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 and forward GVC linkages. Using dynamic panel regressions and the local projection method 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 also 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 between backward and forward productions suggest that policies aimed at managing currency risk in trade should be tailored to the specific GVC structure and invoicing practices of each economy, thus 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; Asian Development Bank, 2021). 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 price 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 curtail 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, here 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 captures where firms often 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 substitution of more 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 the imported intermediate goods used in export production. While more predefined by the previous entity's forward capability, backward value also accounts for the possible domestic value-added embedded in the imported inputs before (products travel across the same border more than twice). That's said, the country relies on foreign inputs for production that are either consumed domestically or exported. Backward GVC participation improves productivities 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, when comes to the case of GVC participation, early research finds exchange rate has less significant impact on GVC trade. These studies typically relied on bilateral exchange rates and home 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 investigated 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 updating World Input-Output Table for GVC studies, Patel et al. (2019) develop 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) Bems and Johnson (2017) also construct a novel value-added real effective exchange rate dataset and find that value-added REERs indicate larger competitive imbalances than conventional REERs.

Adding on the use of more precise proxies, studies also suggest a potential reverse causal link between participation in GVCs and the ERPT to import and export prices. That is, a larger share of imports (the rise of GVC) has been argued to reduce the ERPT into import prices. de Soyres et al. (2021) examine how the growing value chains affect export elasticities and find that increased GVC participation 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 exchange rate fluctuation's influence on trade prices through the ERPT. According to Georgiadis et al. (2019), ERPT is defined as "the degree to which exchange rate changes feed through to import prices," shaping how currency fluctuations affect the prices of both imports and exports. In the context of rising GVCs, imported inputs partially limits 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 accounting for 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 international economics, as export is assume to be invoiced in either partner's currency instead of a third party's. Empirical evidence in Boz et al. (2022) show that a significant portion of global trade is invoiced in US dollars, even for transactions not involving the United States. This dollar dominance in trade invoicing has brought up the questions of how exchange rate fluctuations affect GVC trade and prices with a prevalent dominant currency invoicing practice in the non-dominant economies.

The practice of dominant currency invoicing has the potential to facilitate GVC participation in several ways. Primarily, dominant currency invoicing provides a hedge against the volatility of bilateral exchange rates, thereby stabilizing operational costs when goods cross multiple boarders and therefore has to undergone through 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 potential unstable monetary environments (which is likely in developing economies), ensuring a more predictable and secure financial landscape (Amador et al., 2024).

At the same time, it is common for major importers to also actively engage in export activity. As a result of the role of both an importer and exporter at the same time, firms 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 greater ERPT to export prices. Therefore, firms would favor dominant currency invoicing to avoid bilateral exchange rate movements, and ultimately 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

[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)

significantly from that of final goods trade. Specifically, they find that in response to a US 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 of 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. Even in recent GVC studies, many focus 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.

Therefore, the empirical section of this paper firstly 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. In addition, the empirical analysis is conducted at disaggregated level to investigate whether the sensitivity to exchange rate fluctuation varied across different types of GVC productions.

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 the productions in different segments of the GVCs.

In practice, exporters have the flexibility to choose the currency in which they invoice their products. They can opt for their own domestic currency, the currency of the trading partner, or a dominant currency such as the US dollar. In the producer currency pricing paradigm, which trade is conventionally assumed to invoice in the exporter's (the producer) 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 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.

Moving to the case of the emergence of GVCs, to evaluate the net gains of GVC participation under producer currency pricing, there are two scenarios to consider: being both an importer and exporter simultaneously and being solely an exporter. For firms that both import intermediate inputs and export to the next stage of the value chain, the net gain from home currency depreciation is lower than in a traditional trade model because the imported inputs embedded in export production have become more expensive and ultimately rise the cost of export production. Export competitiveness is also reduced by the exposure to multiple exchange rates, adding another layer of complexity. Sole exporters, 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 for exports.

A similar logic applies to GVC trade in the context of dominant currency invoicing: bilateral exchange rate fluctuations make little impact on trade among non-dominant economies and instead, trade is more exposed to the risk dominant currency movements. While GVC trade is more subject to dominant currency movements as traditional trade, the impact of dominant currency invoicing can be different for forward and backward GVC participation. For firms who are importer and exporter at the same time, a stronger dollar rises the cost of the imported inputs and the prices of their exports. Therefore, the backward participation goes up as the value of imported inputs increased and the forward participation are likely to remain the same as domestic inputs (capital and labor) are invoiced in domestic 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.

The 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 invoice trade in a dominant currency and one large 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.

The Cook and Patel (2023), just as many of the literature on dominant 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 for imported inputs can be time-consuming. Firms 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 participations are 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 the shock results in the import price increasing and a decrease in gross imports in all pricing paradigms except local currency paradigm. Export competitiveness is limited in the model with dominant currency invoicing, suggesting that this practice limits the exchange rate pass-through of depreciation into import 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 domestic 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 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 export 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 export also exhibits a large decline in the GVC model with dominant currency invoicing, and such decline is driven by decline in export to all locations. However, due to the switching from imported inputs to domestic inputs, value added exports fall by less than gross exports, value-added exports decline less than gross exports in the context of dominant currency invoicing within GVC trade.

The offsetting export competitiveness and expenditure switching patterns highlight the need for further studies on the forward and backward GVC participation in addition to the general GVC participation under a dominant currency paradigm. While Cook and Patel (2023) study the impact of exchange rate shocks on value-added and gross exports, this essay will investigate how exchange rate fluctuations affect forward and backward participation in GVCs differently in addition to the general GVC participation.

Higher backward GVC participation indicates a greater reliance on foreign content in exports. When the dominant currency appreciates, imported inputs become more expensive, which can initially disrupt sectors heavily dependent on these inputs, leading to higher backward participation in the short run. However, over time, if firms adjust by substituting domestic inputs for the more costly imports, backward participation decreases as the share of foreign inputs declines. Simultaneously, this adjustment may lead to increased forward participation, as sectors integrate 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. Commodity exporters typically exhibit high forward linkage values. 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-related productions are more responsive to movements of the dominant currency compared to movements in domestic or non-dominant trading partner currencies.

Hypothesis II: In the short run, backward GVC participation is more sensitive to shocks in the dominant currency than forward GVC participation due to price stickiness and the difficulty of quickly switching suppliers.

Given that prices are sticky in the short run (Benguria and Saffie, 2024; Cook and Patel, 2023; Georgiadis et al., 2019; Nakamura and Steinsson, 2013) firms relying on imported inputs face limited flexibility to switch to cheaper domestic substitutes instantly when the dominant currency appreciates. This raises the cost of imported intermediates, initially increasing backward participation as firms must continue relying on their existing supply chains. In contrast, forward participation—focused on exports—experiences a smaller impact because trading partners, even if faced with higher prices, struggle to find adequate substitutes in the short run, limiting the decline in demand.

Over time, backward participation decreases as firms gradually switch to domestic substitutes or alternative foreign suppliers. Meanwhile, forward participation stabilizes or improves as firms maintain export relationships despite the higher costs, supported by the lack of immediate substitutes for their products in international markets. This dynamic is reflected as the magnitude of the short-run effect is more pronounced for backward participation than forward participation.

Hypothesis III: There is reverse causality between dominant currency invoicing and GVC participation. As GVC networks expand, incumbent firms can pressure newcomers to adopt dominant currency invoicing, as these incumbents often set operational standards within the network. Simultaneously, the growing prominence of GVCs reinforces the use of dominant currency invoicing. For newcomers—particularly upstream suppliers and downstream customers—aligning with established invoicing practices becomes essential for seamless integration into the GVC system.

The hypotheses presented are grounded in the previously discussed concepts and research findings. 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). This study utilizes

GVC production information from the WITS database, which compiles comprehensive GVC data from multiple sources at the country-sectoral level, ensuring the most extensive coverage possible.

An important distinction in this analysis lies between GVC-related trade and GVC-related output. GVC-related trade measures the value-added of exported. In contrast, 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 a comprehensive assessment of each participants' involvement in GVCs, captures indirect contributions, and offers insights into how domestic production integrates into global networks.

The WITS database provides GVC output information for four categories, as defined by Borin and Mancini (2019):

1. Backward GVC-related output: This measures output crossing more than one border, traced in the sector completing final goods or services. 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 imports specialized 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 all GVC-related output types, 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 indirect contributions to GVCs and domestic activities that support GVC participation, even if they 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

Trade invoicing data is 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, in some cases, home currencies) for 115 countries. The data, primarily compiled from records of customs revenue authorities and regional and national banks, spans from 1990 onward and underscores the dominant role of the US dollar in global trade and the general inertia in invoicing currency patterns at the global level. However, the dataset also reveals that invoicing preferences can change rapidly at the country level under specific circumstances.

It is important to note that the dataset has some limitations. In particular, it excludes data from China and Mexico China and Mexico —two major global exporters—and exhibits a backloaded temporal distribution, with fewer observations available in the earlier years and a higher concentration of data points available toward the end of the dataset's timeline. This uneven distribution reduces the number of observations for analysis and may limit the ability to capture long-term trends or early shifts in invoicing behavior.

The empirical analysis incorporates two key exchange rate measures, both reflecting fluctuations in domestic currency value in different contexts. Bilateral exchange rates against the U.S. dollar, expressed as local currency per USD, are sourced from the Bank for International Settlements. This measure captures the movement of the domestic currency relative to the U.S. dollar, focusing on bilateral relationships but not isolating changes in the value of the dollar itself. Real effective exchange rates (REERs), sourced from Darvas (2021), offer a broader perspective by adjusting for inflation and comparing the domestic currency to a weighted basket of foreign currencies. These CPI-based REERs are available in two series: one against 172 trading partners (from 1995) and another against 67 countries (from 1960), both at annual frequency. For the primary analysis, the REER against 67 trading partners is used, as it better reflects trade relationships with more advanced economies, aligning with the income distribution of the dataset.

Other economic development data to construct the control variables, including capital-to-GDP ratio, domestic industrial capacity (measured as manufacturing value-added divided by GDP), trade to GDP ratio, and the capital openness index are sourced from the World Bank Database and Chinn and Ito (2008).

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 consist information of 96 countries from 1990 to 2020, offering a relatively diverse sample in terms of geography and income levels. The United States is excluded from the following empirical analysis due to its unique position as the issuer of the dominant currency under study. Despite this exclusion, the dataset maintains broad geographic coverage. The sample composition is weighted towards more economically advanced nations, with over half of the countries classified as upper-middle income or above, based on World Bank classifications. This composition enables an analysis of GVC participation and currency invoicing practices in more developed economies.

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

This sample structure aligns with the study's focus on examining the interplay between GVC participation and dollar invoicing in relatively advanced economies. It allows for an exploration of how currency choice in international trade affects and is affected by GVC integration in countries with more developed financial systems and trade networks. The temporal span of three decades provides sufficient variation to capture long-term trends and structural changes in global trade patterns.

It is also important to note that the dataset's backloaded structure, with more observations concentrated in the later years, reduces the total number of usable observations from 2,927 (used for prelimenary exchange rate analysis) to 927 (used to dominant currency invoicing analysis). This temporal distribution may introduce some limitations in analyzing early trends and should be taken into account when interpreting the results. While the dataset's composition may introduce some bias toward higher-income economies, it reflects the realities of global trade, where advanced economies play a central role in GVCs. As invoicing data coverage improves, future research could extend this analysis to a broader set of developing economies, potentially uncovering different dynamics in GVC participation and currency choice across various stages of economic development. A descriptive statistics table for the variables of interest is included in the appendix.

5 Empirical Strategy

To test the hypotheses, the econometric models in this section examine 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:

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

The specification is estimated separately for each of the four types of GVC participation $\ln(\mathrm{GVC}_{it})$: overall, mixed, backward, and forward GVC production of country i in year t. $\ln(\mathrm{ER}_{\$t})$ is the natural log of bilateral exchange rate against the US dollar. An increase in $\ln(\mathrm{ER}_{\$t})$ signifies a dollar appreciation or a depreciation in the domestic currency against the US dollar. $\ln(\mathrm{RER}_{it})$ denotes the log real effective exchange rate, an increase of $\ln(\mathrm{RER}_{it})$ signifies a home purchasing power increase. f_i and f_t are the country and year fixed effect.

The benchmark specification for estimating the direct effects of dominant currency trade invoicing and the impact of real exchange rate fluctuations on GVC participation is:

$$\begin{aligned}\ln(\mathrm{GVC}_{it}) = {} & \delta_1 \ln(\mathrm{ER}_{\$t}) + \delta_2 \ln(\mathrm{DCP}^{\mathrm{EX}}_{it}) + \delta_3 \ln(\mathrm{DCP}^{\mathrm{IM}}_{it}) \\ & + \delta_3 \left(\ln(\mathrm{DCP}^{\mathrm{EX}}_{it}) \times \ln(\mathrm{ER}_{\$t})\right) + \delta_4 \left(\ln(\mathrm{DCP}^{\mathrm{IM}}_{it}) \times \ln(\mathrm{ER}_{\$t})\right) \\ & + \delta_5 \ln(\mathrm{RER}_{it}) + \delta_6 Z_{it} + f_i + f_t + \epsilon_{it}\end{aligned} \tag{2}$$

In this specification, $\ln(\mathrm{DCP}^{\mathrm{EX}}_{it})$ and $\ln(\mathrm{DCP}^{\mathrm{IM}}_{it})$ 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.

Different from much other research on trade invoicing that use intensity (percentage) as measurement, the proxy $\ln(\text{DCP}_{it})$ is constructed by multiplying the share of trade invoiced in U.S. 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 (Chinn and Ito, 2008; 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, the following model compares the sensitivity of GVC production to dollar exchange rate movements and home currency movements within the context of dominant currency invoicing. By incorporating the interaction between the real exchange rate and the trade invoiced in U.S. dollars, the model captures the marginal effect of dominant currency invoicing during both dollar and RER fluctuations:

$$\begin{aligned}\ln(\mathrm{GVC}_{it}) = &\ \delta_1 \ln(\mathrm{ER}_{\$t}) + \delta_2 \ln(\mathrm{DCP}_{it}) + \delta_3 \left(\ln(\mathrm{DCP}_{it}) \times \ln(\mathrm{ER}_{\$t})\right) \\ &+ \delta_4 \ln(\mathrm{RER}_{it}) + \delta_5 \left(\ln(\mathrm{DCP}_{it}) \times \ln(\mathrm{RER}_{it})\right) \\ &+ \delta_6 Z_{it} + f_i + f_t + \epsilon_{it} \end{aligned} \tag{3}$$

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

δ_1 anticipated to be negative across all four regression models to be consistent with the theoretical framework of dominant currency pricing. This expectation is based on the premise that dominant currency invoicing enhances trade sensitivity to fluctuations in the dominant currency. Specifically, 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 is expected to be positive or close to zero 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 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, I also conduct lag effect analysis by replacing the key explanatory variables in this specification 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 replace 1-, 2-, and 3-year lags of all the variables of interest except the control variables in Equation 3 to test the sensitivity of the GVC productions and see whether and how lagged invoicing practice and exchange rate fluctuation from k years ago affect the GVC productions at time t.

In addition, a side exercise to uncover the sensitivity of the GVC productions across income levels is also conducted using the following specification:

$$\begin{aligned}\ln(\text{GVC}_{it}) = {} & \delta_1 \ln(\text{RER}_{it-1}) + \delta_2 \ln(\text{DCP }(\%)_{it-1}) + \delta_3 \left(\ln(\text{RER}_{it-1}) \times \ln(\text{DCP }(\%)_{it-1})\right) \\ & + \delta_4 \left(\ln(\text{RER}_{\$t-1}) \times \ln(\text{DCP }(\%)_{it-1})\right) + \delta_5 Z_{it} + f_i + f_t + \epsilon_{it} \end{aligned} \tag{4}$$

$\ln(\text{DCP}(\%)_{it-1})$ 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 the vector of $\ln(\text{DCP}(\%)^{\text{EX}}_{it-1})$ and $\ln(\text{DCP}(\%)^{\text{IM}}_{it-1})$ for overall and mixed GVC models, while only $\ln(\text{DCP}(\%)^{\text{EX}}_{it})$ or $\ln(\text{DCP}(\%)^{\text{IM}}_{it})$. $\ln(\text{RER}_{\$t-1})$ is the natural log of US real effective exchange rate.

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

Using a one-year lag for all variables of interest, except the control variables, enables a closer examination of the relationships between exchange rate movements, dollar invoicing practices, and GVC participation across three income groups: high, upper-middle, and low and lower-middle income countries. This approach captures potential delayed effects of currency movements, partially addresses endogeneity concerns, and facilitates an analysis of how domestic and dominant currency movements jointly influence GVC dynamics while accounting for income-level heterogeneity.

5.1 Local Projection Method

The local projection method (Jorda, 2005; Jorda and Taylor, 2024) is another way to address the simultaneous movement or potential prolonged impacts of invoicing decisions and dominant currency invoicing on GVC productions. The prolonged effect can be attributed to several factors. First, as noted by Gopinath et al. (2010), the average ERPT remains significantly different between dollar-invoiced and non-dollar-invoiced trades even after 24 months, indicating persistent effects. Secondly, trade flows and business operations don't adjust instantaneously to exchange rate changes; it takes time for firms to modify their sourcing strategies, renegotiate contracts, or alter production locations within GVCs. Thirdly, many international trade contracts are set for extended periods, causing a delay in the reflection of exchange rate changes in trade patterns. In addition, the complex nature of GVCs, with multiple stages of production spread across different countries, can lead to a ripple effect of exchange rate shocks throughout the supply chain, extending the impact over time. Given these factors, a local projection method for estimating the effects of invoicing decisions and exchange rate movements on GVC participation becomes necessary. Local projection estimation allows for a more detailed understanding of how these variables interact over different time horizons, capturing both immediate and delayed impacts on the three economic activities.

I start with using local projection method to estimate the general interplay of GVC production and dominant currency invoicing. This approach would also allow to see if there is reverse causality between dominant currency invoicing and GVC participations as mentioned in the literature review section and hypothesis III. The specification to test this potential reversed causality is set as Equation (5):

$$
\begin{aligned}
\ln(\mathrm{GVC}_{it+h}) &= \zeta_{1,h}\ln(\mathrm{DCP}^{\mathrm{EX}}_{it}) + \zeta_{2,h}\ln(\mathrm{DCP}^{\mathrm{IM}}_{it}) + \zeta_{3,h}W_{it} + \nu_{it+h} \\
\ln(\mathrm{DCP}^{\mathrm{EX}}_{it+h}) &= \eta_{1,h}\ln(\mathrm{GVC}^{F}_{it}) + \eta_{2,h}W_{it} + \omega_{it+h} \\
\ln(\mathrm{DCP}^{\mathrm{IM}}_{it+h}) &= \theta_{1,h}\ln(\mathrm{GVC}^{B}_{it}) + \theta_{2,h}W_{it} + \omega_{it+h}
\end{aligned} \tag{5}
$$

where h = 1, . . . , H indicates the number of projected periods ahead. The system is similar to the regression setting in previous subsection, as $\ln(\mathrm{GVC}_{it+h})$ refers to the projected GVC production in h periods ahead. The control variable vector W_{it} includes lag values (up to 3 periods) of $\ln(\mathrm{DCP}_{it})$ and $\ln(\mathrm{GVC}_{it})$ together with other control variables in Z_{it} before.

As the local projection method is less susceptible to misspecification biases that can plague VAR models, especially in the presence of nonlinearities or structural breaks. By partially mitigating the endogeneity concerns, the local projection method enables a more reliable analysis of how invoicing practices interact with exchange rates over time, providing insights into the persistence and implications of these relationships for GVC production and exchange rate policy. In order to estimate the degree to which invoicing decisions can alter the persistence of exchange rate shocks on GVC trade, local projection methods estimate a system of equations on how dependent variables respond in the future to a present-day shock to itself or another endogenous variable in the model.

To utilize local projection method to further project the impact of dominant currency invoicing, the first set of the equations I estimate based on the local projection method is:

$$
\ln(\mathrm{GVC}_{it+h}) = \delta_{1,h}\ln(\mathrm{DCP}^{\mathrm{EX}}_{it}) + \delta_{2,h}\ln(\mathrm{DCP}^{\mathrm{IM}}_{it}) + \delta_{3,h}X_{it} + \epsilon_{it+h} \tag{6}
$$

The control variable vector X_{it} includes lag values (up to k periods) of $\ln(\mathrm{DCP}_{it-k})$ and $\ln(\mathrm{GVC}_{it-k})$. This approach offers distinct advantages in addressing the potential endogeneity of exchange rates, a common challenge in international trade studies. By allowing for direct estimation of impulse responses at each horizon ahead and through the inclusion of lagged values of the GVC productions and the trade invoicing values in the regression framework, local projections provide a more flexible and robust alternative to traditional VAR models. This flexibility is particularly valuable when examining the dynamic effects of invoicing currencies and exchange rate fluctuations, as it can capture the time-varying relationships without imposing restrictive assumptions on the underlying economic structure.

The specification is then expanded to include the dollar exchange rate and its interaction with the invoicing trade values to assess the marginal effects of dominant currency invoicing:

$$\begin{aligned}\ln(\mathrm{GVC}_{it+h}) = {} & \delta_{1,h}\ln(\mathrm{DCP}^{\mathrm{EX}}_{it}) + \delta_{2,h}\ln(\mathrm{DCP}^{\mathrm{IM}}_{it}) + \delta_{3,h}\ln(\mathrm{ER}_{st}) \\ & + \delta_{4,h}\left(\ln(\mathrm{ER}_{st}) \times \ln(\mathrm{DCP}^{\mathrm{EX}}_{it})\right) \\ & + \delta_{5,h}\left(\ln(\mathrm{ER}_{st}) \times \ln(\mathrm{DCP}^{\mathrm{IM}}_{it})\right) \\ & + \delta_{6,h}X_{it} + \epsilon_{it+h}\end{aligned} \tag{7}$$

Finally, Equation (3) is analyzed using the local projection method, as outlined in Equation (8), to evaluate the impact of real exchange rate movements on GVC production and the marginal effects of dominant currency invoicing, accounting for changes in domestic purchasing power. The local projection method offers flexibility in capturing dynamic responses over time, allowing for a clearer understanding of the short- and long-term effects and provides insights into the timing and persistence of these effects:

$$\begin{aligned}\ln(\mathrm{GVC}_{it+h}) = {} & \delta_{1,h}\ln(\mathrm{DCP}^{\mathrm{EX}}_{it}) + \delta_{2,h}\ln(\mathrm{DCP}^{\mathrm{IM}}_{it}) + \delta_{3,h}\ln(\mathrm{ER}_{st}) \\ & + \delta_{4,h}\left(\ln(\mathrm{ER}_{st}) \times \ln(\mathrm{DCP}^{\mathrm{EX}}_{it})\right) + \delta_{5,h}\left(\ln(\mathrm{ER}_{st}) \times \ln(\mathrm{DCP}^{\mathrm{IM}}_{it})\right) \\ & + \delta_{6,h}\ln(\mathrm{RER}_{it}) + \delta_{7,h}\left(\ln(\mathrm{RER}_{it}) \times \ln(\mathrm{DCP}^{\mathrm{EX}}_{it})\right) \\ & + \delta_{8,h}\left(\ln(\mathrm{RER}_{it}) \times \ln(\mathrm{DCP}^{\mathrm{IM}}_{it})\right) + \delta_{9,h}X_{it} + \epsilon_{it+h}\end{aligned} \tag{8}$$

All four types of GVC production are estimated following the same approach used in the fixed effect regression from the previous subsection. This ensures consistency in methodology while allowing for a dynamic analysis of the impact of exchange rate movements and dominant currency invoicing across different GVC production types.

6 Empirical Results

Table 3: Real Exchange Rate and Dollar Exchange Rate Movements

	(1) General GVC	(2) Mixed GVC	(3) Backward GVC	(4) Forward GVC
Real Effective Exchange Rate	0.116	0.0629	0.271***	0.301***
	(0.132)	(0.147)	(0.0657)	(0.0766)
Dollar Exchange Rate	0.0400	0.0369	0.0665	0.0611***
	(0.0265)	(0.0286)	(0.0347)	(0.0168)
_cons	8.975***	8.651***	6.644***	6.455***
	(0.651)	(0.726)	(0.299)	(0.350)
N	2585	2583	2585	2572
adj. R^2	0.983	0.980	0.979	0.984

Standard errors in parentheses

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

Table 3 reports the results of Equation (1). Coefficients of real effective exchange rate (REER) movements and dollar exchange rate movements in column 1 support the findings from previous literature: neither the real exchange rate nor the dollar exchange rate movements exhibit a statistically significant relationship with general GVC production. However, when coming to the disaggregated level of backward and forward GVC production, there are different dynamics. A 1% appreciation in the domestic REER is associated with a 0.271% increase in backward GVC production (Column 3) and a 0.3% increase in forward GVC production (Column 4). This suggests that a stronger domestic currency is positively correlated with higher levels of backward and forward GVC productions.

Meanwhile, movements in the dollar exchange rate only show statistical significance in the forward GVC production model (Column 4). Specifically, a 1% US dollar appreciation (against home currency) is associated with a 0.0611% increase in forward GVC production. This suggests that the forward GVC activities, such as those exporting intermediate goods, 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)	-0.570**	-0.505*	-0.680***	-0.367
	(0.197)	(0.211)	(0.0965)	(0.307)
ln(Real Effective Exchange Rate)	0.752***	0.716***	0.844***	0.719**
	(0.150)	(0.172)	(0.0931)	(0.216)
ln(Dollar-Invoiced Export)	0.0533	0.0912		0.107
	(0.0679)	(0.0794)		(0.0995)
ln(Dollar-Invoiced Import)	0.0636	0.0629	0.0351	
	(0.0453)	(0.0519)	(0.0238)	
ln(Dollar-Invoiced Export)	0.0284	0.0264		0.0160
*ln(Dollar Exchange Rate)	(0.0194)	(0.0222)		(0.0109)
ln(Dollar-Invoiced Import)	-0.00303	-0.00325	0.0292***	
*ln(Dollar Exchange Rate)	(0.0218)	(0.0239)	(0.00408)	
ln(Capital to GDP Ratio)	0.222*	0.188	0.331***	0.127
	(0.0847)	(0.103)	(0.0741)	(0.0933)
ln(Trade to GDP Ratio)	0.518***	0.598***	0.448***	0.352**
	(0.0896)	(0.105)	(0.0828)	(0.112)
ln(Capital Openness)	0.00365	0.00119	-0.00914	0.00786
	(0.0369)	(0.0447)	(0.0289)	(0.0374)
_cons	1.623	-0.0777	1.977*	1.355
	(1.783)	(2.054)	(0.967)	(2.787)
N	895	895	924	911
adj. R^2	0.991	0.989	0.991	0.985

Standard errors in parentheses

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

Table 4 shows the estimation results based on Equation 2 and investigates the effects of dollar movements and invoicing practices on GVC participation across four types. A stronger dollar is negatively associated with all GVC productions, with strong statistically significancy on the general, mixed, and backward production model (column 3). A 1% appreciation in dollar against home currency leads to a 0.0.57%, 0.505%, and 0.68% decline in general, mixed, and backward GVC productions. This finding aligns with the hypotheses that a stronger dollar raises the cost of imported inputs and thus especially weaken the backward GVC production in the short run. The effect on forward GVC production (Column 4) is also negative but not statistically significant, indicating that the dollar exchange rate may have a limited impact on exporting intermediates.

The impact of the REER is consistently positive and statistically significant across all models. The coefficients indicate that a 1% appreciation in the REER results in increases of 0.752% in general GVC, 0.716% in mixed GVC, 0.844% in backward GVC, and 0.719% in forward GVC productions. This suggests that home purchasing power appreciation benefits GVC participations, potentially by lowering the costs of imported intermediates.

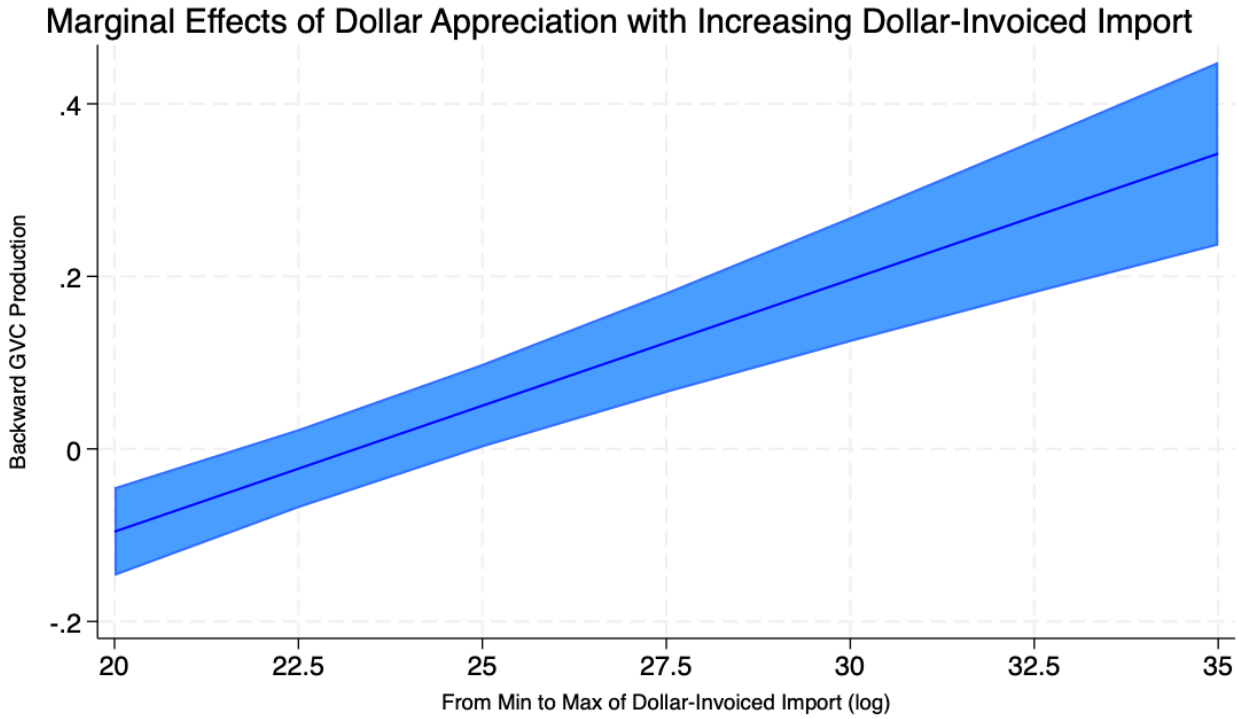
The results for dollar-invoiced trade show small and insignificant standalone effect across all models. The positive sign indicates that invoicing exports in dollars may help stabilize trade operations, but the limited significance suggests that this effect is not strong across all GVC productions.

The interaction terms provide further infomation on the marginal effect of exchange rate fluctuations. The interaction between the dollar exchange rate and dollar-invoiced imports is significant for backward GVC production, with a coefficient of 0.0292. This positive and significant effect suggests that invoicing imports in dollar can mitigate the negative impact of a stronger dollar on imported input, stabilizing the backward GVC production.

Among the control variables, a higher capital intensity supports all GVC productions. Trade openness is also significant in all models. But, the effect of financial openness is mixed, with a small and insignificant effects.

Figure 1 and 2 capture how dollar appreciation affect the backward and forward GVC production with increasing levels of dollar-invoiced trade. In Figure 1, the marginal effect of dollar appreciation becomes more positive as the value of dollar-invoiced imports increases. This

Figure 1: Marginal Effects with Increasing Dollar-Invoiced Import

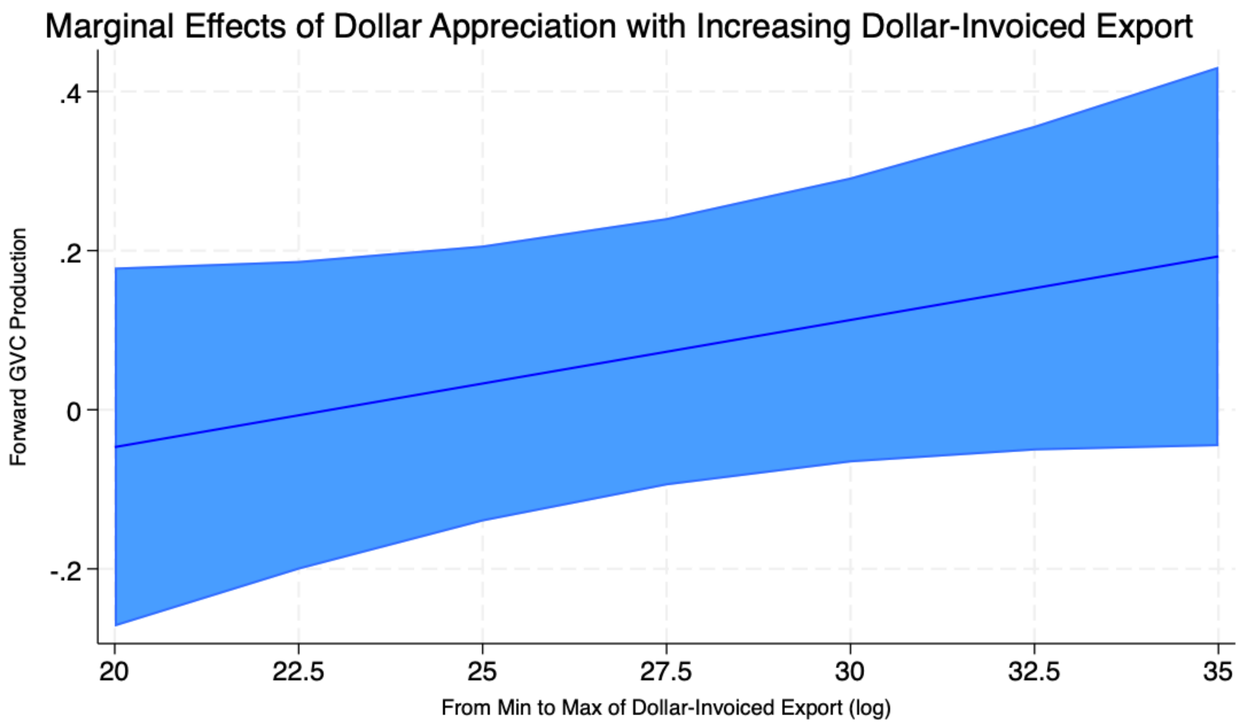


trend suggests that invoicing higher level of imports in dollar can better absorb the negative impacts of dollar appreciation, possibly due to reduced currency risk in the imported input costs. The increasing slope indicates a transition from negative or neutral effects to a positive impact, highlighting the stabilizing role of dollar invoicing in mitigating dollar volatility for backward GVC production.

In Figure 2, the marginal effect of dollar appreciation is generally positive but diminishes slightly at higher levels of dollar-invoiced exports. Although the effect remains positive, the slight downward slope suggests that heavy reliance on dollar invoicing in exports may not amplify the benefits of dollar appreciation for forward GVC production as much as expected. This could reflect potential frictions or costs associated with increased exposure to exchange rate movements.

These two marginal effect plots indicate that while dollar-invoiced imports help firms mitigate the adverse effects of currency fluctuations in backward GVCs, the benefits of dollar-

Figure 2: Marginal Effects with Increasing Dollar-Invoiced Export



invoiced exports in forward GVCs are less pronounced and may level off at higher invoicing volumes.

Overall, findings from Table 4 and Figure 1 and 2 indicate that dollar movements and invoicing practices have significant but varied impacts across GVC production types. A stronger dollar negatively affects GVCs, while home purchasing power (REER) appreciation consistently boosts GVC participation across all categories. Invoicing practices, particularly dollar-invoiced imports, help mitigate some of the adverse effects of dollar fluctuations, particularly for backward GVC production. These findings show the importance of how trade-invoicing practices can affect the intergation into global trade network based on domestic GVC structures.

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)	-0.567**	-0.496*	-0.685***	-0.367
	(0.196)	(0.211)	(0.0955)	(0.310)
ln(Real Effective Exchange Rate)	0.630	0.390	1.131*	0.721
	(0.655)	(0.718)	(0.527)	(0.815)
ln(Dollar-Invoiced Export)	0.135	0.230		0.107
	(0.566)	(0.667)		(0.151)
ln(Dollar-Invoiced Import)	-0.0432	-0.141	0.0881	
	(0.621)	(0.721)	(0.101)	
ln(Dollar-Invoiced Export)	0.0291	0.0287		0.0160
*ln(Dollar Exchange Rate)	(0.0184)	(0.0203)		(0.0110)
ln(Dollar-Invoiced Import)	-0.00393	-0.00591	0.0294***	
*ln(Dollar Exchange Rate)	(0.0207)	(0.0219)	(0.00405)	
ln(Dollar-Invoiced Export)	-0.0182	-0.0314		-0.0000572
*ln(Real Effective Exchange Rate)	(0.120)	(0.141)		(0.0277)
ln(Dollar-Invoiced Import)	0.0227	0.0435	-0.0107	
*ln(Real Effective Exchange Rate)	(0.130)	(0.150)	(0.0200)	
ln(Capital to GDP Ratio)	0.226*	0.197	0.330***	0.127
	(0.0890)	(0.109)	(0.0738)	(0.0943)
ln(Trade to GDP Ratio)	0.522***	0.608***	0.439***	0.352**
	(0.0981)	(0.116)	(0.0907)	(0.122)
ln(Capital Openness)	0.00413	0.00248	-0.0101	0.00785
	(0.0380)	(0.0458)	(0.0295)	(0.0383)
_cons	2.272	1.624	0.593	1.347
	(3.435)	(3.771)	(2.499)	(4.168)
N	895	895	924	911
adj. R^2	0.991	0.989	0.991	0.985

Standard errors in parentheses

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

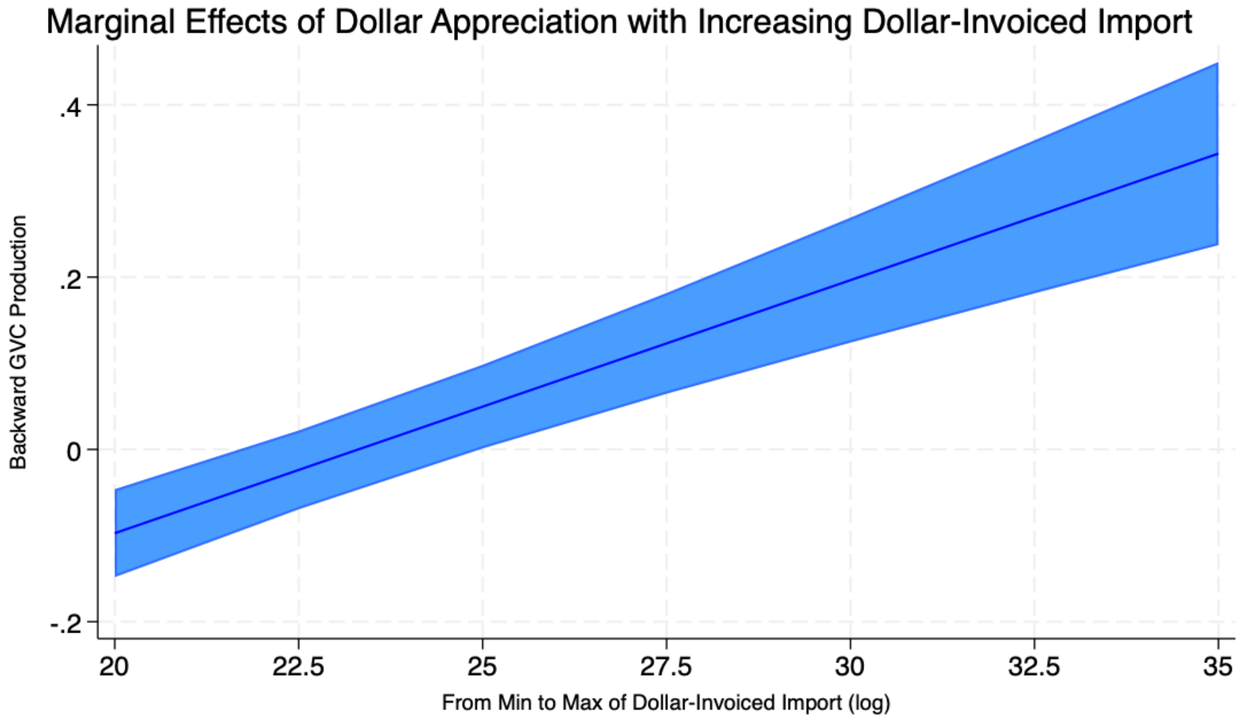
Table 5 summarizes the estimation results of Equation 3 which incorporate additional interaction term of dollar-invoicing trade and the REER to capture the marginal effect of home purchasing power. The coefficients for the dollar exchange rate are again negative in all types of GVC production, with statistically significant impact on general, mixed, and backward GVC production, suggests that a 1% dollar appreciation reduces genenal GVC by 0.567%, mixed GVC in 0.49%, and backward GVC production by 0.685%, once again shows sensitivity of GVCs to currency movements in the short run. The effect on forward GVC production (Column 4) is negative but not statistically significant, indicating that the influence of exchange rate movements on value-added export activities is more muted in the short run, which aligns with the Hypothesis II.

The REER shows consistently positive effects, particularly significant on backward GVC production. The coefficient of 1.131 for backward GVCs indicates that a 1% increase in the home purchasing power boosts backward production by 1.131%, suggesting that a stronger domestic currency lowers input costs, thereby enhancing the backward productions. The positive impact of REER on other GVCs, although substantial, lacks statistical significance, implying that the benefits of REER appreciation may be concentrated more on upstream production.

Dollar-invoiced trade shows similar pattern to Table 4: vary but lack significancy on standalone effects across models. The interaction between the dollar exchange rate and dollar-invoiced imports is significant and positive for backward GVC production, with a coefficient of 0.0294. This suggests that heavy imported input users benefit from invoicing more imports in dollar amid a stronger dollar episode, stabilizing input costs and enhancing upstream participation. The interaction between the REER and invoicing practices does not yield statistically significant results, suggesting that combined effects may vary by GVC type.

For a marginal effect analysis, Figure 3 and 4 capture a similar impact of dollar appreciation on backward and forward GVC production given an increasing value of dollar-invoiced trade as above. In Figure 3, the marginal effect of dollar appreciation becomes increasingly positive as the volume of dollar-invoiced imports rises. The effect shifts from negative at lower levels of invoicing to significantly positive at higher levels, indicating that invoicing imports in dollar

Figure 3: Marginal Effects with Increasing Dollar-Invoiced Import

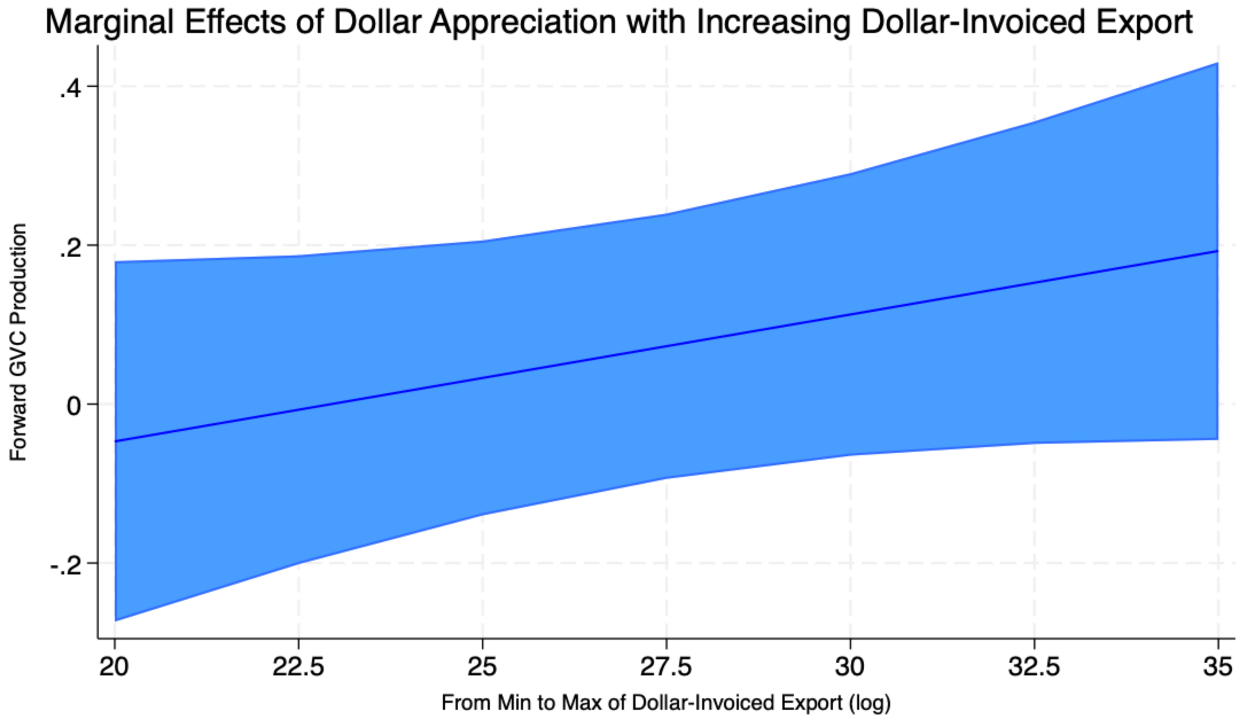


allows to cushion the adverse effects of dollar appreciation. Figure 4 shows the marginal effect of dollar appreciation on forward GVC production as dollar-invoiced exports increase. The effect starts slightly negative at low levels of invoicing but becomes positive and grows steadily with higher invoicing 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.

These 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 Figure 3 and 4 show that dollar appreciation

Figure 4: Marginal Effects with Increasing Dollar-Invoiced Export



negatively impacts GVCs. 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.

Additional regression results (attached in the Appendix) 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 3) and across income levels (Equation 4).

In the lagged analysis based on Equation 3, the one-year lag analysis aligns with the findings from the non-lagged model in Table 5, indicating dollar appreciation from a year ago has a strong, statistically significant negative impact on general and backward GVC production. And the REER positively affect backward GVC production, showing the role of a stronger home currency in facilitating the import of necessary intermediates. Dollar-invoiced exports exhibit a positive and significant effect on mixed GVC production, suggesting that firms that are both importing and exporting intermediaries benefiting from stability in invoicing in dominant currency. And the interaction term between dollar exchange rate and dollar-invoiced imports shows a significant positive impact on backward GVC production, implying that dollar invoicing practice can mitigate adverse effects from exchange rate volatility in the short run.

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

In the three-year lag analysis, the effects of the dollar exchange rate on GVC production become less pronounced. The negative impacts of dollar appreciation on backward GVC production drops, with coefficient became smaller. The positive influence of REER remain for general and backward GVC productions, but it is weaker and not statistically significant than 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-, medium-, and long-run impacts, the results suggest that the effects of dollar and REER movements on GVC production are 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 exports 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.

The income level analysis based on Equation 4 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): A 1% appreciation in the home real exchange rate for Group 3 is linked to a 9.5% increase in overall GVC participation. However, this positive effect is influenced by dollar invoicing practices: a higher share of dollar-invoiced imports reduces overall GVC participation when the home currency strengthens, but enhances participation when the US dollar appreciates. The strong positive relationship could be due to the lower income countries' improved purchasing power for imported inputs. However, the negative interaction with dollar-invoiced imports suggests that when imports are priced in dollars, currency appreciation benefits are partially offset by relatively more expensive inputs.

In contrast, Group 1 shows limited statistical significance for the effects of currency movements and dollar invoicing, suggesting a weaker relationship. Meanwhile, Group 2 reveals a negative association between home currency appreciation and overall GVC participation, indicating that upper-middle-income economies experience a decline in participation 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.

Mixed GVC Production (Table 11): A similar pattern emerges in the mixed GVC model, though with smaller coefficients. In Group 3, the interaction terms between dollar-invoiced import shares 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 compared to their counterparts in higher-income economies. The stronger effects in Group 3 compared to higher-income groups could be because firms in lower income countries are more likely to be involved in assembly and processing trade, where both imported inputs and exported outputs are crucial. Their thinner profit margins make them more sensitive to cost changes induced by currency movements and invoicing practices.

Backward GVC Production (Table 12): In the backward GVC model, Group 3 countries also display statistical significant responsiveness to both home currency and dollar movements, though the statistical power is weaker compared to the overall and mixed GVC models. Groups 1 and 2 do not show any statistically significant responses to either home currency fluctuations or dominant currency movements. One possible reason for this pattern could be because lower-income countries are more reliant on imported inputs for their exports. Higher-income countries may have more domestic alternatives or better hedging strategies, making them less sensitive to these factors.

Forward GVC Production (Table 13): Forward GVC participation exhibits slightly different dynamics in this income level analysis. In Group 1, it is negatively associated with a higher share of dollar-invoiced exports. In Group 3, forward participation is positively linked to stronger home currency purchasing power. However, the interaction terms reveal that in Group 3, home currency appreciation combined with a higher share of dollar-invoiced exports negatively impacts forward participation. Conversely, a stronger US dollar enhances the positive relationship between dollar-invoiced exports and forward GVC participation. The positive interaction between stronger dollar and dollar-invoiced exports in Group 3 could indicate that when the dollar strengthens, countries with more dollar-invoiced exports become more attractive suppliers in GVCs, possibly due to increased stability in dollar-denominated contracts.

These income-level findings, combined with the lagged analysis, highlight that currency movements and dollar invoicing practices have the strongest impact on low- and lower-middle-income countries' GVC participations, while high-income and upper-middle-income countries show more muted responses. This heightened sensitivity among lower-income countries can be attributed to two potential factors: 1. Greater dependence on imported inputs for their production processes; 2. Higher vulnerability to external economic shocks. These effects are particularly pronounced in the short to medium term, suggesting that lower-income countries face significant challenges in managing their GVC participation when faced with currency fluctuations or changes in dollar invoicing patterns.

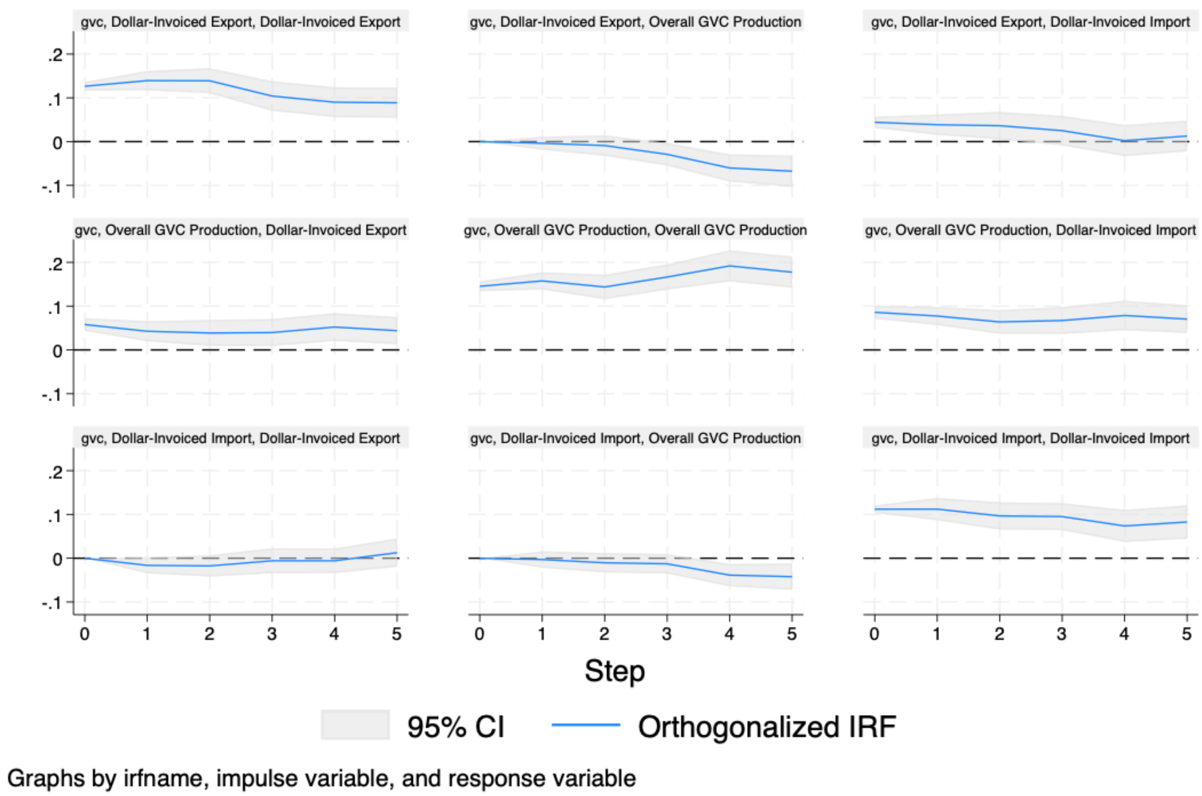
6.1 Local Projection Results

Building on the previous analysis of the lagged effects of dollar invoicing, dollar exchange rate volatility, and REER volatility, this section employs the local projection method to further investigate the interaction of these three economic activities. The local projection method not only allows to test the potential delayed effects discussed earlier from a more dynamic econometric aspect, but also useful for exploring the potential reverse causal relationship among these economic activities.

Figure 5, 6, and 7 summarize the Impulse Response Functions (IRFs) capturing the interactions between dollar-invoiced exports, dollar-invoiced imports, and overall GVC production as specified in Equation 5. The middle column displays the responses of overall GVC production over five periods following shocks to dollar-invoiced exports, overall GVC production, and dollar-invoiced imports at time t. These panels suggest that shocks to dollar-invoiced exports and imports have no immediate effect on overall GVC production, with the impact emerging only after the third year.

In the left column, the middle panel shows that a positive shock to overall GVC production leads to an increase in future dollar-invoiced exports, supporting the hypothesis of bidirectional

Figure 5: IRFs of Overall GVC Production

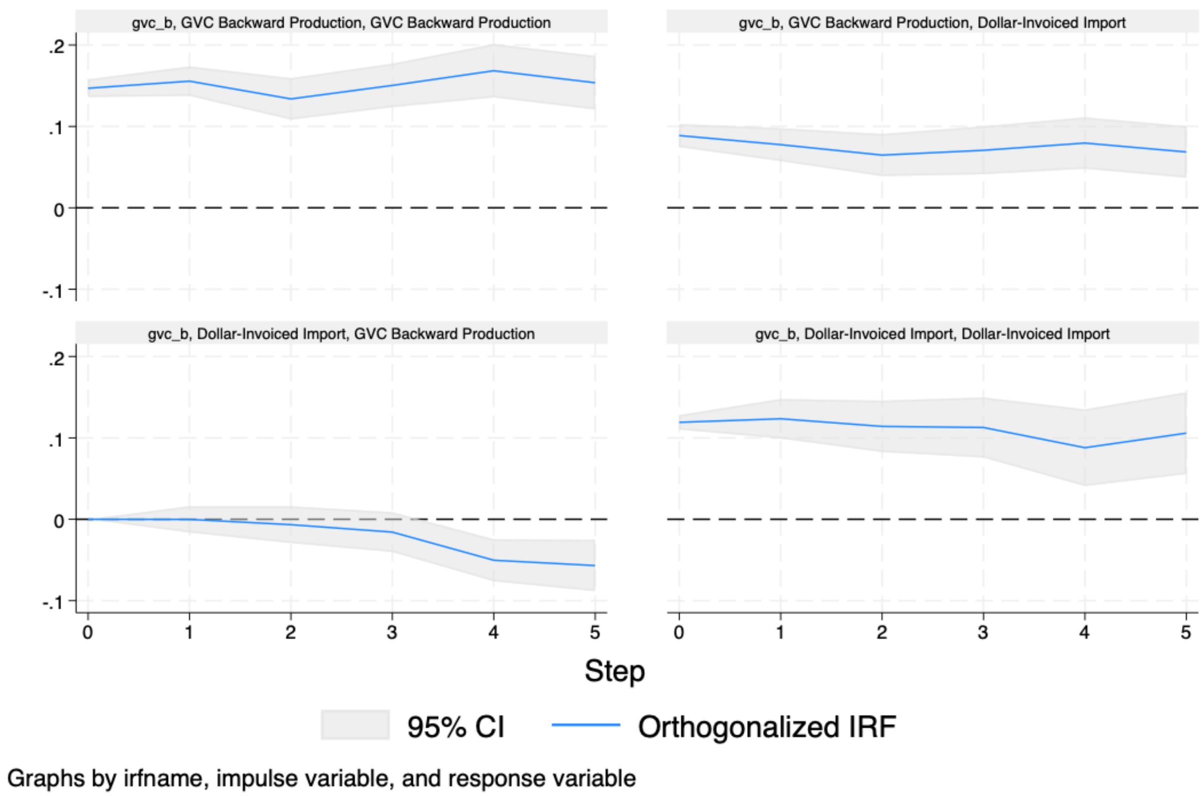


causality—GVC integration can reinforce dominant currency invoicing practices mentioned in the literature review. While the lower panel in the left reveals that a higher dollar-invoiced import does not significantly encourage greater dollar-invoiced exports, the top panel in the right column indicates that a shock to dollar-invoiced exports leads to an increase in dollar-invoiced imports over time, suggesting that dollar-invoiced exports are positively associated with future import practices.

Additionally, the middle panel in the right column supports the reverse causality hypothesis, showing that a positive shock to overall GVC production is associated with higher dollar-invoiced imports. This finding highlights the interdependence between GVC participation and dominant currency invoicing across multiple trade flows. The IRFs of the Mixed GVC production model is omitted here as they show a mimicking pattern as the overall GVC ones.

Figure 6 presents the projected interactions between dollar-invoiced imports and GVC back-

Figure 6: IRFs of Backward GVC Production



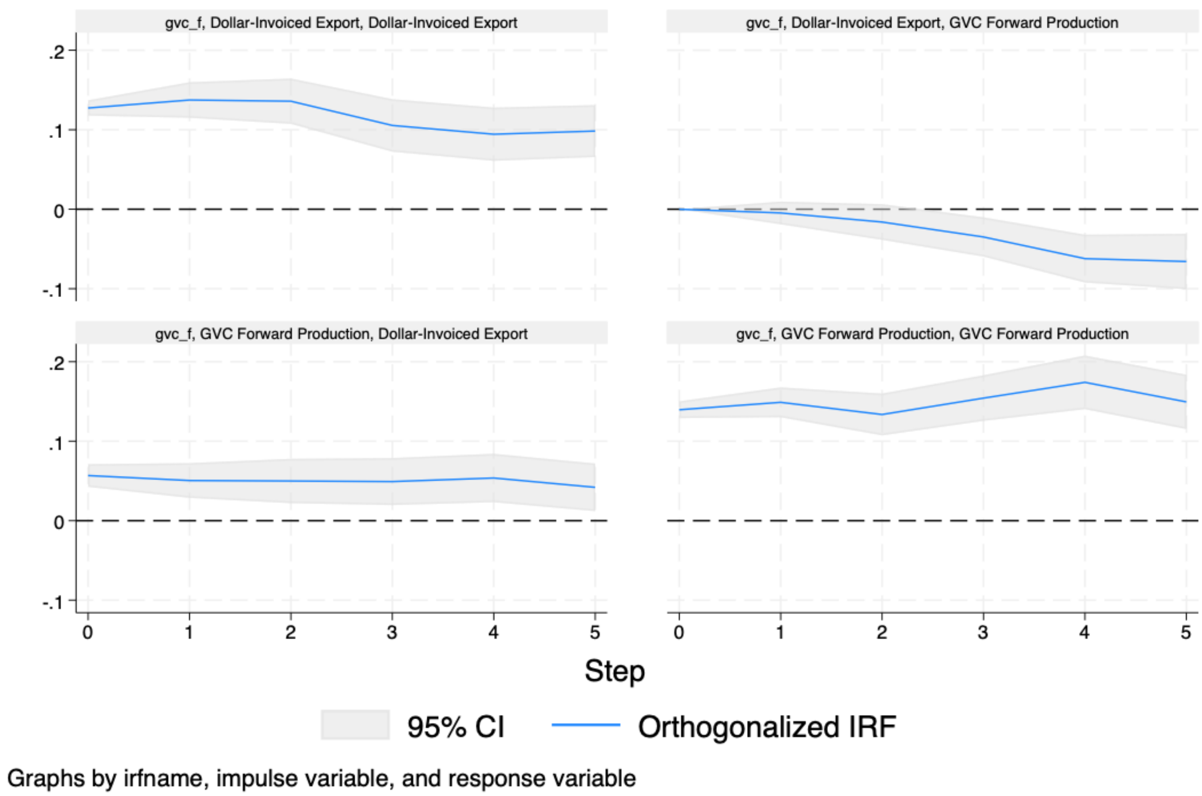
ward production. The top-right panel shows that a shock to GVC backward production has an immediate positive impact on dollar-invoiced imports. In contrast, the lower-left panel indicates that a shock to dollar-invoiced imports has little statistically significant effect on GVC backward production in the short to intermediate term.

Figure 7 summarizes the interactions between dollar-invoiced exports and GVC forward production. The lower-left panel suggests that a shock to GVC forward production leads to an immediate positive impact on dollar-invoiced exports. However, the upper-right panel shows that a shock to dollar-invoiced imports has minimal statistically significant effects on GVC backward production in the short term.

The estimation results based on Equations 6, 7, and 8 provide deeper insights into the interplay between dollar exchange rate movements, invoicing practices, and GVC participation.

When estimating Equations 6, 7, and 8 with local projection methods, the dependent vari-

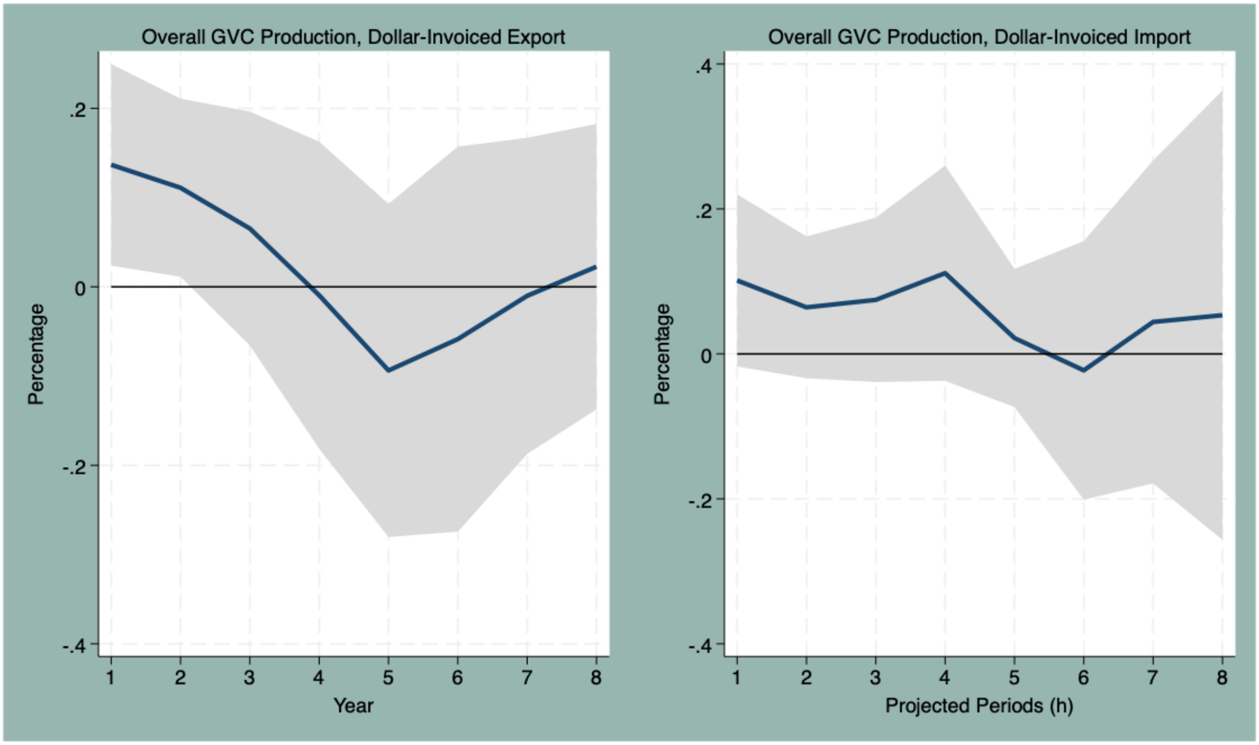
Figure 7: IRFs of Forward GVC Production



ables, or responses are the four types of GVC productions respectively projected eight horizons ahead after one shock from the independent variables. The independent variables, or impulses, consist of dollar-invoiced export, dollar-invoiced import, dollar exchange rate, the real effective exchange rate, and interaction terms: dollar invoiced trade multiplied by the dollar exchange rate and by the real effective exchange rate in accordance with each specification, allowing the model to capture cumulative IRFs, among these variables. All variables are expressed in natural logarithms. The regression also includes lagged values of dollar-invoiced trade and dependent variable (GVC productions) up to the third lag and use robust standard errors, which accounts for temporal dependencies and potential feedback effects.

Figure 8 shows the cumulative IRFs from result of Equation 6 that capturing the response of overall GVC production to shock to dollar-invoiced exports and dollar-invoiced import. In the left panel, the overall GVC production is projected to increase in response to a positive

Figure 8: IRFs of Overall GVC Production to Dollar-Invoiced Trade Shocks

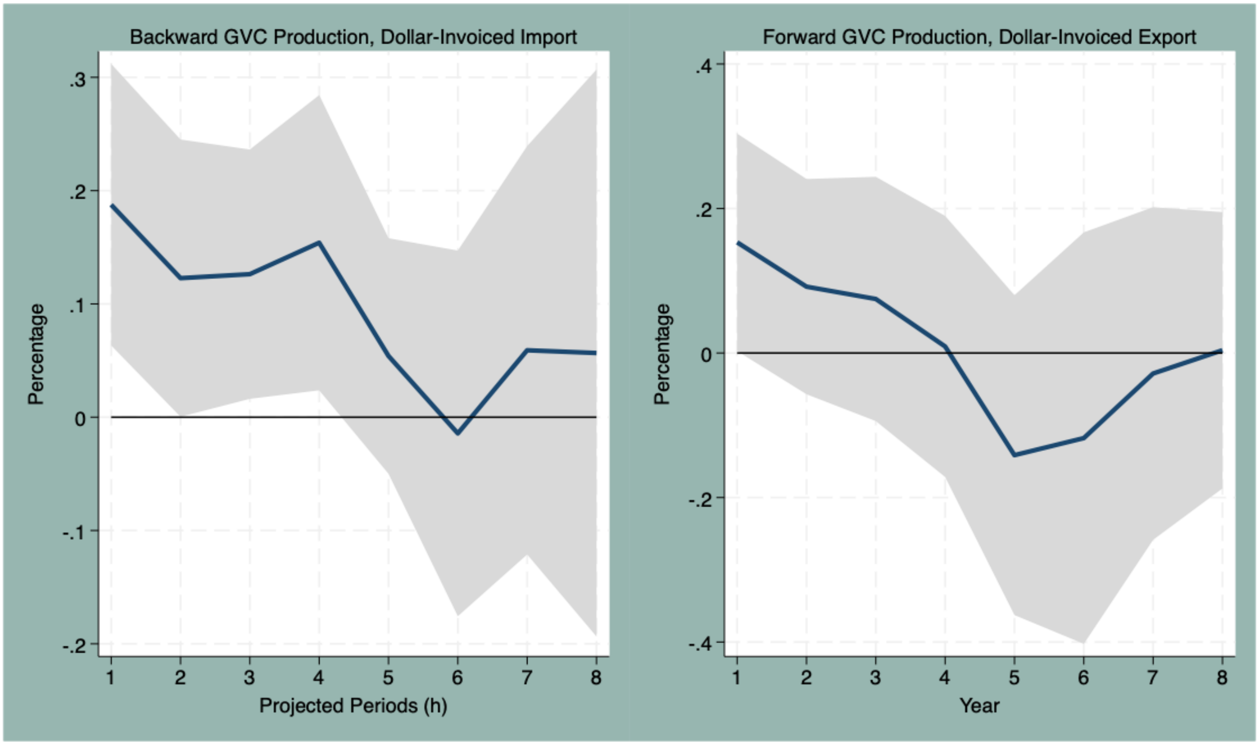


shock to dollar-invoiced export, and such impact lasts for two periods, which suggests that one unit increase in dollar-invoiced export is projected to increase overall GVC for 1.3% in after two years. Shocks to dollar-invoiced import has positive impact, but not statistically significant. And the pattern of mixed GVC production exhibits a similar trend.

The cumulative IRFs in Figure 9 present the impacts of shocks to dollar-invoiced imports on backward GVC production (left panel) and dollar-invoiced exports on forward GVC production (right panel). The left panel shows the impact of a shock to dollar-invoiced imports on backward GVC production is initially positive, with backward GVC production increasing by approximately 2% in the first two periods. However, the effect gradually declines over time, eventually approaching zero, indicating that the benefits of dollar-invoiced imports for backward GVCs diminish after a few periods.

In the right panel, the response of forward GVC production to a shock in dollar-invoiced exports initially starts as positive, with forward GVC production start to fall in the medium run.

Figure 9: IRFs of Backward and Forward GVC Production to Dollar-Invoiced Trade Shocks

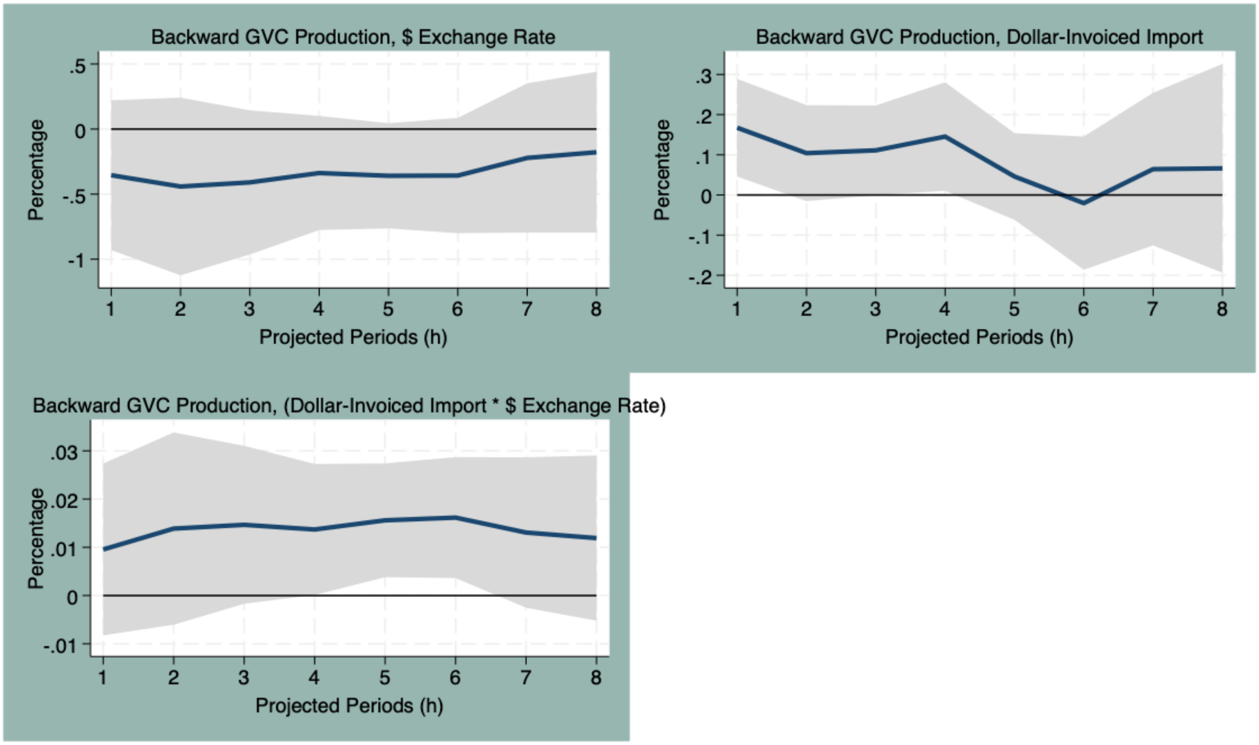


Over time, the effect gradually moves toward zero and suggests that, forward GVC production adjusts to the shock (firms might switch from imported input to domestic input), and the adverse effects of dollar invoicing diminish in the medium to long term.

Both panels display a relatively wide confidence intervals, especially beyond the third or fourth period, indicating that the estimates become less precise over time. This implies some degree of uncertainty, particularly for the longer-term dynamics. The precise long-term effects should be further estimate with more variables taken into considerations. Overall, the findings suggest that dollar-invoiced imports provide short-term benefits for backward GVCs, while the impact of dollar-invoiced exports on forward GVCs is short-lived.

Equation 7 is then estimated with the incorporation of dollar exchange rate and the terms of its interaction with dollar-invoiced export and import respectively. Figure 10 presents the local projection estimation in the backward GVC productions. In the upper left panel, the cumulative response of backward GVC production to a dollar appreciation shock starts negative

Figure 10: Backward GVC Production to Dollar Movements and Dollar-Invoiced Import Shocks



and remains below zero throughout the projection period. Initially, the cumulative decline reaches about 0.5%, and though the rate of decline slows slightly, the effect remains persistently negative across the projection horizons. This suggests that a stronger lasting disruptions in backward GVC participation, with firms facing difficulties in importing intermediate goods.

In the upper right panel, the cumulative response to a shock in dollar-invoiced imports is initially positive, peaking around 1.7% within the first two projected periods. However, the effect begins to drop, and the cumulative impact approaches zero by the seventh or eighth period. This pattern indicates that while dollar-invoiced imports provide a short-term cumulative facilitation to backward GVC productions, the stabilizing impact fades over time, suggesting diminishing benefits from dollar invoicing in the medium term.

In the bottom left panel, the cumulative effect for the interaction between dollar-invoiced imports and exchange rate movements shows a negligible effect: it remains near zero with minimal variation over time. This flat response suggests that the interaction between dollar invoicing and exchange rate movements though shows small positive impact in the medium to long run, does not generate very big economic impact on backward GVC production. These findings highlight the vulnerability of backward GVC production to dollar movements and suggest that while dollar-invoicing practices can mitigate risks in the short term.

Figure 11: Forward GVC Production to Dollar Movements and Dollar-Invoiced Export Shocks

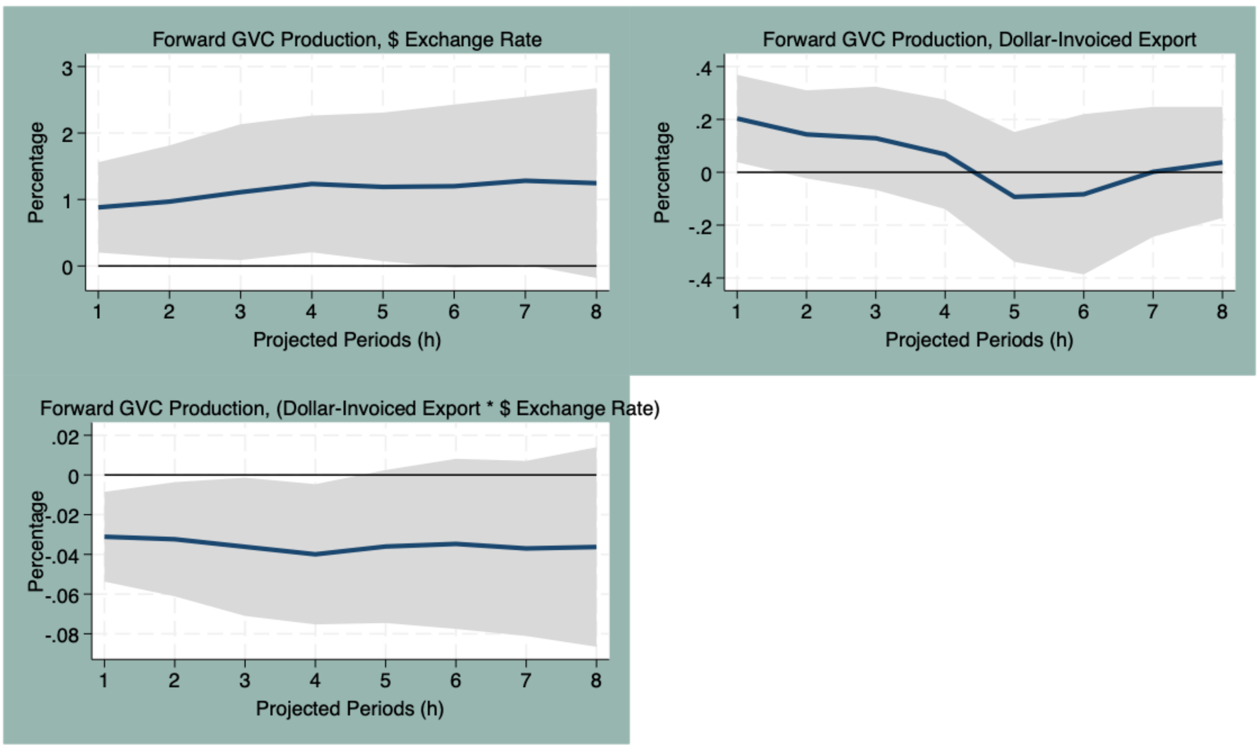
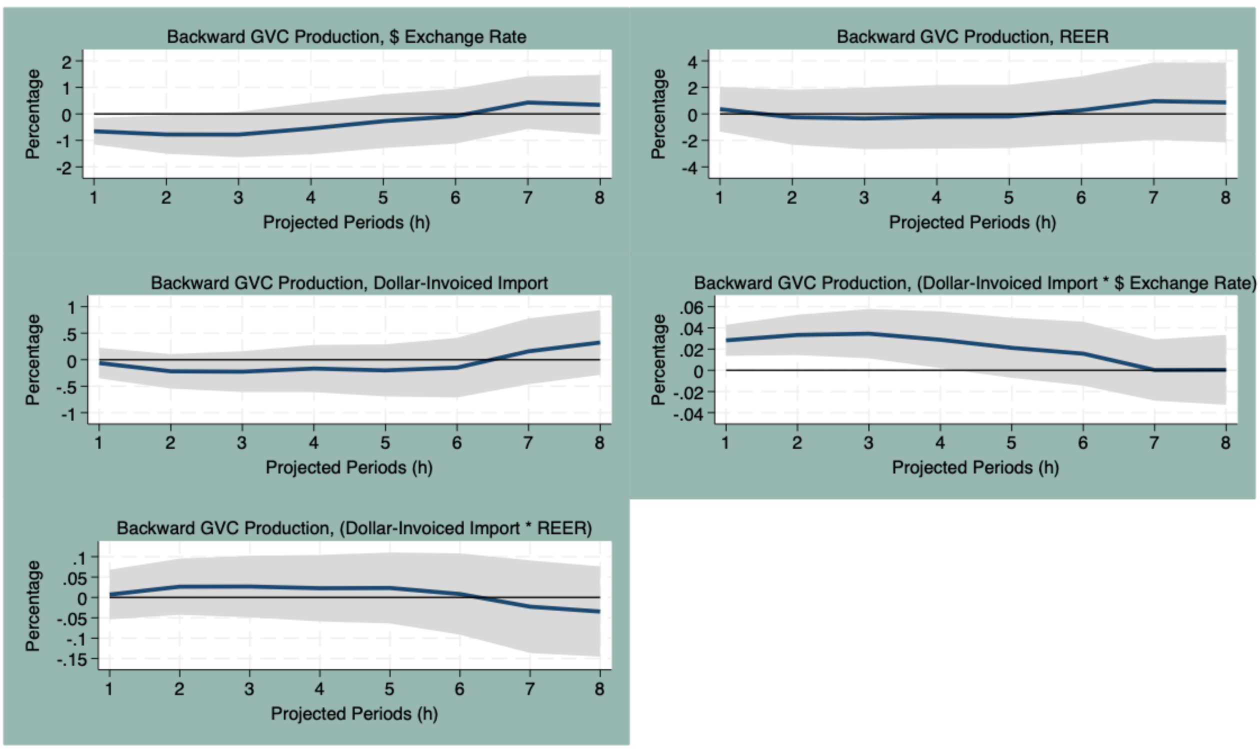


Figure 11 summarizes the local projection estimation in the forward GVC productions. The cumulative IRF on the upper left panel suggests that a dollar appreciation shock has a positive effect on forward GVC production, but it doesn't have a significant or persistent impact. A shock to dollar-invoiced exports (upper right panel) shows that it has a positive and statistically significant impact on forward GVC production in the first two periods, with production increasing by nearly 2%. However, after this initial boost, the cumulative response starts to decline, and the positive effect gradually fades, trending towards zero. This suggests that while dollar-invoiced exports can initially stimulate forward GVC participation, the effect is short-lived, and any advantages diminish over time.

The cumulative IRF for the interaction between dollar-invoiced exports and dollar movements in the lower left panel shows a small but consistently negative impact on forward GVC production, remaining around -0.04% throughout the entire projection horizon. This suggests that dollar-invoiced export in the context of dollar appreciation creates mild but persistent constraints on forward GVC production, possibly reflecting risks associated with dollar exchange rate volatility combined with dollar invoicing.

Figure 12: Backward GVC Production to Dollar Movements, Real Effective Exchange Rate Movements, and Dollar-Invoiced Import Shocks



Figures 12 and 13 present the results of local projection estimation of the backward and forward models based on Equation 8, which seeks to capture the dollar movement and home currency movement's impact on GVC production in the context of dollar invoicing.

In the top left panel of Figures 12, in the short run, backward GVC production declines in response to a shock to the dollar exchange rate (i.e., a dollar appreciation). This initial decline suggests that dollar appreciation increases the cost of imported inputs, which negatively impacts firms engaged in backward GVCs. However, the cumulative response begins to recover after the second or third period and becomes positive by the end of the projection horizon. This pattern indicates that while a stronger dollar initially constrains backward GVC participation, the negative impact diminishes over time, possibly due to firms successfully found local input that reduce costs over the longer term.

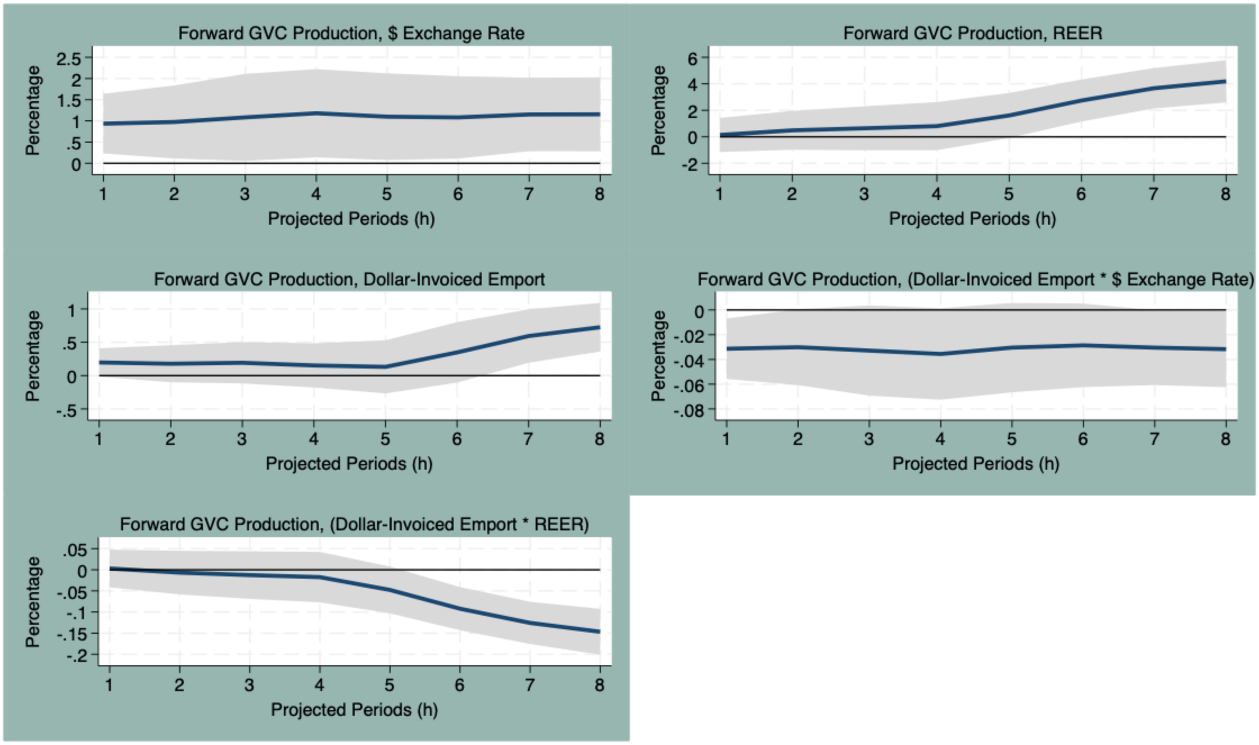
A REER appreciation shock results in a small-positive but not statistically significant impact on backward GVC production throughout the projection horizon. And the cumulative IRF for dollar-invoiced imports shows a small negative effect, but this impact remains not statistically significant over the entire projection period. However, the cumulative IRF for the interaction between dollar-invoiced imports and the dollar exchange rate shows a positive cumulative effect on backward GVC production in the first four years. In this scenario, with a dollar appreciation, firms relying on dollar-invoiced imports experience a boost in backward GVC participation over time. This suggests that while dollar appreciation alone initially hinders backward GVC participation, the combination of dollar invoicing with dollar appreciation stabilizes input costs and mitigates the negative impact, leading to a positive outcome for backward GVC participation.

These findings reveal that backward GVC production is sensitive to exchange rate dynamics and invoicing practices. Dollar appreciation alone initially hinders backward GVC participation, but when firms rely on dollar-invoiced imports, the negative effect is mitigated, leading to positive cumulative outcomes.

The cumulative IRFs in Figure 13 illustrate the dynamic impact of various shocks on forward GVC production over time. In the top left panel, there's a positive cumulative impact of a dollar appreciation shock on forward GVC production. The response reaching approximately 1.6% by the eighth period. This suggests that dollar appreciation benefits forward GVC production, possibly by improving export pricing competitiveness just as traditional trade theory predicts.

A shock to the REER (top right panel) results in a positive cumulative impact on forward GVC production, with the effect growing throughout the projection horizon. By the eighth period, the cumulative response reaches about 4%, indicating that REER appreciation enhances forward GVC participation by lowering input costs or increasing the attractiveness of

Figure 13: Forward GVC Production to Dollar Movements, Real Effective Exchange Rate Movements, and Dollar-Invoiced Export Shocks



intermediates in global markets.

The cumulative response to dollar-invoiced exports (middle left panel) shows that shocks to dollar-invoiced export provides a delayed cumulative benefit to forward GVC production. This delayed impact might reflect that firms exporting in dollars gain stability over time, reducing currency risks and improving their participation in forward GVCs.

The cumulative IRF for the interaction between dollar-invoiced exports and the dollar exchange rate (middle right panel) remains close to zero and shows scatter statistical significancy throughout the projection horizon. It indicates that the combined effect of dollar-invoiced exports and dollar exchange rate fluctuations is neutral, suggesting that any positive or negative effects may cancel each other out.

The bottom left panel shows that, the interaction between dollar-invoiced exports and REER shows a mild but persistent negative impact on forward GVC production. The cumulative decline reaches about -0.3% by the eighth period, indicating that while dollar invoicing or

REER appreciation alone may be beneficial, their combination introduces frictions or costs that hinder forward GVC participation over time.

The local projection estimation reveals complex impacts of dollar movements, invoicing practices, and their interactions on backward and forward GVC production. Dollar movements affect the two GVC types differently: Dollar appreciation initially hinders backward GVC participation by raising input costs, but firms seem to adjust over time, leading to positive cumulative outcomes. Conversely, forward GVC production benefits modestly from dollar appreciation, with cumulative gains reaching 1.6% over the projection horizon, aligning with traditional trade theory predictions about improved export competitiveness.

Invoicing practices have distinct effects: Dollar-invoiced imports provide a short-term boost to backward GVC production, but their benefits diminish over time, suggesting that the stabilizing effects are not sustained. Similarly, dollar-invoiced exports stimulate forward GVC production with a delayed positive cumulative effect in the long run.

The interactions between invoicing and exchange rate movements exhibit both positive and negative dynamics. For backward GVCs, the combination of dollar appreciation and dollar-invoiced imports results in a positive cumulative impact in the short to medium run, mitigating the negative effects of dollar appreciation. However, for forward GVCs, the interaction between dollar-invoiced exports and dollar appreciation produces a persistent negative impact, indicating that while invoicing and dollar appreciation individually support GVC participation, their interaction introduces frictions and costs that hinder forward GVC integration.

Overall, findings from the local projection estimation highlight the sensitivity of GVC production to exchange rate dynamics and the complex role of invoicing practices, with varying impacts depending on the type of GVC activity and the interaction between invoicing and currency movements. Effective management of exchange rate exposures and invoicing strategies is critical to sustaining long-term GVC participation.

7 Conclusion

This paper empirically investigates how different types of GVC production respond to dollar exchange rate and real exchange rate fluctuations, with a focus on the role of dominant currency (dollar) invoicing. First, the findings reveal that, unlike some prior GVC literature, real exchange rate movements is a key determinant of GVC production, particularly in backward and forward GVC productions. Moreover, the results show that dollar appreciation dampens GVC productions, especially the backward production, and trade invoicing in dollars mitigates some of these negative effects.

The results support Hypothesis I: GVC production in countries with a higher level of trade invoiced in a dominant currency is responsive to fluctuations in that currency. Backward GVC production, in particular, is highly sensitive to dollar exchange rate shocks, with this sensitivity being statistically significant in the short to medium term. This confirms that dominant currency invoicing amplifies the impact of dominant currency fluctuations on GVC participation.

For Hypothesis II, the findings suggest that forward GVC production is less affected by dollar exchange rate fluctuations in compared to backward production. The panel regressions show muted sensitivity of forward production to dollar movements. The local projection analysis further reveals distinct dynamics: Dollar appreciation initially constrains backward GVC participation, but the such impact fades over time. Conversely, forward GVC production benefits modestly from dollar appreciation, with cumulative gains of 1.6% over the projection horizon, aligning with traditional trade theory predictions on improved export competitiveness. Invoicing practices also exhibit complex effects—while dollar-invoiced imports provide a short-term boost to backward GVC production, the effect diminishes over time. Similarly, dollar-invoiced exports generate positive cumulative effects for forward GVC production, though these benefits emerge gradually in the long run.

Hypothesis III, which posits the potential for reverse causality between dominant currency invoicing and GVC participation, is also supported by the prelimenary local projection analysis.

As GVC networks expand, they appear to reinforce the adoption of dominant currency invoicing, with incumbents establishing invoicing practices that align with GVC standards.

These findings highlight the interplay between dominant currency invoicing and exchange rate movements in shaping different types of GVC participation across income levels. Understanding these dynamics is essential for policymakers seeking to enhance economic resilience and competitiveness in the global market. Countries with a higher share of dollar-invoiced trade face amplified effects from dollar exchange rate fluctuations, particularly in backward GVC production. This highlights the need for tailored policies to mitigate currency risks and support economic stability based on domestic GVC production structures.

The differential impacts on forward and backward GVC production reiterate the importance of aligning policy strategies with a country's specific GVC structure. The findings show that dominant currency invoicing creates both opportunities and vulnerabilities. Strategies such as currency diversification, local currency invoicing, or targeted hedging mechanisms could reduce exposure to exchange rate risks. Additionally, fostering greater flexibility within production networks and enhancing value-added capabilities can help economies manage volatility more effectively.

In conclusion, this paper demonstrates how the widespread use of dollar invoicing in international trade significantly influences countries' participation in GVCs under exchange rate fluctuations. The analysis reveals that different segments of GVCs react differently to currency movements: backward participation, which involves importing inputs, is particularly sensitive to changes in the dollar exchange rate, while forward participation, focused on supplying inputs to others, exhibits distinct and less immediate patterns.

These findings have important practical implications for trade and economic policy. Policies designed to address the challenges of currency fluctuations must account for a country's position within GVCs—whether it primarily imports intermediate inputs or supplies them to other economies. Understanding this dynamic is crucial for developing targeted strategies to manage currency risks, enhance economic resilience, and maintain stable trade relationships in today's interconnected global economy.

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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)	-0.508*	-0.401	-0.723***	-0.312
	(0.222)	(0.234)	(0.111)	(0.311)
L.ln(Real Effective Exchange Rate)	0.599	0.497	0.952***	0.173
	(0.374)	(0.436)	(0.227)	(0.618)
L.ln(Dollar-Invoiced Export)	0.0925	0.133*		0.0447
	(0.0469)	(0.0579)		(0.0575)
L.ln(Dollar-Invoiced Import)	0.0555	0.0485	0.0797	
	(0.0423)	(0.0486)	(0.0454)	
L.ln(Dollar-Invoiced Export)	0.0202	0.0190		0.0140
*ln(Dollar Exchange Rate)	(0.0169)	(0.0199)		(0.0110)
L.ln(Dollar-Invoiced Import)	0.00226	-0.000302	0.0301***	
*ln(Dollar Exchange Rate)	(0.0201)	(0.0222)	(0.00458)	
L.ln(Dollar-Invoiced Export)	0.00442	0.00502		0.0153
*L.ln(Real Effective Exchange Rate)	(0.0154)	(0.0181)		(0.0207)
L.ln(Dollar-Invoiced Import)	-0.00508	-0.00330	-0.00970	
*L.ln(Real Effective Exchange Rate)	(0.00930)	(0.0106)	(0.00811)	
ln(Capital to GDP Ratio)	0.242**	0.205*	0.349***	0.140
	(0.0766)	(0.0919)	(0.0767)	(0.0930)
ln(Trade to GDP Ratio)	0.457***	0.535***	0.381***	0.348**
	(0.0946)	(0.114)	(0.0928)	(0.116)
ln(Capital Openness)	0.0207	0.0154	0.00919	0.0260
	(0.0366)	(0.0451)	(0.0264)	(0.0364)
_cons	1.936	0.367	1.847	3.707
	(1.533)	(1.703)	(1.331)	(2.048)
N	778	778	809	793
adj. R^2	0.992	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)	-0.483	-0.392	-0.611***	-0.322
	(0.250)	(0.252)	(0.144)	(0.333)
L2.ln(Real Effective Exchange Rate)	0.407	0.326	0.746*	-0.0705
	(0.505)	(0.591)	(0.285)	(0.693)
L2.ln(Dollar-Invoiced Export)	0.0631	0.106		0.00566
	(0.0491)	(0.0603)		(0.0621)
L2.ln(Dollar-Invoiced Import)	0.0840	0.0740	0.105	
	(0.0564)	(0.0598)	(0.0600)	
L2.ln(Dollar-Invoiced Export)	0.0235	0.0208		0.0153
*L2.ln(Dollar Exchange Rate)	(0.0181)	(0.0211)		(0.0120)
L2.ln(Dollar-Invoiced Import)	-0.00154	-0.00172	0.0255***	
*L2.ln(Dollar Exchange Rate)	(0.0204)	(0.0219)	(0.00555)	
L2.ln(Dollar-Invoiced Export)	0.00907	0.0109		0.0180
*L2.ln(Real Effective Exchange Rate)	(0.0151)	(0.0181)		(0.0226)
L2.ln(Dollar-Invoiced Import)	-0.00904	-0.00920	-0.00791	
*L2.ln(Real Effective Exchange Rate)	(0.0101)	(0.0122)	(0.00936)	
ln(Capital to GDP Ratio)	0.307***	0.271**	0.424***	0.152
	(0.0844)	(0.101)	(0.0789)	(0.0997)
ln(Trade to GDP Ratio)	0.404***	0.496***	0.274**	0.293*
	(0.113)	(0.133)	(0.101)	(0.143)
ln(Capital Openness)	0.0378	0.0287	0.0261	0.0494
	(0.0430)	(0.0526)	(0.0285)	(0.0449)
_cons	2.984	1.325	2.420	5.756*
	(1.722)	(1.866)	(1.608)	(2.216)
N	735	735	765	749
adj. R^2	0.991	0.988	0.991	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)	-0.409	-0.330	-0.534***	-0.264
	(0.242)	(0.251)	(0.153)	(0.286)
L3.ln(Real Effective Exchange Rate)	0.0494	-0.0304	0.509	-0.335
	(0.491)	(0.593)	(0.306)	(0.677)
L3.ln(Dollar-Invoiced Export)	0.0306	0.0624		-0.0435
	(0.0499)	(0.0636)		(0.0688)
L3.ln(Dollar-Invoiced Import)	0.0647	0.0576	0.0815	
	(0.0535)	(0.0585)	(0.0509)	
L3.ln(Dollar-Invoiced Export)	0.0146	0.0131		0.0140
*L3.ln(Dollar Exchange Rate)	(0.0181)	(0.0220)		(0.0108)
L3.ln(Dollar-Invoiced Import)	0.00540	0.00483	0.0230***	
*L3.ln(Dollar Exchange Rate)	(0.0197)	(0.0218)	(0.00585)	
L3.ln(Dollar-Invoiced Export)	0.0215	0.0249		0.0259
*L3.ln(Real Effective Exchange Rate)	(0.0141)	(0.0175)		(0.0215)
L3.ln(Dollar-Invoiced Import)	-0.0107	-0.0128	-0.00163	
*L3.ln(Real Effective Exchange Rate)	(0.0105)	(0.0132)	(0.00982)	
ln(Capital to GDP Ratio)	0.321***	0.302**	0.428***	0.174
	(0.0760)	(0.0963)	(0.0763)	(0.0955)
ln(Trade to GDP Ratio)	0.386**	0.498**	0.232*	0.273
	(0.122)	(0.146)	(0.101)	(0.164)
ln(Capital Openness)	0.0323	0.0186	0.0317	0.0322
	(0.0435)	(0.0542)	(0.0289)	(0.0413)
_cons	4.771*	3.243	3.605*	7.372**
	(1.912)	(2.236)	(1.515)	(2.368)
N	660	660	686	673
adj. R^2	0.992	0.989	0.992	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)	(2)	(3)
	High Income	Upper Middle	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 %)	-0.249	0.913	-0.0453
*L.ln(Real Effective Exchange Rate)	(0.194)	(0.626)	(0.328)
L.ln(Dollar-Invoiced Import %)	0.363	0.0558	-1.495***
*L.ln(Real Effective Exchange Rate)	(0.314)	(0.431)	(0.371)
L.ln(Dollar-Invoiced Export %) 0.266	-0.928	-0.00585	
*L.ln(US Real Effective Exchange Rate)	(0.192)	(0.642)	(0.302)
L.ln(Dollar-Invoiced Import %)	-0.384	-0.0759	1.481***
*L.ln(US Real Effective Exchange Rate)	(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 %) *L.ln(Real Effective Exchange Rate)	-0.0975	-0.0923	0.131
	(0.0609)	(0.134)	(0.151)
L.ln(Dollar-Invoiced Import %) *L.ln(Real Effective Exchange Rate)	-0.0289	-0.259	-1.430*
	(0.128)	(0.376)	(0.763)
L.ln(Dollar-Invoiced Import %) *L.ln(US Real Effective Exchange Rate)	0.00844	0.273	1.349*
	(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 %)	-0.0131	0.511	-1.696**
*L.ln(Real Effective Exchange Rate)	(0.153)	(0.417)	(0.685)
L.ln(Dollar-Invoiced Export %)	0.0355	-0.557	1.650**
*L.ln(US Real Effective Exchange Rate)	(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