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An Exploration of the Importance of Financial System in Promoting Green Global Value Chain Management: Insights from Global Sample

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ABSTRACT

Green global value chain (GGVC) plays a critical role in minimizing the overall ecological influences, and this article explores the role of financial systems. This paper empirically analyses the impacts of financial development (FD) on green global value chain (GGVC) management. We employ five aspects of green global value chain index score (GLIScore), including Customs Score (*GGVC_CS*), Infrastructure Score (*GGVC_IS*), International Shipments Score (*GGVC_ISS*), and Logistics Competence and Quality Score (*GGVC_LCQ*), Timeliness Score (*GGVC_TLS*), and Tracking and Tracing Score (*GGVC_TS*). Financial development encompasses the composite financial development index (*FD_FD*), financial institutions' development (*FD_FI*), financial markets' development (*FD_FM*), and the depth, accessibility, and efficiency of financial institutions and financial markets. Different econometric techniques are utilized in a database of 51 developing and 24 developed countries from 2001 to 2021. Our estimation results demonstrate that countries implementing FD play a critical role in managing the GGVC, especially the composite FD and financial market development activities. Furthermore, promoting the development of depth, access, and efficiency of financial markets and financial institutions has the potential to contribute significantly to the effectiveness of GGVC management, especially in promoting in-depth development. For further discussion on the role of FD, we reveal the short-run and long-run effects of FD_FD, FD_FI, and FD_FM on GGVC and compare the influence of FD on GGVC. The results suggest that the FD nexus is more likely to exist in the long run. Notably, promoting FD will enormously enhance GGVC performance in all aspects in developed and developing countries, highlighting GGVC's performance in developing countries.

Keywords: *financial development, global sample, global uncertainty, green global value chain*

1. INTRODUCTION

Today, the globe is facing major problems in the fields of environmental, social, and economic issues. Reduced economic inequality, climate change management, poverty alleviation, and the ongoing threat of pandemics all demand primary financial expenditures and resources (Pizzi *et al*., 2022). The global economic crisis, aggravated by the COVID-19 pandemic, has increased global financial limitations. Isolation and lockdowns have created uncertainty about economic and production outputs, while the continuous deficiency in sustainable financial policies poses a vital issue (Iqbal *et al*., 2021). As a result, examining the influence of financial development (FD) and other socioeconomic factors on long-term economic development (SED) is critical.

The term "Green Global Value Chain" (GGVC) is defined differently. Reverse logistics, lowering carbon emissions, and improving the environmental aspects of supply chain operations are all combined into what Abukhader & Jönson (2004) call the GGVC. The management of information and material mobility to achieve economic growth while considering the interests of all stakeholders and maintaining environmental sustainability is what Seuring & Müller (2008) referred to as GGVC. According to Sbihi & Eglese (2010), GGVC refers to the environmentally and socially responsible production and delivery of goods. The GGVC, according to Dekker *et al*., (2012), is a sustainable strategy that aims to balance social, environmental, and economic concerns to lessen the environmental impact of logistical operations. The GGVC is regarded as a management style by Pazirandeh & Jafari (2013). They define the management of the GGVC as resource conservation, waste reduction, operational effectiveness enhancement, and compliance with public demands for environmental protection. According to Jedliński (2014), GGVC refers to coordinating all activities required to move a good or service through the supply chain while minimizing global costs and meeting customer expectations (such as air pollution, noise pollution, accidents, and climate change). However, as stated by Blanco & Sheffi (2017), GGVC refers to determining, assessing, and eventually lessening the environmental impact of logistics services. Implementing sustainable logistics practices, such as using greener packaging and routing, is the other definition (Fahimnia *et al*., 2015). Diverse definitions of GGVC arise because different researchers assess logistics from different angles. Notably, there are differences between production, distribution, storage, recycling, and packaging in terms of the sources of pollution, and there are variations in the definition of GGVC

depending on the viewpoint. As a result, the recommendations across studies are not always aligned. This variation highlights the need to interpret each study's findings within its specific definitional context.

The GGVC management (GGVCM) is to minimize the overall ecological influences of both forward and reverse flows through internal as well as external management (Feng *et al*., 2018). This is accomplished through the use of internal GGVCM and external GGVCM practices. Some GGVCM techniques, nevertheless, do not result in enhanced business efficiency. The findings from investigations on the association between GGVCM and business efficiency have been uneven, sporadic, and occasionally contradictory. A recently published meta-analysis by Golicic & Smith (2013) found that GGVCM had minimal beneficial benefits on businesses' financial results, and those beneficial impacts were less than the influence of GGVCM on functional and market-based efficiency. This clarifies why numerous executives are suspicious about the economic advantages of GGVCM (Preuss, 2005).

Despite several counterarguments and significant studies on the subtle influence of FD on economic growth, the agreement on the FD-growth nexus remains prevalent. Notably, the banking industry has a significant impact on long-term growth, which can be achieved via altering investment decisions, technical innovation, and savings rates (Levine, 2005). FD, facilitated by banks or equity markets, catalyzes economic development, as evidenced by the accumulation and consolidation of savings and intentional resource allocation to businesses predicted to provide beneficial economic consequences (Beck and Levine, 2004). Simultaneously, both micro- and macro-prudential rules play an important role in long-term economic growth by funding structural reforms for environmentally conscious societies.

However, there is a scarcity of information in the available literature on the influence of FD on GGVC practices in both developing and developed countries. Due to lower savings rates, many nations face difficulty in raising and accessing capital, limiting capital availability and creating allocation concerns across industries. Despite the need to switch to cleaner industrial techniques to support GGVC practices, many tasks still require investment. Because of antiquated technical setups, the developing nations' reliance on agriculture contributes to growing air and water pollution (IPCC, 2014). In this context, financial inclusion is critical, particularly in many poor nations where major climate change catastrophes hurt health and general well-being. The present article tackles four research concerns in light of this research gap: (1) How does the efficiency of the financial system contribute directly to improved GGVC implementation? (2) Are there differences in the effect of financial development on GGVC participation between developed and developing countries? (3) How does financial system development influence GGVC implementation in the short run versus the long run, and what are the dynamic effects over time? (4) What are the government's policies in promoting the use of financial systems in enhancing the GGVC?

The present article expands on prior work by elucidating the impact of FD on GGVCM. Some theoretical advances could be achieved by clarifying whether financial performance is directly or indirectly responsible for GGVCM practices. It clarifies whether prior studies' incoherent and unclear empirical results are influenced by how GGVCM structures are evaluated. In this paper, we employ diverse econometric techniques to an international database extracted from the World Bank (2024a, 2024b, 2024c) and the International Monetary Fund (2024) during the 2000-2021 period. To measure FD in this study, we take nine factors from the Financial Development Index database. In this research, we consistently use the panel-corrected standard errors (PCSE) model after tests demonstrating our dataset's cross-sectional dependence (Beck & Katz, 1995). We also employ the feasible generalized least square estimates (FGLS) model, which accounts for heteroscedasticity and fixed effects (Greene, 2003), and the two-step generalized method of moment (two-step GMM), which addresses endogeneity resulting from financialization and GGVC performance variables, to guarantee the precision and robustness of our findings (Hansen, 1982). To address endogeneity even more, the model's independent variables are all one year behind. The lag-pooled mean group autoregressive distributed lag (PMG-ARDL) approach is also taken into consideration in order to evaluate the long- and short-term effects of financialization on the performance of the GGVC (Pesaran *et al*., 1999). Three subsamples classified by income levels and particular types of GGVC performance are subjected to a parallel empirical analysis in order to shed light on the connection between financialization and GGVC performance.

2. THEORETICAL FRAMEWORK AND HYPOTHESES DEVELOPMENT

2.1 The Definition of GGVCM

It has become increasingly common for academics and corporations to study sustainable logistics management (Silva *et al*., 2023; Tetteh *et al*., 2024). Sustainable logistics administration is logistics administration that takes into account the economic, ecological, and social standards that every member of the logistics must meet. This reasoning is consistent with the notion of long-term viability and the triple bottom line (TBL) (Elkington, 1997), which give metrics of company durability about the economy, society, and the environment. To achieve sustainable logistics, these dimensions should be incorporated throughout the entire process (Pagell & Wu, 2009). Nevertheless, evaluating all three aspects concurrently across the supply chain is problematic (Pagell & Wu, 2009). Regardless of the inherently complicated nature of the idea of sustainability, it has been suggested that from a logistics viewpoint, the concern for executives and scholars to resolve ought not to be whether to become truly environmentally-friendly (through every TBL measurement), but to employ TBL to gauge progress towards being truly sustainable as the ultimate goal (Pagell & Wu, 2009).

GGVCM refers to maintaining an organization's internal environmental management practices as well as its external environmental management initiatives, which are considered subsets of sustainable supply chain management. This approach emphasizes cooperation across functions as well as with customers and suppliers. Within an organization, suitable managerial procedures and initiatives that collaborate with end-users and upstream vendors

increase the preservation of the environment. The procedures of collaborators in the logistics are essential to GGVCM, through interactive logistics and attempts, namely green buying implemented in supply exchanges between producers, vendors, and consumers, with cross-functional collaboration to achieve the most significant possible advantages over time in which eventually, companies reap the advantages of environmental governance when the supply chain operates coherently. Therefore, GGVCM must be integrated beyond organizational departments, and ecological procedures must be done via cooperation.

In our research, we define GGVCM as an individual dimensional structure that includes cross-functional collaboration for long-term enhancements as well as collaborative engagement with consumers and vendors. According to Zhu and Sarkis (2004) and Zhu *et al*., (2008a), most academics operationalize GGVCM by separating it into both inside and outside organizational concepts. Despite the fact that annotated and outside environmental management practices are closely linked, this approach clarifies the distinct influence of both inside and outside environmental administration. Because all GGVCM activities ought to support each other and thus be a vital element of a firm's ecological governance practices, a single GGVCM framework is necessary. To optimize the use of environmental information, a concerted set of GGVCM practices is required (Solér *et al*., 2010). Furthermore, creating trust along the whole supply chain is the only way to mitigate risk in a supply chain with ecological difficulties.

2.2 Review of Empirical Studies

To investigate the drivers of an integrated GGVCM, this article explores the role of financial systems. FD plays a critical role in boosting this trend. Like other sectors, FD is a complex concept defined in diverse ways. The most widely acknowledged definition is the one provided by Kpodar & Guillaumont (2006), based on the definition of the Department of International Development. According to Kpodar & Guillaumont (2006), a developed financial system has the following characteristics: (i) accumulation of financial assets, (ii) diversification of financial assets and institutions, (iii) improved effectiveness and competitiveness of financial system, (iv) financial inclusion. There are three plausible reasons to believe that FD is important for countries with these characteristics worldwide. The first is the diversification of both institutions and financial instruments, which is a condition that determines the risk level of the system. Risks in the financial system can decrease investor confidence, thus preventing trade termination between members in the GGVC. Second, the financial system promotes international trade transactions between consumers and sellers. To implement GGVCM, cross-border businesses must have a foreign account or an account approved by an official financial institution with international agents. The third reason is that upgrading technology enhances financial access from the financial system if it is sufficiently diversified in financial instruments and institutions to reach a wide range of investors with different characteristics. This article will show some theories and literature on the importance of FD in influencing the decision to participate in the GGVCM of countries.

There are multiple directions in which research in the field of GGVC is evolving. Numerous scholarly works examine the implications of GGVC within a sustainable supply chain framework and consider this. Accordingly, the development of green supply chains depends primarily on the GGVC (Singh and Trivedi, 2016; Fahimnia *et al*., 2015). The terms "GGVC" and "green supply chain management" are not universally agreed upon. However, it generally involves incorporating environmental consciousness into all the stages of supply chain management, from product creation to raw material procurement, production, shipment of final products, and recycling of used goods (Srivastava, 2007). Data are the basis for the majority of studies. For instance, Geng *et al*., (2017) examined the impact of environmentally friendly supply chain management, focusing on developing Asian economies. They explored the relationship between the implications of GGVC and the FD of firms through meta-analysis. They concluded that the development of businesses' economies is correlated with the adoption of green supply chains. Another example is the study conducted in 2005 by Rao and Holt, which examined how applications of green supply chains affected socioeconomic and environmental metrics for South Asian economies. According to the researchers, green supply chain management and practices boost competitiveness. Similarly, Oberhofer and Dieplinger (2014) regard the GGVC as an integral component of sustainable supply chains.

The literature's other group studies have concentrated on the connection between firms' economic development and GGVC techniques. Lai and Wong (2012), for example, concentrated on how GGVC affects financial results. To illustrate economic success, they employed the activities of Chinese manufacturing firms. The study revealed a strong association between GGVC and financial performance. They concluded that exporters are more competitive and that a GGVC reduces carbon emissions. Nevertheless, Boukherroub *et al*., (2015) demonstrated that businesses that mitigate the adverse influences of carbon dioxide from logistics improved their financial performance, the opening up of new markets, and the preservation of the environment.

Additional studies that comprise the body of literature address the GGVC on a national scale. These studies look at the connection between different measures of economic development and the GGVC. It is widely acknowledged that using GGVC techniques boosts a nation's economic development (Yu & Zhu, 2023). In order to demonstrate this, Zaman and Shamsuddin (2017) looked into the relationship between some indicators of economic development and logistic performance using the GMM method. They discovered that enhanced logistics efficiency and economic expansion are positively correlated. They also proposed that a cleaner logistics infrastructure would decrease emissions in 27 European countries. Khan *et al*., (2018) looked at the correlation between economic development and GGVC indicators for a subset of 15 countries between 2007 and 2015. According to their argument, a GGVC plays a significant role in economic expansion. They also proposed the link between increased emissions and unfavorable economic outcomes and the declining performance of the GGVC.

In contrast, Wang *et al*., (2018) conducted a thorough investigation to determine how GGVC affected international trade. The study analyzed data from 113 nations, classifying them as developed or developing between 2007 and 2014.

The findings showed a statistically significant relationship between the GGVC and national exports. Transportation has adversely affected the environmental sustainability of assets in the BRICS, according to Aldakhil *et al*., (2018), who also stated that the logistics sector is the main contributor to greenhouse gases and carbon emissions. They have suggested that nations should put laws into place to lessen the emissions produced by the logistics sector and to help it transition to carbon-free operations. Khan *et al*., (2018) examined the relationship between ecological quality, public health spending, renewable energy, and logistics performance indicators for the ASEAN region. According to the researchers, countries' economies grow more favorably when green energy is used in logistics operations. GGVC operations favor economic growth indicators, particularly foreign direct investment, in 42 nations, according to follow-up research by Khan *et al*., (2018).

A substantial body of research has explored the impact of logistics on both environmental quality and economic growth. For instance, Ong *et al*., (2022) examined how green practices within the value chain influence firm performance in developing countries, highlighting the dual benefits of both economic advancement and environmental sustainability. However, there remains a gap in the literature concerning the direct examination of how various economic development metrics—such as FD, R&D, and foreign direct investment (FDI)—specifically influence GGVCM. While studies have established that FD can enhance green technological innovation (Farooq *et al*., 2024) and that FDI can positively impact green innovation under certain policy environments (Chen *et al*., 2023), their collective effects on GGVCM have been underexplored. Therefore, investigating these variables concerning GGVCM will contribute meaningfully to the academic discourse. A clearer understanding of these relationships can assist policymakers in designing more effective strategies to foster environmentally sustainable and economically integrated global value chains.

3. EMPIRICAL METHODOLOGY

To investigate the relationship between FD and participation in the GGVC, the authors construct an econometric model grounded in existing literature. The aim is to uncover whether and how FD facilitates a country's integration into environmentally sustainable segments of global value chains. This approach is motivated by studies suggesting that well-developed financial systems can enhance investment in green technologies, improve access to sustainable financing, and support innovation (Ostapenko *et al*., 2020; Yang & Khan, 2022; Ha, 2022a, 2022b). The following model to examine the nexus between the financial development index (FD) and green global value chain (GGVC) is expressed as follows:

$$GGVC_{i,t} = \beta_0 + \beta_1 FD_{i,t} + \beta_2 INC_{i,t} + \beta_3 EXP_{i,t} + \beta_4 GE_{i,t} + \beta_5 FDI_{i,t} + \beta_6 IND_{i,t} + \beta_7 EPI_{i,t} + \beta_8 CE\_MW_{i,t} + \beta_9 EI\_ISO_{i,t} + \varepsilon_{i,t} \quad (1)$$

where i and t represent country i and year t, respectively.

3.1 Dependent Variable: Green Global Value Chain (GGVC)

The key explanatory variable is a GGVC index score (GGVCMIScore). This variable demonstrates a number of climate-related financial policies per year implemented by nations during 2010-2020. These data are sourced from World Bank (2024a), and the methodology for constructing the GGVC was first developed by Ostapenko *et al*., (2020). The GGVCMIScore 2023 ranks countries on six dimensions of trade, encompassing customs, infrastructure, international shipments, logistics quality and competence, tracking and tracing, and timeliness. The data utilized in the ranking is derived from a survey of logistics professionals answering inquiries about foreign nations in which they carry out work. Customs Score (GGVC_CS) represents the efficiency of customs and border management clearance. Infrastructure Score (GGVC_IS) captures the quality of trade and transport infrastructure. International Shipments Score (GGVC_ISS) and Logistics Competence and Quality Score (GGVC_LCQ) illustrate the ease of arranging competitively priced shipments, while Timeliness Score (GGVC_TLS) presents the frequency with which shipments reach consignees within scheduled or expected delivery times. Finally, the ability to track and trace consignments is captured by the Tracking and Tracing Score (GGVC_TS).

3.2 Key Explanatory Variable: Financial Development Index

We collect financial development data from the financial development database of the International Monetary Fund (FD-IMF). The financial development is measured by the composite financial development index (FD_FD). To calculate this, we use 2 indexes: financial institution's development (FD_FI) and financial market's development (FD_FM). The former index is a composite index of three indicators related to financial institutions, namely financial institution depth (FD_FID), financial institution access (FD_FIA), and financial institution efficiency (FD_FIE), whereas the latter index is a composite index of three indicators related to financial markets, such as financial market depth (FD_FMD), financial market access (FD_FMA), and financial market efficiency (FD_FME). All indexes have been normalized between 0 and 1, except the composite financial development index. Thus, the highest (lowest) value of a given variable across time and countries is equal to one (zero), and all other values are measured relative to these maximum (minimum) values.

3.3 Control Variables

When evaluating the impact of FD on GGVC performance, GDP per capita (constant 2010 US dollars) (INC) is taken into account (Fu *et al*., 2020; Ha, 2022a, 2022b; Thanh, 2022). Studies like Rao & Holt (2005) have demonstrated that export (EXP) is a significant element determining the performance of the green global value chain; however, actual data in the literature have produced some contradictory results. We incorporated the inflow of net foreign direct investment (FDI) into our theoretical model, drawing on the work of Bu *et al*., (2019), and Shahbaz *et al*., (2018). The industrial value-added to GDP ratio is used to calculate the industrialization index (IND), which is based on research by Wang & Shao (2023), Yang & Khan (2022) and Yu & Zhu (2023). Data on INC, EXP, FDI, and IND are

provided by the Worldwide Development Indicators (WDI) (World Bank, 2024b). To further examine the influence of political issues, we also take into account the government effectiveness index (GE), as reported by Le & Hoang (2021), Lee & Min (2015). We also follow Walton *et al*., (1998), Walker *et al*., (2008), and Rao and Holt (2005) to consider the role of government policies. We use government effectiveness, which is sourced from the World Governance Indicator (WGI) (World Bank, 2024c), to evaluate government effectiveness. Furthermore, based on the argument of Zhu & Sarkis (2006), Rao & Holt (2005), Hu & Hsu (2008), Vachon (2007), and Holt & Ghobadian (2009), we also quantify the influence of environmental innovations (EPI) on the adoption of green global value chain.

3.4 Statistical Summary

As shown in Table 1, we offer data about each variable and its statistical description. Based on the cleaned data, 21 nations were included in the final sample from 2001 to 2020. Table A.1 (Appendix) shows that GGVCM and FD seem to be positively correlated.

To verify the data further, Pesaran (2021) recommended using a cross-sectional dependence analysis. Several tests are designed to determine if data with cross-dependence (CD) are stationary. These tests include Levin-Lin-Chu (Levin *et al*., 2002) and Im-Pesaran-Shin (Im *et al*., 2003). Afterward, PCSE is used to investigate how CD and stationarity affect the first difference variable (Table A.2 (Appendix)). To guarantee that the data is highly balanced and supports applied methodologies and tests, gaps, missing observations, and outliers are eliminated throughout the data-cleaning procedure. Twenty-one nations in Europe participate in the empirical estimations that follow. All explanatory factors lag one period behind because of the synergistic link between digitalization and exports or insufficient data availability. Gala *et al*., (2018) and Sweet & Maggio (2015) use an FGLS model in addition to Equation (1). Moreover, possible endogeneity issues are addressed by the two-step Generalized Method of Moments (GMM) system in Equation (1) (Maggio & Sweet, 2015; Ha, 2022a).

This article explores the differences between short- and long-term impacts in addition to comparing them. To solve this problem, Pesaran & Smith (1995) developed a technique using autoregressive distributed lags. Pesaran & Shin (1998) estimated fixed effects while investigating causal linkages between variables and taking endogeneity in EU member states into account. The next stage was applying the Kao cointegration test, Pedroni test, and Westerlund test to determine if two variables are cointegrated, as proposed by Kao (1999), Pedroni (2004), and Westerlund (2005). The results indicating cointegration between the GGVC and FD are described in Table A.3 (Appendix).

Table 1 Description of variables

Variable	Definition	Measure	Source	Obs	Mean	SD	Min	Max
GGVCMIScore	Green global value chain index score	The LPI 2023 ranks countries on six dimensions of trade, including customs, infrastructure, international shipments, logistics quality and competence, tracking and tracing, and timeliness	Lpi.worldbank	1125	2.93	0.55	1.72	4.23
GGVCM_CS	Customs Score	The efficiency of customs and border management clearance	Lpi.worldbank	1125	2.70	0.58	1.60	4.18
GGVCM_IS	Infrastructure Score	The quality of trade and transport infrastructure	Lpi.worldbank	1125	2.77	0.66	1.40	4.44
GGVCM_ISS	International Shipments Score	The ease of arranging competitively priced shipments	Lpi.worldbank	1125	2.90	0.50	1.67	4.18
GGVCM_LCQ	Logistics Competence and Quality Score	The competence and quality of logistics services—trucking, forwarding, and customs brokerage	Lpi.worldbank	1125	2.88	0.59	1.56	4.31
GGVCM_TLS	Timeliness Score	The frequency with which shipments reach consignees within scheduled or expected delivery times	Lpi.worldbank	1125	3.34	0.54	2.02	4.53
GGVCM_TS	Tracking and Tracing Score	The ability to track and trace consignments	Lpi.worldbank	440	2.74	0.43	1.54	3.77
FD_FD	Financial development	The composite financial development index	FD-IMF	1125	2.97	0.60	1.56	4.27
FD_FI	Financial institution's development	The financial institutions development	FD-IMF	1125	0.24	0.21	0.00	0.93
FD_FM	Financial market's development	The financial markets development	FD-IMF	1125	0.31	0.24	0.00	0.95
FD_FID	Financial institution depth	The financial institution depth	FD-IMF	1125	0.22	0.27	0.00	1.00
FD_FIA	Financial institution access	The financial institution access	FD-IMF	1125	0.20	0.24	0.00	1.00
FD_FIE	Financial institution efficiency	The financial institution market efficiency	FD-IMF	1125	0.47	0.23	0.00	0.96
FD_FMD	Financial market depth	The financial market depth	FD-IMF	1125	0.15	0.21	0.00	1.00
FD_FMA	Financial market access	The financial market access	FD-IMF	1125	0.14	0.21	0.00	0.99
FD_FME	Financial market efficiency	The financial market efficiency	FD-IMF	1125	0.22	0.32	0.00	1.00

Table 1 Description of variables (Cont'd).

Variable	Definition	Measure	Source	Obs	Mean	SD	Min	Max
INC	Real output growth	The real GDP per capita (constant 2010 US dollars).	WDI	1125	8.64	1.31	6.02	11.40
EXP	Trade share	The proportion of GDP.	WDI	1125	7.45	1.73	3.85	11.79
GE	The level of government effectiveness	The government effectiveness index	WGI	1125	0.01	0.94	-2.19	2.43
FDI	Net inflow of foreign direct investment	The proportion of GDP.	WDI	1125	4.98	1.80	-3.30	10.83
IND	Industrialization level	The value added to GDP.	WDI	914	9.68	1.12	7.04	12.62
EPI	Environmental performance index	The score is scaled between 0 and 100, where 0 and 100 mean the worst and best performance, respectively.	YCELP	465	44.19	12.78	15.83	77.83
CE_MW	Per capita municipal waste	Generation of municipal waste per capita (Kilograms per capita)	Eurostat	233	443.92	108.23	0.00	772.00
EI_ISO	ISO14001 certification	The number of firms with ISO14001 certification	OECD.Stat	210	126.42	72.88	27.23	273.38

4. EMPIRICAL RESULTS

4.1 Baseline Results

Table 2 analyzes the relationship between composite FD and the GGVC, focusing on the GGVC. In Panel A, we mainly focus on investigating the relationship between variables using PCSE (columns 1-3) and FGLS (columns 4-6) estimates. To check for sure, we perform the same analysis on different model specifications. The study results show that FD's impact on the GGVCMIScore is significantly and consistently positive when changing control variables. This implies that promoting FD will likely increase GGVC performance. Similarly, control variables such as NC and GE show a positive and significant relationship with GGVCMIScore at the 1% significance level. In contrast, FDI and IND show negative relationships with GGVC indicators in all models.

For Panel B, we use two-step GMM estimation to investigate the relationship between FD and GGVCMIScore to confirm our first findings. The results are consistent with the two FGLS estimates, and PCSE estimates that suggest that FD will promote GGVCM efficiency. Furthermore, this table shows that adding the IND control variable to the model will reduce the impact coefficient of FD on GGVCMIScore. These findings provide valuable insights into the relationship between the financial development index, control variables, and GGVC index score, highlighting the potential of the financial development index in promoting GGVC performance and the different impacts of control variables on different GGVC indices.

To delve deeper into the impact of FD on GGVC performance, in Table 3 panel A, we analyze the estimation results of FD_FD on five aspects of GGVCMIScore, including Customs Score (GGVCM_CS), Infrastructure Score (GGVCM_IS), International Shipments Score (GGVCM_ISS), and Logistics Competence and Quality Score (GGVCM_LCQ), Timeliness Score (GGVCM_TLS). The results in both estimates of PCSE and FGLS are pretty similar. Financial composite development has inconsistent correlations with GGVCM indicators. Specifically, at the 1% significance level, FD has a significant positive effect on GGVCM_CS and GGVCM_IS but a significant negative effect on GGVCM_LCQ and GGVCM_TLS, and it does not significantly affect GGVCM_ISS. This implies that FD will be able to promote two aspects of the GGVC, including Customs Score and Infrastructure Score. However, that can negatively impact the Logistics Competence, Quality Score, and Timeliness Score. Regarding the control variables, real output growth (INC) significantly positively affects all aspects of GGVCM at the 1% significance level, with coefficients ranging from 0.16 to 0.60. This trend is also shown in the level of government effectiveness (GE), which shows a positive relationship with all variables, with coefficients ranging from 0.31 to 0.43. In contrast, trade share (EXP) has a negative and statistically significant impact on all variables in the PCSE estimates. However, in FGLS estimation, EXP has no significant effect on GGVCM_CS, while it has a significant negative effect on the remaining aspects at the 5% significance level. The net inflow of FDI shows a negative and statistically significant relationship with three indexes: GGVCM_CS, GGVCM_IS, and GGVCM_ISS. Meanwhile, industrialization level (IND) significantly negatively affects GGVCM_IS and GGVCM_ISS but has a significantly positive impact on GGVCM_LCQ at the 5% significance level.

Next, in Table 3, Panel B, we examine the impact of two other aspects of FD, Financial Market Development (FD_FM) and Financial Institution Development (FD_FI), on the environmental performance index based on PCSE and FGLS estimates. Clearly, FD_FM and FD_FI both show a favorable and statistically significant influence on GGVCMIScore at the 1% significance level. Furthermore, this result is consistent when changing the control variables in the model, with the impact coefficients of FD_FM on GGVCMIScore ranging from 0.44 to 0.49, while FD_FM on GGVCMIScore ranges from 0.31 to 0.34. These findings imply that applying policies to advance Financial Market

Development and Financial Institution Development will promote GGVC performance, especially financial market development activities.

Table 4 illustrates the impact of FD on GGVC performance, especially in terms of the depth, accessibility, and efficiency of financial markets (FD_FMA, FD_FMD, and FD_FME) and financial institutions (FD_FIA, FD_FID, and FD_FIE) using two methods: FGLS and PCSE. Research results show that the activities of financial markets and financial institutions have a significant positive impact on the GGVCMIScore, with coefficients ranging from 0.10 to 0.39. In particular, the depth of the financial market and financial institutions have the most significant impact on the GGVCMIScore, with estimated coefficients of 0.35 and 0.39, respectively. These findings suggest that promoting FD can contribute significantly to the effectiveness of GGVC management, especially in fostering in-depth development.

Regarding control variables, the impact of INC and GE on GGVCMIScore is positive and statistically significant at the 1% level. In contrast, FDI consistently exhibits statistical significance and negative effects across most of the six models in the PCSE and FGLS estimates. Meanwhile, EXP shows an insignificant impact on GGVC indicators. The above results show that besides deepening financial development, promoting INC and GE contributes to increasing GGVC performance.

Table 2 The effects of financial development on green global value chain performance: Composite financial development index

Panel A

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	**PCSE (GGVCMI Score)**			**FGLS (GGVCMI Score)**		
L.FD_FD	0.57‡	0.57‡	0.53‡	0.57‡	0.57‡	0.53‡
	(0.094)	(0.075)	(0.094)	(0.053)	(0.060)	(0.064)
L.INC	0.07‡	0.16‡	0.07‡	0.07‡	0.16‡	0.07‡
	(0.014)	(0.011)	(0.020)	(0.017)	(0.025)	(0.025)
L.EXP	0.03†	0.01	-0.02	0.03†	0.01	-0.02
	(0.013)	(0.009)	(0.018)	(0.013)	(0.015)	(0.022)
L.GE	0.34‡	0.32‡	0.44‡	0.34‡	0.32‡	0.44‡
	(0.019)	(0.025)	(0.016)	(0.016)	(0.018)	(0.025)
L.FDI	-0.03‡	-0.03‡	-0.03‡	-0.03‡	-0.03‡	-0.03‡
	(0.009)	(0.009)	(0.012)	(0.008)	(0.009)	(0.012)
L.IND		-0.07‡			-0.07‡	
		(0.003)			(0.017)	
L.EPI			-0.00			-0.00
			(0.001)			(0.001)
Observations	1,050	914	434	1,050	914	434
Number of economies	75	75	31	75	75	31

*Standard errors in parentheses, ‡p<0.01, †p<0.05, *p<0.1*

Panel B

VARIABLES	**Two-step GMM (GGVCMI Scores)**		
L.FD_FD	0.72*	0.22†	0.61*
	(0.024)	(0.025)	(0.023)
L.INC	0.31‡	0.00	-0.01
	(0.032)	(0.044)	(0.036)
L.EXP	2.01‡	0.12	-0.67
	(0.634)	(1.286)	(1.037)
L.GE	-0.11	0.55	0.49
	(0.279)	(0.408)	(0.344)
L.FDI	-11.86†	-12.31†	-12.27‡
	(4.082)	(5.957)	(5.124)
L.IND		0.00	0.00
		(0.001)	(0.003)
L.EPI			0.00
			(0.000)
L.CE_MW			-0.00‡
			(0.000)
Observations	1,050	914	434
Number of nations	75	75	31

*Standard errors in parentheses ‡p<0.01, †p<0.05, *p<0.1*

Table 3 The effects of financial development on green global value chain performance: Alternative measure of green global value chain performance

Panel A

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	PCSE					FGLS				
VARIABLES	GGVCM_CS	GGVCM_IS	GGVCM_ISS	GGVCM_LCQ	GGVCM_TLS	GGVCM_CS	GGVCM_IS	GGVCM_ISS	GGVCM_LCQ	GGVCM_TLS
L.FD_FD	0.04‡	0.03‡	0.00	-0.08‡	-0.08‡	0.04‡	0.03‡	0.00	-0.08‡	-0.08‡
	(0.005)	(0.006)	(0.004)	(0.009)	(0.007)	(0.008)	(0.009)	(0.011)	(0.012)	(0.014)
L.INC	0.16‡	0.24‡	0.31‡	0.47‡	0.60‡	0.16‡	0.24‡	0.31‡	0.47‡	0.60‡
	(0.009)	(0.008)	(0.022)	(0.102)	(0.099)	(0.020)	(0.033)	(0.041)	(0.111)	(0.145)
L.EXP	-0.02*	-0.04‡	-0.13‡	-0.31‡	-0.26‡	-0.02	-0.04†	-0.13‡	-0.31‡	-0.26‡
	(0.009)	(0.008)	(0.015)	(0.044)	(0.067)	(0.016)	(0.018)	(0.030)	(0.042)	(0.054)
L.GE	0.42‡	0.41‡	0.43‡	0.37‡	0.31‡	0.42‡	0.41‡	0.43‡	0.37‡	0.31‡
	(0.015)	(0.025)	(0.032)	(0.028)	(0.049)	(0.018)	(0.020)	(0.029)	(0.045)	(0.060)
L.FDI	-0.05‡	-0.05‡	-0.02*	0.01	0.01	-0.05‡	-0.05‡	-0.02*	0.01	0.01
	(0.012)	(0.013)	(0.013)	(0.014)	(0.015)	(0.008)	(0.009)	(0.013)	(0.014)	(0.015)
L.IND		-0.05‡	-0.09‡	0.14†	0.05		-0.05†	-0.09‡	0.14*	0.05
		(0.011)	(0.017)	(0.065)	(0.063)		(0.023)	(0.032)	(0.078)	(0.101)
L.EPI			0.00*	-0.01‡	-0.00			0.00*	-0.01‡	-0.00
			(0.002)	(0.002)	(0.003)			(0.002)	(0.002)	(0.004)
L.CE_MW				-0.00	-0.00*				-0.00	-0.00*
				(0.000)	(0.000)				(0.000)	(0.000)
L.EI_ISO					-0.00*					-0.00
					(0.000)					(0.000)
Observations	1,008	887	432	192	166	1,008	887	432	192	166
Num. nations	72	72	36	15	13	72	72	36	15	13

*Standard errors in parentheses ‡ p<0.01, † p<0.05, * p<0.1*

Panel B Financial institution and financial market development.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Financial Market Development (GGVCMI Score)						Financial Institution Development (GGVCMI Score)					
VARIABLE	PCSE			FGLS			PCSE			FGLS		
L.FD_FM	0.47‡	0.49‡	0.44‡	0.47‡	0.49‡	0.44‡						
	(0.080)	(0.089)	(0.089)	(0.044)	(0.051)	(0.052)						
L.FD_FI							0.33‡	0.31‡	0.34‡	0.33‡	0.31‡	0.34‡
							(0.057)	(0.031)	(0.061)	(0.049)	(0.052)	(0.064)
L.INC	0.09‡	0.17‡	0.09‡	0.09‡	0.17‡	0.09‡	0.09‡	0.18‡	0.10‡	0.09‡	0.18‡	0.10‡
	(0.013)	(0.012)	(0.020)	(0.017)	(0.025)	(0.024)	(0.011)	(0.008)	(0.016)	(0.018)	(0.026)	(0.026)
L.EXP	0.01	-0.00	-0.04†	0.01	-0.00	-0.04*	0.02*	-0.01	-0.03*	0.02	-0.01	-0.03
	(0.011)	(0.011)	(0.016)	(0.013)	(0.015)	(0.022)	(0.012)	(0.011)	(0.017)	(0.014)	(0.016)	(0.023)
L.GE	0.36‡	0.34‡	0.47‡	0.36‡	0.34‡	0.47‡	0.36‡	0.35‡	0.46‡	0.36‡	0.35‡	0.46‡
	(0.016)	(0.026)	(0.014)	(0.015)	(0.017)	(0.024)	(0.018)	(0.031)	(0.018)	(0.016)	(0.018)	(0.027)
L.FDI	-0.03‡	-0.03‡	-0.03†	-0.03‡	-0.03‡	-0.03†	-0.04‡	-0.04‡	-0.03‡	-0.04‡	-0.04‡	-0.03‡
	(0.009)	(0.009)	(0.012)	(0.008)	(0.009)	(0.012)	(0.009)	(0.010)	(0.012)	(0.008)	(0.009)	(0.012)
L.IND		-0.07‡			-0.07‡			-0.06‡			-0.06‡	
		(0.003)			(0.017)			(0.004)			(0.018)	

*Standard errors in parentheses ‡p<0.01, †p<0.05, *p<0.1*

Table 3 The effects of financial development on green global value chain performance: Alternative measure of green global value chain performance (Cont'd)

Panel B Financial institution and financial market development (Cont'd).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Financial Market Development						Financial Institution Development					
VARIABLES	PCSE			FGLS			PCSE			FGLS		
L.EPI			0.00			0.00			-0.00†			-0.00*
			(0.001)			(0.001)			(0.001)			(0.001)
Observations	1,050	914	434	1,050	914	434	1,050	914	434	1,050	914	434
Num. Nations	75	75	31	75	75	31	75	75	31	75	75	31

*Standard errors in parentheses, ‡p<0.01, †p<0.05, *p<0.1*

Table 4 The effects of financial development on green global value chain performance: Different dimensions of financial market and financial institutions development.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	PCSE (GGVCMI Score)						FGLS (GGVCMI Score)					
L.FD_FMA	0.21‡						0.21‡					
	(0.042)						(0.043)					
L.FD_FMD		0.35‡						0.35‡				
		(0.065)						(0.045)				
L.FD_FME			0.32‡						0.32‡			
			(0.050)						(0.027)			
L.FD_FIA				0.21‡						0.21‡		
				(0.040)						(0.042)		
L.FD_FID					0.39‡						0.39‡	
					(0.048)						(0.050)	
L.FD_FIE						0.10‡						0.10‡
						(0.030)						(0.035)
L.INC	0.12‡	0.12‡	0.09‡	0.09‡	0.10‡	0.13‡	0.12‡	0.12‡	0.09‡	0.09‡	0.10‡	0.13‡
	(0.011)	(0.011)	(0.013)	(0.012)	(0.009)	(0.010)	(0.017)	(0.017)	(0.016)	(0.019)	(0.017)	(0.017)
L.EXP	-0.00	0.01	0.02	0.02	0.01	-0.00	-0.00	0.01	0.02	0.02	0.01	-0.00
	(0.010)	(0.010)	(0.011)	(0.012)	(0.010)	(0.010)	(0.014)	(0.013)	(0.013)	(0.014)	(0.014)	(0.014)
L.GE	0.40‡	0.37‡	0.36‡	0.39‡	0.35‡	0.40‡	0.40‡	0.37‡	0.36‡	0.39‡	0.35‡	0.40‡
	(0.016)	(0.017)	(0.015)	(0.017)	(0.019)	(0.017)	(0.015)	(0.015)	(0.015)	(0.015)	(0.016)	(0.015)
L.FDI	-0.04‡	-0.04‡	-0.03‡	-0.03‡	-0.04‡	-0.04‡	-0.04‡	-0.04‡	-0.03‡	-0.03‡	-0.04‡	-0.04‡
	(0.009)	(0.009)	(0.008)	(0.009)	(0.010)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Observations	1,050	1,050	1,050	1,050	1,050	1,050	1,050	1,050	1,050	1,050	1,050	1,050
Num. nations	75	75	75	75	75	75	75	75	75	75	75	75

Table 5 The effects of financial development on green global value chain performance: Two-step GMM

	Two-step GMM		
VARIABLES	**Financial Development**	**Financial Market Development**	**Financial Institution Development**
FD	0.11*	0.07†	0.11*
	(0.004)	(0.001)	(0.003)
INC	0.11‡	0.001	-0.003
	(0.032)	(0.014)	(0.006)
EXP	0.71‡	0.041	-0.17
	(0.034)	(0.286)	(0.037)
GE	-0.01	0.13	0.133
	(0.279)	(0.408)	(0.114)
FDI	-3.36†	-2.31†	-3.127‡
	(0.042)	(1.957)	(1.124)
Observations	1,080	1,080	1,080
Number of nations	75	75	75

Standard errors in parentheses
*‡ p<0.01, † p<0.05, * p<0.1*

Table 6 The influence of financial development on green global value chain performance: Short-run and long-run effects

VARIABLES	(1) FD-FD	(2) FD-FM	(3) FD-FI
	Short-run impact		
EC term	-0.079*	-0.311‡	-0.291‡
	(0.045)	(0.043)	(0.052)
D.FD	-0.031	0.013	-0.022
	(0.02)	(0.006)	(0.019)
	Long-run impact		
FD	0.44‡	0.41‡	0.43†
	(0.004)	(0.003)	(0.005)
Observations	686	650	378

*Standard errors in parentheses, ‡p<0.01, †p<0.05, *p<0.1*

Furthermore, by using two-step GMM estimation, we consider the impact of FD_FD, FD_FM, and FD_FI on GGVCMIScore with four control variables (Table 5). The results all show a positive and significant impact of all three aspects of FD on the GGVC at the 10% significance level. Among them, the aspects FD_FD and FD_FI show the largest impact, with the same estimated coefficient of 0.11. Once again, it affirms that FD promotes effective GGVC management, especially FD in composite and financial institutions. With control variables, only INC and EXP have a significant positive influence on GGVCMIScore in terms of FD. Meanwhile, FDI has a negative and statistically significant correlation at the 5% level with the GGVC index.

Table 6 examines the effect of financial development on GGVC performance in both the short- and long-run in the above three aspects, which can be expressed as follows:

$$\Delta GGVC_t = \alpha + \beta_1 EC_{t-1} + \beta_2 \Delta FD_t + \epsilon_t \text{ (short-run)}$$
$$GGVC_t = \gamma + \delta FD_{t-1} + u_t \text{ (long-run)} \quad (2)$$

where β_1 captures lagged residual from long-run model, β_2 is the coefficient of D.FD (first-difference of FD), which captures short-run changes, and δ reflects the steady-state effect of FD on GGVC.

According to Table 6, in the long run, the results show that overall FD has a significant positive impact on GGVC variables at the 5% significance level. In particular, FD has the most substantial impact on GGVCMI Score in Financial Development, Financial Institution Development, and finally, Financial Market Development, with estimated coefficients of 0.44, 0.43, and 0.41, respectively. This implies that promoting FD will improve GGVC performance. In contrast to the long-term relationship, we did not find a statistically significant impact of FD on GGVC performance in the short term. It suggests that FD is not empirically apparent in the short run. In addition, the coefficient EC_term is negative and statistically significant in all three models, ranging from -0.079 to -0.311. This finding shows that about 7.9% to 31.1% of the disequilibrium caused by shocks in the previous period will return to equilibrium in the long run.

Table 7 The influence of financial development on green global value chain performance: Alternative measures of green global value chain

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	PCSE						FGLS					
VARIABLES	GGVCM_CS	GGVCM_IS	GGVCM_ISS	GGVCM_LCQ	GGVCM_TLS	GGVCM_TS	GGVCM_CS	GGVCM_IS	GGVCM_ISS	GGVCM_LCQ	GGVCM_TLS	GGVCM_TS
L.FD_FD	0.56‡	0.69‡	0.40‡	0.68‡	0.46‡	0.65‡	0.56‡	0.69‡	0.40‡	0.68‡	0.46‡	0.65‡
	(0.095)	(0.114)	(0.085)	(0.107)	(0.093)	(0.103)	(0.062)	(0.064)	(0.063)	(0.062)	(0.068)	(0.066)
L.INC	0.01	0.15‡	-0.02	0.10‡	0.08‡	0.12‡	0.01	0.15‡	-0.02	0.10‡	0.08‡	0.12‡
	(0.017)	(0.019)	(0.018)	(0.019)	(0.023)	(0.018)	(0.020)	(0.021)	(0.020)	(0.020)	(0.022)	(0.021)
L.EXP	0.05‡	-0.02	0.06‡	0.02	0.05†	0.00	0.05‡	-0.02	0.06‡	0.02	0.05‡	0.00
	(0.013)	(0.017)	(0.013)	(0.014)	(0.018)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.017)	(0.017)
L.GE	0.39‡	0.40‡	0.31‡	0.33‡	0.29‡	0.33‡	0.39‡	0.40‡	0.31‡	0.33‡	0.29‡	0.33‡
	(0.019)	(0.024)	(0.018)	(0.018)	(0.028)	(0.019)	(0.018)	(0.019)	(0.019)	(0.018)	(0.020)	(0.020)
L.FDI	-0.02†	-0.03‡	-0.02†	-0.03‡	-0.05‡	-0.04‡	-0.02†	-0.03‡	-0.02†	-0.03‡	-0.05‡	-0.04‡
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.010)	(0.010)
Observations	1,050	1,050	1,050	1,050	1,050	1,050	1,050	1,050	1,050	1,050	1,050	1,050
Num. nations	75	75	75	75	75	75	75	75	75	75	75	75

*Standard errors in parentheses, ‡p<0.01, †p<0.05, *p<0.1*

4.2 Robustness Checks on GGVC Performance

4.2.1 Effects of FD on GGVC: Alternative Measures

We analyze the linear relationship between FD and six aspects of GGVC performance with four given control variables. Table 7 shows the research results. There is a consistent and statistically significant positive correlation between FD and all GGVCM variables at the 1% significance level, with coefficients ranging from 0.40 to 0.69. This implies that FD will potentially improve and promote the efficiency of GGVC activities. Regarding control variables, INC has a positive and significant correlation with most aspects of the GGVC at the 1% significance level, except GGVCM_CS and GGVCM_ISS. Trade share has a positive and statistically significant impact

on GGVCM_CS, GGVCM_ISS, and GGVCM_TLS but has no significant influence on the remaining aspects. The level of GE significantly positively affects all GGVCM aspects at the 1% significance level. In contrast, FDI negatively correlates with all the indicators at the 5% significance level.

4.2.2 FD & GGVC in Developing & Developed Countries

We are interested in whether the relationship between FD and GGVC indicators performance differs between developing and developed economies. We divide the sample into 51 developing countries and 24 developed countries. Two estimation techniques are applied as before, demonstrated in Table 8. In Panel A, we use PSCE estimates to evaluate the relationship between FD_FD and GGVCM's indicators. It stands out that the coefficients of FD_FD are positive and significant at 1% for subsamples based on a country's income level. However, the coefficients of FD_FD in developing countries are relatively more robust than those for the sample of the developed countries, implying that composite FD promotes the efficiency of the GGVC, especially in developing countries. Furthermore, the study results also indicate that FD has a strong favorable influence on GGVCM_IS performance in developing countries, while for developed countries, it poses a great influence on GGVCM_LCQ activities.

Table 8 The effects of financial development on GGVC performance: developing and developed countries.
Panel A: PCSE estimates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Developing nations							Developed nations						
VARIABLES	GGVCMI Score	GGVCM_CS	GGVCM_IS	GGVCM_ISS	GGVCM_LCQ	GGVCM_TLS	GGVCM_TS	GGVCMI Score	GGVCM_CS	GGVCM_IS	GGVCM_ISS	GGVCM_LCQ	GGVCM_TLS	GGVCM_TS
L.FD_FD	0.79‡	0.72‡	0.98‡	0.63‡	0.93‡	0.67‡	0.86‡	0.33‡	0.28‡	0.27†	0.25‡	0.45‡	0.32‡	0.40‡
	(0.135)	(0.137)	(0.157)	(0.144)	(0.155)	(0.138)	(0.147)	(0.090)	(0.093)	(0.107)	(0.088)	(0.108)	(0.102)	(0.103)
L.INC	0.01	-0.11‡	0.04†	-0.02	0.04	0.05*	0.07‡	0.17‡	0.10†	0.40‡	0.03	0.17‡	0.12‡	0.22‡
	(0.015)	(0.017)	(0.019)	(0.017)	(0.024)	(0.029)	(0.020)	(0.038)	(0.041)	(0.056)	(0.040)	(0.048)	(0.044)	(0.045)
L.EXP	0.07‡	0.13‡	0.05†	0.07‡	0.06‡	0.07†	0.05†	-0.06‡	-0.08‡	-0.17‡	0.03	-0.04	-0.02	-0.10‡
	(0.017)	(0.018)	(0.022)	(0.016)	(0.018)	(0.026)	(0.022)	(0.022)	(0.021)	(0.027)	(0.023)	(0.027)	(0.031)	(0.030)
L.GE	0.28‡	0.28‡	0.31‡	0.30‡	0.26‡	0.25‡	0.27‡	0.38‡	0.56‡	0.42‡	0.27‡	0.38‡	0.30‡	0.37‡
	(0.024)	(0.023)	(0.028)	(0.024)	(0.026)	(0.033)	(0.026)	(0.028)	(0.038)	(0.038)	(0.033)	(0.037)	(0.040)	(0.035)
L.FDI	-0.04‡	-0.02†	-0.02†	-0.04‡	-0.03‡	-0.06‡	-0.05‡	-0.01	0.01	-0.03	0.00	-0.01	-0.02	-0.00
	(0.009)	(0.010)	(0.009)	(0.011)	(0.011)	(0.011)	(0.010)	(0.013)	(0.015)	(0.019)	(0.015)	(0.015)	(0.015)	(0.013)
Observations	714	714	714	714	714	714	714	336	336	336	336	336	336	336
Num. nations	51	51	51	51	51	51	51	24	24	24	24	24	24	24

*Standard errors in parentheses, ‡p<0.01, †p<0.05, *p<0.1*

Table 8 The effects of financial development on GGVC performance: developing and developed countries.
Panel B: FGLS estimates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Developing nations							Developed nations						
VARIABLES	GGVCMI Score	GGVCM_CS	GGVCM_IS	GGVCM_ISS	GGVCM_LCQ	GGVCM_TLS	GGVCM_TS	GGVCMI Score	GGVCM_CS	GGVCM_IS	GGVCM_ISS	GGVCM_LCQ	GGVCM_TLS	GGVCM_TS
L.FD_FD	0.79‡	0.72‡	0.98‡	0.63‡	0.93‡	0.67‡	0.86‡	0.33‡	0.28‡	0.27‡	0.25‡	0.45‡	0.32‡	0.40‡
	(0.091)	(0.103)	(0.107)	(0.108)	(0.108)	(0.115)	(0.115)	(0.067)	(0.075)	(0.078)	(0.080)	(0.074)	(0.088)	(0.083)
L.INC	0.01	-0.11‡	0.04	-0.02	0.04	0.05*	0.07†	0.17‡	0.10†	0.40‡	0.03	0.17‡	0.12†	0.22‡
	(0.021)	(0.024)	(0.025)	(0.025)	(0.025)	(0.027)	(0.027)	(0.043)	(0.047)	(0.049)	(0.051)	(0.047)	(0.055)	(0.052)
L.EXP	0.07‡	0.13‡	0.05‡	0.07‡	0.06‡	0.07‡	0.05†	-0.06†	-0.08‡	-0.17‡	0.03	-0.04	-0.02	-0.10‡
	(0.017)	(0.019)	(0.020)	(0.020)	(0.020)	(0.021)	(0.021)	(0.028)	(0.031)	(0.032)	(0.033)	(0.030)	(0.036)	(0.034)
L.GE	0.28‡	0.28‡	0.31‡	0.30‡	0.26‡	0.25‡	0.27‡	0.38‡	0.56‡	0.42‡	0.27‡	0.38‡	0.30‡	0.37‡
	(0.020)	(0.023)	(0.024)	(0.024)	(0.024)	(0.026)	(0.025)	(0.042)	(0.047)	(0.049)	(0.050)	(0.046)	(0.055)	(0.051)
L.FDI	-0.04‡	-0.02†	-0.02†	-0.04‡	-0.03‡	-0.06‡	-0.05‡	-0.01	0.01	-0.03†	0.00	-0.01	-0.02	-0.00
	(0.010)	(0.011)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.013)	(0.015)	(0.016)	(0.016)	(0.015)	(0.018)	(0.017)
Observations	714	714	714	714	714	714	714	336	336	336	336	336	336	336
Num. nations	51	51	51	51	51	51	51	24	24	24	24	24	24	24

*Standard errors in parentheses, ‡p<0.01, †p<0.05, *p<0.1*

5. CONCLUSIONS

The world is currently dealing with serious environmental, social, and economic challenges. Through both internal and external management, GGVC management (GGVCM) aims to reduce the total ecological impacts of both forward and reverse flows. Therefore, enhancing GGVCM performance is essential. This article examines the function of financial systems in order to look at the factors

that influence an integrated GGVCM. This study attempts to find answers to whether implementing FD promotes or hurts GGVC performance management. Using an international sample of 51 developing and 24 developed countries during the 2001-2021 period, we reveal interesting findings. First, we demonstrate that implementing FD in countries benefits the efficiency of GGVC activities. In particular, Financial Market Development and Financial Institution Development have a relatively strong positive impact on GGVC performance. Second, referring to FD's short-term and long-term impact on GGVCM, we reinforce the effectiveness of government implementation of FD to GGVC management in three aspects: FD, Financial Market Development, and Financial Institution Development. Third, the study examines the impact of FD on GGVC performance by considering the effect on all six dimensions of GGVCM with four given control variables. The results confirm that these developments help promote GGVC performance. This is also the basis for considering the impact of FD on GGVCM in each country group. Notably, by promoting FD, it will greatly enhance the efficiency of GGVC activities in both groups of developed and developing countries in all aspects, especially in developing countries.

Our study's conclusions offer evidence-based guidance for countries aiming to enhance their FD as a strategic pathway to improve GGVC performance, as demonstrated by the consistently positive and significant relationships identified across multiple models and robustness checks. To attain operational efficiency, governments are encouraged to make financial investments a top priority in R&D. Furthermore, by exploiting the correlation between FD and environmental performance within an economy, this research can be used as a model for nations to build relevant tools and strategies. In light of the unpredictability of the global economy, strengthening ecosystems and human health is synonymous with improving environmental performance, which is a critical component of sustainable economic development. Our additional discussion highlights the critical role the government plays, highlighting the likelihood of a beneficial association between FD and GGVC in more hospitable institutional frameworks.

DECLARATION OF INTERESTS

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

DATA AVAILABILITY STATEMENT

Data available on request due to privacy/ethical restrictions.

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APPENDIX 1: CORRELATION COEFFICIENTS

Table A.1 Correlation coefficients.

	GGVCMI Score	GGVCM_CS	GGVCM_IS	GGVCM_ISS	GGVCM_LCQ	GGVCM_TLS	GGVCM_TS	FD_FD	FD_FI	FD_FM	FD_FIA	FD_FID	FD_FIE	FD_FMA	FD_FMD	FD_FME
GGVCMI Score	1															
GGVCM_CS	0.943‡	1														
GGVCM_IS	0.938‡	0.893‡	1	1												
GGVCM_ISS	0.894‡	0.787‡	0.770‡	1												
GGVCM_LCQ	0.976‡	0.923‡	0.922‡	0.875‡	1											
GGVCM_TLS	0.872‡	0.790‡	0.717‡	0.751‡	0.811‡	1										
GGVCM_TS	0.950‡	0.846‡	0.896‡	0.818‡	0.905‡	0.841‡	1									
FD_FD	0.527‡	0.443‡	0.488‡	0.426‡	0.543‡	0.491‡	0.557‡	1								
FD_FI	0.505‡	0.423‡	0.476‡	0.411‡	0.515‡	0.442‡	0.551‡	0.923‡	1							
FD_FM	0.455‡	0.385‡	0.411‡	0.364‡	0.476‡	0.455‡	0.461‡	0.903‡	0.683‡	1						
FD_FIA	0.330‡	0.249†	0.297†	0.263†	0.338‡	0.312‡	0.391‡	0.826‡	0.924‡	0.565‡	1					
FD_FID	0.635‡	0.581‡	0.627‡	0.522‡	0.649‡	0.506‡	0.646‡	0.855‡	0.889‡	0.660‡	0.665‡	1				
FD_FIE	0.409‡	0.310‡	0.364‡	0.341‡	0.413‡	0.407‡	0.467‡	0.814‡	0.882‡	0.589‡	0.759‡	0.754‡	1			
FD_FMA	0.229*	0.182	0.143	0.225*	0.248†	0.257†	0.243†	0.696‡	0.504‡	0.785‡	0.362‡	0.541‡	0.521‡	1		
FD_FMD	0.372‡	0.311‡	0.384‡	0.264†	0.374‡	0.354‡	0.391‡	0.830‡	0.665‡	0.863‡	0.570‡	0.674‡	0.512‡	0.625‡	1	
FD_FME	0.492‡	0.426‡	0.451‡	0.391‡	0.519‡	0.486‡	0.479‡	0.740‡	0.517‡	0.854‡	0.470‡	0.468‡	0.460‡	0.449‡	0.577‡	1
INC	0.754‡	0.707‡	0.803‡	0.614‡	0.759‡	0.529‡	0.765‡	0.532‡	0.574‡	0.387‡	0.335‡	0.778‡	0.453‡	0.320‡	0.441‡	0.237*
EXP	0.508‡	0.537‡	0.492‡	0.479‡	0.522‡	0.291†	0.478‡	0.281†	0.335‡	0.169	0.0670	0.619‡	0.254†	0.357‡	0.205*	-0.0524
GE	0.741‡	0.769‡	0.747‡	0.630‡	0.746‡	0.516‡	0.688‡	0.374‡	0.439‡	0.231*	0.240†	0.647‡	0.278‡	0.0516	0.297†	0.211*
FDI	0.289†	0.306‡	0.220*	0.299†	0.327‡	0.181	0.272†	0.278†	0.356‡	0.139	0.159	0.542‡	0.284†	0.327‡	0.174	-0.0690
IND	0.661‡	0.599‡	0.694‡	0.548‡	0.662‡	0.464‡	0.696‡	0.534‡	0.551‡	0.418‡	0.317‡	0.736‡	0.470‡	0.469‡	0.437‡	0.203*
EPI	0.501‡	0.547‡	0.657‡	0.344‡	0.482‡	0.237*	0.458‡	0.0825	0.119	0.0270	-0.0747	0.349‡	0.0725	-0.0900	0.144	0.00586
CE_MW	0.676‡	0.617‡	0.743‡	0.514‡	0.663‡	0.504‡	0.712‡	0.559‡	0.628‡	0.379‡	0.458‡	0.737‡	0.495‡	0.278†	0.438‡	0.252†
EI_ISO	-0.313‡	-0.219*	-0.252†	-0.264†	-0.273†	-0.356‡	-0.408‡	-0.297†	-0.250†	-0.295†	-0.227*	-0.201*	-0.276†	-0.114	-0.114	-0.440‡

	INC	EXP	GE	FDI1	IND	EPI	CE_MW	EI_ISO
INC	1							
EXP	0.788‡	1						
GE	0.748‡	0.684‡	1					
FDI1	0.546‡	0.787‡	0.492‡	1				
IND	0.940‡	0.782‡	0.565‡	0.553‡	1			
EPI	0.580‡	0.499‡	0.637‡	0.188*	0.500‡	1		
CE_MW	0.883‡	0.593‡	0.599‡	0.392‡	0.815‡	0.456‡	1	
EI_ISO	-0.0979	0.180	-0.0146	0.280†	-0.106	-0.0220	-0.254†	1

* $p < 0.05$, † $p < 0.01$, ‡ $p < 0.001$

APPENDIX 2: CROSS-SECTIONAL DEPENDENCE TESTS AND STATIONARY TESTS

Table A.2 Cross-sectional dependence tests and stationary tests

Variable (in level)	CD-test, Pesaran (2004)	Im-Pesaran-Shin test (Z-bar)	Variable (in difference)	Im-Pesaran-Shin test (Z-bar)
LPIScore	18.22‡	-9.32‡	DLPIScore	-15.47‡
GGVCM_CS	13.54‡	-10.21‡	DGGVCM_CS	-20.43‡
GGVCM_IS	18.70‡	-9.99‡	DGGVCM_IS	-18.93‡
GGVCM_ISS	7.712‡	4.135	DGGVCM_ISS	-2.524‡
GGVCM_LCQ	15.30‡	4.00	DGGVCM_LCQ	-19.84‡
GGVCM_TLS	47.17‡	-6.73‡	DGGVCM_TLS	-15.25‡
GGVCM_TS	4.17‡	-3.73‡	DGGVCM_TS	-31.15‡

Table A.2 Cross-sectional dependence tests and stationary tests (Cont'd)

Variable (in level)	CD-test, Pesaran (2004)	Im-Pesaran-Shin test (Z-bar)	Variable (in difference)	Im-Pesaran-Shin test (Z-bar)
FD_FD	6.50‡	-3.32‡	DECI	-8.43‡
FD_FI	6.92‡	-2.16†	DFD_FD	-4.54‡
FD_FM	8.58‡	-1.46	DFD_FI	-20.36‡
FD_FIA	6.43‡	-1.43	DFD_FM	-5.36‡
FD_FID	3.31‡	-1.45	DFD_FIA	-52.65‡
FD_FIE	17.82‡	-1.42	DFD_FID	-2.39‡
FD_FMA	0.62	-3.30‡	DFD_FIE	-16.05‡
FD_FMD	17.92‡	-2.26‡	DFD_FMA	-4.83‡
FD_FME	5.43‡	-4.41‡	DCOI	-6.33‡
INC	1.44	-7.91‡	DINC	-6.93‡
EXP	23.55‡	-11.97‡	DEXP	-2.84‡
GE	4.17‡	-4.73‡	DGE	-8.25‡
FDI	5.17‡	-5.73‡	DFDI	-3.15‡
IND	3.50‡	-3.32‡	DIND	-7.43‡
EPI	2.44	5.91‡	DEPI	-6.93‡
CE_MW	3.55‡	-21.97‡	DCE_MW	-8.84‡
EI_ISO	4.17‡	-3.73‡	DEI_ISO	-6.25‡

Note: Regarding the CD test, the null hypothesis is that the cross-section is independent. P-value is closed to zero, implying that data are correlated across panel groups. Regarding the Im-Pesaran-Shin test, the null hypothesis is "All panels contain unit root" and the alternative hypothesis is "At least one panel is stationary".

**, †, ‡ are significant levels at 10%, 5%, and 1%, respectively.*

APPENDIX 3: COINTEGRATION TEST

Table A.3 Cointegration test.

Model: f(FD and GGVCM)	Kao test	Pedroni test	Westerlund test
	Dickey-Fuller test	Phillips-Perron t	Variance ratio
	GGVCM	GGVCM	GGVCM
FD_FD	-4.32‡	3.43‡	4.65‡
FD_FI	-4.88‡	3.72‡	4.17‡
FD_FM	-6.41‡	5.13‡	6.15‡

Note: Regarding the Kao test, the null hypothesis is "No cointegration," while the alternative hypothesis is "All panels are cointegrated.". Regarding the Pedroni test, the null hypothesis is "No cointegration,", while the alternative hypothesis is "All panels are cointegrated". Regarding the Westerlund test, the null hypothesis is "No cointegration," while the alternative hypothesis is "Some panels are cointegrated"

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