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# Global value chain participation in boosting innovativeness of European businesses: Evidence from the European Union countries

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## Abstract

**Aim/purpose** – Global value chains (GVCs), along with their specific forms of forward and backward linkages, remain the predominant mode of global production. However, their consequences for national economies are not universally clear. Our study aims to assess the impact of forward (FWD) and backward (BWD) GVC participation on business innovation in the European Union (EU) countries. We analyze this influence using a dual approach: examining all member states as well as four subgroups of EU countries, categorized by their level of innovation and length of EU membership.

**Design/methodology/approach** – Macro-panel regressions based on data for 27 EU countries were used to achieve these aims. Followed by the variance inflation factors (VIFs) tests, the Breusch–Pagan tests, and the Hausman tests, we estimated panel regressions with fixed effects, controlled for heteroscedasticity, autocorrelation, and cross-sectional dependence.

**Findings** – Results confirm that backward GVC linkages have a positive impact on the innovativeness of European businesses. When considering subgroups of EU countries, the impact of backward GVC participation on innovation is stronger in countries with a lower level of innovativeness compared to those with higher innovativeness, and in countries with shorter EU membership compared to those with longer membership. The

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impact of forward GVC participation is mostly statistically insignificant, with the only effect being a reduction in innovation among companies in the “new” EU countries. Thus, we confirm the differences in the impact of GVC linkages on the innovativeness of businesses at the EU macro level.

**Research implications/limitations** – Practical implications of the study include recommendations for increasing the innovation capabilities and absorptive capacity of European businesses through backward participation in GVCs, with nuances related to the characteristics of the EU countries. The innovation policies should reflect differences between “old” and “new” EU members to bridge the EU’s innovation gap.

**Originality/value/contribution** – Our paper contributes to the discussion on innovation and its connection with the GVC. We delve deeper into the impact of GVC linkages on the innovativeness of European businesses by decomposing them into the forward and backward GVC participation and by categorizing EU countries into groups with relatively high or low levels of business innovation, as well as into “old” and “new” member states. Our findings confirm the complexity of these relationships depending on the nuances of countries’ characteristics, which have not yet been clearly highlighted in the existing literature on the GVC-innovation nexus within the EU.

**Keywords:** global value chains (GVCs), backward GVC participation, forward GVC participation, innovation, European Union.

**JEL Classification:** F10, F20.

## 1. Introduction

Innovations play an essential role in the economic development of the European Union (EU) (Banyuls & Vides, 2024), supporting the economic growth theories (Pinto, 2009). To remain globally competitive, Europe must innovate to capture new markets, counter low-cost or unique foreign products, and enable its companies to quickly adapt to rapid technological changes for survival (Del-Aguila-Arcentales et al., 2023).

However, the EU failed to achieve the target of 3% of GDP for research and development (R&D) expenditure, as a measure of innovativeness, initially set in the Lisbon Strategy for 2010 and later extended to 2020 under the Europe 2020 Strategy (European Commission, 2020). According to the latest report (European Commission, 2024), South Korea (4.9% of GDP on R&D), the United States (3.5%), Japan (3.3%), and China (2.4%) surpassed the EU’s R&D spending intensity (2.2%), primarily because of a shortfall in private R&D investments. According to OECD data, the gap between the EU and these countries widened in 2021-22, mainly due to a reduction in spending to 2.1% of GDP<sup>1</sup>.

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<sup>1</sup> <https://www.oecd.org/en/data/indicators/gross-domestic-spending-on-r-d.html?oecdcontrol-8027380c62-var3=2022>

There are several approaches to examining the factors impacting innovation. Innovation creation is often analyzed within the framework of regional or national innovation systems (Pinto, 2009; K. Xu et al., 2023), along with the helix of innovation operating within them. The well-recognized triple helix approach assumes the creation of innovation through the cooperation of industry, government, and university (Murillo-Luna & Hernández-Trasobares, 2023; Zakaria et al., 2024). Another perspective is the significance of entrepreneurial ecosystems as the environment for innovation creation (Radinger-Peer et al., 2018; Song, 2019; Spigel & Harrison, 2018). All these perspectives assume that the geographical proximity of stakeholders is the main advantage in fostering innovation.

While the impact of national and regional innovation systems or the innovation helix on innovation is well discussed in the EU (Banyuls & Vides, 2024; Brodny & Tutak, 2024; Kacprzyk & Doryń, 2017; Pinto, 2009), much less is known about the influence of global factors. However, there is some evidence of the positive influence of regional openness, among other factors, on innovation efficiency in most EU regions (K. Xu et al., 2024). To fill this gap, we investigate the impact of internationalization on the innovation of firms in the EU at the macro level, in line with the importance of private R&D spending in the EU in the context of catching up with leading countries (European Commission, 2024). In particular, we analyze internationalization through the lens of global value chains (GVCs), which, in contrast to the traditional approach to international trade, provides a holistic view of global industries by mapping value-added sequences, actors, and their roles across regions, tracing the shifting patterns of global production (Gereffi, 2019). This provides an opportunity to grasp the increasingly disaggregated and geographically dispersed value chains of MNCs from both market and hierarchy perspectives (Benito et al., 2019).

Despite the multidirectional nature of current globalization processes, sometimes described as “deglobalization” or “slowbalization” (Antràs, 2020), GVCs, as a form of global production (Neilson et al., 2014) and international division of labor (Coveri & Zanfei, 2023; Fritsch & Matthes, 2020), continue to spread and expand, despite a series of external shocks (caused among others by PRC–US trade tensions and the COVID-19 pandemic). In 2022, the gross value added generated within the GVCs accounted for almost half of world exports, which is a record in the entire history of GVCs tracking (Mariasingham et al., 2023).

There is no universal view on the impact of GVC participation as a whole or its particular forms, such as forward and backward GVC linkages, on national economies, industries, and individual companies. In the mainstream GVC literature and the recommendations of some international organizations (for example,

the World Bank<sup>2</sup>), participation in GVC is generally believed to be beneficial. However, other researchers are relatively skeptical about any form of participation in GVCs and believe that the criterion for a country's effective participation in the international division of labor is the share of domestic value added in exports (or in gross output) (Yu & Luo, 2018). Here again, empirical evidence shows that both highly and least developed countries can meet this criterion (L. Xin et al., 2019). The benefits of participation in GVCs differ for emerging and advanced economies, with the former being more beneficial (Guei, 2021).

Narrowing the scope of internationalization to backward and forward GVC participation, the specific aims of the study are (1) to assess the impact of these forms of GVC participation on the innovation of businesses in the EU countries at the macro level, measured by the business enterprise expenditure on research and development (BERD), and (2) to determine whether the impact of backward and forward GVC participation on companies' innovativeness varies among subgroups of EU countries, categorized by their level of innovation and length of EU membership. Specifically, the study investigates the following research questions: how backward and forward GVC linkages affect business innovation in the EU (RQ1), whether a country's level of innovation influences the relationship between GVC participation and innovation (RQ2), and whether the length of EU membership shapes this relationship (RQ3).

This study contributes to the research field by examining the impact of backward and forward GVC participation on innovation in EU countries and by analyzing how this influence varies based on countries' innovation level and duration of EU membership.

The structure of the paper is as follows. First, we present a literature review on the importance of GVCs and their impact on enterprise innovation, based on which we derive research questions. Next, we present research assumptions and results. Then, we conclude with a discussion of our research results.

## 2. Literature review

In its contemporary understanding, the term GVC typically refers to the full range of activities carried out by diverse production units to bring a product or service from its conception to its end use, recycling, or reuse (Ponte et al., 2019). GVC operations are regionally (P et al., 2023), geographically, and functionally dispersed (De Backer & Miroudot, 2013; Wignaraja et al., 2017). The structure

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<sup>2</sup> <https://www.worldbank.org/en/topic/global-value-chains>

of GVCs is, to a large extent, shaped by “lead firms,” which often come from developed countries and concentrate high-value-added activities (design, innovation, marketing, etc.), and offshoring low-value-added activities (like material production) (Schmeisser, 2013). However, the recent decade has revealed a tendency toward the rise of emerging market lead firms (Cuervo-Cazurra & Pananond, 2023). The strategies of transnational corporations about the fragmentation of production under the virtualization of value chains are also discussed (Pakulska, 2016).

According to the input-output approach, GVC participation rates are calculated as follows. Backward GVC participation is the ratio of the sum of foreign value-added and pure double counting to exports. Forward GVC participation is the ratio of the sum of domestic value-added sent to the importer, then re-exported to the third country, and ultimately absorbed abroad, and domestic value-added sent to the importer, then re-exported and ultimately absorbed back by the exporter (Borin & Mancini, 2019; Koopman et al., 2014).

With the expansion of GVCs worldwide and the growing issues of economic convergence and catching up, leading GVC researchers developed the term “GVC upgrade.” Such upgrading allows national economies, regions, industries, and particular firms to shift toward higher value-added activities through product, process, functional, and chain upgrading (Gereffi, 2019). GVC upgrade is associated with changing patterns of GVC participation. One study (Mehta, 2022) suggested that at the least developed stage (I), industries and firms are characterized by low both backward and forward linkages with lower levels of productivity growth. At the next stage (II), backward linkages increase, as these industries and firms begin to make widespread use of foreign components to manufacture their exported products. There is a significant risk of being trapped at the relatively low value-added Stage II (Stojčić & Matić, 2024). Otherwise, successful absorption of technological capabilities leads to a transition to Stage III with increasing forwardness of GVC linkages. In Stage IV, both backward and forward linkages decline again, albeit with higher levels of productivity growth (Mehta, 2022).

As the impact of backward and forward GVC participation on developed economies, as the EU countries, remains relatively under-researched, we formulate the first research question: RQ1. How do the backward and forward linkages in GVCs affect the innovativeness of companies at the EU macro level?

The discussion in the literature and research findings point to multidimensional interactions between GVCs and innovation (Fischer et al., 2024). In general, the problem is whether to protect domestic innovation or absorb foreign technologies within the GVCs (Yang & Wang, 2024). On the one hand, the impact of GVC participation on innovation has been confirmed for green technolo-

gy innovation (Hu et al., 2022), patents (Ito et al., 2023), innovation efficacy (Hu et al., 2021), and innovation outputs (Qian et al., 2022). However, evidence has also been found on the inverted U-shaped impact of GVC participation on innovation performance (Yang et al., 2020). In addition, when different types of innovation are analyzed, the results show that integration into GVCs does not promote the development of new products, but rather the improvement of existing products and production processes (Vu et al., 2024).

On the other hand, the influence of the national innovation system on a country's participation in different stages of GVCs has also been confirmed (Caliari et al., 2023), as well as the potential of radical innovation to change GVCs (Reis et al., 2021). The next issue discussed is related to the impact of global innovation networks on the GVC status (S. Xu et al., 2024).

Knowledge is driven by interactions in its co-creation, interpretation, integration, and transformation (Fischer et al., 2024), and knowledge spillovers are crucial for innovation (Ito et al., 2023). These interactions in knowledge creation as a prerequisite for innovation can be maintained through participation in GVCs. The complexity of the interaction between innovation and GVCs leads to the identification of varieties of innovation with a 2x2 matrix based on the geographical concentration of GVC stages and the company's control over operations, with four types of innovation: globally distributed innovation, captive innovation, producer-driven innovation, and buyer-driven innovation (Buciuni & Pisano, 2021).

Additionally, several studies have investigated the mediators of the impact of GVC participation on innovation. For example, previous research has confirmed that external conditions of environmental regulation mediate the impact of GVC participation on innovation (Hu et al., 2022), by human capital (Qian et al., 2022), by the degree of agglomeration (Yang et al., 2020), by the quality of local business environment (Vu et al., 2024), or by financial constraints (Elshaarawy & Ezzat, 2023).

Backward participation (i.e., foreign value added in exports) is linked with learning from component suppliers and access to new technologies (Grodzicki, 2018). However, a number of studies show that, in fact, intensive backward participation does not show any positive correlation with economic growth and increasing innovation capabilities, especially for the smaller economies (Fagerberg et al., 2018), and may instead cause a deterioration in the balance of payments (López-Villavicencio & Mignon, 2021). At the EU level, it was found that GVC embeddedness, embodied both in backward and forward GVC linkages, is associated with higher levels of innovation performance of organizations related both to product and process innovations (Van Zijl & Koster, 2024).

Backward GVC participation allows companies to access advanced inputs, technologies, and knowledge from foreign suppliers (Grodzicki, 2018). It can serve as a catalyst for innovation, providing a foundation for formulating hypothesis 1.

**H1:** A higher level of backward GVC participation is positively associated with company innovativeness at the macro level in EU countries.

Forward linkages (i.e., domestic value in export that is further reexported) are associated with learning from buyers and increased access to world markets (Grodzicki, 2018). Intensive forward linkages may also be caused by specialization in the production and export of raw materials and semi-finished products, i.e., less entrepreneurial and innovative industries generating a low share of value added (Arora & Siddiqui, 2020; L. Xin et al., 2019). Therefore, as forward GVC participation involves providing goods or services to foreign companies (Grodzicki, 2018), it can drive companies' innovation through the need to meet high international standards or adapt offers to different markets, allowing us to formulate hypothesis 2.

**H2:** A higher level of forward GVC participation is positively associated with company innovativeness at the macro level in EU countries.

Generally, participation in GVCs is more beneficial for emerging economies; the share of advanced countries in the total value added has significantly decreased recently (Guei, 2021). Thus, as the EU countries are advanced economies, instead of the level of their economic development as a division criterion, we focus on the level of companies' innovativeness and verify the differences in the GVCs participation's impact on innovation in subgroups of EU countries, based on their level of innovativeness and the length of EU membership. Therefore, we formulate the following research question: RQ2. How does a country's level of innovativeness in the EU affect the relationship between backward and forward linkages in GVCs and company innovation at the macro level?

The impact of backward and forward GVC participation on innovation is proven to be dependent on the level of economic development of the country (Karaboga et al., 2024). The advantages of GVC participation for innovation are often investigated and proven for developing countries (Elshaarawy & Ezzat, 2023). In contrast to this, other studies find that backward GVC participation opens more upgrading opportunities for developing countries and leads to higher absolute levels of their gross exports, domestic value added, and employment (Veeramani & Dhir, 2022) by providing them with more sophisticated inputs.

Meanwhile, a weaker positive impact of backward linkages on industrial upgrading in developed countries is also assumed (Tian et al., 2022).

The EU innovation system, while based on long-term EU policy, is complex and diverse, as it consists of the innovation systems of individual member states, shaped by factors such as geographical distribution, diversity of actors, institutional and cultural differences, as well as variations in technological and economic development (K. Xu et al., 2024). As a result, member states exhibit diversity in their innovation performance (Pinto, 2009; K. Xu et al., 2023), with no absolute convergence in R&D expenditures among EU countries. Instead, convergence occurs in clusters of countries at different levels of R&D expenditure (Banyuls & Vides, 2024). There are no commonly accepted criteria for dividing EU countries based on their innovativeness, as some research suggests five clusters (Pinto, 2009), while others suggest three (Banyuls & Vides, 2024).

Therefore, referring to RQ2, we assume that countries with lower levels of innovation may benefit more from backward GVC participation due to their relatively limited domestic technological capabilities. At the same time, foreign inputs and knowledge embedded in imported intermediates may serve as a source of innovation. As companies in these contexts can rely more on learning from abroad, the knowledge spillover effects from backward GVC participation are likely to be more pronounced. Thus, the positive relationship between backward GVC participation and company innovativeness is expected to be stronger in less innovative EU countries, as hypothesis 3 assumes:

**H3:** The positive relationship between backward GVC participation and company innovativeness is stronger in EU countries with lower levels of innovation.

It was noted that forward participation has deleterious effects on economic growth in less developed and developing economies (P et al., 2023). The other study finds that the forward GVC participation effect on economic growth is insignificant, suggesting that merely contributing inputs to other countries' exports may not directly enhance a nation's economic growth (Kim & Seo, 2025). In contrast, another study observes a positive upgrading effect of forward participation on developed countries (Tian et al., 2022). Companies operating in less innovative countries may experience greater pressure to innovate when supplying foreign buyers, making forward GVC participation a potential stimulus for innovation. Based on that, investigating RQ2, we formulate hypothesis 4.

**H4:** The positive relationship between forward GVC participation and company innovativeness is stronger in EU countries with lower levels of innovation.

The fragmentation of production is especially deep within the framework of integration associations, where there are no barriers to the free movement of goods, services, and factors of production, one of the most illustrative cases being the EU (Bolea et al., 2022). Therefore, we formulate the third research question: RQ3. How does the duration of membership in the EU affect the relationship between involvement in backward and forward linkages of GVCs and company innovation at the macro level?

As a result of the fifth, sixth, and seventh enlargements of the EU (in 2004, 2007, and 2013), 13 countries joined, bringing the total number of member states to 27.<sup>3</sup> Based on their length of membership, there is a common distinction between “old” and “new” member states in studies examining the innovation-economic growth nexus (Kacprzyk & Doryń, 2017). Most of the “new” EU countries, apart from Cyprus and Malta, are Central and Eastern European countries that underwent political transformation in the 1990s; however, their innovation potential is proven to be highly differentiated (Brodny & Tutak, 2024).

Specific studies on the GVC integration of EU countries (Grodzicki, 2018; Grodzicki & Geodecki, 2016) point to very different patterns of their GVC participation, attributing the majority of the Central and Eastern European countries, as well as Southern Europe, to peripheral and semi-peripheral economies, heavily dependent on the “headquarters” economies, such as Germany (Kordalska et al., 2022). It is also stressed that the gaps between the “headquarters” and “fabrication” destinations across EU countries and sectors, in terms of technology and functional specialization, have not narrowed (Bontadini et al., 2024). Capello et al. (2024) confirmed a divide in GVC participation between Eastern and Western Europe, along with its particular modes for individual countries and regions within them. Like Grodzicki (2018) and Grodzicki and Geodecki (2016), the authors find that more advanced EU countries take advantage of GVC involvement as “GVC controllers,” enjoying superior terms of trade in GVC.

The new EU member states in the years 1995-2011 experienced a notably greater growth in foreign value added share in export (i.e., backward GVC participation) than the EU-15 (Ambroziak, 2015). Mainly similar determinants of GVC participation were identified for EU-15 countries and new member states (Kersan-Škabić, 2019). Another study found that imported intangibles (as an element of backward GVC participation) are a driver for exports for all EU-28 countries, especially for those outside the euro area (Dimas et al., 2022).

Considering the abovementioned provisions, we assume that GVC participation in the form of backward linkages has a stronger positive impact on R&D intensity of European businesses in newer EU member countries than in old EU

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<sup>3</sup> [https://european-union.europa.eu/principles-countries-history/eu-enlargement\\_en](https://european-union.europa.eu/principles-countries-history/eu-enlargement_en)

states, as these countries typically have less mature and more diverse innovation systems (Brodny & Tutak, 2024). We assume that newer EU countries benefit more from backward GVC participation by relying on foreign inputs and knowledge to drive innovation. In contrast, older members are more likely to depend on domestic capabilities. These assumptions are reflected in hypothesis 5.

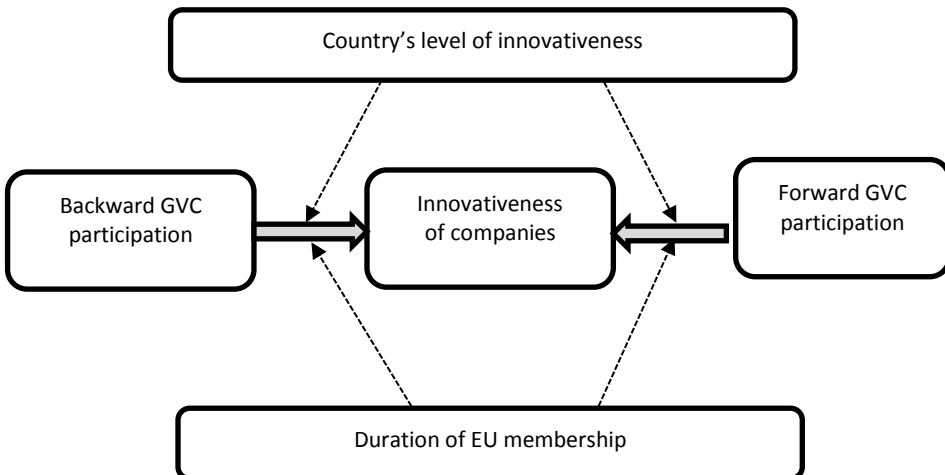
**H5:** The positive relationship between backward GVC participation and company innovativeness is stronger in newer EU member countries compared to older ones.

Newer EU member countries may experience a stronger positive impact from forward GVC participation due to their greater exposure to external market demands and pressure to meet international standards. With less entrenched domestic capabilities, firms in these countries can be more likely to rely on exporting relationships as a catalyst for upgrading products, processes, and technologies. Therefore, forward GVC participation may act as a key mechanism for catching up technologically, which results in formulating hypothesis 6:

**H6:** The positive relationship between forward GVC participation and company innovativeness is stronger in newer EU member countries compared to older ones.

The conceptualization of our hypotheses is presented in Figure 1.

**Figure 1.** Conceptual model

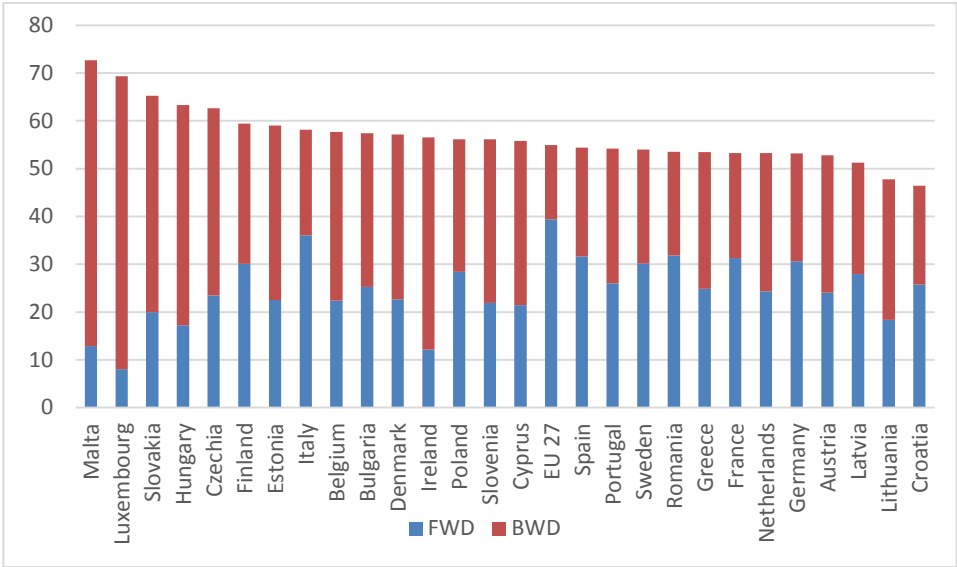


Source: Authors' own elaboration.

3. Research methodology

To answer the research questions, we designed and conducted a study using secondary data for all 27 EU member states as examples of developed economies. As Figure 2 shows, EU countries are characterized by different intensities and patterns of GVC participation, typically with a predominance of backward GVC linkages over forward ones.

**Figure 2.** Average backward (BWD) and forward (FWD) GVC participation of EU countries in 2008-2020, % of gross exports



Source: Authors' own calculation based on TIVA OECD (2023).

Thus, to better understand the nuances of the impact of GVCs on EU business innovation, we examine the relationships in three perspectives: (1) for all 27 EU countries, to answer the RQ1, (2) dividing countries into subgroups of lower and higher BERD countries to answer the RQ2, and (3) subgroups of “old” and “new” EU countries to answer the RQ3. Details of the division of countries into subgroups are given in Table 1.

**Table 1.** Subgroups of the EU countries investigated

| Countries with higher BERD | Countries with lower BERD | “Old” EU countries         | “New” EU countries         |
|----------------------------|---------------------------|----------------------------|----------------------------|
| Estonia (0.80%)            | Cyprus (0.16%)            | Austria, Belgium, Denmark, | Bulgaria, Croatia, Cyprus, |
| Hungary (0.89%)            | Latvia (0.17%)            | Finland, France, Germany,  | Czechia, Estonia, Hungary, |
| Czechia (0.98%)            | Romania (0.21%)           | Greece, Ireland, Italy,    | Latvia, Lithuania, Malta,  |
| Ireland (0.98%)            | Lithuania (0.30%)         | Luxembourg, Netherlands,   | Poland, Romania,           |
| Netherlands (1.23%)        | Slovakia (0.35%)          | Portugal, Spain, Sweden    | Slovakia, Slovenia         |
| France (1.42%)             | Malta (0.37%)             |                            |                            |
| Slovenia (1.56%)           | Greece (0.38%)            |                            |                            |
| Belgium (1.74%)            | Croatia (0.41%)           |                            |                            |
| Denmark (1.93%)            | Bulgaria (0.43%)          |                            |                            |
| Germany (1.98%)            | Poland (0.48%)            |                            |                            |
| Austria (2.05%)            | Spain (0.69%)             |                            |                            |
| Finland (2.17%)            | Portugal (0.69%)          |                            |                            |
| Sweden (2.31%)             | Italy (0.77%)             |                            |                            |
|                            | Luxembourg (0.78%)        |                            |                            |

Note: In brackets – average for years 2008–2020, BERD as a share of GDP.

Source: Authors’ own elaboration.

The research period covers the years 2008–2020, and data are taken from publicly available Eurostat and OECD databases. Cross-country analyses of the GVCs and innovation have also been undertaken in other studies (Caliari et al., 2023). With a macro-panel dataset at our disposal, we applied macro-panel regressions. As the dependent variable, we adopted business enterprise expenditure on research and development (BERD), being the commonly accepted measure of companies’ innovativeness (Elshaarawy & Ezzat, 2023; Yang & Wang, 2024). As independent variables, we included the decomposition of GVCs, namely the backward (BWD) and forward participation in GVCs (FWD).

Using the OECD Trade in Value Added (TIVA) database,<sup>4</sup> we calculated forward (FWD) and backward (BWD) GVC linkages according to the following formulas:

$$FWD = \frac{DVX}{\text{Gross Exports}} * 100\%, \quad (1)$$

$$BWD = \frac{FVA}{\text{Gross Exports}} * 100\%, \quad (2)$$

where:

DVX – indirect domestic value added in gross exports; indirect value added (DVX) is the domestic value-added in intermediate goods further re-exported by the partner country; DVX captures the contribution of the domestic sectors to the

<sup>4</sup> <https://www.oecd.org/en/topics/sub-issues/trade-in-value-added.html>

exports of other countries and indicates the extent of involvement in forward GVC linkages (Nenci, 2020).

*FVA* – foreign value added in gross exports, the share of which indicates the extent of involvement in backward GVC linkages.

We controlled our models with three macroeconomic variables: the government expenditure (GE), gross domestic product per capita (GDP), and the share of people with higher education (HE). The first one, government expenditure, shows the level of public engagement in the economy by indicating the overall amount of public spending. The importance of public involvement in the country's innovation system is an element of the innovation helix concept, which, in its most well-known triple helix approach, assumes that innovations are created through the cooperation of three entities: industry, government, and university (Zakaria et al., 2024). The role of government in the triple helix is multidimensional, including direct public demand, supporting private demand, and regulatory functions. To reflect this, we have included total government spending as a control variable (Gachie, 2020). This control variable is in line with the approach in other studies to control GVC models by the type of government expenditure important for the investigated context (Caliari et al., 2023; Yang et al., 2020).

The second control variable was gross domestic product per capita (GDP), which reflected the overall economic conditions as may affect business investment in R&D. The level of economic development, often measured by GDP per capita, impacts innovation (K. Xu et al., 2024) and is often used as a control variable in GVC models (Caliari et al., 2023; S. Xu et al., 2024). To reflect the diversity of EU countries, we have adopted a relative measure that shows the GDP per capita of a given EU country as a percentage of the total GDP per capita of all 27 EU countries.

The third control variable, the share of the population with higher education, reflected the level of human capital as a significant predictor of innovation (Del-Aguila-Arcentales et al., 2023). Additionally, human capital is recognized as interacting with GVCs (Qian et al., 2022).

The explanations of all variables, together with descriptive statistics of the raw data, are presented in Table 2.

**Table 2.** List of variables, their measurement, and descriptive statistics of raw data for 2008-2020

| Variable                               | Abbreviation | Explanation                                                                                                                                     | Mean  | Standard deviation | Minimum | Maximum |
|----------------------------------------|--------------|-------------------------------------------------------------------------------------------------------------------------------------------------|-------|--------------------|---------|---------|
| <b>Dependent variables</b>             |              |                                                                                                                                                 |       |                    |         |         |
| Business enterprise expenditure on R&D | BERD         | Business enterprise expenditure on research and development as a percentage of GDP (in %)                                                       | 0.97  | 0.69               | 0.07    | 2.67    |
| <b>Independent variables</b>           |              |                                                                                                                                                 |       |                    |         |         |
| Backward GVC linkage                   | BWD          | Foreign value added in gross exports as a share of gross exports (in %)                                                                         | 32.71 | 10.94              | 18.56   | 66.17   |
| Forward GVC linkage                    | FWD          | Indirect domestic value added in gross exports as a share of gross exports (in %)                                                               | 24.12 | 6.64               | 5.44    | 37.82   |
| <b>Control variables</b>               |              |                                                                                                                                                 |       |                    |         |         |
| Government expenditure                 | GE           | The share of total general government expenditure in gross domestic product (GDP) (in %)                                                        | 45.67 | 6.86               | 24.3    | 64.9    |
| Higher education                       | HE           | Percentage of population aged 25-64 with tertiary education (levels 5-8)                                                                        | 29.92 | 8.77               | 12.80   | 49.90   |
| GDP per capita                         | GDP          | Gross domestic product per capita of a country as a percentage of the 27 EU total per capita (EU total=100%), based on purchasing power parity. | 99.85 | 43.69              | 43.10   | 280.20  |

Source: Authors' own elaboration.

We then estimated panel regression models. To control for heteroscedasticity and linearize the relationships, we converted all raw data into natural logarithms (ln). Following the variance inflation factor (VIF) tests, we then estimated the panel regression with the determination of fixed or random effects based on the Breusch–Pagan and Hausman tests. A similar research attitude has also been adopted in other studies in the field (Hu et al., 2022). The initial model was based on the following equation:

$$\ln BERD_{it} = \beta_0 + \beta_1 \ln BWD_{it} + \beta_2 \ln FWD_{it} + \beta_3 \ln GE_{it} + \beta_4 \ln HE_{it} + \beta_5 \ln GDP_{it} + v_{it} \quad (3)$$

After the estimation of the initial model based on equation (3), we tested for heteroscedasticity (Wald test), autocorrelation (Wooldridge test), and cross-sectional dependence (Pesaran CD test) to determine the final estimation tech-

niques. A similar research procedure was applied to the entire sample of 27 EU countries and in two types of subgroups: (1) for countries with relatively higher and lower BERD levels, and (2) for the “new” and “old” EU countries.

4. Research findings

In four out of five initial models, the results of the VIFs tests (Table 3) were below the thresholds of 10, indicating no problems with multi-collinearity. However, the initial model for “old” EU countries (model 4.1) showed multi-collinearity in forward linkages of GVCs (lnFWD). This necessitated the exclusion of this variable and re-estimation of the model (model 4.2), which subsequently showed no multicollinearity.

**Table 3.** Results of the VIF tests for initial models

| Variables | Model 1 | Model 2<br>(countries<br>with higher<br>BERD) | Model 3<br>(countries<br>with lower<br>BERD) | Model 4.1<br>(“old” EU<br>countries) | Model 4.2<br>(“old” EU<br>countries) | Model 5<br>(“new” EU<br>countries) |
|-----------|---------|-----------------------------------------------|----------------------------------------------|--------------------------------------|--------------------------------------|------------------------------------|
| lnBWD     | 3.980   | 4.834                                         | 4.921                                        | 8.674                                | 1.999                                | 3.589                              |
| lnFWD     | 5.393   | 5.393                                         | 6.807                                        | 12.307                               | –                                    | 3.416                              |
| lnGE      | 1.455   | 1.657                                         | 1.263                                        | 1.887                                | 1.283                                | 1.043                              |
| lnHE      | 1.310   | 1.289                                         | 1.292                                        | 1.324                                | 1.323                                | 1.182                              |
| lnGDP     | 1.774   | 1.927                                         | 2.224                                        | 2.424                                | 2.125                                | 1.666                              |

Source: Authors’ own elaboration.

The results of the Breusch–Pagan and Hausman tests indicate that, for all estimated models, the appropriate estimation method is panel regression with fixed effects. The Wald, Wooldridge, and Pesaran CD tests indicated issues with heteroscedasticity, autocorrelation, and cross-sectional dependence in Models 1, 3, 4.1, and 4.2, while Models 2 and 5 exhibited heteroscedasticity and autocorrelation. To address these issues, we applied Driscoll–Kraay standard errors in Models 1, 3, 4.1, and 4.2, and clustered robust standard errors in Models 2 and 5. Full details are provided in Table 4.

**Table 4.** Results of models' estimations with innovativeness of companies (lnBERD) as a dependent variable

| Variable                     | Model 1                                                     | Model 2 (countries with higher BERD)                   | Model 3 (countries with lower BERD)                         | Model 4.1 ("old" EU countries)                            | Model 4.2 ("old" EU countries)                            | Model 5 ("new" EU countries)                                |
|------------------------------|-------------------------------------------------------------|--------------------------------------------------------|-------------------------------------------------------------|-----------------------------------------------------------|-----------------------------------------------------------|-------------------------------------------------------------|
| <i>I</i>                     | 2                                                           | 3                                                      | 4                                                           | 5                                                         | 6                                                         | 7                                                           |
| Constant                     | $\beta = -13.12^{***}$<br>DKSE = 2.47<br>CI (-18.19; -8.05) | $\beta = -8.57^*$<br>CRSE = 3.22<br>CI (-15.58; -1.55) | $\beta = -13.09^{***}$<br>DKSE = 3.16<br>CI (-19.92; -6.27) | $\beta = 4.81^{**}$<br>DKSE = 1.46<br>CI (1.66; 7.96)     | $\beta = 6.23^{**}$<br>DKSE = 1.59<br>CI (2.79; 9.67)     | $\beta = -12.56^{***}$<br>CRSE = 2.78<br>CI (-18.62; -6.50) |
| <b>Independent variables</b> |                                                             |                                                        |                                                             |                                                           |                                                           |                                                             |
| lnBWD                        | $\beta = 1.58^{***}$<br>DKSE = 0.35<br>CI (0.87; 2.30)      | $\beta = 1.07^*$<br>CRSE = 0.36<br>CI (0.29; 1.85)     | $\beta = 1.68^{**}$<br>DKSE = 0.47<br>CI (0.67; 2.70)       | $\beta = 0.56^{**}$<br>DKSE = 0.16<br>CI (0.20; 0.91)     | $\beta = 0.48^{**}$<br>DKSE = 0.14<br>CI (0.17; 0.78)     | $\beta = 1.54^{**}$<br>CRSE = 0.39<br>CI (0.69; 2.39)       |
| lnFWD                        | $\beta = 0.09$<br>DKSE = 0.16<br>CI (-0.23; 0.40)           | $\beta = -0.03$<br>CRSE = 0.24<br>CI (-0.55; 0.49)     | $\beta = -0.01$<br>DKSE = 0.27<br>CI (-0.60; 0.57)          | $\beta = 0.14$<br>DKSE = 0.11<br>CI (-0.10; 0.39)         |                                                           | $\beta = -0.79^*$<br>CRSE = 0.35<br>CI (-1.55; -0.03)       |
| <b>Control variables</b>     |                                                             |                                                        |                                                             |                                                           |                                                           |                                                             |
| lnGE                         | $\beta = 0.56^{***}$<br>DKSE = 0.15<br>CI (0.26; 0.86)      | $\beta = 0.58^*$<br>CRSE = 0.21<br>CI (0.13; 1.03)     | $\beta = 0.30$<br>DKSE = 0.28<br>CI (-.30; 0.89)            | $\beta = -0.46^*$<br>DKSE = 0.16<br>CI (-0.79; -0.12)     | $\beta = -0.44^*$<br>DKSE = 0.15<br>CI (-0.76; -0.12)     | $\beta = 0.86^*$<br>CRSE = 0.28<br>CI (0.24; 1.48)          |
| lnHE                         | $\beta = 0.60^{***}$<br>DKSE = 0.06<br>CI (0.48; 0.72)      | $\beta = 0.51^*$<br>CRSE = 0.21<br>CI (0.04; 0.97)     | $\beta = 0.61^{***}$<br>DKSE = 0.10<br>CI (0.40; 0.83)      | $\beta = 0.07$<br>DKSE = 0.11<br>CI (-0.16; 0.31)         | $\beta = 0.03$<br>DKSE = 0.13<br>CI (-0.24; 0.30)         | $\beta = 0.77^*$<br>CRSE = 0.27<br>CI (0.19; 1.34)          |
| lnGDP                        | $\beta = 0.65^*$<br>DKSE = 0.24<br>CI (0.15; 1.14)          | $\beta = 0.28$<br>CRSE = 0.50<br>CI (-0.82; 1.38)      | $\beta = 0.75^{**}$<br>DKSE = 0.24<br>CI (0.22; 1.28)       | $\beta = -1.14^{***}$<br>DKSE = 0.14<br>CI (-1.44; -0.84) | $\beta = -1.27^{***}$<br>DKSE = 0.14<br>CI (-1.57; -0.97) | $\beta = 0.71$<br>CRSE = 0.44<br>CI (-0.25; 1.66)           |
| <b>Fit statistics</b>        |                                                             |                                                        |                                                             |                                                           |                                                           |                                                             |
| Breusch-Pagan test           | $\chi^2(1) = 1118.75$ ,<br>$p < 0.001$                      | $\chi^2(1) = 223.93$ ,<br>$p < 0.001$                  | $\chi^2(1) = 328.31$ ,<br>$p < 0.001$                       | $\chi^2(1) = 508.08$ ,<br>$p < 0.001$                     | $\chi^2(1) = 515.81$ , $p < 0.001$                        | $\chi^2(1) = 459.24$ ,<br>$p < 0.001$                       |
| Hausman test                 | $\chi^2(5) = 36.21$ ,<br>$p < 0.001$                        | $\chi^2(5) = 31.23$ ,<br>$p < 0.001$                   | $\chi^2(5) = 27.18$ ,<br>$p < 0.001$                        | $\chi^2(5) = 25.92$ ,<br>$p < 0.001$                      | $\chi^2(4) = 24.07$ ,<br>$p < 0.001$                      | $\chi^2(5) = 13.30$ ,<br>$p = 0.021$                        |
| Wald test                    | $\chi^2(27) = 4682.41$ ,<br>$p = 0$                         | $\chi^2(13) = 893.65$ ,<br>$p = 0$                     | $\chi^2(14) = 828.15$ ,<br>$p = 0$                          | $\chi^2(14) = 2215.72$ ,<br>$p = 0$                       | $\chi^2(14) = 2124.23$ ,<br>$p = 0$                       | $\chi^2(13) = 425.85$ ,<br>$p = 0$                          |

Table 4 cont.

| 1                     | 2                                   | 3                                 | 4                                  | 5                                  | 6                                | 7                                 |
|-----------------------|-------------------------------------|-----------------------------------|------------------------------------|------------------------------------|----------------------------------|-----------------------------------|
| Wooldridge test       | F(1, 26) = 215.11, p < 0.001        | F(1, 12)=119.33, p<0.001          | F(1, 13)=132.01, p<0.001           | F(1, 13) = 40.66, p < 0.001        | F(1, 13) = 40.83, p < 0.001      | F(1, 12) = 178.17, p<0.001        |
| Pesaran CD test       | z = 3.77, p < 0.001                 | z = -0.17, p = 0.87               | z = 2.91, p = 0.004                | z = 3.67, p < 0.001                | z = 3.33, p < 0.001              | z = -0.75, p = 0.46               |
| Effects               | fixed                               | fixed                             | fixed                              | fixed                              | fixed                            | fixed                             |
| No. of countries      | 27                                  | 13                                | 14                                 | 14                                 | 14                               | 13                                |
| No of obs.            | 351                                 | 169                               | 182                                | 182                                | 182                              | 169                               |
| Within R <sup>2</sup> | 0.38                                | 0.33                              | 0.41                               | 0.25                               | 0.25                             | 0.58                              |
| F                     | F(5, 26) = 301.09, Prob > F = 0.000 | F(5, 12) = 8.00 Prob > F = 0.0016 | F(5, 13) = 54.64, Prob > F = 0.000 | F(5, 13) = 35.19, Prob > F = 0.000 | F(4, 13) = 44.85, Prob>F = 0.000 | F(5, 12) = 78.88 Prob > F = 0.000 |

Note: \*\*\* p < 0.001, \*\* p < 0.01, \* p < 0.05; DKSE – Driscoll–Kraay standard errors; CRSE – clustered robust standard errors; CI – 95% confidential interval.  
Source: Authors’ own elaboration.

The estimation results of Model 1, which answer the research question RQ1, indicate that, at the macro-level, backward GVC linkages positively impact the innovativeness of companies in the EU countries ( $\beta = 1.58^{***}$ , H1 supported). In contrast, forward GVC linkages are statistically insignificant in explaining innovativeness (H2 rejected). The increase in backward GVC linkages affects the rise in business innovativeness measured by companies' R&D spending.

When comparing subgroups of the EU countries, with Models 2 and 3 referring to the research question RQ2, we found a stronger impact of backward GVC participation on innovation in the countries with relatively lower level of BERD (Model 3,  $\beta = 1.68^{**}$ ) than in countries with relatively higher level of BERD (Model 2,  $\beta = 1.07^*$ , H3 supported). In contrast, the forward GVC participation was insignificant in both subgroups (H4 rejected).

For subgroups of the EU countries based on the length of membership, and Models 4.2 and 5 answering the research question RQ3, the differences are even more pronounced. The influence of backward GVC participation on BERD in "old" EU countries is three times weaker (Model 4.2,  $\beta = 0.48^{**}$ ) compared to "new" EU countries (Model 5,  $\beta = 1.54^{**}$ , H5 supported). The subgroup of "new" EU countries is the only one where forward GVC participation is significant in explaining business innovation (Model 5,  $\beta = -0.79^*$ ); however, the highest forward participation reduces the innovation (H6 rejected).

## 5. Discussion

This study aimed to investigate how participation in GVCs, particularly through backward and forward linkages, influences the innovativeness of businesses across EU countries. By decomposing GVC engagement and analyzing differences across subgroups defined by innovation capacity and EU membership duration, we provide a nuanced understanding of how international integration shapes innovation outcomes in varying national contexts.

Answering RQ1, our results confirm the positive impact of companies' backward participation in GVCs at the macro-level on their innovativeness, which supports H1, and find no statistically significant impact of forward participation in GVCs of EU companies at the macro-level on their innovativeness, which rejects H2.

When addressing RQ2, we investigated how a country's level of innovativeness influences the relationship between backward and forward GVC participation and company innovativeness. Our results confirm that the positive im-

impact of companies' backward participation in GVCs on their innovativeness at the macro level is stronger in countries with lower levels of innovativeness, supporting H3. However, since the impact of forward GVC participation was statistically insignificant in both groups of countries, these results suggest rejecting H4.

In research question RQ3, we aim to assess the impact of the duration of EU membership on the relationship between involvement in backward and forward linkages in GVCs and company innovation. By comparing the results of the two subgroups of countries, "old" and "new" EU members, we confirmed that the effect of backward GVC participation is significantly stronger in "new" EU countries, supporting H5. However, we did not find support for H6, as the impact of forward GVC participation is statistically insignificant in the subgroup of "old" EU countries. At the same time, it negatively affects innovativeness in the "new" EU countries.

About previous results confirming the positive impact of total GVC participation on high-tech in relatively higher-income countries (Altun et al., 2023), we found the significance and positive effect of only backward GVC linkages on business innovativeness in EU countries. Thus, for the sample researched, we cannot confirm that "both types of GVC participation are conducive to knowledge spillovers" (Piermartini & Rubínová, 2021), identifying only backward GVC participation, positively and significantly influencing the innovativeness of European businesses. In contrast to Fagerberg et al. (2018), whose study was conducted across all countries of the world, at the EU level, we find a positive relationship between backward GVC participation and innovation capabilities, expressed as the share of BERD in GDP.

Contrary to some other research (Hu et al., 2022; Ito et al., 2023), we did not find evidence of an impact of forward GVC linkages on innovation, while we confirmed the positive impact of backward GVC linkages on the innovativeness of European businesses. However, our results are in line with other studies showing no significant effect of forward GVC participation on EU countries' exports (Guei, 2021).

Our results contribute to research and theory by confirming the need to separately investigate the effects of backward and forward participation, as decomposed GVC linkages, on companies' innovativeness, as well as the importance of country-specific characteristics in shaping these relationships. As the difference between our study and other studies (Hu et al., 2022; Ito et al., 2023) relates to the country investigated (China, Japan versus EU countries), this confirms the importance of the national context, as well as the diversity of innovation in GVCs (Buciuni & Pisano, 2021).

Given that high-income EU countries dominate the study sample, the results are consistent with findings showing the positive impact of backward GVC linkages on the innovativeness of later-stage countries (Mehta, 2022). The context of countries is also important from the perspective of integration within the EU single market, considered to be significant for the development of GVCs (Kersan-Škabić, 2019).

If we regard countries with higher BERD intensity and longer membership in the EU as relatively more developed, compared to the "new" EU countries and countries with a relatively lower share of BERD in GDP, our results confirm a greater upgrading effect from backward linkages for catching up countries (Tian et al., 2022; Veeramani & Dhir, 2022). The most significant difference in the strength of backward GVC participation effect on business innovation for the countries of "old" and "new" Europe confirms the peculiarities of Central and Eastern Europe as a specific group of countries with a relatively lower level of development (Grodzicki & Geodecki, 2016). Our results contrast with the previous studies, which found no difference in the innovation-economic development nexus between "old" and "new" members of the EU (Kacprzyk & Doryń, 2017).

Once more, our results are in line with those that find forward GVC participation statistically insignificant (Kim & Seo, 2025), which applies to both relatively more and less developed countries. However, consideration of the institutional component may change the game, since it is exclusive to the group of newer EU countries (EU-13). The impact of forward GVC linkages on BERD is statistically significant, though negative. A possible explanation for this may lie in the evidence that intensive forward GVC linkages, accompanied by a relatively lower share of foreign value added and a respective higher share of domestic value added in exports, are associated with upstream GVC position. One of the EU-level studies characterizes such a model of GVC involvement as "GVC suppliers," attributing it mainly to the supply of basic resources (including energy) to a broad market (Capello et al., 2023). It is known that such types of activity lead to the formation of relatively short domestic value chains and do not provide significant upgrading opportunities (Gereffi, 2019).

## 6. Conclusions

### 6.1. Main findings

Our study aimed to assess whether and how the backward and forward GVC linkages affect the innovativeness of companies at the EU macro level (RQ1) and how an EU country's level of innovativeness (RQ2) and length of EU mem-

bership (RQ3) affect the relationship between backward and forward GVC participation and company innovation at the macro level.

Our research found that GVC backward linkages have a positive impact on the innovativeness of businesses in EU countries, while the impact of GVC forward linkages is statistically insignificant. Backward GVC participation has a stronger effect on innovation in countries with relatively lower levels of innovation than in those with relatively higher levels. It suggests that countries with weaker innovation systems may experience greater dependence on external knowledge but struggle to internalize it for positive innovation outcomes. When examining subgroups based on the length of EU membership, the differences become even stronger. In “old” EU countries, the effect of backward GVC participation on BERD is three times weaker compared to “new” EU countries. These results provide insights into the discussion on the role of economic integration and institutional maturity in shaping innovation outcomes. Notably, the subgroup of “new” EU countries is the only one where forward GVC participation significantly explains business innovation, but its effect is adverse, reducing innovation. This challenges the view of participation in GVCs, as forward participation in GVCs may hinder rather than support innovation. This finding calls for further research on policies that could mitigate such adverse effects, for example, by strengthening local innovation ecosystems.

## 6.2. Implications for research and theory

The novelty of our research lies in examining the decomposition of GVC participation and its impact on the innovativeness of developed countries. Developing economies are more likely to reap the benefits of GVC participation for innovation (Elshaarawy & Ezzat, 2023; Guei, 2021). To date, studies have discussed backward GVC participation more in the context of developing countries as an opportunity to learn through inputs of import, while forward GVC participation in the context of developed countries has been seen as an upgrading effect (Tian et al., 2022). In contrast, we found the positive effect of backward GVC participation on the innovativeness of EU businesses, which confirms the importance of learning from suppliers and access to new technologies (Grodzicki, 2018). Learning from buyers and access to world markets as the main features of forward GVC participation (Grodzicki, 2018) seem to have no significant impact on the innovativeness of EU businesses.

The negative impact of forward GVC linkages is statistically significant for only newer EU countries (EU-13) and requires further examination, since this component is relatively under-researched at the EU level. It points to the need to

consider institutional aspects in GVC studies (Eckhardt & Poletti, 2018), which, as has been shown, may be even more important than divergences in terms of innovation development.

Our contribution is also related to the understanding of the nuances of the benefits of global production networks for innovation development and the need for a context-dependent approach to investigations. Our results confirm the need to consider the decomposition of GVCs and examine the impact of backward and forward GVC linkages on economies separately. We also indicate the need to include the context of a country's level of development and institutional differences as a significant aspect of the economic impact of GVC participation.

### **6.3. Practical implications**

The political implications refer to the need for tailored country-specific innovation strategies, as the impact of backward GVC participation varies across EU countries. In less innovative nations, enhancing absorptive capacity can help firms better integrate foreign knowledge. In contrast, in more innovative countries, the weaker effect of backward GVC participation indicates that domestic capabilities and R&D investments play a greater role in sustaining innovation. The differences in these relationships between “old” and “new” EU countries suggest stronger domestic innovation ecosystems and higher levels of technological self-sufficiency in “old” EU countries.

### **6.4. Limitations and further research**

As our research focuses on the macro level, its limitation lies in not accounting for industry-specific differences or company-level interactions. Further research should take a more detailed approach, examining the industry- and company-level perspective on the relationship between GVC participation and innovation. At the sectoral level, there is a need to delve deeper into the influence of industries' technological intensity and their dependence on global supply chains in shaping the backward and forward GVC participation impact on innovation in high-tech, medium-tech, and low-tech sectors. At the company level, further research should investigate how firm size, R&D intensity, and export activity moderate the GVC-innovation nexus. The differences in effects across subgroups of EU countries also suggest the need to examine how national innovation policies, institutional quality, and government support shape the effects of GVC participation on innovation.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

## Authors contribution

**Aleksandra Gawel** – 50% (research concept and design; collection and/or assembly of data; data analysis and interpretation; writing the article; critical revision of the article, final approval of the article).

**Oleksandr Patlatoi** – 50% (research concept and design; collection and/or assembly of data; data analysis and interpretation; writing the article; critical revision of the article, final approval of the article).

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