U.S. Dollar Invoicing and GVC Participation: A Two-Way Interaction

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December 09, 2025

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Abstract

This paper investigates the bidirectional relationship between dollar-invoiced trade and bilateral global value chain (GVC) participation using a two-stage least squares (2SLS) instrumental variables approach. Empirical results reveal a robust and negative feedback loop: greater reliance on the US dollar for trade invoicing constrains deeper integration into GVCs, while increased GVC participation reduces dependence on the dollar as an invoicing currency. These relationships vary with exchange rate volatility, highlighting complex policy trade-offs under conditions of currency uncertainty. The findings contribute to an understanding of how dominant currency use and GVC participation interact, with implications for exchange rate management and trade policy design in an increasingly interconnected global economy.

Keywords: Dollar Invoicing, Exchange Rate Volatility, Global Value Chains

JEL Codes: F14, F31, F36, C36

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†I am grateful to Professor Kara Reynolds, Professor Robert Blecker, Professor Juan Montecino, and Professor Valentina Bruno for their thoughtful comments on earlier drafts. Their feedback strengthened the motivation, empirical design and interpretation of the results. All remaining shortcomings are my responsibility.

1 Introduction

The international trade system has undergone rapid transformations over recent decades, marked by two concurrent phenomena: the proliferation of global value chains (GVCs) and the persistent dominance of invoicing in a few vehicle currencies, particularly the US dollar. GVC production networks spanning multiple countries in which components cross borders multiple times before final assembly and consumption, now account for nearly 70% of international trade (World Bank, 2020). Simultaneously, approximately 40% of non-US international trade transactions are invoiced in US dollars, despite not having a direct connection to the United States (Gopinath et al., 2020; Boz et al., 2022).

The theoretical motivation for examining this bidirectional relationship stems from fundamental tensions in how firms organize their international production. On one hand, dollar invoicing may facilitate GVC participation by providing a common unit of account that reduces transaction costs and exchange rate uncertainty across multiple countries and currencies. On the other hand, deep integration into GVCs may create incentives for firms to either toward or move away from dollar dependence through natural hedging mechanisms, relationship-specific currency arrangements, or regional invoicing practices that better match their production geography.

This essay investigates whether the relationship between the US dollar invoicing in trade and the participation in GVCs is bidirectional. The empirical strategy estimates each causal direction separately using two-stage least squares (2SLS), where instruments are selected to account for potential endogeneity in dollar invoicing and GVC participation, respectively. This approach enables me to isolate exogenous variation in each variable and credibly assess the direction and magnitude of their influence on each other. To further examine the role of macroeconomic conditions, I extend the analysis by conducting subsample regressions across different exchange rate volatility regimes.

The empirical analysis uncovers a robust negative bidirectional relationship between dollar invoicing and GVC participation that challenges conventional wisdom about currency dominance and production networks. Specifically, I find that a 1% increase in dollar-invoiced trade reduces overall GVC participation by approximately 0.83%, while a 1% increase in GVC production decreases dollar invoicing export share by 0.51%. These effects are economically significant and statistically robust across multiple specifications and estimation methods.

In addition, results show that exchange rate volatility alters these relationships. In low-volatility (relatively more stable) environments, the negative trade-offs are stronger, with a 1% increase in dollar invoicing reducing backward GVC participation by 1.53%. However, in high-volatility regimes, the relationships become less intense: the same increase in dollar invoicing reduces backward participation by approximately 0.6%. In contrast, the difference in the impacts of GVCs on the dollar-invoiced trade is less intense across exchange rate volatility regimes.

This subsample investigation finding suggests that exchange rate volatility alters the mechanisms through which currency choices interact with production networks. During periods of high volatility, the stabilizing role of dollar invoicing in mitigating transactional uncertainty appears to partially offset its negative impact on GVC integration.

This study contributes to the international economics literature along theoretical, empirical, and methodological dimensions. On the theoretical front, it provides a detailed explanation of how the role of a dominant currency (specifically the US dollar in this study) may be reshaped in the context of GVCs. Empirically, it employs an instrumental variable strategy to identify bidirectional causal effects, addressing limitations in earlier unidirectional analyses. Methodologically, it incorporates volatility-based subsample analysis,[1] which reveals heterogeneity in the relationship that is often masked in standard linear specifications.

[1]Complemented by a robustness check using Three-Stage Least Squares (3SLS) estimation to account for potential cross-equation residual correlation , but the 3SLS estimates are not consistent suggesting that the 2SLS estimates are the most reliable.

The remainder of this paper is organized as follows. Section 2 reviews the existing literature on dominant currency invoicing and GVC participation, highlighting the lack of studies addressing their bidirectional relationship. Section 3 introduces the theoretical framework, which links currency choice and GVC participation through interaction costs. Section 4 details the data sources and empirical methodology, including the instrumental variable construction. Section 5 presents the main empirical findings, focusing on the bidirectional effects, the moderating role of exchange rate volatility. Section 6 concludes.

2 Literature Review

The theoretical foundation for understanding currency invoicing patterns was established by Goldberg and Tille (2008), who introduced the concept of "vehicle currencies" that facilitate international transactions beyond bilateral trade relationships. This framework was recently advanced by Gopinath et al. (2020), whose Dominant Currency Paradigm (DCP) demonstrates that the US dollar and other major currencies' role in trade invoicing creates three key features: dominant currency pricing (where firms in non-dominant countries set prices in dollars regardless of trade partners), strategic complementarities in pricing (if most competitors are pricing their exports in a dominant currency, it becomes optimal for a firm to do the same), and imported input effects that amplify exchange rate pass-through.

Empirical evidence supporting the DCP has been extensive. Boz et al. (2022) document that approximately 40% of global trade is invoiced in US dollars, despite the US accounting for roughly 10% of global trade. This dominance is even more pronounced in emerging markets, where dollar-invoiced trade exceeds 60% (Gopinath and Itskhoki, 2021). Casas et al. (2017) show that this dollar dominance alters exchange rate pass-through mechanisms, with dollar appreciation reducing both export and import prices globally. Georgiadis et al. (2021) extend this analysis to show that dollar invoicing creates asymmetric responses to exchange

rate movements, with dollar appreciation having larger effects than bilateral exchange rate depreciation.

Recent advances have refined the understanding of vehicle currency mechanisms at the firm level. Amiti et al. (2022) provide firm-level evidence from Belgium, showing that larger, more import-intensive firms are more likely to invoice in foreign currencies, particularly the US dollar. Their analysis reveals strategic complementarities in currency choice, where firms' decisions are influenced by their competitors' invoicing patterns at destination market, supporting the theoretical predictions of the DCP framework.

The literature on GVCs has evolved through multiple theoretical generations, with recent work emphasizing the complex interactions between production fragmentation and macroeconomic dynamics. Antràs (2020) develope comprehensive frameworks linking GVC participation to firm-level characteristics, contractual arrangements, and institutional quality. Empirical studies have identified multiple determinants of GVC participation. Johnson and Noguera (2012) show that trade agreements significantly increase value-added trade flows. Koopman et al. (2014) develop decomposition methods that account for different types of GVCs[2] revealing that GVC trade accounts for more than half of global commerce.

A growing literature examines the intersection between currency invoicing and GVC participation, though with important limitations. Most existing studies focus on unidirectional relationships, missing potential feedback effects that my theoretical framework incorporates.

Dollar Invoicing and Its Impact on GVC Participation: Few papers investigate how dominant currency invoicing in trade affects GVC participation. Cook and Patel (2023) report that higher US-dollar invoicing corresponds with increased domestic content embedded in exports to the US as dollar invoicing insulates firms from exchange rate volatility. Georgiadis et al. (2019) document a negative association between US dollar invoicing and

[2]Overall (total GVC productions), Mixed (values of imported-input and domestic value added in export), Backward (imported input embedded in export), and Forward (domestic value added in export). Detail GVCs definitions can be found in the next section

backward participation that vanishes when European countries are excluded.

GVC Participation and Its Impact on Currency Choice: The reverse direction has received more attention, though with mixed findings. Georgiadis et al. (2019) document positive correlations between GVC integration and dollar invoicing across European countries, suggesting that production network complexity drives firms toward vehicle currencies. Mercado et al. (2023) note that in Asia-Pacific settings the dollar invoicing effect is especially pronounced, with statistically significant evidence of regional variation.

Mercado et al. (2023) also reveal a regional contrast: while Asia-Pacific economies with higher GVC participation tend to have higher shares of US dollar invoicing in both exports and imports, non-regional economies show the opposite pattern, with higher GVC participation associated with lower dollar invoicing. This suggests that the relationship between GVCs and currency choice is different across regions, potentially due to varying extent of regional trade exposure and the use of major regional currencies.

The role of exchange rate volatility in international trade has received renewed attention following DCP insights, though its interaction with the invoicing currency-GVC dynamics remains underexplored. Gopinath et al. (2020) show that dollar appreciation has contractionary effects on global trade through both trade and financial channels, with effects that persist beyond immediate exchange rate movements. Recent work by Cook and Patel (2023) shows that dollar appreciation triggered by US monetary policy has differential effects on various types of trade flows. Specifically, they find that final goods trade between non-US countries contracts more than global value chain-oriented trade that services US final demand, highlighting how GVC structures can mitigate external shocks.

The current literature suffers from three limitations that this study addresses:

- Unidirectional Focus: To the best of my knowledge at the time of this writing, there no existing study simultaneously models currency invoicing and GVC participation

as jointly determined endogenous variables. This creates identification problems and prevents understanding of feedback effects.

- Volatility Neglect: Despite extensive separate literatures on exchange rate volatility and trade, few of them examine how currency volatility moderates the currency invoicing - GVC relationship.

- Linear Assumptions: Most work assumes linear relationships, potentially missing threshold effects or accelerating trade-offs at extreme positions.

I address these gaps through a theoretical framework that models currency invoicing and GVC decisions as jointly endogenous and identifies volatility regimes as key moderators. The empirical strategy combines instrumental variable techniques with volatility-split analysis to uncover these complex dynamics.

3 Theoretical Framework

GVC trade differs from traditional trade in ways that have important implications for currency invoicing decisions. Unlike traditional trade, which typically involves the sale of final goods from firms to foreign wholesalers or consumers, GVC trade is characterized by cross-border, firm-to-firm exchanges of intermediate inputs. These transactions tend to be more customized, relationship-specific, and embedded within long-term contractual arrangements that fundamentally alter the conventional assumptions underlying currency invoicing decisions.

In (Johnson and Noguera, 2012) the definition of four types of GVC participation based on their position are defined as:

- ***Overall GVC participation*** is often measured as the ratio of GVC-related goods to gross exports, reflecting the sum of all traded goods involved in all types of GVC-

related activities. This measure provides a broad view of a country's integration into global production networks.

- ***Mixed or two-sided GVC participation*** refers to a country's simultaneous involvement in both forward and backward linkages within global value chains. This type of participation reflects firms that both import intermediate inputs and export semi-finished goods that are further processed in other countries. In the context of currency risk, sectors with mixed GVC participation may be particularly sensitive to exchange rate fluctuations, as both their inputs and outputs are likely to be priced in different currencies. This could potentially amplify the effects of bilateral exchange rate fluctuation on their competitiveness and profitability.

- ***Forward GVC participation*** measures the domestic value-added that is used as an intermediate input by other producers abroad. Countries exporting goods that require less processing or refinement abroad (e.g., agricultural commodities or crude oil) feature higher forward participation. At an aggregated level (country and sector), factors driving an increase in forward participation could include: an increase in the number of exporters (e.g., more firms engaging in export activities), higher labor hours used in exports (or higher wages in export sectors), and switching from imported inputs to domestic materials for exports. This type of participation demonstrates how much a sector or country truly contributes to final products. Higher forward participation is often associated with increased productivity and economic growth, and it also encourages interactions with producers in the next phase, especially those in the advanced economies and therefore gain exposure to new production techniques, quality standards, and technological know-how.

- ***Backward GVC participation*** refers to imported intermediate goods used in export production. While more predefined by the previous entity's forward capability,

backward value also accounts for the domestic value-added embedded in the imported inputs before (products travel across the same border more than twice). Backward GVC participation improves productivity by providing access to cheaper, higher quality, or high-tech embedded inputs. Veeramani and Dhir (2022) find a robust positive impact of backward participation on domestic productivity, gross exports, and employment, particularly in developing countries that specialize in final assembly activities.

GVC transactions involve relationship-specific investments and repeated interactions between upstream suppliers and downstream buyers. Various firms participating in a GVC often exchange highly customized inputs on a repeated basis, with contracts governing these exchanges featuring higher complexity than traditional spot market transactions. This creates what research frequently discusses as "supply chain stickiness," where trading relationships persist over time due to the challenges of searching for alternative suppliers, long-term contracts, and investments specific to particular relationships (Martin et al., 2023). The stickiness also emerges because high matching costs encourage relationship-specific investment, leading to high switching costs and a "lock-in" effect, especially in new markets (Qiang et al., 2021).

GVC participants face different demand elasticities compared to traditional exporters. While traditional exporters selling final goods to consumers must consider how exchange rate movements affect profit margins and consumer demand, GVC participants selling intermediate inputs to other firms face industrial buyers whose demand may be less sensitive to short-term price fluctuations. This reduced demand elasticity stems from the fact that industrial buyers often have limited substitution possibilities in the short run and may be locked into supply relationships through contracts or relationship-specific investments.

The contractual stickiness inherent in GVC relationship creates different dynamics for exchange rate pass-through (ERPT). GVC integration is associated with more stable trading

relationships, with factors such as processing infrastructure capacity and relationship-specific investments increasing the persistence of trading connections (Reis et al., 2023). This stickiness means that firms engaged in GVC trade may be less responsive to exchange rate fluctuations than traditional exporters, as they cannot easily switch suppliers or customers.

Building on the understanding that GVC trade differs from traditional trade, this section develops a theoretical framework that recognizes GVC participation and currency invoicing decisions as jointly determined through several interconnected mechanisms. The framework addresses how GVC participation might alter dollar invoicing decisions, and how dollar invoicing could affect GVC participation.

The trade-off facing exporters remains between the benefits and costs of dominant currency invoicing, but the GVC context alters the relative importance of these factors. There are three broad benefits associated with dollar invoicing in trade. First, dominant currency invoicing can isolate demand from price shocks associated with bilateral exchange rate fluctuations, particularly important when serving price-sensitive markets (Gopinath et al., 2020). Second, strategic complementarities in pricing emerge when competitors use dominant currency invoicing at destination markets, as coordination on the same currency reduces transaction costs and facilitates price comparisons (Yoshida et al., 2024). Third, using a dominant currency in trade with multiple partners along the chain leverages the network effects of the dominant currency, reducing the costs of currency conversion and hedging.

However, when invoicing in the dominant currency, firms lose pricing flexibility and must bear exchange rate risk rather than passing it through to customers. For some firms, pricing in a dominant currency may involve additional transaction costs, particularly when their cost base is in other currencies.

In GVC relationships, the **demand stickiness** created by relationship-specific investments and contracts reduces the sensitivity of demand to exchange rate fluctuations. When suppliers are integrated into established supply chains, buyers are less likely to switch suppli-

ers in response to short-term price changes. This reduces the benefits of dollar invoicing for demand isolation, as GVC relationships create natural demand stability. This stickiness operates through several channels: the challenges of finding alternative suppliers, the existence of long-term contracts, and relationship-specific investments that create switching costs.

GVC participation brings **natural hedging opportunities** that reduce reliance on dominant currency invoicing for risk management. When firms are integrated into GVCs, they often develop matched currency exposures across their operations. For mixed and backward GVC participation, firms importing intermediate inputs and exporting intermediate and final goods may find that their currency exposures naturally offset each other, reducing the need for dominant invoicing as a hedging mechanism. Adler et al. (2023) show that GVC participation reduces the exchange rate elasticity of gross trade volumes, suggesting that GVC integration provides alternative mechanisms for managing exchange rate risk that may substitute for dollar invoicing. The hedging effect emerges when firms import inputs and export goods, creating offsets to currency fluctuations.

The **regional clustering** of GVC activities creates opportunities for regional currency coordination that compete with global dollar-based systems. Baldwin and Lopez-Gonzalez (2015) go so far as to claim that "supply chain trade is not global—it's regional" and that even within regions, distance and contiguity matter more for the formation of GVCs. When GVC relationships are concentrated within particular regions, participants may develop alternative coordination mechanisms that reduce dependence on a internationally dominant currency as a vehicle currency. This regional clustering creates information advantages and reduces transaction costs for regional currencies, potentially making them more attractive than the dollar (as a non-regional currency) for intra-regional GVC transactions.

While strategic complementarities in pricing favors a internationally dominant currency invoicing in traditional trade contexts, in GVC contexts this mechanism operates differently. Rather than coordinating with all competitors in a global market, GVC participants may

find it more beneficial to coordinate with their specific supply chain partners. This creates the possibility of multiple coordination equilibria where different GVC networks coordinate on different currencies, even within the same industry (Mancini Griffoli et al., 2024).

The bidirectional relationship between dominant currency and GVC participation emerges because GVC participation creates bilateral information networks that reduce the informational advantages traditionally associated with dominant currency pricing. When firms engage in intensive GVC relationships, they develop specialized knowledge about their trading partners' operations, preferences, and constraints. This bilateral information advantage can overcome the network effects that typically favor dominant currencies.

Lastly, deep GVC participation alters the transaction cost structure of international trade in ways that create joint endogeneity with currency invoicing decisions. When GVC participants generate sufficient transaction volumes in bilateral relationships, they can justify the fixed costs of using non-dominant currencies. Long-term GVC relationships involve relationship-specific investments that reduce the transaction cost advantages traditionally associated with dominant currency usage.

This theoretical framework suggests that GVC participation can both increase and decrease dollar invoicing shares through competing mechanisms. GVC participation may reduce dominant invoicing when regional clustering effects and natural hedging opportunities dominate the traditional coordination benefits. The development of alternative risk management mechanisms through matched currency exposures reduces the need for dollar invoicing as a hedging tool.

Conversely, GVC participation may increase the use of dominant currency invoicing, as the complexity of international transactions makes coordination on a single currency more valuable. This strategic complementarity is likely to be amplified when firms operate across multiple production stages and engage with diverse trading partners, increasing the incentives to adopt a widely accepted invoicing currency.

In the reverse direction, dominant invoicing may facilitate GVC participation by providing a common coordination mechanism that reduces transaction costs across the value chain as it does to the traditional trade. The network effects of dollar invoicing may make it easier for firms to engage in complex international production arrangements.

Alternatively, higher dominant currency invoicing in trade may reduce GVC participation when dominant currency invoicing concentrates exchange rate risk and makes firms more cautious about international production fragmentation. The concentration of currency risk in adopting an international dominant currency in trade may increase coordination costs and make deep GVC integration more difficult.

Exchange rate volatility plays a crucial role in moderating the relationship between GVC participation and currency invoicing through several channels. In periods of high exchange rate volatility, the conventional benefits of dominant currency invoicing for managing currency risk become more pronounced. However, GVC participation can offer alternative forms of risk mitigation that may reduce reliance on dominant currency invoicing.

Kiyotaka and Zhang (2019) find that GVC integration (especially when through regional value chains) reduces the negative effects of exchange rate volatility on exports, indicating that firms embedded in production networks may adjust differently to currency fluctuations. Their study further shows that once a country's GVC participation exceeds a certain threshold, exchange rate volatility may even have a positive effect on export performance. Higher volatility may increase the value of natural hedging opportunities embedded in GVC structures, potentially making regional currency coordination more attractive relative to reliance on dollar invoicing.

The framework predicts different effects for different types of GVC participation. In forward GVC participation, firms exporting intermediate inputs for further processing abroad face buyers who are themselves engaged in production for export. These buyers may be less price-sensitive than final consumers, reducing the benefits of dollar invoicing for demand

isolation. However, forward participants may still benefit from dominant currency invoicing if their buyers are selling to global markets where dominant currency, such as US dollar pricing, is prevalent.

In backward GVC participation, firms importing intermediate inputs for export production face different considerations. For example, if their imported inputs are dollar-invoiced, they may benefit from dollar invoicing of their exports to create a natural hedge. However, if they source inputs regionally or have developed alternative hedging mechanisms, the benefits of dollar invoicing may be reduced.

For firms engaged in mixed GVC participation, the dynamics are more complex as they combine elements of both forward and backward linkages. These firms import intermediate goods, add value, and then export them as more processed intermediates for subsequent stages of production. This position in the middle of a value chain exposes the firm to currency risks on both its costs and its revenues. The natural hedging motive becomes particularly important here, as the optimal invoicing choice for exports is heavily influenced by the currency structure of its imported inputs. The effect of mixed GVC participation on dominant currency invoicing is therefore theoretically ambiguous. It depends on the specific architecture of the value chain a firm is embedded in. If the chain is predominantly global and coordinated in dollars, a firm in the middle will face strong pressure to conform. Conversely, if the chain is more regional and utilizes a non-dollar currency, the incentive to use the dollar will be much lower.

Based on the theoretical framework, here are some testable predictions about the relationship between GVC participation and US dollar invoicing:

Hypothesis I: Firm's decision about GVC participation and the currency of invoicing for exports are jointly determined through strategic complementarities in pricing, natural hedging, and regional clustering mechanisms. This predicts that there's a bidirectional relationship between GVC participation and dollar invoicing.

Hypothesis II: The relationship between GVC participation and dollar invoicing depends on the exchange rate volatility regime. In high volatility regimes, the natural hedging benefits of GVC participation might strengthen the relationship with dollar invoicing.

Hypothesis III: The relationship exhibits threshold behavior where the effects of GVC participation on dollar invoicing become stronger when volatility exceeds certain levels or when GVC participation reaches sufficient intensity.

4 Empirical Strategies and Data

4.1 Testing the Bidirectional Relationships

This section outlines my empirical examination of the hypothesized bidirectional relationship between dollar-invoiced trade and GVC participation. Using separate 2SLS estimations for each causal direction, the analysis evaluates how variations in the share of trade invoiced in US dollars (as an internationally dominant currency) and the degree of GVC-related production mutually influence one another.

To test for bidirectional causality, I employ a single-equation 2SLS approach for each direction. This methodology allows for the separate identification of each causal pathway using direction-specific instrumental variables. Equation 1 specifies two separate structural equations capturing the potential bidirectional relationship between GVC-related production and the share of dollar invoiced trade (DIT).

$$\begin{aligned} \ln \mathrm{GVC}_{ijt} &= \alpha_0 + \alpha_1 \ln \mathrm{DIT}_{it} + \alpha_2 \ln FX_{ijt} + f_{ij} + f_t + \epsilon_{ijt} \\ \ln \mathrm{DIT}_{it} &= \beta_0 + \beta_1 \ln \mathrm{GVC}_{ijt} + \beta_2 \ln FX_{ijt} + f_{ij} + f_t + \delta_{ijt} \end{aligned} \tag{1}$$

The **forward specification** examines how dollar invoicing influences GVC participation, treating $\ln \mathrm{DIT}_{it}$ as endogenous. The **reverse specification** evaluates how GVC participa-

tion affects dollar invoicing decisions, treating $\ln \mathrm{GVC}_{ijt}$ as endogenous. Each equation is estimated separately using 2SLS with equation-specific instruments that satisfy the relevance and exogeneity conditions for that particular causal direction.

The variable $\ln \mathrm{GVC}_{ijt}$ measures the log of GVC trade flows between Country i and Country j in year t. Similarly, $\ln \mathrm{DIT}_{it}$ captures the log of the share of exports of Country i invoiced in US dollars in year t. The control variable $\ln FX_{ijt}$ is the nominal bilateral exchange rate between Country i and Country j. An increase in this exchange rate indicates a depreciation of Country i's currency with respect to its trading partner j. I include country-pair (f_{ij}) and time (f_t) fixed-effects to control for unobserved time-invariant and global macro fluctuations in this and all subsequent specifications.

To address endogeneity concerns in each causal direction, I employ direction-specific instrumental variables within the 2SLS framework. For the forward specification (DIT $\rightarrow$ GVC), I instrument dollar-invoiced exports using the Export Weighted Index (EWI). For the reverse specification (GVC $\rightarrow$ DIT). For the reverse specification I instrument GVC-related production using Regional Trade Agreements (RTAs). This approach ensures that each equation satisfies the identification requirements independently, with instruments chosen based on their relevance to the specific endogenous variable and their exogeneity with respect to the outcome variable in each equation.

Dominant currency paradigm studies have shown that exporters tend to invoice in dollars when their key trading partners predominantly purchase imports in dollars to reduce the risk of bilateral exchange rate and remain competitive against their competitors. I take advantage of this strategic complementarities in pricing to create an instrument for the country's share of exports invoiced in dollars (DIT_{it}). Specifically, the Export Weighted Index (EWI) is calculated as the weighted average share of imports invoiced in dollars across all of country i's trading partners, where the weights are defined as country i's GVC flows to country j

relative to all GVC flows into that market:

$$\text{Export Weighted Index}_{ijt} = \sum_{j} \frac{\text{GVC}_{ijt}}{\text{GVC}_{it}} * \text{Dollar-Invoiced Import Share}_{jt}$$

EWI strongly predicts dollar invoicing because exporters face complementary pricing incentives: to align with the pricing norm, they are more likely to invoice in dollars if their competitors in a market are also invoicing in dollars. Importantly, EWI affects GVC participation only through its impact on dollar invoicing decisions, not directly, satisfying the exclusion restriction required for valid instrumental variable estimation. EWI captures competitors' dollar preferences at destination markets, making it orthogonal to bilateral GVC-specific factors between the exporter and importer. An exporter's decision to deepen GVC ties with a specific partner depends on production complementarities, logistics, and bilateral trust—factors unrelated to that partner's dollar invoicing patterns with third countries.

Figure 1 displays the distribution of the EWI for all country pairs in the years 2005, 2010, 2015, and 2019. The EWI values are widely dispersed, from about 20 to 80 percent, reflecting considerable heterogeneity in export concentration across pairs. In addition, there is no strong trend toward convergence or divergence over time, indicating the diversity in export destination structure among country pairs is a persistent feature throughout the sample period.

I instrument for the value of bilateral GVC flows using the number of active regional trade agreements (RTAs) in which the exporting and importing countries (Country i and Country j) jointly participate. RTAs facilitate bilateral GVC flows by reducing trade barriers, harmonizing technical standards, and lowering transaction costs, all of which encourage firms to fragment production across borders and expand their cross-border supply chains.

RTAs can be a strong instrument because they directly promote GVC participation by making it easier and more efficient for firms to engage in international production networks.

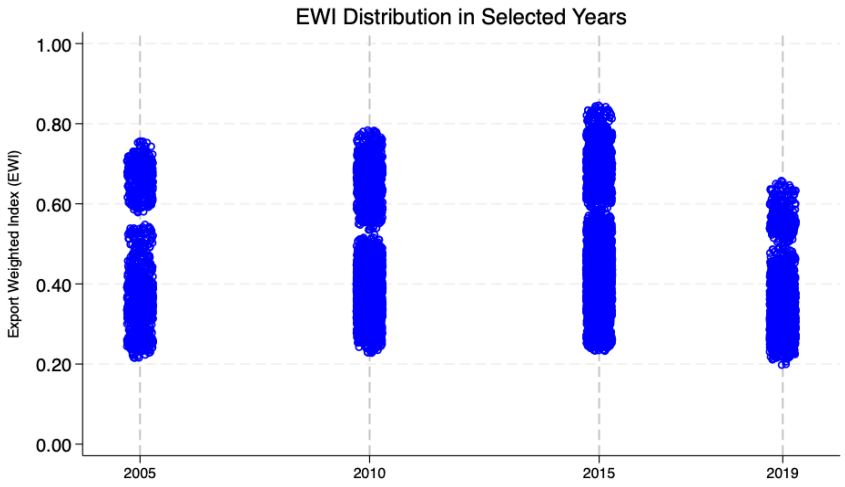

Figure 1. Percentage Distribution of EWI

Importantly, RTAs do not mechanically determine currency invoicing choices. The decision to invoice trade in a particular currency is shaped more by macroeconomic factors such as exchange rate volatility and financial market development and credit access than by the presence of a trade agreements. This exclusion restriction is supported by empirical evidence from Flaaen et al. (2024), who demonstrate that RTAs significantly strengthen GVC linkages, particularly through improved input sourcing and export complementarities.

Figure 2 shows that over 50% of the country pairs are not common members of any RTAs, which provides variation for identifying the causal effects of RTAs on GVC participation and dollar invoicing patterns. This heterogeneity in RTA membership across country-pairs ensures that it has sufficient power to isolate exogenous variation in GVC integration in the IV estimation, as RTA formation is driven by geographical, political, and historical factors rather than contemporaneous trade finance. The prevalence of non-RTA pairs further validates the exclusion restriction: RTAs influence dollar invoicing via GVC participation, not direct currency coordination. In the empirical studies, the number of RTAs is transformed using the inverse hyperbolic sine function : $RTA = asinh(\text{RTA})$. The inverse hyperbolic sine transfor-

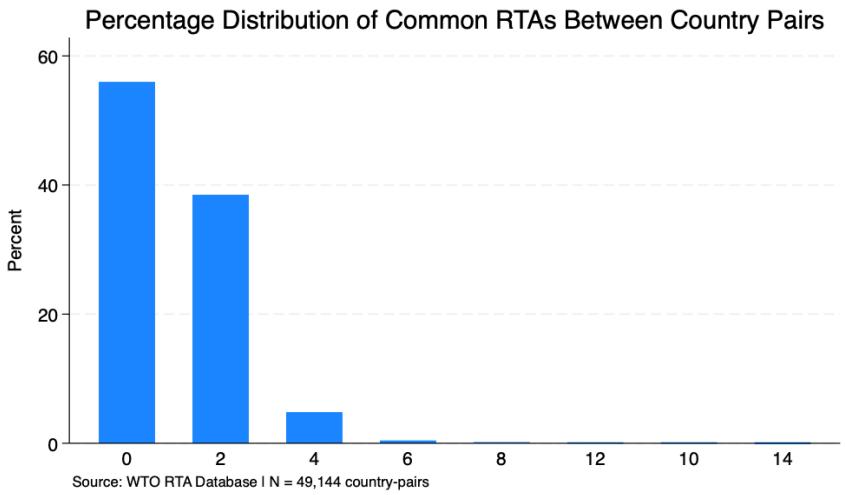

Figure 2. Percentage Distribution of Common RTAs

mation is preferred in this context because it appropriately handles zeros while preserving an interpretation similar to that of a logarithmic transformation. This is particularly relevant for variables such as the number of trade agreements, which may include zero observations (countries with no joint trade agreements). As the commonly used log(1+x) transformation may introduce bias and lacks a strong theoretical foundation, the IHS transformation maintains the economic meaning of zero-valued observations and reduces the influence of outliers in right-skewed distributions.

To examine the marginal effects of GVC participation and the share of dollar-invoiced trade, Equations 1 are extended by instrumenting both the main variables and their interaction terms with the bilateral exchange rate. The instruments include the original IVs as well as their interaction terms.

$$\begin{aligned} \ln \mathrm{GVC}_{ijt} &= \alpha_0 + \alpha_1 \ln \hat{\mathrm{DIT}}_{it} + \alpha_2 \ln \hat{\mathrm{DIT}}_{it} * \ln FX_{ijt} + \alpha_3 \ln FX_{ijt} + \epsilon_{ijt} \\ \ln \mathrm{DIT}_{it} &= \beta_0 + \beta_1 \ln \hat{\mathrm{GVC}}_{ijt} + \beta_2 \ln \hat{\mathrm{GVC}}_{ijt} * \ln FX_{ijt} + \beta_3 \ln FX_{ijt} + \delta_{ijt} \end{aligned} \tag{2}$$

My analysis based on Equation 2 will extend the baseline specifications in two ways. First,

it examines four distinct GVC types (Overall, Mixed, Backward, and Forward) to capture segment depth of GVC heterogeneity in production networks. Second, I will conduct subsample analysis based on exchange rate volatility thresholds (divided into two subsample by the median exchange rate fluctuations) to investigate how macroeconomic instability moderates the bidirectional relationship.

In addition, to address Hypothesis III, I modify Equation 1 to include the squared terms of DIT and GVC, which allows me to test the prediction that trade-offs accelerate at extreme positions:

$$\begin{aligned} \ln \mathrm{GVC}_{ijt} &= \alpha_0 + \alpha_1 \ln \mathrm{DIT}_{it} + +\alpha_2 \ln \mathrm{DIT}_{it}^2 + \alpha_3 \ln FX_{ijt} + f_{ij} + f_t + \epsilon_{ijt} \\ \ln \mathrm{DIT}_{it} &= \beta_0 + \beta_1 \ln \mathrm{GVC}_{ijt} + \beta_2 \ln \mathrm{GVC}_{ijt}^2 + \beta_3 \ln FX_{ijt} + f_{ij} + f_t + \delta_{ijt} \end{aligned} \tag{3}$$

Finally, a Three-Stage Least Squares (3SLS) estimation is employed as a sensitivity test. Compared to equation-by-equation 2SLS, 3SLS offers potential efficiency gains by accounting for cross-equation correlations in the residuals by estimating the equations as a simultaneous system. However, these efficiency gains rely on the correct specification of the entire system of equations—an assumption that may be difficult to fully satisfy in empirical applications. To assess the robustness of the results, Hausman tests are conducted to compare 2SLS and 3SLS estimates. Significant test statistics suggest potential model misspecification, in which case the more robust 2SLS estimates are preferred over the potentially biased 3SLS results.

4.2 Data

The empirical study employs an unbalanced panel dataset covering bilateral trade relationships for 87 countries, using annual data for 1990 to 2020, constructed from multiple sources. Bilateral GVC data are obtained from the World Integrated Trade Solution (WITS), providing measures of gross and GVC-related trade flows between country pairs. Dollar invoicing

shares are sourced from Boz et al. (2022), capturing the share of exports invoiced in US dollars at the country level. Additional controls, including exchange rates, are taken from Müller et al. (2025), and regional trade agreement data are drawn from the WTO RTA database.

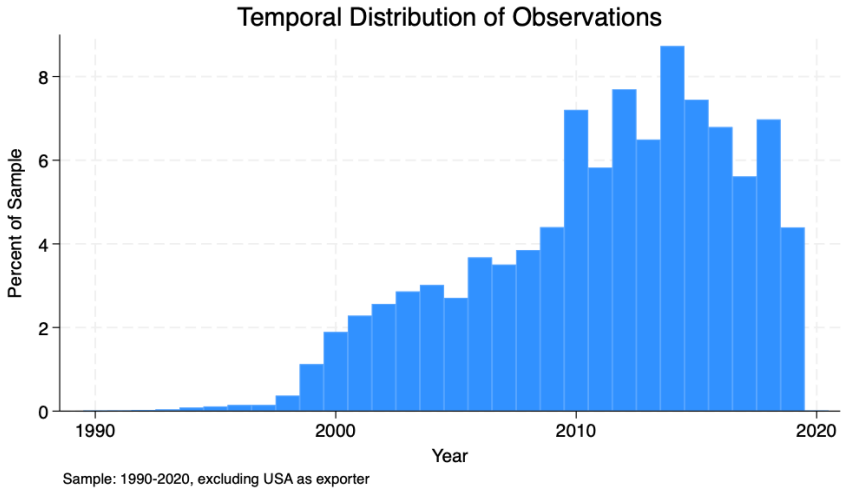

Figure 3. Temporal distribution of observations across years

The final dataset comprises 48,374 observations across 87 countries, forming 6,425 country pairs. As shown in Figure 3, the data are primarily concentrated in the post-2000 period. While coverage is limited in the early 1990s, the dataset offers more consistent representation from 2000 to 2019, capturing approximately 20–50% of global trade under major structural changes including the rise of China and the 2008 financial crisis. The United States is excluded as an exporter to avoid mechanical correlations between dollar dominance and invoicing patterns.

The correlation matrix in Figure 4 presents a sketch of the relationships among the key variables in the analysis in the following section. There is a negative correlation between overall GVC participation and dollar-invoiced trade (DIT), showing initial evidence of a trade-off between these variables. The Export Weighted Index (EWI) shows a strong positive

correlation with DIT (0.64), confirming its relevance as an instrument for dollar invoicing, while RTA exhibit a positive correlation with GVC participation (0.27), supporting its use as an instrument for GVC integration.

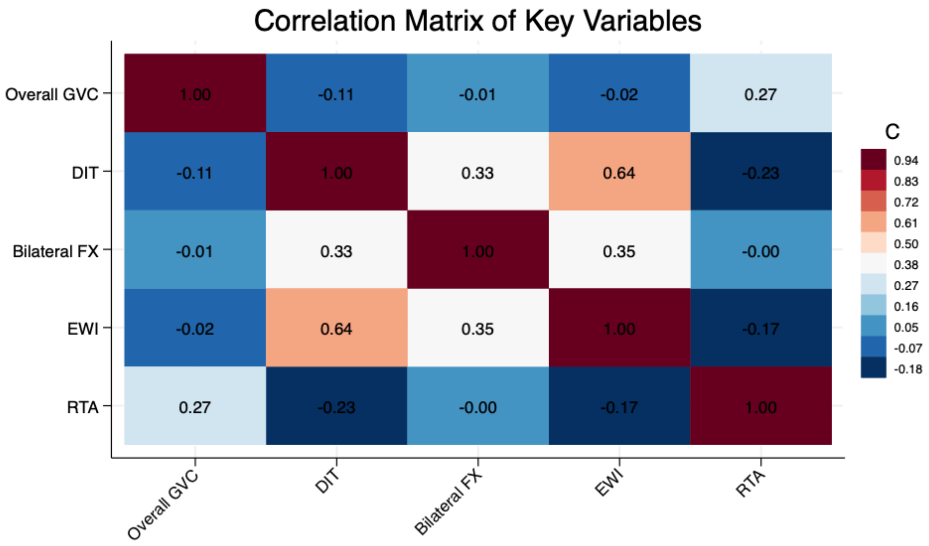

Figure 4. Percentage Distribution of Common RTAs

5 Empirical Results

Results in this section present a consistent negative bidirectional relationship between GVC participation and DIT. Specifically, a higher level of GVC production tends to reduce a country's use of U.S. dollar invoicing, while increased use of dollar invoicing is linked to a decline in GVC-related productions.

5.1 Benchmark Analysis

As a benchmark, Tables 1 and 2 present the results from OLS estimates that fails to account for the endogeneity of GVC and dollar-invoiced export. Table 1 shows the estimated effects of

dollar-invoiced export shares on the four different types of GVC participation. The estimates show that a 1% increase in the share of exports invoiced in US dollars is associated with more than a 0.3% reduction in overall, mixed, and backward GVC production, which is statistically significant. The negative relationship is strongest for backward GVC participation, while the forward GVC production shows a slightly smaller but still statistically significant decline of around 0.23%.

Table 1. OLS Results: Forward Causality - Full Sample

	(1) Overall GVC	(2) Mixed GVC	(3) Backward GVC	(4) Forward GVC
DIT	-0.3002***	-0.3224***	-0.3173***	-0.2306***
	(0.0276)	(0.0310)	(0.0262)	(0.0308)
Bilateral FX	0.0115	0.0706**	0.0452*	-0.0269
	(0.0221)	(0.0246)	(0.0223)	(0.0231)
F-statistic	59.062	55.690	73.758	29.846
R-squared	0.975	0.973	0.974	0.972
Observations	47,168	47,167	47,168	47,104

Standard errors in parentheses
All models include pair and year fixed effects.
Standard errors clustered at pair level.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The estimates show mixed findings for the role of bilateral exchange rate movements (Bilateral FX). A depreciation of the home currency relative to the trading partner's currency is associated with increased activity in mixed and backward GVC participation, but the former is significant only at the 10% level and there is no statistical significant effect on overall or forward GVC measures.

Table 2 presents the results of OLS estimation of the impact of GVC participation on DIT. This reverse specification shows symmetrical negative relationships: backward GVC participation shows the strongest negative impact on dollar use among all four types of the GVCs. However, these reverse causal effects are an order of magnitude smaller than the estimated effects of DIT on GVC participation shown in Table 1. Bilateral exchange rate

Table 2. OLS Results: Reverse Causality - Full Sample

	(1) DIT	(2) DIT	(3) DIT	(4) DIT
Bilateral FX	0.0238**	0.0262**	0.0254**	0.0226*
	(0.0091)	(0.0092)	(0.0091)	(0.0092)
Overall GVC	-0.0452***			
	(0.0046)			
Mixed GVC		-0.0411***		
		(0.0043)		
Backward GVC			-0.0462***	
			(0.0042)	
Forward GVC				-0.0312***
				(0.0044)
F-statistic	49.729	47.666	62.459	27.963
R-squared	0.957	0.957	0.957	0.957
Observations	47,168	47,167	47,168	47,104

Standard errors in parentheses
All models include pair and year fixed effects.
Standard errors clustered at pair level.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

depreciation has consistently negative and significant effects on DIT, at least at the 10% level.

Although these preliminary findings suggest a bidirectional trade-off between dollar-invoiced trade and GVC participation, several methodological limitations merit attention. The simultaneity inherent in the relationship between these two variables violates the exogeneity assumptions required for OLS estimates, introducing potential bias. Additionally, omitted variables such as firm-level pricing and supply chain strategies may confound the relationship by jointly affecting both outcomes. Measurement error in key variables may further attenuate the estimated coefficients, implying that the results likely represent lower bounds. These concerns highlight the need for more rigorous identification in subsequent analyses.

The OLS estimates in the previous subsection establish the baseline empirical patterns while highlighting the need for a causal identification strategy. The consistently negative correlations for both directions of causality across specifications motivate the use of 2SLS (IV) estimation to identify the causal effects and test for the presence of simultaneity bias in the OLS estimates.

Appendix table 15 presents the first-stage results. Standard statistical tests confirm the relevance of the instrumental variables for predicting dollar-invoiced export shares. The coefficient of 1.37 on EWI explains a substantial portion of DIT variation, even after controlling for exchange rates and fixed effects. The F-statistic strongly rejects the null hypothesis of weak instruments, confirming its initial suitability for identifying the forward relationship. As expected, a greater export weight to the destination market is positively associated with dollar-invoiced export.

Appendix table 16 shows that RTA is a statistically significant predictor of GVC participation, with F-statistics comfortably above the weak-instrument threshold. The stronger F-stats for mixed and backward GVC align with theory, as RTAs encourage trade in inter-

mediate goods. However, the coefficients on RTA in Table 16 are an order of magnitude smaller than those on EWI in Table 15, indicating the weaker explanatory power of the former instrument.

The above tests confirm that both the EWI (for dollar-invoiced trade) and the number of RTAs (for GVC participation) are statistically valid instruments. These results validate the IV strategy and provide a basis for drawing causal inferences in the analyses that follow.

Given the confirmation of the validity of the IVs, Table 3 presents the second-stage regression results for the causality from DIT to the four measures of GVC participation. The results show evidence that greater use of dollar invoicing is associated with lower participation in all types of GVC production, with the largest negative effect observed in backward GVCs: a 1% increase in dollar-invoiced export share is associated with 0.95% reduction in bilateral backward GVC flow. Though less substantial compared to the other three types of GVCs, a 1% increase in dollar-invoiced export share is also associated with 0.53% reduction in bilateral forward GVC. These results imply that countries that prioritize currency stability through dollar invoicing may face constraints in integrating into imported-input intensive GVCs.

The estimates in Table 3 show mixed effects of nominal bilateral exchange rate depreciation: significantly positive for mixed and backward GVC participation but insignificant for overall and forward GVC participation. One plausible reason for this could be, in the mixed and backward models, a depreciation of the home currency makes the country's exports more price-competitive in foreign markets, potentially boosting demand for goods produced with imported intermediates and thus increasing mixed and backward GVC flows. Simultaneously, while imported intermediate inputs become more expensive, firms participating in GVCs might have established relationships or can pass on some of these costs through price adjustments or productivity improvements, resulting in increased net activity.

When comparing these 2SLS results to the simpler OLS regressions in Table 1, the

Table 3. 2SLS Estimates: Impact of Dollar Invoicing on GVC Participation

	(1) Overall GVC	(2) Mixed GVC	(3) Backward GVC	(4) Forward GVC
Bilateral FX	0.0240	0.0814***	0.0600***	-0.0198
	(0.0226)	(0.0251)	(0.0229)	(0.0235)
DIT	-0.8293***	-0.7810***	-0.9452***	-0.5289***
	(0.1042)	(0.1080)	(0.1085)	(0.1049)
KP LM Stat	314.69	314.69	314.69	314.71
KP Wald F	373.53	373.52	373.53	373.51
Adj R-squared	-0.029	-0.013	-0.043	-0.005
Observations	47,168	47,167	47,168	47,104

Standard errors in parentheses
All models include pair and year fixed effects.
Standard errors clustered at pair level.
Instruments: Export Weighted Index
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

IV estimates generally yield larger negative coefficients, which is the expected direction of bias if endogeneity in dollar invoicing attenuates the true negative effect in OLS models. The findings reinforce that the dampening effect of dollar invoicing on GVC participation is robust and likely understated in OLS specifications, and they shed new light on how invoicing currency practices can constrain participation in both upstream and downstream segments of value chains.

In the reverse causality analysis, the second-stage regression results shown in Table 4 show that deeper GVC integration reduces reliance on dollar invoicing. All types of GVC participation have negative and statistically significant effects on the DIT. The impact is strongest for forward GVC participation, indicating that an increase in home value-added has the greatest impact in reducing dollar invoicing in exports within GVCs. A 1% increase in forward GVC production reduces 0.65% reliance on the dollar-invoicing share of export (column (4)), suggesting that countries specializing in supplying inputs to other countries' exports are particularly active in reducing dollar exposure. The bilateral exchange rate is positive and statistically significant for overall, mixed, and backward GVC participation,

Table 4. 2SLS Estimates: Impact of GVC Participation on Dollar Invoicing

	(1) DIT	(2) DIT	(3) DIT	(4) DIT
Bilateral FX	0.0259*	0.0505***	0.0408***	0.0027
	(0.0135)	(0.0141)	(0.0132)	(0.0174)
Overall GVC	-0.5091***			
	(0.0864)			
Mixed GVC		-0.4264***		
		(0.0677)		
Backward GVC			-0.4558***	
			(0.0741)	
Forward GVC				-0.6480***
				(0.1297)
KP LM Stat	53.50	73.07	62.51	35.20
KP Wald F	53.06	73.32	62.78	34.72
Adj R-squared	-1.416	-1.149	-1.137	-2.798
Observations	47,168	47,167	47,168	47,104

Standard errors in parentheses

All models include pair and year fixed effects.

Standard errors clustered at pair level.

Instrument: Regional Trade Agreements (rta_asinh)

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

while its effect is weaker and not significant for the forward GVC participation.

Similarly, when comparing to the OLS results in Table 2, the coefficients of this IV estimates also yield much larger negative coefficients, going from around -0.04 in the OLS model to -0.4 in the 2SLS model.

The results in Tables 3 and Table 4 together show that the negative relationship between dollar use and GVC integration persists across specifications, with dollar invoicing effects on GVCs (-0.53% to -0.95%) exceeding reverse effects (-0.43% to -0.65%). Backward GVCs are most vulnerable to dollar dominance, while forward GVCs show greater resilience but stronger reverse impacts.

To further explore the dynamics between dollar invoicing (DIT) and GVC participation, I introduce interaction terms between these key variables and the bilateral exchange rate (FX). This allows me to test whether the observed relationships are conditional upon the relative valuation of the exporter's currency against its trading partner's currency.

Table 5 presents the 2SLS estimates for the impact of DIT on GVCs with the inclusion of an interaction term of DIT and the bilateral exchange rate. The main effect of DIT remains robustly negative and statistically significant across all GVC types, with coefficients ranging from -0.73 (Forward GVC) to -1.22 (Backward GVC). This reinforces the baseline finding that increased DIT is detrimental to GVC integration.

Interestingly, the coefficient on the bilateral exchange rate itself is now negative and highly significant in all specifications. This suggests that, a depreciation of the exporter's currency (an increase in Bilateral FX) is associated with contraction in GVC production.

The interaction term (DIT * Bilateral FX) is consistently negative and highly significant. This negative interaction implies that the adverse effect of DIT on GVC participation is exacerbated by the depreciation of the exporter's currency. In other words, when an exporter's currency weakens, the negative impact of relying on dollar invoicing for GVC participation becomes even more pronounced. This finding is somewhat counterintuitive to the notion

Table 5. 2SLS with Interactions: Dollar Invoicing → GVC Participation

	(1) Overall GVC	(2) Mixed GVC	(3) Backward GVC	(4) Forward GVC
Bilateral FX	-0.2437***	-0.1350**	-0.2449***	-0.2453***
	(0.0545)	(0.0528)	(0.0592)	(0.0540)
DIT	-1.0705***	-0.9760***	-1.2200***	-0.7321***
	(0.1391)	(0.1370)	(0.1498)	(0.1364)
DIT * Bilateral FX	-0.3024***	-0.2445***	-0.3445***	-0.2546***
	(0.0584)	(0.0568)	(0.0643)	(0.0569)
KP LM Stat	112.78	112.78	112.78	112.74
KP Wald F	64.45	64.45	64.45	64.43
Adj R-squared	-0.158	-0.075	-0.212	-0.087
Observations	47,168	47,167	47,168	47,104

Standard errors in parentheses
All models include pair and year fixed effects.
Standard errors clustered at pair level.
Instruments for DIT and DIT*FX: EWI and EWI*FX
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

that a weaker currency might cushion such effects by boosting export competitiveness. It could reflect that during periods of currency depreciation, which might signal underlying economic instability, the perceived benefits of dollar invoicing (e.g., stability, reduced transaction costs) do not lead firms to prioritize the dollar use in trade. Alternatively, currency depreciation might amplify the pass-through of dollar-denominated costs within GVCs, further straining these production networks. This phenomenon may be partly explained by the fact that GVC flows, which are often regional in nature, could benefit more from alternative currency arrangements, such as the use of regional currencies or regionally dominant invoicing currencies.

Table 6 presents the reverse causality estimation, where GVC participation influences DIT with the incorporation of an interaction with the bilateral exchange rate. The main negative effect of GVC participation on DIT remains consistent with the baseline findings. This indicates that greater involvement in GVCs is associated with a reduced share of trade

invoiced in US dollars.

However, the interaction term (GVC * Bilateral FX) is found to be statistically insignificant across all types of GVC participation. This suggests that the extent to which GVC participation leads to a reduction in dollar invoicing does not significantly depend on the level of the bilateral exchange rate. The propensity of GVC-active firms or sectors to use non-dollar invoicing seems to be a more structural characteristic, less influenced by short-to-medium term fluctuations in the bilateral exchange rate. Instrument strength, as indicated by KP Wald F-statistics, remains adequate for most GVC types, though it is notably lower for the Forward GVC specification (F=14.36) when interactions are included and instrumented by the interaction term of (RTA * Bilateral FX).

The inclusion of interaction terms reveals an interesting asymmetry: while the bilateral exchange rate significantly exacerbate the impact of DIT on GVCs, it does not appear to alter the way GVC participation influences dollar invoiced trade.

Table 6. 2SLS with Interactions: GVC Participation→ Dollar Invoicing

	(1) DIT	(2) DIT	(3) DIT	(4) DIT
Bilateral FX	0.0442*	0.0453***	0.0365**	0.0442
	(0.0227)	(0.0157)	(0.0175)	(0.0271)
Overall GVC	-0.5111***			
	(0.0872)			
Mixed GVC		-0.4267***		
		(0.0676)		
Backward GVC			-0.4564***	
			(0.0743)	
Forward GVC				-0.6681***
				(0.1416)
Overall GVC * Bilateral FX	-0.0036			
	(0.0041)			
Mixed GVC * Bilateral FX		0.0018		
		(0.0035)		
Backward GVC * Bilateral FX			0.0011	
			(0.0035)	
Forward GVC * Bilateral FX				-0.0108
				(0.0067)
KP LM Stat	53.73	73.57	62.91	29.15
KP Wald F	26.61	36.91	31.64	14.36
Adj R-squared	-1.431	-1.149	-1.141	-3.049
Observations	47,168	47,167	47,168	47,104

Standard errors in parentheses
All models include pair and year fixed effects.
Standard errors clustered at pair level.
Instruments for GVC and GVC*FX: RTA and RTA*FX (rta_asinh and c.rta_asinhc.ln_exchange)
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5.2 Comparing High and Low Exchange Rate Volatility Subsamples

The stability of bilateral exchange rate environments plays a critical role in shaping trade and currency choices, particularly in globally fragmented production networks. To examine whether the identified bidirectional relationship between dollar-invoiced trade and GVC participation varies across different currency environments, I split the sample at the country-pair level based on the median level of bilateral exchange rate volatility, as measured over the entire sample period. For example, if the Germany-Italy pair has above-median volatility over 1990–2020, all Germany-Italy observations enter the "high volatility" subsample. Within each regime (high or low volatility), I then estimate the baseline 2SLS regressions using all country-year observations associated with country-pairs in that regime. This subsample analysis aims to test the hypothesis that currency stability moderates the core trade-off between dollar use and GVC integration, with implications for both the magnitude and direction of these effects. Countries operating in stable exchange rate regimes may exhibit stronger sensitivity to the dollar-GVC relationship, while those in volatile environments may prioritize currency hedging over production expansion.

The preliminary OLS estimates (not controlling for endogeneity) reveal heterogeneity across volatilities. In the forward causality analysis (Table 17 in the appendix), the negative impact of dollar invoicing on GVC participation is stable across volatility regimes. However, the impact of bilateral exchange rate depreciation is uneven: positive and significant in high-volatility environments (particularly for mixed and backward GVCs), but insignificant in the low-volatility subsample. This pattern suggests that exchange rate movements provide compensatory effects for GVC integration only during turbulent periods.

The reverse causality estimates in Table 18 in the appendix show a slightly more pronounced volatility-dependent patterns. GVC participation reduces dollar invoicing relatively

more in low-volatility environments compared to high-volatility environments. Bilateral exchange rate depreciation increases dollar use in a high-volatility environment but decreases it in a low-volatility environment. This reversal suggests that during stable periods, currency depreciation may facilitate non-dollar invoicing (which could be either another major currency, such as a regionally dominant one, or else the local currency of the exporter or importer), while during volatile periods, firms retreat to dollar invoicing to shelter GVC productions from bilateral exchange rate fluctuations.

The instrumental variable framework estimation confirms and amplifies these volatility-dependent patterns. For the baseline 2SLS analysis, Table 7 shows the impact of dollar invoicing on GVC production is substantially stronger in low-volatility environments. For overall GVC participation, the coefficient is -1.30 in low-volatility periods compared to -0.54 in high-volatility periods. This pattern holds across all GVC types, with backward GVCs showing the strongest volatility sensitivity.

IV strength varies systematically with volatility: the Kleibergen-Paap F-statistics for the forward causality models are substantially higher in high-volatility periods than low-volatility periods. This suggests that EWI becomes a more powerful predictor of dollar invoicing during turbulent periods.

Table 7. Baseline 2SLS: Impact of Dollar Invoicing on GVC (Subsamples)

	High Volatility				Low Volatility			
	Overall	Mixed	Backward	Forward	Overall	Mixed	Backward	Forward
DIT	-0.5408***	-0.5039***	-0.5907***	-0.2664**	-1.3021***	-1.2251***	-1.5261***	-0.9695***
	(0.1223)	(0.1214)	(0.1286)	(0.1241)	(0.1877)	(0.1989)	(0.1999)	(0.1816)
Bilateral FX	0.0157	0.0741***	0.0551**	-0.0310	-0.0520	-0.0102	-0.1809*	0.0170
	(0.0229)	(0.0255)	(0.0228)	(0.0241)	(0.0985)	(0.1044)	(0.1045)	(0.1013)
KP Wald F	224.43	224.43	224.43	224.40	143.25	143.23	143.25	143.32
KP LM Stat	171.87	171.87	171.87	171.84	132.95	132.94	132.95	133.03
Adj R-squared	0.004	0.009	0.007	0.003	-0.154	-0.096	-0.236	-0.060
Observations	23,636	23,636	23,636	23,624	23,532	23,531	23,532	23,480

Standard errors in parentheses

All models include pair and year fixed effects. SEs clustered at pair level.

Instrument for DIT: EWI.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 8. Baseline 2SLS: Impact of GVC on Dollar Invoicing (Subsamples)

	High Volatility				Low Volatility			
	DIT	DIT	DIT	DIT	DIT	DIT	DIT	DIT
Bilateral FX	0.0293**	0.0553***	0.0482***	-0.0011	-0.0851*	-0.0758	-0.1253***	-0.0668
	(0.0146)	(0.0153)	(0.0149)	(0.0222)	(0.0457)	(0.0464)	(0.0423)	(0.0540)
Overall GVC	-0.5582***				-0.3937***			
	(0.1391)				(0.0739)			
Mixed GVC		-0.4361***				-0.3730***		
		(0.0983)				(0.0687)		
Backward GVC			-0.4967***				-0.3388***	
			(0.1187)				(0.0590)	
Forward GVC				-0.7848***				-0.4555***
				(0.2449)				(0.0971)
KP Wald F	23.72	38.37	28.55	13.03	53.72	55.60	72.49	38.41
KP LM Stat	24.35	38.94	29.06	13.35	49.88	51.71	64.50	36.76
Adj R-squared	-1.878	-1.252	-1.526	-4.291	-0.744	-0.833	-0.523	-1.293
Observations	23,636	23,636	23,636	23,624	23,532	23,531	23,532	23,480

Standard errors in parentheses

All models include pair and year fixed effects. SEs clustered at pair level.

Instrument for GVC: RTAs.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

In Table 8, the reverse causality estimation exhibits similar but less contrasted patterns across volatility regimes, with GVC effects on dollar invoicing ranging from -0.44 to -0.79 in high volatility regime and -0.34 to -0.46 in low volatility regime. A bilateral depreciation increases dollar invoicing in the high volatility regime, but reduces dollar dependency in trade in the low volatility regime. And the regional trade agreements better predict GVC participation during stable periods (low volatility).

The interaction models (Table 9 and Table 10) suggest that exchange rate moderation effects are amplified in low-volatility environments. In Table 9, Dollar invoicing is negatively associated with all types of GVC production, with higher negative association in the low volatility regime. The interaction term (DIT * FX) is consistently negative and significant across both volatility regimes, but the magnitude is nearly twice as large in low-volatility periods compared to high-volatility periods in overall and backward GVC productions.

Conversely, in Table 10, the reverse interaction terms (GVC * FX) remain largely insignificant across volatility regimes, confirming that GVC effects on dollar invoicing are structurally stable regardless of exchange rate dynamics.

Compared to the full sample analysis, the subsample analysis shows that exchange rate volatility modifies the strength of the bidirectional dollar-invoicing and GVC productions relationship. The trade-off between dollar invoicing and GVC participation is amplified in stable currency environments, where both the negative impact of DIT on GVC and of the reverse are larger in magnitude. In contrast, during periods of high volatility, these relationships are attenuated, and the bilateral exchange rate itself can even reinforce dollar use. The results suggest that policies aimed at promoting GVC integration through currency diversification may be effective during periods of exchange rate stability.

Table 9. 2SLS with Interactions: Dollar Invoicing → GVC (Subsamples)

	High Volatility				Low Volatility			
	Overall	Mixed	Backward	Forward	Overall	Mixed	Backward	Forward
DIT	-0.8608***	-0.8101***	-0.8629***	-0.5725***	-1.4294***	-1.3039***	-1.7191***	-1.0610***
	(0.1861)	(0.1793)	(0.1950)	(0.1838)	(0.2199)	(0.2189)	(0.2543)	(0.2071)
DIT * FX	-0.2497***	-0.2389***	-0.2124***	-0.2388***	-0.4452***	-0.2753**	-0.6747***	-0.3203***
	(0.0666)	(0.0647)	(0.0706)	(0.0653)	(0.1221)	(0.1194)	(0.1466)	(0.1180)
Bilateral FX	-0.1986***	-0.1309**	-0.1272**	-0.2361***	-0.5805***	-0.3370*	-0.9819***	-0.3652*
	(0.0581)	(0.0565)	(0.0603)	(0.0585)	(0.1867)	(0.1868)	(0.2131)	(0.1876)
KP Wald F	45.75	45.75	45.75	45.73	15.61	15.61	15.61	15.61
KP LM Stat	72.86	72.86	72.86	72.82	31.66	31.65	31.66	31.65
Adj R-squared	-0.108	-0.068	-0.071	-0.101	-0.311	-0.125	-0.658	-0.121
Observations	23,636	23,636	23,636	23,624	23,532	23,531	23,532	23,480

Standard errors in parentheses

All models include pair/year FE. SEs clustered at pair level.

Instruments: EWI + EWI*FX

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 10. 2SLS with Interactions: GVC → Dollar Invoicing (Subsamples)

	High Volatility				Low Volatility			
	DIT	DIT	DIT	DIT	DIT	DIT	DIT	DIT
Bilateral FX	0.0402	0.0406**	0.0281	0.0716	-0.0626	-0.0700	-0.1148***	-0.0519
	(0.0313)	(0.0179)	(0.0227)	(0.0509)	(0.0501)	(0.0473)	(0.0431)	(0.0583)
Overall GVC	-0.5606***				-0.3936***			
	(0.1411)				(0.0739)			
Overall GVC * FX	-0.0021				-0.0064			
	(0.0060)				(0.0046)			
Mixed GVC		-0.4365***				-0.3725***		
		(0.0978)				(0.0686)		
Mixed GVC * FX		0.0051				-0.0041		
		(0.0046)				(0.0047)		
Backward GVC			-0.4985***				-0.3367***	
			(0.1194)				(0.0587)	
Backward GVC * FX			0.0048				-0.0048	
			(0.0051)				(0.0039)	
Forward GVC				-0.8473***				-0.4570***
				(0.3029)				(0.0979)
Forward GVC * FX				-0.0190				-0.0058
				(0.0149)				(0.0056)
KP Wald F	11.73	19.28	14.28	4.41	26.99	27.97	36.98	18.50
KP LM Stat	24.15	39.14	29.04	9.01	50.16	52.02	65.58	35.51
Adj R-squared	-1.898	-1.253	-1.551	-5.226	-0.745	-0.834	-0.514	-1.320
Observations	23,636	23,636	23,636	23,624	23,532	23,531	23,532	23,480

Standard errors in parentheses

All models include pair/year FE. SEs clustered at pair level.

Instruments: RTA + RTA*FX

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5.3 Testing for Nonlinear Effects

To investigate whether the relationship between dollar invoicing and GVC participation accelerates at extreme values, I modify the baseline specifications by including quadratic terms for both DIT and GVC measures as shown in Equation 3. These nonlinear forms allow a direct test of Hypothesis III, which posits that the trade-offs associated with dollar invoicing become increasingly pronounced at very high or very low levels of GVC participation and vice versa.

Table 11 looks at the forward relationship: how the share of dollar-invoiced exports affects GVCs. Notably, the squared term for DIT is positive and significant for overall and backward GVCs, with corresponding main effects also positive and significant in these columns. This implies a convex (U-shaped) relationship: at low to moderate dollar-invoiced export share, the effect of further dollarization on GVC participation is limited or perhaps even positive, but as dollar invoicing becomes very pronounced, the marginal effect on GVC participation sharply increases (possibly reflecting higher vulnerability or dynamic adjustments). For mixed and forward GVC, neither the main nor the squared DIT coefficients are significant, so there is no strong evidence for nonlinearity in these segments.

Table 12 presents the results on testing whether different types of GVC participation, accounting for potential nonlinearities, influence dollar-invoiced export shares. However, these results must be viewed with considerable caution because the first-stage KP Wald F-statistics across all models are well below conventional thresholds, signaling weak instrument problems. This lack of statistical power means the estimates are not robust and do not support strong causal inference.

Taken at face value, the linear coefficients for overall and backward GVC participation are large, negative, and statistically significant, in line with the notion that greater GVC integration—especially with more imported inputs—is associated with lower reliance on dollar

Table 11. 2SLS with Squared Terms: Impact of Dollar Invoicing on GVC Participation

	(1) Overall GVC	(2) Mixed GVC	(3) Backward GVC	(4) Forward GVC
Bilateral FX	0.0617**	0.0971***	0.1166***	0.0022
	(0.0301)	(0.0298)	(0.0338)	(0.0287)
DIT	2.1131*	0.4452	3.4643**	1.1846
	(1.1630)	(1.0615)	(1.3804)	(1.0505)
DIT Squared	0.6977**	0.2907	1.0456***	0.4063
	(0.2871)	(0.2575)	(0.3432)	(0.2572)
KP LM Stat	27.16	27.16	27.16	27.14
KP Wald F	13.80	13.80	13.80	13.79
N	47,168	47,167	47,168	47,104

Standard errors in parentheses
All models include pair and year fixed effects.
Standard errors clustered at pair level.
Instruments: EWI for DIT, EWI^2 for DIT^2
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

invoicing. The only hint of nonlinearity appears in the backward GVC model, where the positive and marginally significant squared term suggests diminishing returns at very high GVC participation levels. Nonetheless, in light of the weak IV problem, these patterns should be interpreted as merely suggestive rather than conclusive evidence of possible nonlinear effects.

5.4 Robustness Check and Supplemental Analysis with 3SLS Method

To account for potential efficiency gains from correlated errors across equations, I further estimate Equations 1 as a system of simultaneous equations using 3SLS. The 3SLS estimates in Table 13 appear to confirm a bidirectional negative relationship between dollar-invoiced trade and overall GVC participation. However, the Hausman test stats reject 3SLS consistency in this estimation, suggesting potential misspecification propagating across equations and favoring the 2SLS estimates.

The baseline linear 3SLS results in Table 13 (column (2)) seem to confirm the negative

Table 12. 2SLS with Squared Terms: Impact of GVC Participation on Dollar Invoicing

	(1) DIT	(2) DIT	(3) DIT	(4) DIT
Bilateral FX	0.0170	0.0618	0.0596**	-0.0325
	(0.0201)	(0.0377)	(0.0238)	(0.0301)
Overall GVC	-1.1187***			
	(0.3913)			
Overall GVC Squared	0.0730			
	(0.0495)			
Mixed GVC		-1.1811		
		(1.0136)		
Mixed GVC Squared		0.1373		
		(0.1937)		
Backward GVC			-0.9462***	
			(0.2791)	
Backward GVC Squared			0.0722*	
			(0.0423)	
Forward GVC				-1.0051***
				(0.2559)
Forward GVC Squared				0.0616
				(0.0448)
KP LM Stat	3.06	0.59	4.02	3.29
KP Wald F	1.89	0.31	2.55	2.06
Observations	47,168	47,167	47,168	47,104

Standard errors in parentheses
All models include pair and year fixed effects.
Standard errors clustered at pair level.
Instruments: RTA for GVC, RTA^2 for GVC^2
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

bidirectional relationship between dollar-invoiced export and GVC participation found with 2SLS. However, the estimated magnitudes of these effects are notably larger when comparing to the 2SLS estimations, with the coefficient for DIT in the GVC equation at -2.76 and for GVC in the DIT equation at -0.36. Introducing nonlinearities (column 3) reveals that both relationships exhibit convexity. The squared terms for DIT and GVC are highly significant and negative, indicating that the negative impact of dollar-invoiced trade on overall GVC productions, and GVCs on dollar-invoiced trade, accelerates at higher levels of the respective variables. In this non-linear specification, the bilateral exchange rate shows a significant positive association with GVC participation and dollar-invoiced export.

The reverse direction (bottom part of column 3) shows relatively stable results, but again the Hausman test shows that the equations do not satisfy the consistency requirement for 3SLS estimation, making the interpretation of the results doubtful. If taken at face value, the linear GVC coefficient remains consistently negative and highly significant. This confirms that deeper bilateral GVC integration reduces firms' reliance on dollar invoicing, appearing to support (but statistically invalid) that production fragmentation enables natural currency diversification and reduces the benefits of universal dollar pricing. The magnitude of this effect is economically meaningful: a 1% increase in total GVC production reduces dollar invoicing by approximately 0.27% - 0.33%, representing a shift away from dollar dependence as firms become more embedded in GVCs.

The non-linear specifications reveal critical differences in how volatility conditions the GVC-DIT relationship. In low volatility regimes, the GVC squared term is statistically insignificant, suggesting that the relationship remains approximately linear when exchange rates are stable. However, in high volatility environments, the squared term becomes highly significant, indicating that the negative impact of GVC participation on dollar use accelerates dramatically at deeper integration. This non-linearity suggests that during turbulent periods, firms with deep GVC ties face exponentially stronger incentives to abandon dollar

Table 13. 3SLS System Estimation: Linear and Non-Linear

	(1) 2SLS	(2) Linear	(3) Non-Linear
Overall GVC			
Bilateral FX	-0.0130	0.0661	0.1347***
	(0.0491)	(0.0573)	(0.0484)
DIT		-2.7587***	-1.8352***
		(0.0176)	(0.1526)
DIT Squared			-4.3938***
			(0.4594)
Export Weighted Index	-2.7052***		
	(0.2807)		
Constant	0.0007	-0.0002	0.2026***
	(0.0031)	(0.0031)	(0.0186)
DIT			
Bilateral FX	0.0228**	0.0240	0.0288**
	(0.0103)	(0.0207)	(0.0126)
Overall GVC		-0.3608***	-0.2716***
		(0.0027)	(0.0108)
GVC Squared			-0.1466***
			(0.0071)
RTA	-0.1200***		
	(0.0080)		
Constant	-0.0001	-0.0001	0.0968***
	(0.0006)	(0.0011)	(0.0047)
Observations	48,374	48,374	48,374

Standard errors in parentheses
All variables are two-way demeaned (pair and year fixed effects).
Standard errors clustered at pair level.
DIT = Dollar Invoiced Trade; FX = Exchange Rate
Identification: Instruments for one equation included as regressors in the other.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

invoicing, likely due to the compounding costs of managing currency mismatches across complex production networks when volatility spikes. The bilateral exchange rate effects further underscore this volatility dependence: while FX depreciation reduces dollar use in stable periods, it actually increases dollar reliance during volatile times, reflecting flight-to-safety behavior where firms prioritize dollar liquidity over operational efficiency when uncertainty peaks.

The Hausman test rejections, combined with the extreme coefficient magnitudes, suggest that great caution should be exercised in interpreting the 3SLS estimates, as they are likely statistically invalid (and therefore the hypothesis tests for statistical significance are spurious). While 3SLS seems to provide richer dynamics especially regarding non-linearities and volatility-dependent effects, the consistency concerns suggest that 2SLS estimates should remain the primary basis for policy conclusions.

6 Conclusions

This study provides an analysis of the bidirectional relationship between dollar-invoiced trade and GVC productions, uncovering the interdependencies that expand our understanding of modern trade architecture. By integrating insights from the DCP and GVC literature within a unified theoretical framework, and employing an instrumental variable (IV-2SLS) approach to address endogeneity, this research offers insights into the co-evolution of currency choice and production fragmentation in the global economy.

The empirical investigation yields three principal findings that advance the literature. First, it establishes a robust, negative bidirectional relationship between dollar invoicing and GVC participation. A 1% increase in dollar-invoiced trade reduces overall GVC participation by 0.83%, while a 1% increase in total GVC production decreases dollar invoicing in export by 0.51%. These effects persist across multiple specifications and estimation methods, providing

strong evidence that there are trade-offs between currency stability vis-à-vis the US dollar and production network flexibility in the context of GVCs.

Second, the analysis reveals that this trade-off is modified by the level of exchange rate volatility. In stable, low-volatility environments, the negative relationship is significantly more pronounced, suggesting that economies with stable currencies are better positioned to pursue currency diversification and GVC expansion simultaneously. In contrast, during periods of high volatility, the relationship is attenuated. This suggests that during turbulent times, firms may prioritize the "safe haven" and liquidity benefits of the dollar, even at the cost of GVC efficiency, altering their optimization decisions.

Third, the estimations using 3SLS approach uncover some nonlinearities, validating the theoretical prediction of accelerating costs. The empirical results, while needs to be interpreted with cautions, show statistical significant negative coefficients on the squared terms of both dollar invoicing and GVC participation, indicate that it becomes disproportionately costly for firms to maintain high levels of both simultaneously. This convexity suggests that firms approaching extreme positions in either dollar dependence or GVC depth face rapidly escalating coordination and risk-management costs, potentially triggering abrupt and costly adjustments rather than smooth, linear trade-offs.

These findings carry important policy implications. The volatility-dependent nature of the trade-off suggests that national and regional policies aimed at promoting local currency use are most effective during periods of macroeconomic calm. The evidence of non-linear "tipping points" implies that gradualist policy interventions may be insufficient for firms that are already heavily reliant on the dollar or deeply integrated into GVCs. Instead, policymakers should consider targeted support for sectors approaching these thresholds, such as providing enhanced hedging facilities or promoting regional settlement frameworks to mitigate systemic risk.

In conclusion, this study shows that the relationship between dollar invoicing and GVC

participation is far more complex than previously understood. Rather than being independent or mutually reinforcing phenomena, they are locked in a negative, bidirectional, and state-dependent relationship. As the world grapples with debates on de-dollarization, supply chain resilience, and the future of the international monetary system, these findings underscore the necessity of a holistic approach. Any effort to reshape global trade architecture must account for the intricate and often conflicting interdependencies between how trade is priced and how it is produced.

Appendix I Tables

Table 14. Descriptive Statistics of Main Variables of Interest

	mean	sd	min	max	count
log(Overall GVC)	3.683	3.054	-7.693	11.679	49144
log(DIT)	-1.090	0.909	-4.605	0.000	49144
log(Bilateral FX)	0.000	3.727	-10.550	10.550	49144
log(EWI)	0.438	0.146	0.200	0.969	49144
log(RTA)	1.019	1.321	0.000	14.000	49144
exchange_vol	0.171	0.177	0.000	1.193	47928
Observations	49144				

Table 15. First-Stage Relevance Tests: Forward Causality

	(1) Overall GVC	(2) Mixed GVC	(3) Backward GVC	(4) Forward GVC
Export Weighted Index	1.3742***	1.3743***	1.3742***	1.3746***
	(0.0711)	(0.0711)	(0.0711)	(0.0711)
Bilateral FX	0.0315***	0.0315***	0.0315***	0.0315***
	(0.0086)	(0.0086)	(0.0086)	(0.0086)
First-stage F	373.5	373.5	373.5	373.5
Observations	47,168	47,167	47,168	47,104

Standard errors in parentheses

All models include pair and year fixed effects.

Standard errors clustered at pair level.

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

Table 16. First-Stage Relevance Tests: Reverse Causality. RTA is instrumented for Overall (1), Mixed (2), Backward (3), and Forward GVC (4)

	(1) DIT	(2) DIT	(3) DIT	(4) DIT
RTA	0.1099***	0.1312***	0.1227***	0.0863***
	(0.0151)	(0.0153)	(0.0155)	(0.0146)
Bilateral FX	0.0046	0.0632**	0.0379	-0.0321
	(0.0222)	(0.0245)	(0.0224)	(0.0231)
First-stage F	53.057	73.323	62.778	34.717
Observations	47,168	47,167	47,168	47,104

Standard errors in parentheses

All models include pair and year fixed effects.

Standard errors clustered at pair level.

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

Table 17. OLS Results: Forward Causality by Exchange Rate Volatility

	High Volatility				Low Volatility			
	Overall	Mixed	Backward	Forward	Overall	Mixed	Backward	Forward
DIT	-0.3085***	-0.3193***	-0.3461***	-0.1870***	-0.2850***	-0.3139***	-0.2834***	-0.2611***
	(0.0343)	(0.0379)	(0.0354)	(0.0344)	(0.0417)	(0.0471)	(0.0376)	(0.0478)
Bilateral FX	0.0089	0.0687**	0.0479*	-0.0334	0.0829	0.1107	-0.0161	0.1116
	(0.0226)	(0.0252)	(0.0226)	(0.0238)	(0.0903)	(0.0981)	(0.0943)	(0.0959)
F-statistic	41.028	36.303	47.822	17.680	24.652	23.852	28.495	16.370
R-squared	0.974	0.972	0.973	0.973	0.976	0.974	0.976	0.972
Observations	23,636	23,636	23,636	23,624	23,532	23,531	23,532	23,480

Standard errors in parentheses

All models include pair and year fixed effects.

Standard errors clustered at pair level.

Dependent variables: Overall GVC, Mixed GVC, Backward GVC, Forward GVC

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

Table 18. OLS Results: Reverse Causality by Exchange Rate Volatility

	High Volatility				Low Volatility			
	DIT	DIT	DIT	DIT	DIT	DIT	DIT	DIT
Bilateral FX	0.0294**	0.0318***	0.0311***	0.0285**	-0.1271***	-0.1264***	-0.1316***	-0.1284***
	(0.0094)	(0.0094)	(0.0094)	(0.0095)	(0.0318)	(0.0318)	(0.0318)	(0.0321)
Overall GVC	-0.0432***				-0.0456***			
	(0.0052)				(0.0073)			
Mixed GVC		-0.0396***				-0.0409***		
		(0.0050)				(0.0067)		
Backward GVC			-0.0456***				-0.0454***	
			(0.0051)				(0.0065)	
Forward GVC				-0.0251***				-0.0353***
				(0.0047)				(0.0069)
F-statistic	36.774	34.977	41.964	18.629	29.886	29.569	34.930	23.433
R-squared	0.962	0.961	0.962	0.961	0.951	0.951	0.951	0.950
Observations	23,636	23,636	23,636	23,624	23,532	23,531	23,532	23,480

Standard errors in parentheses

All models include pair and year fixed effects.

Standard errors clustered at pair level.

Dependent variable: Dollar-Invoiced Export (DIT)

Independent variables: Overall GVC, Mixed GVC, Backward GVC, Forward GVC

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

Appendix II List of Economies Used in the Analysis

Table 19. Economies Grouped by Income Level (World Bank Classification)

Income Group	Economies
High Income	Australia, Austria, Bahamas, Belgium, Canada, Chile, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Latvia, Lithuania, Luxembourg, Macao SAR, Malta, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Saudi Arabia, Slovakia, Slovenia, South Korea, Spain, Sweden, Switzerland, Taiwan, United Kingdom, United States, Uruguay
Upper Middle Income	Albania, Algeria, Argentina, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, China, Colombia, Costa Rica, Ecuador, Fiji, Georgia, Indonesia, Kazakhstan, Maldives, Mauritius, Malaysia, Montenegro, North Macedonia, Paraguay, Russia, Serbia, South Africa, Suriname, Thailand, Turkey
Lower Middle Income	Cambodia, Côte d'Ivoire, Egypt, India, Kyrgyz Republic, Mongolia, Morocco, Pakistan, Senegal, Tanzania, Tunisia, Ukraine
Low Income	Liberia, Madagascar, Malawi

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