The Impact of Trade Invoicing Decisions on Global Value Chain Participation: An Empirical Analysis

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Abstract

Over the past three decades, globalization has created a highly interconnected global production network, fundamentally reshaping trade dynamics. This paper examines how exchange rate fluctuations and dominant currency invoicing influence production across different segments of Global Value Chains (GVCs), focusing on backward (imported inputs) and forward GVC linkages (domestic value-added). Using dynamic panel regressions on a dataset of 96 countries from 1990 to 2020, the findings reveal that real exchange rate movements significantly affect GVC participation, challenging findings from earlier studies. The results show that dominant currency appreciation reduces GVC production, particularly affecting backward linkages in the short run. Invoicing trade in the US dollar helps mitigate some of these adverse effects, underscoring the importance of invoicing preferences. Countries with higher levels of dollar-invoiced trade are more sensitive to dollar fluctuations, with backward GVC production facing stronger short-term impacts, while forward GVC production adjusts more gradually, yielding relatively muted gains over time. These contrasting effects suggest that policies aimed at managing currency risk in trade should be tailored to specific GVC structures and invoicing practices, enhancing resilience and optimizing trade performance.

Keywords: Real Exchange Rate, Dominant Currency Paradigm, Global Value Chains
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1   Introduction

Global value chains (GVCs) are widely recognized as a catalyst for economic development in the past decades, offering increased access to intermediate inputs, technology, and markets (Timmer et al., 2014; **?**). By spreading production stages across the globe, GVCs can raise income levels and allow developing economies to catch up (Raei et al., 2019). However, the fast evolving GVCs also pose unique challenges, such as trapping certain countries in lower value-added tasks and concentrating market power among large multinational firms (Durand and Milberg, 2020).

Alongside these structural dynamics, international trade is also characterized by dominant currency invoicing practices. Many exporters and importers in non-dominant economies opt to invoice in a dominant currency (e.g., the U.S. dollar or the euro) rather than their own or their partner's currency (Amiti et al., 2022). This practice, commonly referred to as the Dominant Currency Paradigm (DCP), can alter how exchange rate movements affect both trade prices and production decisions. Traditional one-time final goods trade models suggest that DCP reduces bilateral exchange rate pass-through (ERPT) and shelters non-dominant economies from bilateral currency fluctuations. However, GVC participation naturally features multiple border crossings of intermediate goods, making it unclear whether these benefits (or costs) accumulate, diminish, or reshape the ways firms participate in GVC trade.

This paper bridges a gap in the literature by analyzing how exchange rate shocks, through the lens of dominant currency invoicing, influence a country's GVC participation. In particular, it focuses on a disaggregated level of GVC participation: overall participation, mixed participation, backward participation, and forward participation. I hypothesize that reliance on a dominant currency may reduce exchange rate shocks for some types of production structure while amplifying them in others, thereby affecting countries' GVC positions.

Using panel data on 96 countries from 1990 to 2020, I first find that real exchange rate movements are a crucial determinant of GVC participation, especially when looking at the disaggregated categories rather than the general sum of GVC participation as discussed in the

prior GVC literature. Second, invoicing in a dominant currency tends to expose GVC participation to the dominant currency's fluctuation and curtails overall GVC trade, with especially pronounced impacts on backward linkages in the short to medium run. These results highlight the complex interplay between macroeconomic fluctuations, currency invoicing practices, and the fragmented global production network.

The remainder of the paper is organized as follows: Section Two reviews the literature on dominant currency invoicing and GVCs. Section Three presents the theoretical framework. Section Four describes the data and research design. Section Five discusses the empirical findings, and Section Six concludes with policy implications and avenues for further research.

2   Literature Review

In recent decades, two significant trends have reshaped international trade: the prevalence of dollar invoicing and the rise of GVCs. This section synthesizes the literature on the relationship between these phenomena, examining how dollar invoicing practice affects GVC participation. In addition to the growing literature on dominant currency invoicing, three relevant strands of literature related to the research questions are explored: the impact of exchange rates on trade flows; the effect of dominant currency pricing on ERPT; how these relationships differ between GVCs and final goods trade.

GVCs represent a fundamental shift in how goods are produced and traded internationally. Timmer et al. (2014) define GVCs as the fragmentation of production processes across countries, where each country specializes in specific tasks or components rather than producing entire goods. This fragmentation has led to an increase in trade in intermediate goods and services. Antràs (2020) provides a comprehensive overview of the conceptual aspects of GVCs, highlighting that the rise of GVCs has necessitated new measures of trade, such as trade in value-added, to accurately capture countries' contributions to global production (Johnson and Noguera, 2012). Of particular importance to this paper is the definition of four types of GVC

participation at a disaggregated level:

- **Overall GVC participation** is measured as the ratio of GVC-related goods to gross exports, reflecting the sum of all traded goods involved in 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 the next producer abroad. Countries exporting goods that require less procession 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.

In conventional trade theory, currency depreciation makes exports cheaper and imports more expensive, thereby influencing both the volume and value of trade. Therefore, exchange rates have long been considered a key determinant of international trade flows (Ozturk, 2006). However, early research on GVC trade finds that exchange rates have a less significant impact on GVC trade. These studies typically relied on domestic real exchange rates that capture gross trade responses, rather than GVC-specific activities. This oversight fails to account for the complexities of intermediate goods crossing borders multiple times, leading to an incomplete understanding of how exchange rate fluctuations impact GVC participation.

Using proxies that do not fully capture the nuances of GVC activity can significantly underestimate the effects of exchange rate changes. For instance, Fernandes et al. (2022) tests the traditional exchange rate appreciation and misalignment indices and suggests negligible effects on GVC participation, highlighting the limitations of conventional approaches in capturing the true impact of exchange rates on GVCs.

Recent GVC literature, prompted by the availability of more comprehensive data sources and the growing interconnection between macro and micro conditions, has increasingly recognized the significance of macroeconomic determinants of GVC participation. Studies have now begun to investigate the causal relationship between these fluctuations and various aspects of GVC dynamics, highlighting the critical influence of macroeconomic conditions such as currency movements on GVC trade (Georgiadis et al., 2019).

With the increasing availability of data sources such as the World Input-Output Table for GVC studies, Patel et al. (2019) develop a GVC real exchange rate (GVC-REER) index based on

the primary interests in the competitiveness of value-added terms and suggest an appreciation of the GVC-REER reduces one's value-added to its export. Bems and Johnson (2017) construct a novel value-added real effective exchange rate dataset and find that estimations using value-added REERs indicate larger competitive imbalances than conventional REERs.

ERPT is defined as 'the degree to which exchange rate changes feed into import prices' (Georgiadis et al., 2019), shaping how currency fluctuations affect both import and export prices. Other studies using more precise proxies for GVC-REER suggest a potential reverse causal link between participation in GVCs and ERPT. That is, a larger share of intermediate input imports (an increase in GVC participation) reduces ERPT into import prices. de Soyres et al. (2021) examine how the increasing importance of value chains affects export elasticities and find that increased participation in GVC generally decreases the exchange rate elasticity of exports. This suggests that as countries become more integrated into GVCs, their exports become less sensitive to exchange rate fluctuations.

Dominant currency invoicing is another factor that could alter the influence of exchange rate fluctuations on trade prices through ERPT. In the context of increasing reliance on GVCs, imported inputs partially limit price adjustments for exports. Gopinath et al. (2010) find that when a non-dominant country's currency depreciates relative to another by 10%, import prices for goods from that country rise by about 8%, suggesting close to complete pass-through in the short run. However, this relationship changes significantly when considering the role of the dollar in trade invoicing.

The dominant currency paradigm, introduced by Gopinath et al. (2020), provides a framework for studying the outsized role of the US dollar in international trade. Under DCP, firms from the non-dominant economies predominantly invoice their export in a few key "vehicle" currencies such as the US dollar and Euro, with the US dollar being the most prominent. This practice contrasts with traditional assumptions of producer currency pricing (PCP) or local currency pricing (LCP), in which exports are assumed to be invoiced in one of the trading partner's currency instead of a third party's. Empirical evidence in Boz et al. (2022) shows

that a significant portion of global trade is invoiced in US dollars, even for transactions not involving the United States. Given the dominance of the dollar in trade invoicing, questions have arisen as to how exchange rate fluctuations affect GVC trade and prices when countries choose to invoice in the US dollar.

The practice of dominant currency invoicing has the potential to facilitate GVC participation in several ways. First, dominant currency invoicing provides a hedge against the volatility of bilateral exchange rates, thereby stabilizing operational costs when goods cross multiple borders and therefore face multiple currency risks (Boz et al., 2022; Bruno et al., 2018). Second, by utilizing dominant currencies, firms safeguard their operations against the adverse effects of potentially unstable internal monetary environments (which is likely in developing economies) and external financial turbulence, ensuring a more predictable and secure financial landscape (Amador et al., 2024). For example, Javadekar et al. (2021) finds that Indian companies with dollar invoicing are better able to sustain stable trade connections during and after a dollar shock, when the cost of dollar credit increases.

With the rise of GVC participation, it is common for importers to also actively engage in export activity. Firms who are both active importers and exporters also opt to invoice their trade in dominant currencies such as the US dollar (Amiti et al., 2022). Georgiadis et al. (2019) study differences in ERPT across three pricing paradigms[1], and argue that countries with a higher proportion of imported intermediates in total inputs have a higher ERPT to export prices. Firms favor dominant currency invoicing to avoid bilateral exchange rate movements and stabilize production and connection during unanticipated shocks (Javadekar et al., 2021), potentially contribute to deepening the prominence of GVCs.

Cook and Patel (2023) provide a comprehensive analysis of how dollar invoicing and GVCs jointly affect international trade dynamics. Using a three-country dynamic stochastic general equilibrium model, they show that the response of GVC trade to exchange rate shocks differs significantly from that of final goods trade. Specifically, they find that in response to a US

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[1]Producer pricing paradigm (trade invoiced in producer's currency), local pricing paradigm (trade invoiced in destination currency), and dominant currency paradigm (trade invoiced in a dominant currency).

dollar appreciation triggered by a US interest rate increase, direct bilateral trade between non-US countries contracts more than GVC-oriented trade feeding US final demand. This finding highlights the importance of considering both invoicing practices and GVC structures when analyzing international trade dynamics. It suggests that the dominant currency paradigm may have different implications for different types of GVC participation.

In sum, earlier literature on the determinants of GVC participation has largely assumed producer currency invoicing, which emphasizes trade invoiced in the exporter's currency and treats exchange rate and real exchange rate movements as secondary factors. This approach overlooks the complex dynamics of exchange rate fluctuations under the more prevalent practice of dominant currency invoicing, particularly dollar invoicing. Recent GVC studies have primarily focused on aggregate GVC participation rather than adopting a more refined approach that distinguishes between different types of GVC participation—such as mixed, backward, and forward participation. This lack of granularity limits the ability to fully comprehend how exchange rate changes impact specific aspects of GVC involvement and production stages, leaving important dimensions of the relationship unexplored.

This paper revisits the impact of dollar exchange rate and real exchange rate movements on GVC participations to fill the gap in understanding how currency movements influence GVC participation under dominant currency pricing, which is a more realistic setting in today's global trade. The empirical analysis is conducted at a disaggregated level to investigate whether the sensitivity to exchange rate fluctuation varies across different types of GVC participation.

3   Theoretical Framework

This essay examines how dominant currency invoicing shapes GVC participation in non-U.S. economies, a topic that remains underexplored in the current literature. Building on frameworks that link exchange rate fluctuations to trade via exchange rate pass-through (ERPT), this study bridges the gap between trade invoicing choices and GVC involvement. Specifically,

it investigates how dominant currency invoicing influences GVC participation, offering new insights into the mechanisms through which invoicing practices affect production in different segments of the GVC.

In practice, exporters have the flexibility to choose the currency in which they invoice their products. They can opt to invoice in their own domestic currency, the currency of the trading partner, or a dominant currency such as the US dollar. In the conventional producer currency pricing paradigm, trade is assumed to be invoiced in the exporter's (producer's) currency. A depreciation of the producer's currency enhances export competitiveness and makes imports more expensive, yielding clear benefits for the exporters and exchange rate risks on importers. Conversely, if the trade is invoiced in the trading partner's currency (local currency pricing), exporters bear the exchange rate risk, as the prices of goods remain stable for the importer in their own currency. In this scenario, fluctuations in the producer's currency have less direct impact on the competitiveness of exports, as the importer's cost does not change with producer's exchange rate movement.

Invoicing in a dominant currency, however, introduces a different set of considerations. In the case of dominant currency invoicing, goods are instead affected by fluctuations in the dominant currency. While dominant currency invoicing can stabilize certain aspects of the trade relationship, it also introduces new risks tied to fluctuations in the dominant currency, which can affect both economies despite their own currencies remaining stable against each other.

Consider an example in which the US dollar serves as the dominant currency outside of the US: trade flows between two non-US economies (e.g., Country A and Country B) are less affected by their bilateral exchange rate movements but more sensitive to movements in the US dollar. For instance, a depreciation of Country A's currency against Country B's currency would have no substantial impact on traditional trade between A and B, where goods only cross the border once (from A to B). Conversely, a depreciation of Country A's currency against the US dollar would make Country A's goods more competitive in the US market while making imports from the US more expensive. Additionally, an appreciation of the US dollar could

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negatively impact trade between A and B, as the value of goods traded between them, priced in dollars, would decrease: to import the same amount of good from country A, country B has to pay more in terms of dollar value, and the same applies to the export from country B to country A.

To evaluate the net gains of GVC participation under producer currency pricing, there are two scenarios to consider: (1) firms that are both an importer of intermediate goods and exporter and (2) firms that solely export [?]. For firms that both import intermediate inputs and export to the next stage, the net gain from home currency depreciation is lower than in a traditional trade model because the imported inputs embedded in production have become more expensive and ultimately increase the cost of export production. Export competitiveness decreases due to exposure to multiple exchange rates, adding another layer of complexity. Exporters of intermediate goods who rely only on domestic inputs for export production, on the other hand, rely only on domestic inputs (invoiced in the domestic currency) for export production. The use of local inputs makes their forward participation less sensitive to the rising input costs caused by exchange rate fluctuation compared to those who rely on imported inputs.

A similar logic applies to GVC trade in the context of dominant currency invoicing: bilateral exchange rate fluctuations have little impact on trade among non-dominant economies and instead, trade is more exposed to the risk arising from dominant currency movements. GVC trade becomes more exposed to dominant currency movements, however the impact of dominant currency invoicing is different for forward and backward GVC participation. For firms that are both an importer of intermediate goods and an exporter, a stronger dollar increases the cost of imported inputs and eventually the prices of their exports. Therefore, without access to cheaper alternatives in the short run, firms' backward participation decreases in response to the increasing imported input costs. Forward participation is likely to remain the same or increase as domestic inputs (capital and labor) are priced in domestic currency and then exported in the dominant currency. Consequently, the net gains are clearer as imports and exports are invoiced in dominant currencies. Sole exporters are less sensitive to dollar movements, thereby

preserving part of their overall forward participation.

A more concrete theoretical foundation of my empirical design is drawn from a three-country model constructed by Cook and Patel (2023) to illustrate trade dynamic responses to exchange rate fluctuations in emerging Asia-Pacific economies. In this model, there are two small countries invoicing trade in a dominant currency and one big country that issues the dominant currency. The small countries operate export platforms that combine value added from all three countries to fulfill final consumption in the large country.

Cook and Patel (2023), just as in many recent papers ondominant currency invoicing and GVCs (Benguria and Saffie, 2024; Boz et al., 2022; Georgiadis et al., 2019; Gopinath, 2015), allows firm to reset optimal prices with an exogenous probability in each period, capturing the sticky price phenomenon caused by menu costs, information constraints, and other real-world frictions. In the context of GVCs, the search for substitutes of imported inputs can be time-consuming. Firms that rely on specific imported components are "trapped" by sticky prices in the short run. Therefore, when a dominant currency appreciation increases the costs of imported inputs, it increases export prices before firms find suitable substitutes (backward and forward participation is expected to increase in the short run).

In their simulation of a domestic monetary policy shock leading to home currency depreciation, Cook and Patel (2023) find that this shock results in an increase in the import price and a decrease in gross imports in all pricing paradigms except the local currency paradigm. Export competitiveness is limited in the model with dominant currency invoicing, suggesting that dominant currency invoicing reduces the ERPT of home depreciation into imported input prices. While gross exports are largely unaffected under the dominant currency pricing paradigm, value-added exports rise sharply following the shock, reflecting an expenditure switch toward greater use of domestic inputs in value-added production. These findings suggest that dominant currency invoicing mitigates the contraction in backward participation and enhances forward participation, particularly when domestic substitutes are available in the face of a depreciation of the home currency.

In practice, for countries that rely on both domestic and imported inputs, home currency depreciation increases the cost of imported inputs, raising overall export costs. This cost increase can offset the typical export competitiveness gains associated with depreciation, potentially undermining overall exports in the short term and leading to less pronounced changes in forward participation. However, the response of value-added exports reveals a shift toward domestic content, driven by higher imported input prices. This pattern of expenditure switching supports increased forward participation, though it is likely to unfold gradually rather than immediately after the depreciation.

In the second simulation examining the effects of a dominant currency appreciation caused by global interest rate shocks, Cook and Patel (2023) show that when imports are invoiced in dominant currencies, there is a sharp and immediate decline in gross imports from all locations. This impact is intensified within the GVC context, resulting in a more pronounced decline in exports and an increasing share of domestic content in exports: because materials imported from all locations priced in dominant currency become more expensive, the non-dominant economies shift toward domestic inputs (increasing forward participation). Gross exports also exhibit a large decline in the GVC model with dominant currency invoicing; the decline is driven by a decline in exports to all locations. However, because firms switch from imported inputs to domestic inputs, value added exports fall by less than gross exports.

To estimate the degree to which the decline of export competitiveness in the wake of exchange rate fluctuations may be offset by intermediate input expenditure switching patterns, further studies on the forward and backward GVC participation under a dominant currency paradigm are needed. Building on the study of Cook and Patel (2023) on the impact of exchange rate shocks on value-added and gross exports, this essay will investigate the heterogeneous impact of exchange rate fluctuations on mixed, backward and forward participation in GVCs in the presence of dominant currency invoicing.

Higher backward GVC participation indicates a greater reliance on foreign content in exports. When the dominant currency appreciates, the costly imported inputs can disrupt pro-

duction, leading to lower backward and forward participation in the short run. However, over time, if firms adjust by substituting domestic inputs for the more costly imports, this adjustment may lead to increasing forward participation, as sectors utilize more domestic inputs into production and export more value-added goods along the supply chain. This dynamic reflects how exchange rate fluctuations can drive shifts in production strategies, influencing both the structure of GVC participation and trade patterns over the long term.

Forward participation measures the extent to which domestic value-added is embedded in exports for further production abroad. Sectors that use more local inputs to export are less impacted by dominant currency fluctuations because local inputs are priced and paid in home currencies. In the subsequent empirical design section, I will utilize the net values of forward and backward GVC production as proxies to examine the impact of dollar invoicing practices.

Building on the theoretical foundation presented, this essay aims to test the following hypotheses:

Hypothesis I: In countries in which a higher value of trade is invoiced in a dominant currency, GVC productions are more responsive to movements of the dominant currency compared to movements in domestic or non-dominant trading partner currencies.

Moving forward, given that prices are sticky in the short run (Goldberg and Tille, 2008; Georgiadis and Schumann, 2021; Georgiadis et al., 2024; Amiti et al., 2022; Cook and Patel, 2023; Benguria and Saffie, 2024) firms relying on imported inputs face limited flexibility to adjust price or switch to cheaper domestic substitutes instantly when the dominant currency appreciates. This raises the cost of imported intermediates, initially decreasing the quantity of imported inputs (backward participation) as firms must continue relying on their existing suppliers. In contrast, forward participation that focused on exports could experience a smaller impact because the production is less exposed to dominant currency shocks.

Over time, backward participation decreases and stabilize at a lower level as firms gradually switch to domestic substitutes or alternative foreign suppliers. Meanwhile, forward participation stabilizes or improves as firms maintain export relationships and the export now worth higher

value in dominant currency term. This dynamic is reflected as the magnitude of the short-run effect is more pronounced for backward participation than forward participation.

Hypothesis II: In the short run, backward GVC participation is more sensitive to dominant currency exchange rate shocks than forward GVC participation due to price stickiness and the difficulty of quickly switching from imported inputs to local inputs.

The theoretical framework posits that dominant currency invoicing can positively influence firms' participation in GVCs by mitigating currency risk and facilitating trade. Furthermore, the impact of dominant currency invoicing on GVC participation may vary based on the degree of forward and backward GVC integration, the direction of exchange rate movements, and the specific sector of production.

4   Data

The empirical analysis in the following sections draws information from two main databases: the World Integrated Trade Solution (WITS) database and Boz et al. (2022).

The GVC production information from the WITS database is compiled from multiple sources at the country-sectoral level, ensuring the most extensive coverage of disaggregated GVC production and allowing for an analysis between GVC-related trade and GVC-related output. GVC-related trade measures both the domestic and foreign value-added components of exports. Differently, GVC-related output represents the output of a country that directly or indirectly crosses more than one border, regardless of its direct involvement in export activities. This study opts for GVC-related output measures to represent GVC participation because it provides an assessment of countries' contribution in each segment of the GVC, captures indirect and direct contributions, and offers insights into how domestic production integrates into global networks.

The WITS database provides GVC output information in four categories defined in Borin and Mancini (2019):

1. Backward GVC-related output: This measures output crossing more than one border, traced in the sector of the completed final good or service. It represents the last link in a chain and can be labeled as "GVC related-final goods and services." For example, the value of the imported intermediate inputs of a Mexican car manufacturer producing finished cars for both export and domestic markets would be captured in this category.

2. Forward GVC-related output: This measures domestic value-added produced by a sector that ultimately crosses more than one border. It is traced at the origin of the value chain and can be labeled as "GVC related-value-added." An example would be the domestic value-added embodied in South Korean exports of advanced semiconductors that are destined for further processing in other countries before reaching final consumers.

3. Two-sided (mixed) GVC-related output: This category includes domestic and foreign inputs bought and sold by a sector as intermediates, crossing more than one border. It represents central positions in the chain, common in industries like electronics or automotive manufacturing. For instance, consider a South Korean electronics manufacturer that imports components (e.g., advanced microchips) from Japan and combines these imported components with domestically produced parts and South Korean technology. The resulting intermediate product (e.g., a sophisticated display panel) is then exported to China for integration into final consumer electronics.

4. GVC-related output: This is the sum of the three GVC-related output types above, representing the total production involved in GVCs. It encompasses all stages of production that are internationally fragmented, from raw materials to final products, crossing borders multiple times in the process.

By using these GVC-related output measures, this study captures a better picture of GVC participation. This approach includes domestic activities that indirectly contribution to GVCs, even if these activities don't directly result in exports. By focusing on GVC-related output rather than GVC-related trade, this study aims to provide a view of how countries integrate into GVCs, capturing both direct and indirect contributions to global production networks.

Figure 1. GVC Production as % of Gross Trade By Income Levels
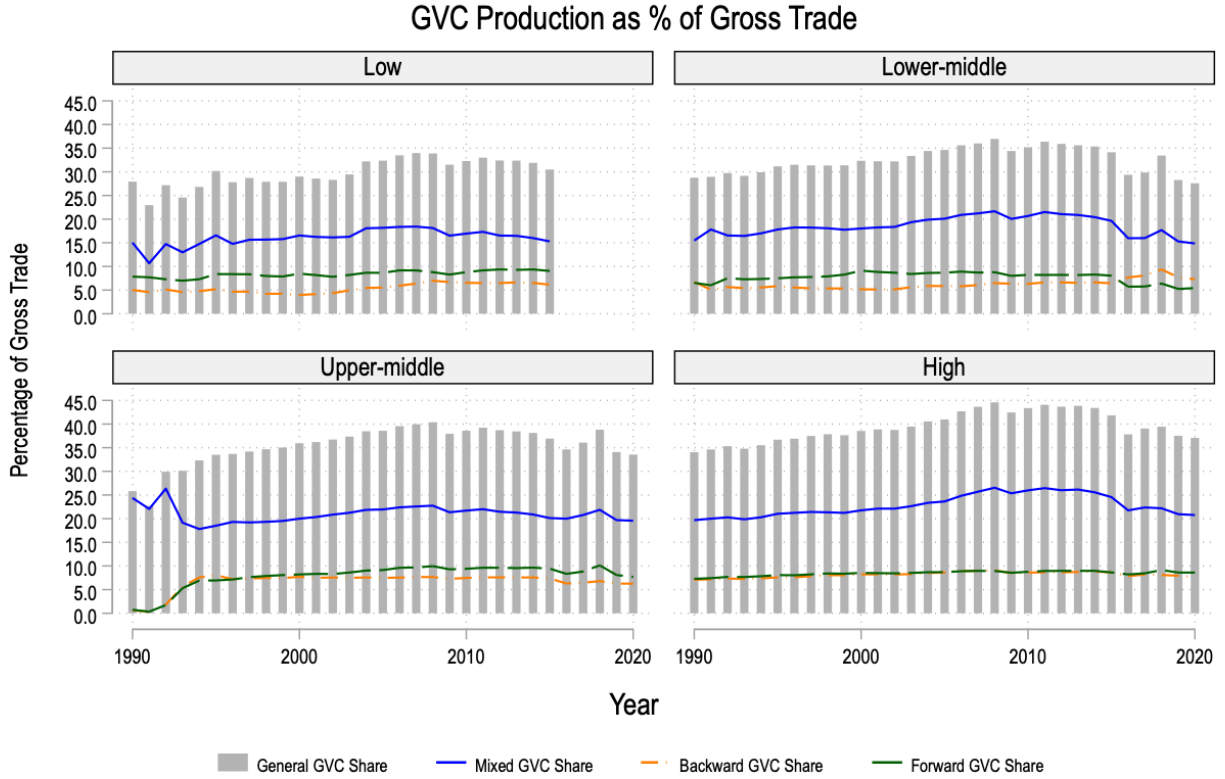
Figure (1) presents the share of GVC production relative to gross trade (sum of import and export) across different income levels in the sample. Over the past three decades, GVC participation has increased, though the pace has slowed since 2015. High- and upper-middle-income countries maintain a relatively larger share of GVC production in their gross trade, suggesting that low- and lower-middle-income countries are still in the process of catching up in GVC integration. This pattern highlights the differing stages of GVC participation across income groups and the potential for further expansion in lower-income economies.

Figure (2) illustrates the share of GVC production relative to total output across different income levels, providing information on the role of GVC participation in overall production. While Figure (1) highlights the significance of GVCs in gross trade, this figure shows that GVC production—particularly when disaggregated into specific segments—accounts for a relatively small share of total output, generally below 10%. This suggests that domestic production

Figure 2. GVC Production as % of Total Output By Income Levels
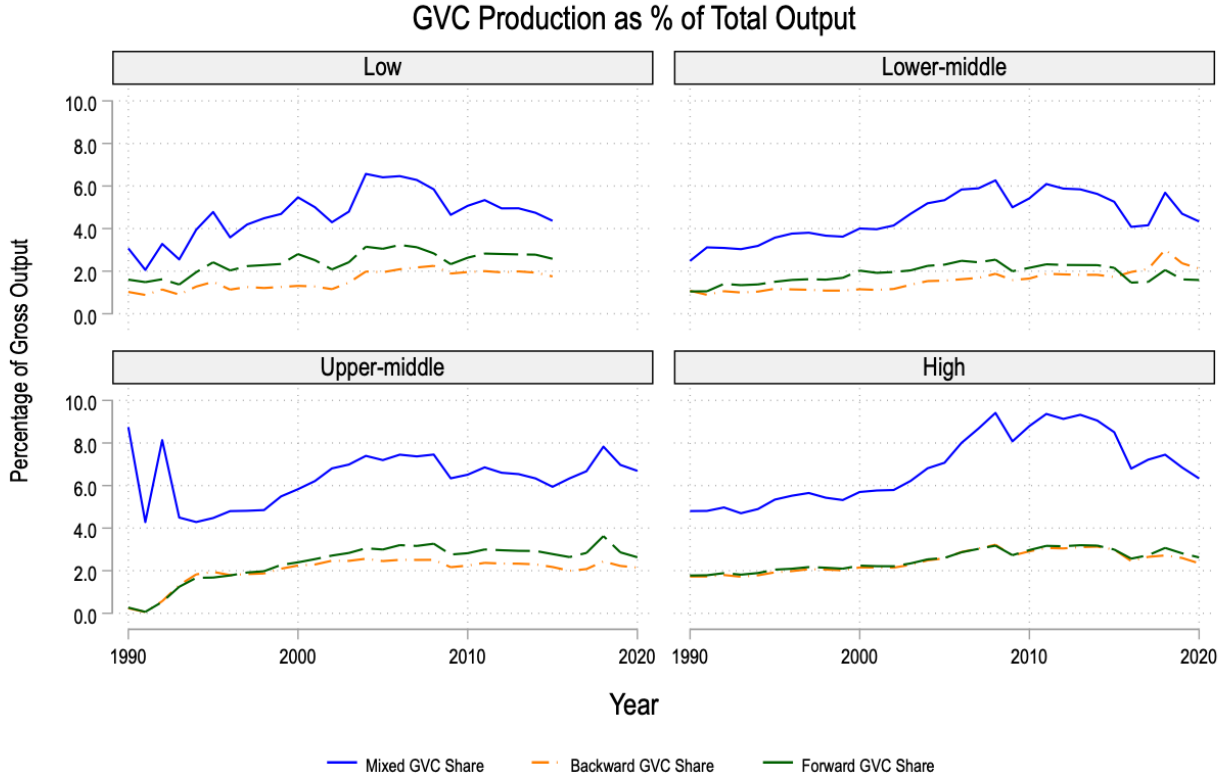
remains the primary driver of economic activity across all income groups while GVC integration influences trade patterns.

Figure (3) presents the geographic distribution of GVC output shares over the past three decades. The figure highlights that GVC production has grown rapidly and accounts for a larger share of total output in two key regions: East Asia & Pacific and Europe & Central Asia. In contrast, other regions have experienced either stagnation or a declining in GVC participation, with relatively low and stable shares over time. This pattern underscores the uneven expansion of GVC integration across different parts of the world.

Despite its smaller share in total output, GVC participation plays a crucial role in linking domestic industries to global markets and driving long-term structural transformation. Understanding how GVC production responds to economic shocks provides insights into how economies integrate into global production networks and the potential benefits and vulner-

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Figure 3. GVC Production as % of Total Output by Geographic Distribution
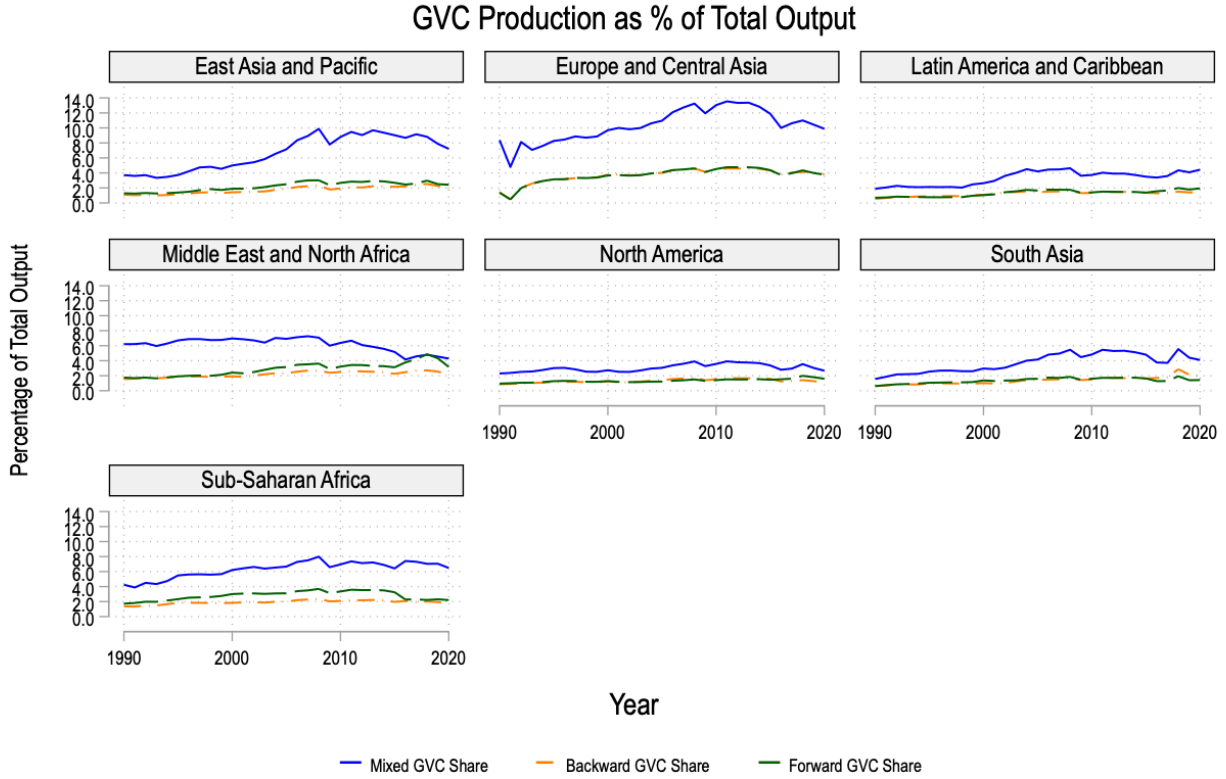
abilities associated with different types of participation in the backdrop of the geoeconomic fragmention.

The figures also reveal shifts in the composition of backward and forward GVC participation. In lower-middle-income (Figure (1) and Figure (2)) and South Asia and Subsaharan Africa group (Figure (3)), backward GVC production has surpassed forward GVC production in the past decade, indicating a structural shift in production patterns. This trend suggests increasing reliance on imported inputs, reflecting deeper integration into upstream segments of GVCs.

Trade invoicing data are sourced from Boz et al. (2022), which provides information on the shares of exports and imports invoiced in US dollars, euros, and other currencies (including home currencies). The dataset, primarily compiled from records of customs revenue authorities and regional and national banks, spans from 1990 onward and highlights the dominant role of the US dollar in global trade, as well as the general inertia in invoicing currency patterns at

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Figure 4. The Use of Dominant Currency in Trade Invoicing by Income Levels

Average Percentage of USD and Euro in Trade Invoicing

Data of the United States is excluded from calculation
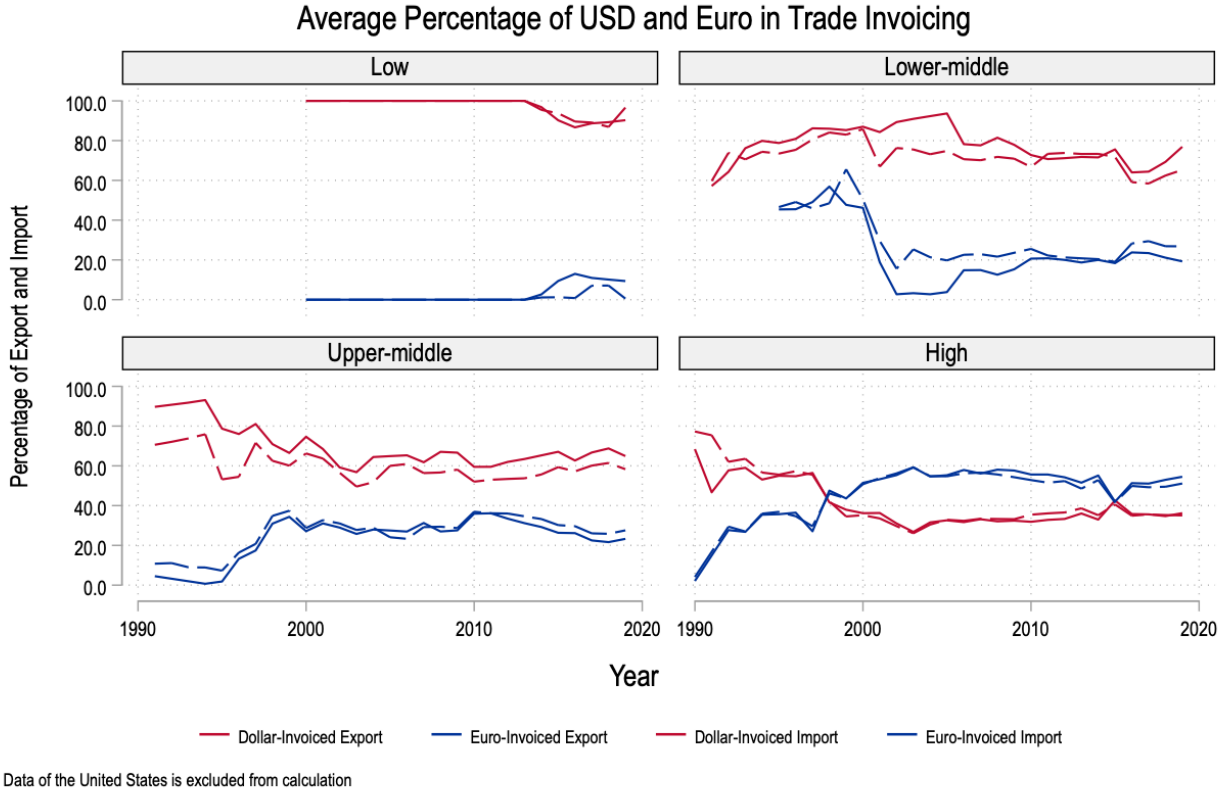
the global level.

Figure (4) shows the use of the US dollar and the euro in international trade between 1990 and 2020. the use of the US dollar and the euro in international trade from 1990 to 2020. The US dollar remains the dominant invoicing currency across all income groups, typically accounting for over 60% of trade transactions. The primary exception is among high-income countries, particularly in Europe, where the euro plays a more significant role. Since around 2010, the share of euro invoicing has declined while dollar invoicing has increased slightly. This trend may be partially attributed to the growing use of the Chinese RMB in trade at the cost of Euro, as suggested by Georgiadis et al. (2021) based on an extended, though unpublished, version of the Boz et al. (2022) dataset, which includes RMB invoicing for a smaller number of countries.

A closer examination of the top euro-invoicing economies in 2003, 2008, 2013, and 2018

Figure 5. Dollar-Invoiced Export in the Top Euro Users

reveals that despite the euro's dominance, the US dollar continues to hold a significant share in trade invoicing. Figures (5) and (6) show that even among these economies, the US dollar accounts for approximately 10% of exports and 20% of imports during the sampled years. This highlights the persistent and dominant role of the dollar in global trade, even in markets where the euro is the preferred invoicing currency.

This trade invoicing dataset is the most comprehensive source of currency invoicing data in terms of coverage and consistency. However, it has two key limitations. First, it does not include data from China and Mexico, two major global exporters, due to data unavailability. As a result, these countries are necessarily excluded from the sample rather than being assumed to have no dominant currency invoicing. Second, the dataset has fewer observations in the earlier years and a higher concentration of data points in later periods.This uneven distribution reduces the number of observations available for analysis, particularly in capturing long-term

Figure 6. Dollar-Invoiced Import in the Top Euro Users

Dollar Use in the Top 10 Countries of Euro Invoicing in Import

Percentage of Imports Invoiced in USD

Data of the United States is excluded from calculation
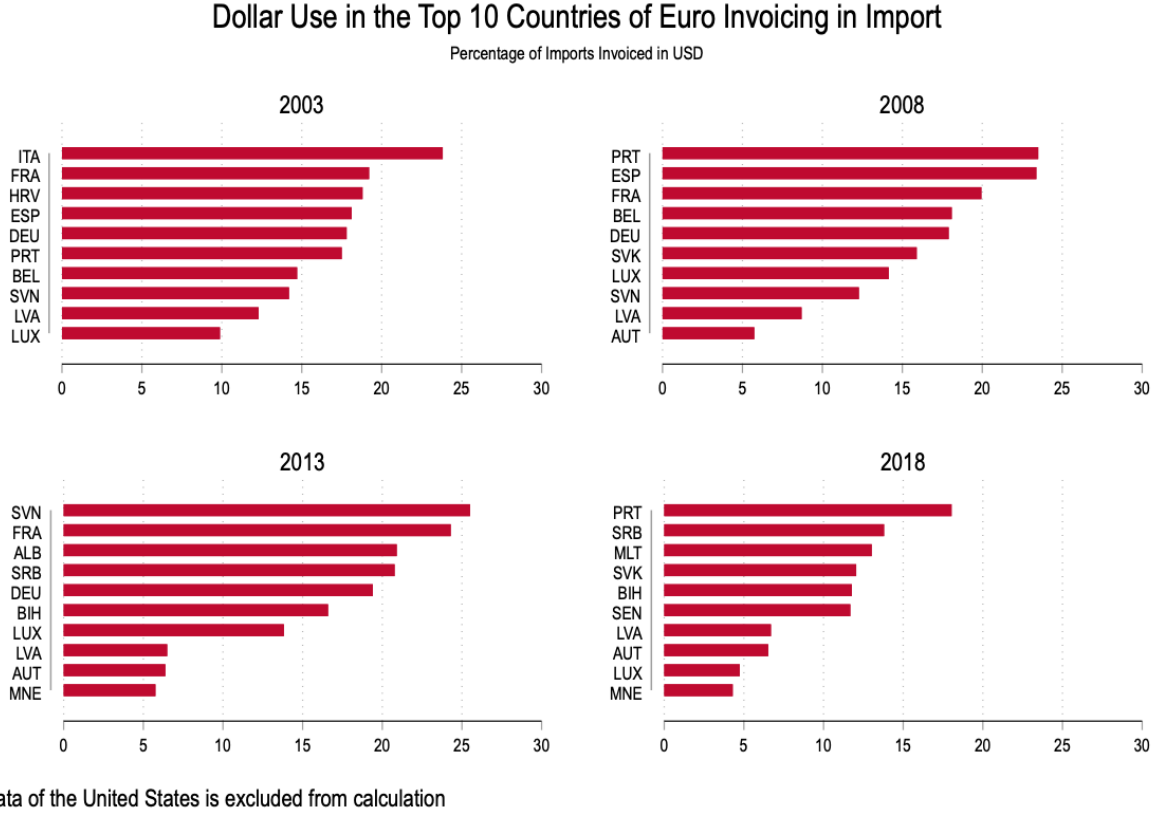
trends or early shifts in invoicing behavior. Additionally, given data constraints, this study focuses on U.S. dollar invoicing as the primary measure of dominant currency use.

The empirical analysis incorporates two key exchange rate measures, both reflecting fluctuations in the value of domestic currencies in different contexts. Bilateral exchange rates against the US dollar, expressed as local currency per USD, captures the movement of the domestic currency relative to the US dollar, focusing on bilateral relationships but not isolating changes in the value of the dollar itself. Real effective exchange rates (REERs), offer a broader perspective by adjusting for inflation and comparing the domestic currency to a weighted basket of foreign currencies. The exchange rates, together with macroeconomic variables such as GDPs, are sourced from the newly available Global Macro Database constructed by Müller et al. (2025).

I include other economic development data as control variables, including capital-to-GDP ratio, trade to GDP ratio, and the capital openness index, all of which are sourced from the

World Bank Database and Chinn and Ito (2008). The capital-to-GDP ratio is a measure of investment levels within an economy, which can affect a country's ability to engage in complex production processes typical of GVCs. A higher capital-to-GDP ratio may indicate greater capacity for investment in infrastructure and technology, potentially enhancing a country's integration into GVCs. The trade-to-GDP ratio reflects a country's openness to international trade, which is also important for GVC participation. Studies have shown that countries with higher trade openness are more likely to engage in GVCs, as they are more integrated into global markets (Fernandes et al., 2022). The capital openness index, as developed by Chinn and Ito (2008), measures the degree of financial openness, which can influence a country's access to foreign capital necessary for investing in GVC-related activities and also make it easier for firms to choose the currency they prefer to invoice (Ito and Kawai, 2016). These variables have been commonly used in GVC studies to control for economic openness and investment capacity, which are key determinants of a country's ability to participate in global value chains.

Table 1. Distribution of Countries by Region

Region	Number of Countries
East Asia and Pacific	14
Europe and Central Asia	46
Latin America and Caribbean	11
Middle East and North Africa	7
North America (USA)	1
South Asia	3
Sub-Saharan Africa	13

The final unbalanced panel dataset covers 96 countries from 1990 to 2020, providing a diverse sample in terms of geography (Table 1) and income levels (Table 2). The United States is excluded from the empirical analysis due to its unique role as the issuer of the dominant currency in this study. Despite this exclusion, the dataset retains broad geographic coverage.

The sample is somewhat skewed toward higher-income economies, with over half classified as upper-middle income or higher based on World Bank classifications. This skewness mainly reflects data availability constraints, as detailed currency invoicing information is more consis-

Table 2. Distribution of Countries by Income Level

Income Level	Number of Countries
High income	44
Upper middle income	28
Lower middle income	20
Low income	3

tently reported and publicly accessible for advanced economies with well-established financial systems and transparent trade reporting practices. Although this limits the representation of lower-income countries, it also provides an opportunity to closely examine how currency choice in international trade affects GVC integration in economies with comprehensive financial data and robust trade networks. Additionally, the dataset's three-decade span offers sufficient variation to capture long-term trends and structural changes in global trade patterns.

The backloaded nature of the invoicing data, as where observations are more concentrated in later years, reduces the total number of usable observations from 2,927 in the preliminary exchange rate analysis to 927 in the dominant currency invoicing analysis. This uneven distribution may limit the ability to capture early trends and should be considered when interpreting the results. Despite this limitation, the dataset remains the most comprehensive source for analyzing the role of dominant currency invoicing in GVC participation. As data coverage improves, future research could extend this analysis to a broader set of less developed economies, providing deeper insights into how GVC integration and currency choice evolve across different stages of economic development. A descriptive statistics table for the key variables is included in the appendix.

5 Empirical Strategy

To test the hypotheses, I estimate the response of four types of GVC production—overall, mixed, backward, and forward—focusing-on the comparative effects of dollar exchange rate and real exchange rate movements. This disaggregated approach highlights how dominant currency

invoicing influences the impact of exchange rate fluctuations, depending on the structure of GVC production.

I first estimate a regression to measure the degree to which dollar exchange rate movements and real exchange rate movements are correlated with GVC production:

$$\ln(\text{GVC}_{it}) = \delta_1 \ln(\text{ER}_{\$t}) + \delta_2 \ln(\text{RER}_{it}) + f_i + f_t + \epsilon_{it} \tag{1}$$

The specification is estimated separately for each of the four types of GVC participation $\ln(\text{GVC}_{it})$: overall (general), mixed, backward, and forward GVC production of country i in year t. $\ln(\text{ER}_{\$t})$ is the natural log of bilateral exchange rate against the US dollar. An increase in $\ln(\text{ER}_{\$t})$ signifies a dollar appreciation against domestic currency for country i or a domestic currency depreciation against the US dollar. This bilateral exchange rate specifically captures the impact of dollar movements on trade invoicing and pricing decisions. Many international transactions are invoiced in US dollars, so changes in this exchange rate directly influence the competitiveness and profitability of firms involved in GVCs, particularly those with dollar-denominated exports or imports.

$\ln(\text{RER}_{it})$ is the natural log of real effective exchange rate of country i, an increase of $\ln(\text{RER}_{it})$ signifies a home purchasing power increase. It provides a broader measure of a country's exchange rate against a basket of currencies, reflecting overall trade competitiveness and purchasing power. Both exchange rates are included because they capture distinct effects on GVC participation. The US dollar exchange rate specifically addresses the influence of dollar invoicing, while the RER provides a comprehensive view of trade competitiveness. Fixed effects for country f_i and year f_t are also included to control for unobserved heterogeneity and temporal trends.

The benchmark specification for estimating the direct effects of dominant currency trade invoicing on GVC participation follows a two-step approach. First, Equation 2 examines the

relationship between the value of trade invoiced in U.S. dollars and GVC production:

$$\ln(\mathrm{GVC}_{it}) = \delta_1 \ln(\mathrm{DCP}_{it}^{\mathrm{EX}}) + \delta_2 \ln(\mathrm{DCP}_{it}^{\mathrm{IM}}) + \delta_3 Z_{it} + f_i + f_t + \epsilon_{it} \tag{2}$$

Then, Equation 3 extends the analysis by incorporating bilateral exchange rate against US dollar and interaction terms between it and dollar-invoiced trade, allowing for an assessment of how exchange rate against dollar fluctuations influence GVC participation through the channel of dominant currency invoicing:

$$\begin{aligned} \ln(\mathrm{GVC}_{it}) = {} & \delta_1 \ln(\mathrm{ER}_{\$t}) + \delta_2 \ln(\mathrm{DCP}_{it}^{\mathrm{EX}}) + \delta_3 \ln(\mathrm{DCP}_{it}^{\mathrm{IM}}) \\ & + \delta_3 \left(\ln(\mathrm{DCP}_{it}^{\mathrm{EX}}) \times \ln(\mathrm{ER}_{\$t}) \right) + \delta_4 \left(\ln(\mathrm{DCP}_{it}^{\mathrm{IM}}) \times \ln(\mathrm{ER}_{\$t}) \right) \\ & + \delta_5 Z_{it} + f_i + f_t + \epsilon_{it} \end{aligned} \tag{3}$$

In these two specifications, $\ln(\mathrm{DCP}_{it}^{\mathrm{EX}})$ and $\ln(\mathrm{DCP}_{it}^{\mathrm{IM}})$ are the value of exports and imports, respectively, invoiced in US dollar. For overall and mixed GVC production regressions, both of exports and imports invoiced in US dollars are included as specified. For backward and forward GVC production regressions, only the log value of imports or exports invoiced in dollars and their interaction term with the dollar exchange rate, respectively, is incorporated. This approach aligns with the theoretical understanding that backward linkages are primarily influenced by import patterns, while forward participation is predominantly determined by export dynamics.

In contrast to other research on trade invoicing that use intensity (percentage) as measurement, the proxy $\ln(\mathrm{DCP}_{it})$ is constructed by multiplying the share of trade invoiced in US dollars by the values of export or import in constant local currency. Using trade values instead of percentages provides a more accurate representation of the economic importance of dollar-invoiced trade. This approach clarifies ambiguities that arise when interpreting percentage shares: an increase in the share of dollar invoicing could stem from either an actual increase in dollar-invoiced trade or a decrease in total trade volume. For instance, a high percentage of dollar invoicing in a small or declining overall trade volume is less economically significant than

a lower percentage in a much larger and growing trade volume. By focusing on absolute values, we capture the true economic impact of dollar-invoiced trade, ensuring that our analysis reflects meaningful changes in trade dynamics rather than shifts caused by fluctuations in total trade volumes. I interact the dollar exchange rate with the value of exports and imports invoiced in dollars. This interaction terms give the marginal effects of dominant currency invoicing with given level of exposure to the US dollar. Z_{it} are control variables selected from GVC and exchange rate studies (Fernandes et al., 2022) to reflect the capital mobility, industry capacity, and trade openness of a country that might not be captured by the country and time fixed effect. It includes capital control index, capital to GDP index, and trade to GDP ratio.

Building on the benchmark specification, Equation 4 compares the sensitivity of GVC production to dollar exchange rate movements and home currency movements within the context of dominant currency invoicing. By incorporating real exchange rate of country i and the interaction between the real exchange rate and the trade invoiced in US dollars, it captures the marginal effect of dominant currency invoicing during both dollar and RER fluctuations:

$$\ln(\text{GVC}_{it}) = \delta_1 \ln(\text{ER}_{\$t}) + \delta_2 \ln(\text{DCP}_{it}) + \delta_3 \left(\ln(\text{DCP}_{it}) \times \ln(\text{ER}_{\$t})\right)$$
$$+ \delta_4 \ln(\text{RER}_{it}) + \delta_5 \left(\ln(\text{DCP}_{it}) \times \ln(\text{RER}_{it})\right)$$
$$+ \delta_6 Z_{it} + f_i + f_t + \epsilon_{it} \tag{4}$$

Regressions are conducted for each type of GVC productions, $\ln(\text{DCP}_{it})$ is the vector of $\ln(\text{DCP}_{it}^{\text{EX}})$ and $\ln(\text{DCP}_{it}^{\text{IM}})$ for overall and mixed GVC models, while only $\ln(\text{DCP}_{it}^{\text{EX}})$ or $\ln(\text{DCP}_{it}^{\text{IM}})$ and its interaction terms with dollar exchange rates and RER are included for the forward and backward model, respectively.

δ_1 is anticipated to be negative across all four regression models to be consistent with the theoretical framework of dominant currency pricing: a stronger dollar dampens value-added trade. This expectation is based on the premise that dominant currency invoicing deepen trade sensitivity to fluctuations in the dominant currency. An appreciation of the dominant

currency is expected to increase import costs, leading to a decline in imports. Consequently, this reduction in imports is likely to result in a decrease in exports that rely on imported inputs, thereby affecting overall GVC participation.

In the model of backward production, δ_2, capturing the effect of dominant currency invoicing, is expected to be positive because dominant currency invoicing practice is hypothesized to reduce the ERPT of currency movement into import prices and therefore offer a relatively stable import flow. δ_3, as the coefficient of the interaction term of invoicing and dollar exchange rate, is expected to be positive to show that dollar invoicing practice could mitigate part of the ERPT into trade with a given level of dollar movements. δ_4 and δ_5 are expected to be positive because a stronger home purchasing power makes imported input less expensive.

In the model of forward participation, δ_2 is expected to be negative in accordance with the disruption of gross and value-added export in the Cook and Patel (2023) simulation. δ_4 and δ_5 are expected to be negative because a home real exchange rate appreciation is hypothesized to reduce the export competitiveness.

To address the potential endogeneity issues of exchange rates such that exchange rates can simultaneously affect and be affected by trade flows and trade patterns, a lag effect analysis is also conducted by replacing the key explanatory variables in Equation 4 with their lagged values. Gopinath et al. (2010) find that the average exchange rate pass-through after 24 months remains significantly different between dollar-invoiced and non-dollar-invoiced trades. Auer et al. (2021) show that the impact of invoicing currency share is strongest within the first three quarters after exchange rate shocks. Therefore, I run sensitivity analyzes that replace my key variables of interest with 1-, 2-, and 3-year lags in Equation 4.

Nevertheless, to ensure that my results aren't impacted by my definition of dominant currency pricing and the argument on the high correlation in bilateral dollar exchange rate and REER, I conduct a side exercise. I estimate the model by measuring dominate currency invoicing as the share of total trade invoiced in the dollar. Additionally, I include only the country-specific REER in the model, omitting the bilateral dollar exchange rate to avoid mul-

ticollinearity concerns. To capture the impact of dollar shock via dollar-invoiced trade, I incorporate an interaction term between the dollar-invoiced share and the US REER. This approach allows me to test whether the main findings remain consistent when using a different measurement strategy for dominant currency pricing and addressing potential correlation between exchange rate variables:

$$\ln(\text{GVC}_{it}) = \delta_1 \ln(\text{RER}_{it-1}) + \delta_2 \ln(\text{DCP (\%)}_{it-1}) + \delta_3 \left(\ln(\text{RER}_{it-1}) \times \ln(\text{DCP (\%)}_{it-1})\right)$$
$$+ \delta_4 \left(\ln(\text{RER}_{\$t-1}) \times \ln(\text{DCP (\%)}_{it-1})\right) + \delta_5 Z_{it} + f_t + \epsilon_{it} \tag{5}$$

$\ln(\text{DCP}(\%)_{it-1})$ denotes the natural log of dollar-invoiced *trade share* at year $t-1$. In accordance with the definition provided earlier, $\ln(\text{DCP}(\%)_{it-1})$ is a vector of $\ln(\text{DCP}(\%)_{it-1}^{\text{EX}})$ and $\ln(\text{DCP}(\%)_{it-1}^{\text{IM}})$ for overall and mixed GVC models, while $\ln(\text{DCP}(\%)_{it}^{\text{IM}})$ (or $\ln(\text{DCP}(\%)_{it}^{\text{EX}})$) is only incorporated in backward (forward) model respectively.

The interaction term $\ln(\text{RER}_{it-1}) \times \ln(\text{DCP (\%)}_{it-1})$ captures the sensitivity of GVC participation to domestic currency fluctuations is mitigated or exacerbated by the share of dollar invoicing. $\ln(\text{RER}_{\$t-1})$ is the natural log of US real effective exchange rate. The interaction term $\ln(\text{RER}_{\$t-1}) \times \ln(\text{DCP (\%)}_{it-1})$ shows how the global prominence of the US dollar affects a country's GVC participation, with a higher share of dollar invoicing intensity.

6 Empirical Results

6.1 Benchmark Analysis

Table 3 reports the results of Equation (1) and presents real effective exchange rate (REER) and dollar exchange rate's impacts on GVC at disaggregted level. Coefficients of REER and dollar exchange rate movements in columns 1 and 2 align with findings from previous literature: neither variable exhibits a statistically significant relationship with overall GVC production. However, I find heterogeneous impacts on backward and forward GVC participation. A 1%

Table 3. Real Exchange Rate and Dollar Exchange Rate Movements

	(1) General GVC	(2) Mixed GVC	(3) Backward GVC	(4) Forward GVC
ln(Real Effective Exchange Rate)	0.00745	-0.0456	0.202**	0.309***
	(0.122)	(0.135)	(0.0730)	(0.0728)
ln(Dollar Exchange Rate)	-0.0181	-0.0225	0.0280	0.0514***
	(0.0418)	(0.0448)	(0.0276)	(0.0110)
_cons	9.538***	9.215***	6.984***	6.377***
	(0.627)	(0.695)	(0.343)	(0.337)
Observations	2665	2663	2665	2652
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Adjusted R-squared	0.970	0.966	0.978	0.984

Standard errors in parentheses

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

appreciation of the domestic currency is associated with a 0.202% increase in backward GVC production (Column 3), which measures the imported inputs embedded in a country's exports. This aligns with economic intuition: as the domestic currency strengthens, imported intermediate inputs become relatively cheaper, encouraging firms to increase their use of foreign inputs in export production.

More interestingly, a 1% appreciation is also associated with a 0.309% increase in forward GVC production (Column 4), which measures the domestic value added used in other countries' exports. This finding might seem counterintuitive at first glance, since currency appreciation typically makes exports more expensive and less competitive. Several reasons could explain this result. First, GVCs often involve long-term contractual relationships that don't adjust immediately to exchange rate fluctuations, creating short-run stickiness in trade patterns. Second, for intermediate inputs, quality and reliability may matter more than price, particularly for specialized components where substitution is difficult. Third, firms experiencing a currency appreciation may be able to import better technology and higher-quality inputs, improving their production capabilities and making their intermediate exports more attractive despite higher prices. Finally, there may be complementarities between backward and forward participation, where improved access to imported inputs enhances a country's ability to produce competitive

intermediate goods for export.

Meanwhile, movements in the dollar exchange rate show statistical significance in the forward GVC production model (Column 4). Specifically, a 1% US dollar appreciation (against home currency) is associated with a 0.0514% increase in forward GVC production. This suggests that the forward GVC activities, such as those exporting intermediates embedded with high labor value-added, benefit from a weaker currency against the dollar, which in line with the prediction that home depreciation could boost export competitiveness in general.

Table 4. Dollar Movements and Its Interaction

	(1) General GVC	(2) Mixed GVC	(3) Backward GVC	(4) Forward GVC
ln(Dollar Exchange Rate)	-0.476***	-0.482***	-0.370*	-0.448***
	(0.0993)	(0.123)	(0.143)	(0.0864)
ln(Dollar-Invoiced Export)	0.232***	0.269***		0.278**
	(0.0649)	(0.0759)		(0.0978)
ln(Dollar-Invoiced Import)	0.0900	0.0880	0.147	
	(0.0543)	(0.0585)	(0.0778)	
ln(Dollar-Invoiced Export)	0.0127	0.00282		0.00996*
*ln(Dollar Exchange Rate)	(0.0185)	(0.0203)		(0.00486)
ln(Dollar-Invoiced Import)	-0.000472	0.00848	0.0144**	
*ln(Dollar Exchange Rate)	(0.0171)	(0.0188)	(0.00496)	
ln(Capital to GDP Ratio)	0.235**	0.174*	0.429***	0.146
	(0.0696)	(0.0834)	(0.0927)	(0.0890)
ln(Trade to GDP Ratio)	0.361***	0.457***	0.306*	0.212
	(0.104)	(0.115)	(0.122)	(0.127)
ln(Capital Openness)	0.0844*	0.0775	0.0741*	0.0893*
	(0.0405)	(0.0466)	(0.0338)	(0.0435)
_cons	2.641*	2.150	0.288	3.524**
	(1.141)	(1.370)	(1.435)	(1.211)
Observations	895	895	924	911
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Adjusted R-squared	0.990	0.989	0.989	0.985

Standard errors in parentheses

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

Table 4 presents the results of Equation 3, which examines the impact of dollar movements and invoicing practices on GVC participation across the four types of GVC production. The

findings in the first row indicate that a stronger dollar is negatively associated with all GVC production types. Specifically, a 1% appreciation of the dollar against the home currency corresponds to a decline of 0.476%, 0.482%, 0.37%, and 0.448% in general, mixed, backward, and forward GVC production, respectively. These results contrast from the findings from previous literature and confirm that GVC productions are sensitive to currency fluctuations.

The coefficients for dollar-invoiced trade show a positive and significant effect across all models, except for the backward GVC model. The statistically significant positive coefficients in columns (1), (2), and (4) suggest that invoicing exports in dollars may help stabilize trade operations in general, mixed, and forward GVC production. The coefficient for dollar-invoiced imports is also positive but not statistically significant.

The interaction terms between the dollar exchange rate and dollar-invoiced trade provide additional insights into the marginal effects of dollar fluctuations under dominant currency paradigm. The interaction between the dollar exchange rate and dollar-invoiced imports in the backward GVC model is significant (coefficient = 0.0144). This means that if a country has a mean level of dollar-invoiced imports, a 1% dollar appreciation would result in a decline of about 0.37% in backward GVC participation. However, for every standard deviation increase in dollar-invoiced imports, the negative impact of a 1% dollar appreciation on backward GVC participation would decrease by approximately 0.0144 times the natural logarithm of that increase. This suggests that while the overall effect remains negative, dollar invoicing can help mitigate some of the adverse effects of dollar appreciation on backward GVC participation.

Among the control variables, capital intensity is positively associated with all types of GVC production, with the strongest effect observed in backward GVCs. Trade openness also has a positive and significant effect across all models except for the forward GVC model. Financial openness exhibits a generally positive effect but with lower statistical significance.

Figure 7 illustrates how dollar appreciation impacts backward and forward GVC production at varying levels of dollar-invoiced trade. In Figure 7a, the marginal effect of dollar appreciation becomes more positive as the share of dollar-invoiced imports increases. This pattern suggests

Figure 7. Marginal Effects of Increasing Dollar-Invoiced Trade
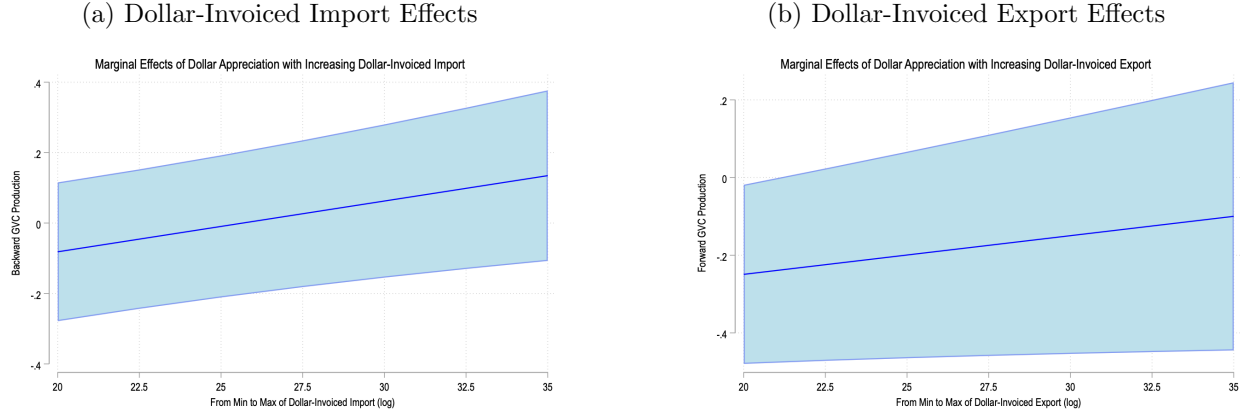
(a) Dollar-Invoiced Import Effects   (b) Dollar-Invoiced Export Effects

Note: Panels (a) and (b) show marginal effects of an increasing levels of dollar-invoiced trade. Solid lines represent point estimates, shaded areas show 95% confidence intervals.

that higher levels of dollar-invoiced imports help mitigate the negative impact of dollar appreciation, likely by reducing currency risk in imported input costs. The upward slope indicates a transition from neutral or negative effects to a stabilizing influence, reinforcing the role of dollar invoicing in shielding backward GVC production from exchange rate volatility.

In contrast, Figure 7b shows that the marginal effect of dollar appreciation on forward GVC production are relatively flat and it slightly diminishes at higher levels of dollar-invoiced exports. This suggests that although dollar invoicing in exports may facilitate trade, its benefits in forward GVC production do not scale proportionally at higher invoicing volumes. The slight downward trend may reflect constraints such as increased exposure to exchange rate fluctuations or associated costs of dominant currency pricing.

Together, these results suggest that while dollar-invoiced imports help firms absorb currency fluctuations in backward GVCs, the benefits of dollar-invoiced exports in forward GVCs are less pronounced.

Overall, findings from Table 4 and Figure 7 highlight the significant yet mixed effects of dollar movements and invoicing practices across GVC types. While a stronger dollar generally dampens GVC trade, trade invoicing in dollars facilitates GVC participation, particularly by mitigating exchange rate risks in backward GVC production. These findings emphasize the role

of dominant currency invoicing in shaping integration into global trade networks and how their impact varies depending on the structure of domestic GVC participation.

Table 5. Dollar and Real Effective Exchange Rate Movements, and Their Interactions

	(1) General GVC	(2) Mixed GVC	(3) Backward GVC	(4) Forward GVC
ln(Dollar Exchange Rate)	-0.350***	-0.373**	-0.270***	-0.339**
	(0.0966)	(0.113)	(0.0469)	(0.108)
ln(Real Effective Exchange Rate)	0.559	0.478	1.030***	0.458
	(0.402)	(0.459)	(0.223)	(0.562)
ln(Dollar-Invoiced Export)	0.253	0.00630		0.187
	(0.755)	(0.958)		(0.122)
ln(Dollar-Invoiced Import)	-0.0232	0.267	0.206*	
	(0.859)	(1.078)	(0.0905)	
ln(Dollar-Invoiced Export)	0.0200	0.0102		0.0117
*ln(Dollar Exchange Rate)	(0.0142)	(0.0165)		(0.00649)
ln(Dollar-Invoiced Import)	-0.00575	0.00278	0.0165***	
*ln(Dollar Exchange Rate)	(0.0145)	(0.0167)	(0.00191)	
ln(Dollar-Invoiced Export)	-0.0233	0.0397		0.00409
*ln(Real Effective Exchange Rate)	(0.164)	(0.207)		(0.0344)
ln(Dollar-Invoiced Import)	0.0236	-0.0381	-0.0202	
*ln(Real Effective Exchange Rate)	(0.180)	(0.226)	(0.0176)	
ln(Capital to GDP Ratio)	0.172*	0.114	0.295***	0.0849
	(0.0700)	(0.0882)	(0.0688)	(0.0851)
ln(Trade to GDP Ratio)	0.503***	0.583***	0.455***	0.337**
	(0.0955)	(0.110)	(0.0908)	(0.116)
ln(Capital Openness)	0.0319	0.0319	0.00866	0.0396
	(0.0403)	(0.0483)	(0.0277)	(0.0427)
_cons	1.146	0.940	-2.978*	2.363
	(1.603)	(1.862)	(1.272)	(2.315)
Observations	895	895	924	911
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Adjusted R-squared	0.991	0.989	0.991	0.986

Standard errors in parentheses

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

Table 5 shows the results of Equation 4 which incorporate the REER and the additional interaction term of dollar-invoiced trade and the REER to capture the marginal effect of home purchasing power. The coefficients for the dollar exchange rate are again negative and statistically significant in all types of GVC production. It suggests that a 1% dollar appreciation

reduces genenal GVC by 0.35%, mixed GVC in 0.373%, backward GVC production by 0.27%, and 0.339% in forward GVC production.

On the other hand, the REER shows consistently positive effects, particularly significant on backward GVC production. The coefficient of 1.03 for backward GVCs indicates that a 1% increase in the home purchasing power boosts backward production by 1.03%, suggesting that a stronger domestic currency is positively associated with the backward productions. REER's positive association to other GVCs, although substantial, lacks statistical significance, implying that the benefits of home currency appreciation may be concentrated more on upstream production.

Dollar-invoiced trade shows similar pattern to Table 4: vary but lack significancy on standalone effects except for the backward GVC model (column (3)). The interaction between the dollar exchange rate and dollar-invoiced imports is significant and positive for backward GVC production, with a coefficient of 0.0165. This suggests that heavy imported input users might be benefited from invoicing more imports in dollar. The interaction between REER and invoicing practices does not yield statistically significant results, suggesting a limited association.

Figure 8. Marginal Effects of Dollar-Invoiced Trade on GVC Participation
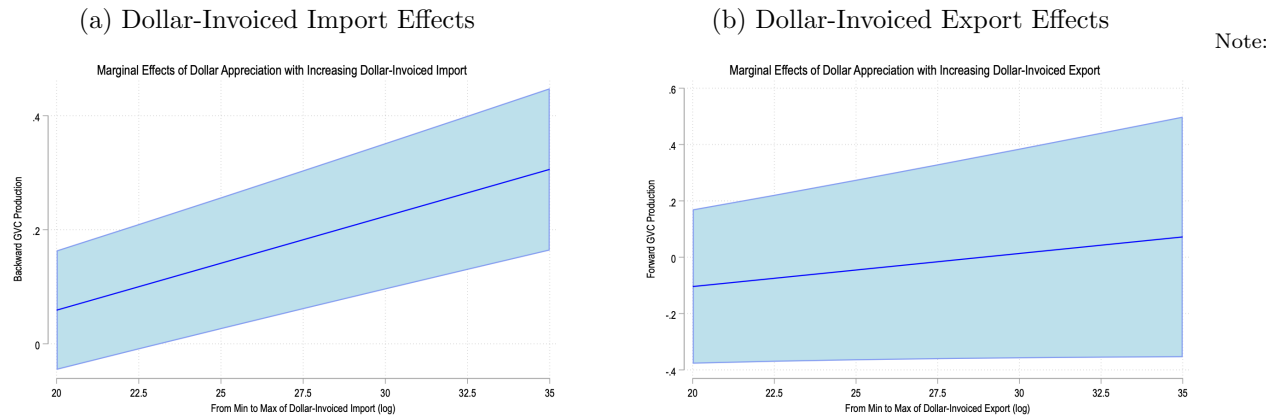
(a) Dollar-Invoiced Import Effects (b) Dollar-Invoiced Export Effects

Note:

Panels (a) and (b) show marginal effects of an increasing levels of dollar-invoiced trade. Solid lines represent point estimates, shaded areas show 95% confidence intervals.

For a marginal effect analysis, Figure 8 captures a similar impact of dollar appreciation on backward and forward GVC production given an increasing value of dollar-invoiced trade as

above. In Figure 8a, the marginal effect of dollar appreciation becomes increasingly positive as the volume of dollar-invoiced imports rises. The effect indicates that invoicing imports in dollar allows to cushion the adverse effects of dollar appreciation. Figure 8b shows the marginal effect of dollar appreciation on forward GVC production as dollar-invoiced exports increase. The effect starts slightly negative at low levels of invoicing but becomes positive and grows steadily with higher invoicing volumes. This trend suggests that a higher level of dollar-invoiced exports benefit from enhanced stability under dollar appreciation. However, the slope of the increase is less pronounced compared to the backward production case, indicating that the stabilizing role of dollar invoicing is relatively weaker for forward GVCs, likely due to differing exposure to input cost dynamics.

Given the incorporation of REER and its interaction term into the estimation, the marginal effect plots reveal that dollar-invoicing practices provide significant cushioning against dollar fluctuations, particularly in backward GVCs, where input costs are more sensitive to currency movements. Forward GVCs also benefit, but to a lesser extent, as the dynamics of export invoicing and dollar appreciation interact differently compared to upstream activities.

Table 5, together with the marginal plots in Figure 8 show that dollar appreciation negatively impacts GVCs. However, the interaction terms suggest that dollar invoicing can mitigate adverse effects on imported inputs for backward GVC production from a stronger dollar. These findings show the need for careful management of exchange rate exposures and invoicing strategies to enhance the integration into GVCs.

6.2 Long-term Impact via Lagged Analysis

Additional regression results with lagged variables (one, two, and three-year lags) show the dynamic impacts of exchange rate movements, invoicing practices, and their interactions on GVC production over time (Equation 4) and across income levels (Equation 5) (Tables are attached in the Appendix).

In the lagged analysis based on Equation 4, the one-year lag analysis (Table 7) aligns with

the findings from the non-lagged model in Table 5, indicating dollar appreciation from a year ago holds a similared-size, statistically significant negative association with all GVC production. And a REER appreciation from a year ago is positively associated with all types of GVCs but only statistically significant in backward GVC production, showing the role of a stronger home currency might benefit the import of intermediates. Dollar-invoiced export is positively and significant related to general, mixed, and forward GVC production, and dollar-invoiced import is positively associated with backward GVCs, suggesting that firms might benefit from invoicing their trade in dominant currency. And the interaction term between dollar exchange rate and dollar-invoiced imports shows a significant positive association with backward GVC production, implying that dollar-invoiced import can mitigate part of the adverse effects from exchange rate volatility in the short run.

The two-year lag analysis in Table 8 shows a similar but weaker pattern in terms of both size and statistical significancy. The negative impact of dollar appreciation on genreal, mixed, and backward GVC production persists, with the coefficient size slightly decreases, suggesting that firms may start adjusting their input strategies to cope with the adverse exchange rate effects. The impact of REER remains positive for backward GVCs, though the significance level and coefficient size slightly drops. The interaction between dollar exchange rate and dollar-invoiced trade still exhibits a positive and significant effect on general, mixed, and backward GVCs, indicating that the mitigating effect of invoicing practices persists over the short to medium term.

In the three-year lag analysis presented in Table 9, the effects of the dollar exchange rate on GVC production become less pronounced in terms of size and statistical significance. The positive influence of REER remains for all GVC productions, but it is weaker and not as statistically significant as in shorter lags, suggesting a gradual adjustment such as switching to domestic substitutes. The impact of dollar-invoiced trade also weakens, indicating that the initial advantages provided by stable invoicing practices may dissipate over time. However, the positive interaction effect between dollar-invoiced imports and dollar fluctuations remains

significant for backward GVC production.

In comparing short- and medium-to-long-run impacts, the results suggest that the effects of dollar and REER movements on GVC production are the strongest in the short run and weaken over time as participants adapt their sourcing and pricing strategies. The initial significant challenges of dollar appreciation for backward GVCs and the benefits of REER appreciation are most pronounced in the first year but gradually decline. Meanwhile, the role of dollar-invoiced trade as a stabilizing factor remains consistent across time horizons, though its effect size reduces marginally in the long run. The interaction terms underscore the sustained benefits of strategic invoicing practices, particularly for backward GVC production, in mitigating exchange rate volatility over extended periods. These results collectively emphasize the temporal dynamics of currency movements and invoicing strategies in shaping GVC participation.

6.3   Income Level Analysis

The income level analysis based on Equation 5 reveals patterns that, despite statistical significant coefficients of real exchange rate movements and invoicing shares scatter in all four types of GVC participation across high-income (Group 1), upper-middle-income (Group 2), and low- and lower-middle-income countries (Group 3), GVC participation in Group 3 is the most sensitive while it's relatively muted in high and upper middle income countries (Group 1 and 2, respectively):

Overall GVC Production (Table 10): Group 1 shows limited statistical significance for the effects of currency movements and dollar invoicing, suggesting a weaker overall GVC responses to invoicing practices in the high income group. Group 2 shows a negative association between home currency appreciation and overall GVC participation, indicating that upper-middle-income economies experience a decline the general activities with a stronger home currency. The negative association between home currency appreciation and GVC participation might indicate that these economies rely more on price competitiveness for their exports. A stronger currency could make their exports less competitive, reducing GVC participation.

Group 3 is the one that is more responsive to currency fluctuations: a 1% appreciation in the home real exchange rate from a year ago is linked to a 9.545% increase in overall GVC participation (column (3)). When comes to the dollar fluctuation as a global shock, the interaction term coefficient shows that, the percentage of dollar-invoiced import is positively associated with overall GVC production amid a stronger dollar.

Mixed GVC Production (Table 11): A similar pattern emerges in the mixed GVC model, though with smaller coefficient magnitudes. In Group 3, the interaction terms between the shares of dollar-invoiced imports and both home currency and dollar movements exhibit strong statistical significance. This suggests that firms importing inputs for export production in low- and lower-middle-income economies are more sensitive to currency fluctuations and dollar-invoicing practices than their counterparts in higher-income economies.

The stronger effects observed in Group 3 compared to higher-income groups may stem from the nature of production in lower-income countries, where firms are more likely to engage in assembly and processing trade. These firms rely heavily on imported inputs for export-oriented production, making them particularly vulnerable to shifts in exchange rates and trade invoicing practices. Additionally, their thinner profit margins amplify the impact of cost changes driven by currency fluctuations, further reinforcing their sensitivity to dominant currency invoicing.

Backward GVC Production (Table 12): In the backward GVC model, Group 3 countries are the only ones that exhibit statistically significant responsiveness to both home currency and dollar movements, although the statistical power is weaker compared to the overall and mixed GVC models. In contrast, Groups 1 and 2 show no statistically significant responses to either home currency fluctuations or dominant currency movements.

One possible explanation for this pattern is that lower-income countries rely more heavily on imported inputs for their exports, making them more vulnerable to exchange rate fluctuations and invoicing practices. In contrast, higher-income countries may have greater access to domestic substitutes, employ more sophisticated hedging strategies, or having lower share of their trade as GVC trade, reducing their sensitivity to currency movements. This difference

highlights the varying degrees of exposure to global currency dynamics across income levels and suggests that firms in lower-income economies may face greater challenges in managing exchange rate risks in backward GVC production.

Forward GVC Production (Table 13): Group 1 displays a distinct dynamic in this forward GVC production income-level analysis. In Group 1, the share of dollar-invoiced exports is negatively associated with forward production, with a small but statistically significant coefficient of -0.0906. This suggests that, in high-income countries, a higher reliance on dollar invoicing in exports may not necessarily enhance forward GVC production and could even be linked to a slight decline.

In Group 3, forward production is positively associated with a stronger home currency, indicating that currency appreciation may improve competitiveness or production capacity in these economies. However, the interaction terms reveal that when home currency appreciation is combined with a higher share of dollar-invoiced exports, forward production declines. This suggests that firms in low- and lower-middle-income countries may face challenges when exporting in dollars during periods of home currency appreciation, possibly due to pricing pressures or contractual rigidities.

Conversely, a stronger dollar enhances the positive relationship between dollar-invoiced exports and forward GVC production in Group 3. This could indicate that when the dollar strengthens, countries with a higher share of dollar-invoiced exports become more attractive suppliers in GVCs, potentially benefiting from greater stability in dollar-denominated contracts. This dynamic underscores the role of dominant currency invoicing in shaping forward GVC production, with its effects varying depending on exchange rate movements and a country's position within GVCs.

The income-level findings, combined with the previous lagged analysis, show that currency movements and dollar invoicing practices exert the strongest influence on GVC production in low- and lower-middle-income countries, while high- and upper-middle-income countries exhibit relatively muted responses. This heightened sensitivity among lower-income economies can

be attributed to two key factors: (1) a greater reliance on imported inputs for production, making them more susceptible to exchange rate fluctuations; and (2) higher exposure to external economic shocks due to weaker financial buffers and limited access to hedging mechanisms.

These effects are particularly pronounced in the short to medium term, indicating that lower-income countries face significant challenges in maintaining stable GVC participation amid currency volatility and shifts in dollar invoicing patterns. The findings suggest that policymakers in these economies may need targeted strategies, such as currency risk management tools or trade diversification efforts, to mitigate the adverse effects of dominant currency fluctuations on their integration into global production networks.

7   Conclusion

This paper empirically examines how different types of GVC production respond to dollar exchange rate and real exchange rate fluctuations, with a particular focus on the role of dominant currency (dollar) invoicing. The findings challenge prior GVC literature by showing that real exchange rate movements play a crucial role in shaping GVC participation, particularly at the disaggregated levels of backward and forward GVC linkages. Furthermore, the results confirm that dollar appreciation dampens GVC production, especially in backward participation, while a higher level and share of trade invoiced in dollars helps mitigate some of these negative effects.

The results provide solid support for Hypothesis I: GVC production in countries with higher levels of dollar-invoiced trade is more responsive to fluctuations in the dollar exchange rate. This effect is particularly pronounced in backward GVC production, where essentially relys on imported inputs for export production. The heightened sensitivity of backward participation to dollar fluctuations reinforces the notion that dominant currency invoicing amplifies exchange rate effects on global production networks.

For Hypothesis II, the findings indicate that forward GVC production is relatively less affected by dollar exchange rate fluctuations, especially when controlling for home purchasing

power (REERs). In Table 5, the coefficients for dollar exchange rate fluctuations show weaker statistical significance for forward production, suggesting a more muted response. This pattern is further supported by the lag analysis (Table 7, Table 8, and Table 9), where forward participation exhibits less volatile responses to exchange rate movements.

Another key contribution of this paper comes from the income-level analysis, which underscores that the interaction between dominant currency invoicing and dollar fluctuation as a global shock is particularly strong in low- and lower-middle-income economies. In these countries, a higher share of dollar-invoiced trade amplifies the effects of dollar fluctuations, particularly in general, mixed, and forward GVC production. This suggests that policymakers in developing economies need to carefully assess their invoicing practices and exposure to exchange rate risks when integrating into global production networks.

In conclusion, this paper shows that the widespread use of dollar invoicing in international trade significantly shapes GVC participation in the face of exchange rate fluctuations. Different segments of GVCs respond asymmetrically to currency movements: backward participation, which relies on imported inputs, is particularly vulnerable to changes in the dollar exchange rate, while forward participation, which involves supplying inputs to others, exhibits distinct and less immediate patterns.

These findings have important implications for trade and economic policy. Policymakers must consider a country's position within GVCs—whether it primarily imports intermediate inputs or serves as a supplier—to design effective strategies for managing currency risks. Given that dollar-invoiced imports can help stabilize backward GVC production by reducing currency risk exposure, policies that facilitate access to trade financing and hedging mechanisms could help firms navigate dollar fluctuations more effectively. Meanwhile, for forward GVC production, which exhibits a more gradual response to currency fluctuations, export competitiveness strategies should account for both invoicing practices and long-term exchange rate dynamics.

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A   Appendix I

Table 6. Descriptive Statistics of Main Variables of Interest

	Mean	Std. Dev.	Min	25th	Median	75th	Max
ExportUSD	46.206	31.942	2.700	17.339	37.000	80.700	100.000
ExportEUR	43.191	33.342	0.000	5.545	48.461	75.492	95.800
ImportUSD	44.408	27.010	1.000	22.395	34.300	71.100	100.000
ImportEUR	43.251	29.966	0.000	8.390	48.656	70.737	93.330
gvco	198,594.629	358,825.300	246.500	14,692.637	55,527.684	209,960.456	2,526,016.724
gvcomix	116,247.830	212,063.892	127.783	8,505.881	31,459.566	124,758.730	1,611,648.616
gvcobp	40,089.329	71,872.425	8.552	3,400.589	12,809.461	43,579.358	480,234.580
gvcofp	42,257.471	79,874.238	30.888	2,551.232	11,597.620	47,487.036	681,446.809
ERUSD	365.011	1,616.095	0.081	0.887	2.695	48.592	14,242.188
REER65	98.731	15.100	50.225	91.620	98.503	105.579	168.429

B Appendix II

Table 7. Lagged Analysis I (Lagged by One Year)

	(1) General GVC	(2) Mixed GVC	(3) Backward GVC	(4) Forward GVC
L.ln(Dollar Exchange Rate)	-0.346***	-0.359***	-0.276***	-0.288*
	(0.0811)	(0.0935)	(0.0518)	(0.113)
L.ln(Real Effective Exchange Rate)	0.470	0.377	0.828***	0.240
	(0.262)	(0.311)	(0.131)	(0.408)
L.ln(Dollar-Invoiced Export)	0.124**	0.162**		0.129*
	(0.0430)	(0.0535)		(0.0536)
L.ln(Dollar-Invoiced Import)	0.129**	0.139*	0.162**	
	(0.0453)	(0.0551)	(0.0520)	
L.ln(Dollar-Invoiced Export) *L.ln(Dollar Exchange Rate)	0.0164	0.00661		0.0105
	(0.0142)	(0.0175)		(0.00742)
L.ln(Dollar-Invoiced Import) *L.ln(Dollar Exchange Rate)	-0.00337	0.00428	0.0166***	
	(0.0136)	(0.0167)	(0.00243)	
L.ln(Dollar-Invoiced Export) *L.ln(Real Effective Exchange Rate)	0.0116	0.0146		0.0141
	(0.0156)	(0.0186)		(0.0212)
L.ln(Dollar-Invoiced Import) *L.ln(Real Effective Exchange Rate)	-0.0160	-0.0174	-0.0147	
	(0.00911)	(0.0102)	(0.00764)	
ln(Capital to GDP Ratio)	0.201**	0.146	0.328***	0.0999
	(0.0613)	(0.0759)	(0.0705)	(0.0844)
ln(Trade to GDP Ratio)	0.432***	0.512***	0.367***	0.329**
	(0.0850)	(0.103)	(0.0845)	(0.112)
ln(Capital Openness)	0.0447	0.0392	0.0287	0.0566
	(0.0394)	(0.0485)	(0.0236)	(0.0408)
_cons	1.485	1.233	-1.870	3.276
	(1.257)	(1.457)	(1.214)	(1.685)
N	780	780	811	795
adj. R^2	0.993	0.990	0.993	0.987

Standard errors in parentheses

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

Table 8. Lagged Analysis II (Lagged by Two Year)

	(1) General GVC	(2) Mixed GVC	(3) Backward GVC	(4) Forward GVC
L2.ln(Dollar Exchange Rate)	-0.336***	-0.339***	-0.308***	-0.212
	(0.0944)	(0.0964)	(0.0783)	(0.133)
L2.ln(Real Effective Exchange Rate)	0.245	0.140	0.521**	0.0764
	(0.329)	(0.395)	(0.188)	(0.424)
L2.ln(Dollar-Invoiced Export)	0.101*	0.142*		0.0929
	(0.0449)	(0.0532)		(0.0600)
L2.ln(Dollar-Invoiced Import)	0.151*	0.158*	0.189**	
	(0.0590)	(0.0669)	(0.0657)	
L2.ln(Dollar-Invoiced Export) *L2.ln(Dollar Exchange Rate)	0.0190	0.00750		0.0103
	(0.0167)	(0.0208)		(0.00883)
L2.ln(Dollar-Invoiced Import) *L2.ln(Dollar Exchange Rate)	-0.00600	0.00310	0.0143***	
	(0.0156)	(0.0189)	(0.00334)	
L2.ln(Dollar-Invoiced Export) *L2.ln(Real Effective Exchange Rate)	0.0155	0.0187		0.0174
	(0.0149)	(0.0180)		(0.0217)
L2.ln(Dollar-Invoiced Import) *L2.ln(Real Effective Exchange Rate)	-0.0156	-0.0166	-0.00611	
	(0.0101)	(0.0120)	(0.00821)	
ln(Capital to GDP Ratio)	0.249***	0.191*	0.371***	0.100
	(0.0689)	(0.0842)	(0.0654)	(0.0903)
ln(Trade to GDP Ratio)	0.393***	0.478***	0.266**	0.282*
	(0.110)	(0.128)	(0.0929)	(0.140)
ln(Capital Openness)	0.0617	0.0528	0.0501	0.0785
	(0.0470)	(0.0578)	(0.0258)	(0.0494)
_cons	1.813	1.570	-1.247	4.402*
	(1.610)	(1.826)	(1.333)	(2.088)
N	738	738	768	752
adj. R^2	0.991	0.989	0.992	0.985

Standard errors in parentheses

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

Table 9. Lagged Analysis III (Lagged by Three Year)

	(1) General GVC	(2) Mixed GVC	(3) Backward GVC	(4) Forward GVC
L3.ln(Dollar Exchange Rate)	-0.254*	-0.247*	-0.256**	-0.130
	(0.0979)	(0.102)	(0.0757)	(0.131)
L3.ln(Real Effective Exchange Rate)	0.173	0.0505	0.493*	0.0189
	(0.298)	(0.366)	(0.186)	(0.385)
L3.ln(Dollar-Invoiced Export)	0.0756	0.101		0.0584
	(0.0456)	(0.0552)		(0.0680)
L3.ln(Dollar-Invoiced Import)	0.122*	0.132*	0.156**	
	(0.0523)	(0.0621)	(0.0513)	
L3.ln(Dollar-Invoiced Export) *L3.ln(Dollar Exchange Rate)	0.0189	0.00983		0.00824
	(0.0176)	(0.0216)		(0.00775)
L3.ln(Dollar-Invoiced Import) *L3.ln(Dollar Exchange Rate)	-0.00723	-0.000143	0.0133***	
	(0.0166)	(0.0196)	(0.00380)	
L3.ln(Dollar-Invoiced Export) *L3.ln(Real Effective Exchange Rate)	0.0248	0.0297		0.0213
	(0.0139)	(0.0171)		(0.0196)
L3.ln(Dollar-Invoiced Import) *L3.ln(Real Effective Exchange Rate)	-0.0208*	-0.0225	-0.00598	
	(0.0101)	(0.0125)	(0.00815)	
ln(Capital to GDP Ratio)	0.313***	0.275**	0.413***	0.137
	(0.0675)	(0.0865)	(0.0641)	(0.0857)
ln(Trade to GDP Ratio)	0.366**	0.471**	0.206*	0.249
	(0.116)	(0.138)	(0.0942)	(0.159)
ln(Capital Openness)	0.0497	0.0368	0.0492	0.0586
	(0.0471)	(0.0590)	(0.0274)	(0.0439)
_cons	1.674	1.200	-1.105	4.386*
	(1.493)	(1.709)	(1.399)	(1.920)
N	664	664	690	677
adj. R^2	0.992	0.990	0.993	0.986

Standard errors in parentheses

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

Table 10. Income Level Analysis - Overall GVC Production

	(1) High Income	(2) Upper Middle	(3) Low and Lower Middle
L.ln(Real Effective Exchange Rate)	0.115	-3.461**	9.545***
	(0.575)	(1.326)	(0.803)
L.ln(Dollar-Invoiced Export %)	-0.0575	0.183	0.108
	(0.0481)	(0.109)	(0.0853)
L.ln(Dollar-Invoiced Import %)	-0.0524	-0.0934	-0.0614
	(0.0930)	(0.0985)	(0.109)
L.ln(Dollar-Invoiced Export %)	-0.171	0.544	0.353
*L.ln(Real Effective Exchange Rate)	(0.172)	(0.399)	(0.337)
L.ln(Dollar-Invoiced Import %)	0.256	0.283	-2.514***
*L.ln(Real Effective Exchange Rate)	(0.259)	(0.290)	(0.403)
L.ln(Dollar-Invoiced Export %)	0.185	-0.542	-0.385
*L.ln(US Real Effective Exchange Rate)	(0.171)	(0.412)	(0.315)
L.ln(Dollar-Invoiced Import %)	-0.278	-0.301	2.475***
*L.ln(US Real Effective Exchange Rate)	(0.264)	(0.299)	(0.335)
ln(Capital to GDP Ratio)	0.155	0.234**	0.113
	(0.143)	(0.0934)	(0.114)
ln(Trade to GDP Ratio)	0.586**	0.413***	0.0891
	(0.223)	(0.0692)	(0.271)
ln(Capital Openness)	0.210	0.0199	0.0842
	(0.172)	(0.119)	(0.114)
_cons	8.305**	24.77***	-33.66***
	(3.681)	(5.918)	(3.748)
N	528	190	68
adj. R^2	0.991	0.996	0.997

Standard errors in parentheses

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

Table 11. Income Level Analysis - Mixed GVC Production

	(1) High Income	(2) Upper Middle	(3) Low and Lower Middle
L.ln(Real Effective Exchange Rate)	-0.0738	-4.174**	6.776***
	(0.718)	(1.899)	(0.797)
L.ln(Dollar-Invoiced Export %)	-0.0555	0.224	0.136
	(0.0531)	(0.153)	(0.0970)
L.ln(Dollar-Invoiced Import %)	-0.0372	-0.0464	-0.0516
	(0.103)	(0.0928)	(0.132)
L.ln(Dollar-Invoiced Export %) *L.ln(Real Effective Exchange Rate)	-0.249	0.913	-0.0453
	(0.194)	(0.626)	(0.328)
L.ln(Dollar-Invoiced Import %) *L.ln(Real Effective Exchange Rate)	0.363	0.0558	-1.495***
	(0.314)	(0.431)	(0.371)
L.ln(Dollar-Invoiced Export %) *L.ln(US Real Effective Exchange Rate)	0.266	-0.928	-0.00585
	(0.192)	(0.642)	(0.302)
L.ln(Dollar-Invoiced Import %) *L.ln(US Real Effective Exchange Rate)	-0.384	-0.0759	1.481***
	(0.320)	(0.449)	(0.309)
ln(Capital to GDP Ratio)	0.131	0.169	-0.0395
	(0.168)	(0.187)	(0.139)
ln(Trade to GDP Ratio)	0.747***	0.473***	-0.138
	(0.258)	(0.128)	(0.291)
ln(Capital Openness)	0.210	0.0258	0.204
	(0.194)	(0.116)	(0.148)
_cons	7.815*	27.21***	-20.85***
	(4.523)	(8.285)	(3.864)
N	528	190	68
adj. R^2	0.989	0.993	0.996

Standard errors in parentheses

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

Table 12. Income Level Analysis - Backward GVC Production

	(1) High Income	(2) Upper Middle	(3) Low and Lower Middle
L.ln(Real Effective Exchange Rate)	0.665	1.765	7.256*
	(0.463)	(1.650)	(3.312)
L.ln(Dollar-Invoiced Import %)	-0.0975	-0.0923	0.131
*L.ln(Real Effective Exchange Rate)	(0.0609)	(0.134)	(0.151)
L.ln(Dollar-Invoiced Import %)	-0.0289	-0.259	-1.430*
*L.ln(Real Effective Exchange Rate)	(0.128)	(0.376)	(0.763)
L.ln(Dollar-Invoiced Import %)	0.00844	0.273	1.349*
*L.ln(US Real Effective Exchange Rate)	(0.127)	(0.376)	(0.692)
ln(Capital to GDP Ratio)	0.313***	0.304***	0.177
	(0.0944)	(0.0980)	(0.117)
ln(Trade to GDP Ratio)	0.449**	0.0686	0.923**
	(0.171)	(0.131)	(0.312)
ln(Capital Openness)	0.166	-0.133	0.0185
	(0.122)	(0.108)	(0.143)
_cons	4.799**	0.691	-28.33*
	(2.025)	(7.641)	(14.38)
N	534	204	80
adj. R^2	0.993	0.994	0.987

Standard errors in parentheses

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

Table 13. Income Level Analysis - Forward GVC Production

	(1) High Income	(2) Upper Middle	(3) Low and Lower Middle
L.ln(Real Effective Exchange Rate)	0.681	-2.242	8.476**
	(0.536)	(1.989)	(3.133)
L.ln(Dollar-Invoiced Export %)	-0.0906*	0.0813	0.112
	(0.0519)	(0.102)	(0.157)
L.ln(Dollar-Invoiced Export %) *L.ln(Real Effective Exchange Rate)	-0.0131	0.511	-1.696**
	(0.153)	(0.417)	(0.685)
L.ln(Dollar-Invoiced Export %) *L.ln(US Real Effective Exchange Rate)	0.0355	-0.557	1.650**
	(0.167)	(0.422)	(0.642)
ln(Capital to GDP Ratio)	0.0944	-0.165	-0.172
	(0.145)	(0.160)	(0.257)
ln(Trade to GDP Ratio)	0.422	0.346***	-0.137
	(0.322)	(0.0802)	(0.610)
ln(Capital Openness)	0.227	-0.0251	0.580
	(0.181)	(0.153)	(0.414)
_cons	4.278	18.34*	-30.46**
	(3.600)	(9.306)	(13.43)
N	531	201	72
adj. R^2	0.984	0.992	0.988

Standard errors in parentheses

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

C Appendix III

Table 14. Full List of Country Names and ISO Codes

ISO Code	Country	ISO Code	Country	ISO Code	Country
ALB	Albania	DEU	Germany	PAK	Pakistan
DZA	Algeria	GHA	Ghana	PRY	Paraguay
AGO	Angola	GRC	Greece	PER	Peru
ARG	Argentina	HUN	Hungary	POL	Poland
ARM	Armenia	ISL	Iceland	PRT	Portugal
AUS	Australia	IND	India	ROU	Romania
AUT	Austria	IDN	Indonesia	RUS	Russia
AZE	Azerbaijan	IRL	Ireland	SAU	Saudi Arabia
BHS	Bahamas	ISR	Israel	SEN	Senegal
BLR	Belarus	ITA	Italy	SRB	Serbia
BEL	Belgium	JPN	Japan	SYC	Seychelles
BIH	Bosnia and Herzegovina	KAZ	Kazakhstan	SVK	Slovak Republic
BWA	Botswana	KGZ	Kyrgyz Republic	SVN	Slovenia
BRA	Brazil	LVA	Latvia	SLB	Solomon Islands
BGR	Bulgaria	LBR	Liberia	ZAF	South Africa
KHM	Cambodia	LTU	Lithuania	KOR	South Korea
CAN	Canada	LUX	Luxembourg	ESP	Spain
CHL	Chile	MAC	Macao	SUR	Suriname
COL	Colombia	MKD	Macedonia	SWZ	Eswatini
CRI	Costa Rica	MDG	Madagascar	SWE	Sweden
CIV	Cote d'Ivoire	MWI	Malawi	CHE	Switzerland
HRV	Croatia	MYS	Malaysia	TWN	Taiwan
CYP	Cyprus	MDV	Maldives	TZA	Tanzania
CZE	Czech Republic	MLT	Malta	THA	Thailand
DNK	Denmark	MUS	Mauritius	TLS	Timor
ECU	Ecuador	MDA	Moldova	TUN	Tunisia
EGY	Egypt	MNG	Mongolia	TUR	Turkey
EST	Estonia	MNE	Montenegro	UKR	Ukraine
FJI	Fiji	MAR	Morocco	GBR	United Kingdom
FIN	Finland	NLD	Netherlands	USA	United States
FRA	France	NZL	New Zealand	URY	Uruguay
GEO	Georgia	NOR	Norway	UZB	Uzbekistan