.07)	0.14*** (0.00)	0.04** (0.02)
lnTAX	-0.54** (0.03)	-0.41*** (0.00)	0.42 (0.43)
lnREER	-0.06 (0.55)	-0.11*** (0.02)	-0.07 (0.51)
lnCI	0.27*** (0.00)	0.73*** (0.00)	0.06 (0.94)
lnUCL	0.73*** (0.00)	1.81*** (0.00)	2.09*** (0.00)
lnUNSKILL	-0.15*** (0.01)	0.02 (0.21)	-0.20** (0.04)
Constant	1.74* (0.07)	-0.74*** (0.00)	2.22* (0.09)
Common Correlated Effects			0.92*** (0.00)
R-Square	0.3468		
F-test	74.35***	143754.31***	
N	476	476	476
Wald			32.82***
Sector Number	34	34	34
AR (1) P-value		0.004	
AR (2) P-value		0.281	
Hansen Test Statistic		33.08	
Hansen P-Value		0.233	
Instrument Number		36	

* p<0.1; ** p<0.05; *** p<0.01, Robust Standard errors in parentheses.

According to the estimation results of equation 1, the FE and System GMM methods are generally statistically significant, and the independent variables strongly explain backward GVC participation. In terms of the System GMM method, the fact that the AR (2) test does not fail, the Hansen test remains at an acceptable level, and the number of instruments is reasonable supports the reliability of the method's results. On the other hand, the significance of the Common Correlated Effects (CCE) in the AMG method indicates that the method accounts for common factors and sectoral differences. These findings suggest that, despite being tested with different estimation methods, the determinants of backward GVC participation remain largely consistent.

The System GMM estimation results in Table 1 indicate that the lagged value of backward GVC participation has a strong influence on backward GVC participation. This finding suggests that the level of backward GVC participation in previous periods significantly influences current participation. Antras & Chor (2021) highlight the role of past participation levels as a determinant in the process of integration into GVCs. This underscores the importance of learning processes in supply chains and production networks. Furthermore, Baldwin et al. (2015) argue that participation in international production networks over time facilitates technology transfer for firms and contributes to productivity growth.

Following the existing studies that indicate a positive relationship between FDI openness and backward GVC participation (Fernandes et al., 2020; Banerjee & Zeman, 2020; World Bank, 2020), the positive impact of FDI on backward GVC participation is evident, with significant effects observed in all three estimation methods. This finding suggests that Türkiye is increasing its participation in global production networks by relying on imports of intermediate goods.

Our estimation results also show that import tariffs have a significant and negative impact on backward GVC participation. This effect is identified through FE and System GMM estimations, whereas no statistically significant relationship is found in the AMG estimations. Our findings are consistent with the existing literature, which suggests that high import tariffs elevate production costs, thereby reducing firms' competitiveness and negatively affecting backward GVC participation.

As far as the sectoral real exchange rate is concerned, while the impact of REER is not statistically significant in the FE and AMG methods, the System GMM estimation identifies a statistically significant and negative effect on backward linkages. This suggests that depreciation of TL (increase in sectoral real exchange rate) negatively affects the integration of Türkiye's into global production networks by decreasing the backward participation in GVCs. This result might be due to the substantial import dependency of the production and exports in Türkiye revealed by Dinçer (2021), Erduman et al. (2020), and Akgündüz et al. (2019).

The FE and System GMM estimation methods validate the statistical significance of the capital intensity. This result suggests that backward GVC participation is particularly prevalent in capital-intensive sectors, and therefore, these sectors are more strongly integrated into global production networks. These findings are largely supported by previous studies in the literature (Fernandes et al., 2020; Banerjee & Zeman, 2020; Cheng et al., 2015).

Unit labor cost also positive and statistically significant impact on backward GVC participation across all estimations, including FE (0.73, $p<0.01$), AMG (1.81, $p<0.01$), and System GMM (2.09, $p<0.01$). This result aligns with previous studies in the literature, suggesting that higher labor costs push firms to rely more on imported intermediate goods in their production processes, thereby increasing backward GVC participation (Rodrik, 2018; Timmer et al., 2016).

Our estimation results show that the coefficient of the unskilled labor is not statistically significant in the System GMM method, but it shows a negative and statistically significant effect on backward GVC participation in the FE and AMG methods.

The estimation results of the Forward GVC Participation (Equation (2)) are presented in Table 2.

Table 2. Forward GVC Participation Estimation Results

	RE	Two-Step System GMM	AMG
Forward		0.93*** (0.00)	
lnFDI	0.01*** (0.00)	0.01** (0.03)	-0.03 (0.42)
lnREER	-0.04*** (0.03)	-1.24*** (0.00)	-1.79*** (0.02)
lnCI	-0.02* (0.06)	-1.37*** (0.00)	-0.05* (0.07)
lnUCL	-0.04** (0.04)	-0.70*** (0.00)	-0.03 (0.46)
lnSKILL	0.02 (0.85)	-0.01 (0.26)	0.02 (0.14)
lnHHI	0.03*** (0.00)	0.11*** (0.00)	0.51* (0.09)
Constant	0.52*** (0.00)	0.43*** (0.00)	1.30*** (0.00)
Common Correlated Effects			0.61*** (0.00)
R-Square	0.13		
F-test		88126.72***	
N	476	476	476
Wald	59.14***		12.85**
Sector Number	34	34	34
AR (1) P-value		0.001	
AR (2) P-value		0.567	
Hansen Test Statistic		19.15	
Hansen P-Value		0.952	
Instrument Number		39	

* p<0.1; ** p<0.05; *** p<0.01, Robust Standard errors in parentheses.

The estimation results indicate that all three estimation methods yield statistically significant results. In terms of the System GMM methods, the fact that the AR (2) test does not fail, the Hansen test remains at an acceptable level, and the number of instruments is reasonable supports the reliability of the results. These findings confirm that the model is properly specified according to dynamic panel assumptions. In the AMG method, the CCE coefficient (0.61, p<0.01) is statistically significant, indicating that the estimation method accounts for common shocks and addresses cross-sectional dependence issues. This suggests that the model is designed to incorporate common global shocks and heterogeneities across different sectors.

Table 2 shows that the coefficient of the lagged dependent variable is positive and statistically significant (0.93, p<0.01) in the System GMM estimation. This finding suggests that the level of GVCs' forward participation in previous periods also significantly influences current forward GVC participation as well.

Regarding FDI, one of the key determinants of forward GVC participation, the RE and System GMM estimation results show that the FDI variable exhibits a positive and significant effect (0.01, p<0.05). This finding is consistent with the studies of Kowalski et al. (2015) and Fernandes et al. (2020), which highlight that FDI inflows enhance firms'

access to global supply chains and promote forward GVC participation. However, the lack of a significant relationship in the AMG method may reflect sectoral differences and the varying impacts of industrial structures on GVC integration (Buelens & Tirpak, 2017). This result further suggests that the role of different sectors within GVCs and the technology transfer processes can influence the impact of FDI, making its effects more heterogeneous across industries.

The coefficient of the REER variable is negative and statistically significant across all methods. The negative impact of REER on forward GVC participation indicates that currency depreciation (increase in sectoral real exchange rate) has an effect of reducing export competitiveness and making it more difficult for firms to supply intermediate goods to international markets. This result, which contradicts theoretical expectations, may stem from Türkiye's export structure. Because of the higher import content of exports compared to total production (Erduman et al., 2020; Akgündüz et al., 2019), currency depreciation might harm exports of Türkiye due to an increase in the imported input costs. This finding reinforces the results of Akgündüz et al. (2019) and Toraganlı & Yalçın (2016), suggesting that high import dependency of exports limits the positive effects of currency depreciation on exports.

Estimation results also indicate a negative and statistically significant relationship between capital intensity and forward GVC participation. This result suggests that although capital-intensive sectors use more imported intermediate goods in their production processes, the intermediate goods they produce are less integrated into GVCs. A possible explanation for this weak forward linkage is that production in capital-intensive sectors largely relies on economies of scale, leading firms to focus more on domestic markets than global supply networks.

The estimation results of the FE and System GMM methods indicate that unit labor cost has a negative and statistically significant impact on forward GVC participation. The results are consistent with Rodrik (2018) and Timmer et al. (2016).

The coefficient of skilled labor on forward GVC participation is statistically insignificant across all three estimated methods. This suggests that an increase in skilled labor does not affect the forward GVC participation in the Turkish case. However, this might be because our skill indicator, which classifies individuals solely based on their level of education, might not fully reflect the complexity of real skill levels. The level of education does not fully reflect skill, as factors such as informal education, work experience, and cognitive and non-cognitive competencies can also significantly affect individuals' participation in GVCs.

The HHI, an indicator of market concentration, exhibits a positive and statistically significant effect across all estimation methods. This result agrees with the findings of Cheng et al. (2015), who argue that sectors with higher market concentration benefit from economies of scale and stronger supplier-buyer relationships within GVC.

Table 3 presents the estimation results of total GVC Participation (Equation (3))

Table 3. Total GVC Participation Estimation Results

	FE	Two-Step System GMM	AMG
GVC Part.		0.42*** (0.00)	
lnFDI	0.02** (0.04)	0.13*** (0.00)	0.03** (0.03)
lnTAX	-0.53** (0.04)	-3.86*** (0.00)	-0.20 (0.36)
lnREER	-0.02 (0.83)	-0.14*** (0.00)	-0.02** (0.04)
lnCI	0.26*** (0.00)	-0.70 (0.95)	0.02 (0.20)
lnUCL	-0.35*** (0.00)	-0.19*** (0.00)	-0.15* (0.08)
lnTOTALLABOR	-3.56 (0.96)	-0.01 (0.544)	-0.03 (0.16)
Constant	2.46*** (0.00)	3.56*** (0.00)	2.30 (0.81)
Common Correlated Effects			0.95*** (0.00)
R-Square	0.33		
F-test	10.86***	45742.39***	
N	476	476	476
Wald			17.51***
Sector Number	34	27	34
AR (1) P-value		0.023	
AR (2) P-value		0.605	
Hansen Test Statistic		21.96	
Hansen P-Value		0.286	
Instrument Number		27	

* p<0.1; ** p<0.05; *** p<0.01, Robust Standard errors in parentheses.

The reliability of the system GMM method is confirmed by the Hansen test statistic (21.96) and p-value (0.286). In addition, the p-value of the AR (2) test is statistically acceptable, and the number of instruments is reasonable. These results demonstrate that the model is consistent with dynamic panel data assumptions and supports the estimated coefficients' reliability. In the AMG method, the CCE (0.95, p<0.01) coefficient being statistically significant indicates that the method accounts for common shocks and considers cross-sectional dependence issues. The sector number is set at 34, with a total of 476 observations, demonstrating that the method has sufficient data to explain differences across heterogeneous sectors.

In Equation 3, the sum of skilled, semi-skilled, and unskilled labor is used in the model because GVC participation is calculated as the sum of backward and forward GVC participation. Additionally, due to the high correlation between the skilled, semi-skilled, and unskilled labor variables, these three variables are not included in the model separately.

Empirical findings indicate that the lagged dependent variable, GVC Participation, is positive and statistically significant in the System GMM method (0.42, p<0.01). This result suggests that sectors that have previously participated in GVCs tend to maintain their integration in the future. This finding aligns with studies that argue that GVC participation exhibits path dependence. Taglioni & Winkler (2016) emphasize that firms integrated into GVCs establish long-term supplier-buyer relationships, and these connections strengthen over time, making it more difficult for firms to exit these networks. Similarly, Kowalski et al. (2015) highlight that firms involved in GVCs develop technological capabilities, knowledge of production processes, and international partnerships, which in turn ensure the continuity of their participation. Another reason for the persistence of GVC participation is the learning process at the firm level and the gradual improvement in production capacity. Javorcik (2004) states that firms engaged in GVCs gain access to new technologies, production standards, and innovative business

models through foreign investors and international customers. This, in turn, enhances firms' global competitiveness and reinforces their dependence on GVCs.

FDI has a positive and statistically significant impact on GVC participation across all three estimation methods. This finding aligns with the literature, indicating that FDI inflows facilitate deeper integration into global production networks by increasing firms' access to capital, technology, and managerial expertise and, as well as promoting technology spillovers, strengthening supply chain linkages, and enhancing the competitiveness of domestic firms in global markets (Javorcik, 2004; Fernandes et al., 2020; Buelens & Tirpak, 2017).

The effect of customs duties on GVCs' participation is negative and statistically significant in the FE method (-0.53, $p<0.05$) and System GMM method (-3.86, $p<0.01$), but insignificant in the AMG method. These results support the widely accepted view that high tariffs hinder participation in international production networks, discourage the use of foreign inputs, and increase production costs for exporters (Cheng et al., 2015; Yanıkkaya et al., 2024).

The impact of the sectoral REER on GVC participation varies according to the estimation methods. While the FE (-0.02, $p=0.83$) estimation results do not show a significant effect, the System GMM (-0.14, $p<0.01$) and the AMG method (-0.02, $p<0.05$) identify a negative and statistically significant relationship, like in forward participation estimation results.

The relationship between capital intensity per worker and GVC participation is positive and significant in the FE estimation results (0.26, $p<0.01$), while it is not statistically significant in the System GMM and AMG estimation results. The positive effect observed in the FE method supports the findings of van der Marel (2015), which suggests that capital-intensive sectors tend to have strong forward linkages in GVCs, as they produce specialized intermediate goods required for complex production networks.

Estimation results indicate a negative and statistically significant relationship between unit labor cost and GVC participation across all methods (FE: -0.35, $p<0.01$; System GMM: -0.19, $p<0.01$; AMG: -0.15, $p<0.10$). These findings align with studies in the literature suggesting that high labor costs reduce international competitiveness and weaken firms' ability to integrate into GVCs (Rodrik, 2018).

The impact of the sum of skilled, semi-skilled, and unskilled labor on GVC participation is statistically insignificant in all three estimation methods. This result suggests that increasing the total workforce (regardless of the skill level) does not directly support GVC integration. Rodrik (2018) emphasizes that due to the nature of global production networks, firms focus not only on the number of workforce but also on qualitative factors such as advanced skills, technological adaptability, and innovation. Therefore, the insignificant effect of this total variable, which includes low, medium, and high-skilled labor together, shows that increasing the quantity of labor alone is not sufficient for GVC participation.

4. Conclusion

The aim of this paper is to identify the determinants of Türkiye's participation in GVCs using data from 34 sectors over the period 2006 to 2020. With this purpose, equations for different GVC participation indicators, namely, backward, forward, and total GVC participation, are estimated using three estimation methods: FE/RE, System GMM, and the AMG methods.

Our estimation results show that FDI is one of the key determinants of Türkiye's GVC participation. The coefficients of FDI are statistically significant and positive for backward, forward, and total GVC participation, according to the three estimation methods: FE/RE, System GMM, and AMG. The inflow of FDI into Türkiye increased backward GVC participation by boosting the imports of intermediate inputs, thereby deepening its integration into the upstream segments of GVCs. FDI also affects Türkiye's forward GVC participation by enabling domestic firms to generate value-added inputs,

which are subsequently re-exported through international production networks, as suggested by Javorcik (2004). Our results show that FDI is a key channel that strengthens the supply chain linkages of the Turkish economy by enhancing both forward and backward linkages.

Another important determinant of Türkiye's GVC participation is unit labor cost. An increase in unit labor cost raises the backward GVC participation. An increase in labor costs in Türkiye leads to an increase in the import of intermediate goods to reduce costs, thereby boosting backward GVC participation, as suggested by Rodrik (2018). Unit labor cost has negative and statistically significant coefficients in the equations for forward and total GVC participation, estimated using three different methods (except AMG). This result suggests that rising labor costs decrease the competitiveness of Türkiye's exports and weaken forward participation in GVCs.

Similarly, the tariff rate imposed on imported goods is another decisive factor that explains backward and total GVC participation. The tariff rate has a negative coefficient in the equations for both backward and total GVC participation, estimated using the FE and System GMM methods. This indicates that an increase in the tariff rate reduces Türkiye's integration into GVCs by decreasing backward GVC participation.

On the other hand, the sectoral real exchange rate has a negative and statistically significant effect on both Türkiye's backward and forward participation in GVC. This suggests that real currency depreciation (an increase in the sectoral real exchange rate) decreases the backward participation of Türkiye's economy in GVCs. Given Türkiye's high import dependency for production and exports, this result is plausible. The negative impact of sectoral real exchange rate on forward GVC participation indicates that real currency depreciation diminishes Türkiye's export competitiveness and makes it more difficult for firms to supply intermediate goods to international markets. This result, which contradicts theoretical expectations, may stem from Türkiye's high import dependency for exports, which neutralizes the positive effects of devaluation on exports. In contrast, the sectoral real exchange rate does not affect the GVC participation. This might be because the positive effect of the sectoral real exchange rate on backward GVC participation by increasing imports is balanced out by its negative effect on forward GVC participation by decreasing the exports of intermediate products.

Similarly, our estimation results show that capital intensity is an important factor in explaining backward integration in Türkiye. The FE and System GMM estimations confirm the statistical significance of the capital intensity variable. This suggests that backward GVC participation is particularly prevalent in capital-intensive sectors. Moreover, capital intensity hurts forward GVC participation. These two results together imply that capital-intensive sectors in Türkiye are more strongly integrated into global production networks through backward linkages.

Since the coefficient for unskilled labor in the backward GVC participation equation estimated using the GMM method, which is a robust model for solving the endogeneity problem, is insignificant, it can be concluded that unskilled labor has no impact on backward participation in GVCs. Similarly, skilled labor has no impact on forward GVC participation, as the coefficient for skilled labor is statistically insignificant across all equations estimated by different methods. Also, total labor is statistically insignificant in total GVC participation according to all three estimation methods.

The ratio of backward GVC participation to forward GVC participation in Türkiye's manufacturing industry has increased by 48 percent from 1995 to 2020, according to TiVA statistics. This suggests that the primary drive in Türkiye's participation in GVC is the rise in backward participation, rather than forward participation. A similar trend was also observed in the services industry. However, strengthening forward linkages is essential as it enhances the gains from participation in GVCs in terms of net value added.

Our estimation results show that Türkiye has increased its backward GVC participation through cost indicators such as unit labor costs, tariff rates, and the real exchange rate. Our results show that increases in FDI as well as decreases in unit costs

boost forward GVC participation. However, increasing forward GVC participation through a reduction in costs leads to a deterioration in income distribution. Therefore, considering also the productivity spillover effects of FDI, Türkiye should implement policies to boost FDI inflows, thereby increasing participation in GVCs without causing a deterioration in income distribution.

This study presents important findings at the sectoral level by addressing the factors affecting Türkiye's participation in GVCs. However, limiting the study to sectoral analysis results in ignoring firm-level and country-level dynamics. Therefore, in future studies, conducting analyses based on firm data, especially at a micro level, will be beneficial for deepening the current findings and policy design. In particular, it would be useful to study the roles of firms of different sizes in GVC integration.

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Appendix

A1. Sectors Samples

Nace Code	Sectors
05	Mining and quarrying, energy producing products
07	Mining and quarrying, non-energy producing products
09	Mining support service activities
10	Food products, beverages and tobacco
13	Textiles, wearing apparel, leather and related products
16	Wood and products of wood and cork
17	Paper products and printing
19	Coke and refined petroleum products
20	Chemical and chemical products
21	Pharmaceuticals, medicinal chemical and botanical products
22	Rubber and plastics products
23	Other non-metallic mineral products
24	Basic metals
25	Fabricated metal products
26	Computer, electronic and optical products
27	Electrical equipment
28	Machinery and equipment n.e.c
29	Motor vehicles, trailers and semi-trailers
30	Other transport equipment
31	Manufacturing nec; repair and installation of machinery and equipment
35	Electricity, gas, steam and air conditioning supply
36	Water supply; sewerage, waste management and remediation activities
41	Construction
46	Wholesale and retail trade; repair of motor vehicles
49	Transportation and storage
55	Accommodation and food service activities
58	Information and communication
68	Real estate activities
70	Professional, scientific and technical activities
77	Administrative and support services activities
85	Education
86	Human health and social work activities
90	Arts, entertainment and recreation
94	Other service activities