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UNRAVELLING THE NEXUS BETWEEN EXCHANGE RATE UNDERVALUATION AND GLOBAL VALUE CHAIN PARTICIPATION

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Abstract

The undervaluation of the real exchange rate (RER) can influence the performance of national exports and affect a country's participation in global value chains (GVCs). Thus, using the Eora dataset for 143 countries over the period 1995-2018, we assess the impact of this policy on a country's foreign value added (FVA) in exports which represents the value added in exports whose outputs are produced by foreign industries (backward participation) and the domestic value added (DVX) in exports, that refers to the value added that is embodied in the exports of other countries (forward linkages). Currency undervaluation displays a positive impact on these two ways of participating in GVCs. Consistent with what has been noted in a recent strand of literature, undervaluation acts as a compensatory factor for countries with weak institutions, and the impact of this undervaluation becomes more pronounced as the level of digitization in the economy increases. Our econometric results remain robust to a battery of sensitivity analysis tests.

Keywords: Global value chains, Exchange rate, Undervaluation, Quality of institutions, Digitalization, Cointegration.
JEL Classifications: F14, F31, F40, O24.

الملخص

كما هو معلوم من الأدبيات المتواترة فإن سياسة تخفيض قيمة سعر الصرف الحقيقي تساهم في زيادة تنافسية الصادرات الوطنية. سنبين في هذه الورقة بأن هذه السياسة يمكن أيضاً أن تدعم مشاركة البلدان في سلاسل القيمة العالمية. في هذا السياق تقيِّم هذه الورقة أثر هذه السياسة على مكونا القيمة المضافة (القيمة المضافة الأجنبية والقيمة المضافة المحلية في صادرات بلد ما باستخدام مجموعة بيانات EORA والتي تشمل 143 بلداً على مدى الفترة 1995-2018. وتمثل القيمة المضافة الأجنبية مساهمة المدخلات المستوردة التي تنتجها الصناعات الأجنبية في صادرات بلدٍ ما (الروابط الخلفية) بينما تشير القيمة المضافة المحلية إلى مساهمة صادرات بلدٍ ما في القيمة المضافة المتجسدة في صادرات البلدان الأخرى (الروابط الأمامية). ويُظهر الانخفاض الحقيقي في قيمة العملة تأثيراً إيجابياً على هذين المكونين في سلاسل القيمة العالمية. تؤيد هذه النتائج تفسير الأدبيات الماثلة والتي تشي بأن تخفيض القيمة الحقيقية للعملة يمكن أن يُنظر إليه بمثابة عامل تعويضي للبلدان ذات المؤسسات الضعيفة، وبحسب نتائج هذه الورقة يصبح هذا العامل التعويضي أكثر قوة مع ارتفاع مستوى الرقمنة في الاقتصاد. تظل نتائج الاقتصاد القياسي التي توصلنا إليها سارية أمام مجموعة من اختبارات تحليل المتانة.

1. Introduction

There is increasing literature that participation in global value chains (GVCs) sustains both high economic growth and the structural transformation of the gross domestic product (GDP). This is because participating countries can enter niches along the chain without having to produce the whole product through vertical specialization (De Melo and Solleder, 2022). This paper intends to contribute to this literature in the context of emerging and developing economies by assessing the role played by real exchange rate (RER) undervaluation among a set of other GVC determinants (Cheng et al., 2016). We measure this integration by the foreign value added (FVA) in exports, which is the value added in exports whose outputs are produced by foreign industries (backward participation), and the domestic value added (DVX) in exports, which refers to the value added that is embodied in the exports of other countries (forward linkages).

The debate regarding the role of RER in macroeconomic policy and long-term growth occupies a central position in economic research. As an economy-wide relative price, it signals for inter-sectoral resource transfers and factor movements in the economy, and it largely determines the relative profitability of investment in both traded and non-traded sectors. Thus, RER significantly affects capital accumulation and effectively regulates the evolution of foreign trade. In this context, the received literature finds a robust association between RER undervaluation and exports. It has been argued that RER undervaluation essentially acts like an economy-wide industrial policy, supporting the competitiveness of a country's exports vis-a-vis other countries' exports in foreign markets. Rodrik (2008) argues that the empirical findings on the prominence of RER is, in fact, a reflection of a deeper causal effect. According to Rodrik, to the extent that tradable economic activities are more "complex" and, therefore, entail more transaction-intensive activities, they tend to be more affected by the cost associated with weak institutions. Hence, the economy-wide subsidy provided by RER undervaluation should at least partially reduce this cost. Evidence of the robust association between mild undervaluation and fast export-oriented growth could be explained by the fact that, in general, tradables tend to be more dynamic than non-tradables. The equally robust evidence on the negative effect of RER overvaluation could be explained as well.[5]

Subscribing to the above discussion, this paper examines whether the evidence from the received literature on the growth and export-promoting role of RER undervaluation also extends to the case of GVCs (Ollivaud et al., 2015; Fauceglia et al., 2018). Yet, in a world characterized by the increasing role of GVCs since the 1990s and cross-border fragmentation of production, the evidence from the previous strands of the literature may become less intuitive. Evidence on the role of RER undervaluation hinges on the assumption that countries export only final goods that do not require imported intermediate inputs. Such a simplifying assumption does not reflect the complex reality of trade relations, especially GVC trade, where products become multi-country products as intermediate inputs are imported, transformed, and

[5] See Dornbusch (1984) and Rodrik (1986).

then re-exported. Thus, GVC-related trade is expected to respond differently to exchange rate undervaluation compared to traditional trade in single-country goods.

Nonetheless, it seems intuitive that the finding on traditional trade should carry over to the received literature's case of "forward" GVC trade. However, for the case of backward GVC participation, the a priori evidence is unclear. As discussed above, the existing literature highlights the significance of institutional quality (Elbadawi and Zaki, 2021) and digital adoption (Cusolito et al., 2020; De Melo and Solleder, 2022a, b) in enhancing trade performance and, consequently, fostering participation in GVCs. Previous studies[6] extensively examine the influence of these factors on trade performance and find that they facilitate intricate processes that contribute to GVC participation. However, there is a dearth of research examining the impact of undervaluation on GVC participation while accounting for these factors.

To examine this question, we use a sample of 143 countries over the period 1995-2018 drawn from the UNCTAD-EORA database, which provides key GVC indicators, including foreign value added (FVA) and domestic value added included in other countries' exports (DVX) generated from the EORA Multi-Region Input-Output tables (MRIOs).

In this context, this paper makes a threefold contribution to the literature. First, it assesses the impact of undervaluation on both forward and backward GVC linkages. Second, it investigates how this impact is contingent upon other factors, most notably institutional quality and the level of digitalization. Third, it examines how the aforementioned impact varies depending on the country's position within the value chain, distinguishing between upstream and downstream countries, whether compares backward or forward linkages relative to the domestic value added included in exports (DVA). This differentiation is crucial as the country's GVC position serves as a measure of the relative strength of its forward and backward linkages.

The empirical analysis reveals that, in line with the conventional trade theory, undervaluation positively impacts forward GVC participation. However, the observed positive impact on backward linkages may initially appear contradictory to prior literature. Nonetheless, this result is consistent with the underlying concept that domestic and foreign value-added within GVCs are complementary in the production process. Hence, producing and exporting more domestic value added increases the derived demand for imported foreign value added. This interplay between domestic and foreign value added further supports the positive impact of undervaluation on backward GVC participation. Accounting for the quality of institutions and the degree of digitalization, we demonstrate that undervaluation can serve as a catalyst for GVCs in countries with deficient institutions. Moreover, we find that the positive impact of undervaluation is further magnified for countries with higher levels of digitalization. To address concerns regarding the potential endogeneity of undervaluation, we employ an

[6] See Freund and Weinhold (2002); Rodrik (2008); Aghion et al. (2009); Elbadawi et al. (2012); Sekkat (2016); Fernandes et al. (2019); Cusolito et al. (2020); Elbadawi and Zaki (2021).

instrumental variable (IV) approach, which reveals a stronger impact for undervaluation compared to the baseline regressions.

Expanding our analysis to consider a country's position within the value chain (either upstream or downstream), we consistently observe a positive impact of undervaluation, irrespective of a country's position. For the impact on the backward linkage, it remains positive and highly significant for downstream countries, while becoming negative for upstream ones. This finding may be attributed to the cushioning effect that downstream countries enjoy over upstream ones due to the price flexibility advantage. To ensure the robustness of our findings, we conduct two additional analyses. First, we investigate whether the impact of RER is predominantly driven by positive values (undervaluation) or negative ones (overvaluation). Secondly, we run separate regressions based on different income levels. These supplementary analyses provide further insights into the implications of undervaluation, strengthening the validity of our results.

The remainder of the paper is organized as follows. Section 2 reviews the literature, highlighting the salient theoretical framework as well as the main empirical predictions underpinning the relationship between exchange rate undervaluation and GVC participation. Section 3 details the data we use. Section 4 presents the econometric specification and discusses the associated empirical findings. Section 5 undertakes some robustness checks. Finally, section 6 concludes and offers some policy implications.

2. Literature Review

The received literature on exchange rate misalignment and its impact on trade performance is quite extensive, with conflicting empirical findings. In this paper, we delve into three main strands of the literature. First, we examine studies that analyze the impact of exchange rate misalignment on conventional trade performance. Second, we investigate the impact of GVC participation on the exchange rate elasticity of exports. Lastly, in view of the prominent focus on them as determinants of countries' participation in GVCs, we explore the role of institutional quality and digital adoption as standard controls.

By way of motivating potential relevance to GVCs, we begin by selectively reviewing the evidence from the literature on the role of RER misalignment on traditional trade. In this literature, exchange rate misalignment has historically been perceived as a policy tool for industrialization and welfare enhancement (Rodrik, 1986). Early studies (Kafka, 1961; Furtado, 1963; Hirschman, 1968) argue that an overvalued exchange rate can simulate industrialization by favorably altering relative prices in the industrial sector. Essentially, an overvalued exchange rate serves as an indirect tax on the export-oriented agricultural sector and a subsidy for the industrial sector, thereby making imported inputs cheaper.[7] However, this argument fails to hold up in real-world scenarios for two reasons. First, this oversimplifying argument assumes that the manufacturing sector is isolated from global markets, which is the

[7] See Rodrik (1986) for more details on the stylized model of a developing country.

case only when domestic production is protected from external competition with the drawbacks observed in the internal resource allocation process. In an open economy, the relative prices between the manufacturing and agricultural sectors are determined by global prices that are independent of the exchange rate. Consequently, an exchange rate policy cannot influence the internal terms of trade among tradables as long as both sectors engage in international trade (unless costly and inefficient multiple exchange rate regimes are adopted, of course). Second, overvaluation cannot be sustained indefinitely since it leads to a deterioration in the balance of payments, necessitating correction at some point. Therefore, the requirement for intertemporal balance in external payments implies that a period of overvaluation (deficit) must be followed by a period of undervaluation (surplus). Hence, a policy of maintaining a misaligned exchange rate in a given period is essentially a policy of promoting the opposite type of misalignment in the following one (Dornbusch, 1984).

Recent studies highlight the critical role of undervaluation as a key driver of export-oriented economic growth in various economies. Notably, there are studies on Japan and West Germany during the postwar era, as well as studies on China, other East Asian countries, and Chile over the past three decades (Dooley et al., 2004). It has been argued that the RER may have to depreciate quite considerably, overshooting its eventual equilibrium value to make the non-traditional export sector an appealing destination for investment (Williamson, 1997).[8] The objective of this is to overcome the initially limited capability of exporting manufactures and other non-traditional products, and to give exporters a competitive edge in the international market. With only a few exceptions,[9] the empirical literature strongly corroborates this view, suggesting that RER undervaluation promotes exports and growth, while overvaluation undermines the economy-wide competitiveness of exports and reduces overall growth.[10]

This evidence coheres with Steinberg (2016), who explains that central banks are likely to attempt to influence exchange rate policy in developing countries with large manufacturing sectors. A developing country can benefit from RER undervaluation in two main ways. First, undervaluation helps developing economies overcome the challenges related to limited export competitiveness they may face by making their exports relatively cheaper and therefore more competitive (Frieden, 1991). Second, countries that intentionally keep their exchange rates undervalued have a lower probability of encountering financial crises. Undervaluation leads to current account surpluses which, in turn, reduces the economy's reliance on foreign capital inflows and mitigates the risk of capital flight (Frankel and Saravelos, 2012). The positive impact of undervaluation is contingent upon many factors, such as the size of the manufacturing sector and the strength of the industrial or agricultural communities.

[8] See Bayoumi et al. (1994); Odedokun (1997); Edwards and Golub (2004); Elbadawi and Helleiner (2004); Frieden et al. (2006); and Freund and Pierola (2012) for similar arguments in the African context.
[9] The very few exceptions include Eaton et al. (2007); Glüzmann et al. (2012); Rowbotham et al. (2014); Rasbin et al. (2021).
[10] See Mamun et al. (2021); Genc and Artar (2014); Bahmani-Oskooee and Ardalani (2006); Haddad and Pancaro (2010); Krugman et al. (2012) as very few examples from this vast strand of the literature.

However, despite these positive effects, it is also important to consider the negative impacts an undervalued exchange rate may have on the national economy. First, an undervalued RER makes imports more expensive, which, in turn, exacerbates inflationary pressures, particularly for countries that heavily rely on imported inputs in foreign value added to produce their final products. Second, RER undervaluation amplifies the burden of foreign debt. Local debtors need a larger amount of domestic currency to finance their foreign currency debt (Pepinsky, 2009; Walter, 2013). Third, an undervalued RER limits the options for fiscal policy. Expansionary fiscal policies tend to raise inflation, which appreciates the RER. Therefore, maintaining an undervalued RER necessitates that the government maintains a relatively conservative fiscal policy.

Against this backdrop, a more balanced and theoretically more appealing strand of the literature is the one that finds only mild undervaluation to be an effective (de facto) policy instrument. In other words, the effect of RER undervaluation is non-monotonic, whereby beyond a certain threshold it might actually undermine export performance and reduce growth as well as the present well-being of the national community.

As discussed in the introduction, despite the robust evidence of the previous strands of literature and their plausible theoretical underpinnings, they do not necessarily carry over to GVC trade. These strands do not distinguish between trade in final goods and trade in value added and intermediate inputs, assuming that countries only export final goods that do not require imported intermediate inputs. This may underestimate or overestimate the impact of exchange rate undervaluation on trade flows for two main reasons. First, deeper integration into GVCs and a higher share of FVA in producing exports is expected to dampen the impacts of undervaluation on exports' performance. An undervaluation leads to an increase in the cost of imported inputs, which, in turn, may reduce the competitive gains from currency undervaluation compared to the traditional case without GVCs. Second, sectors that are large exporters are also large importers. Therefore, aggregating them with sectors that do not trade leads to an overestimation of the domestic value-added content in exports and, consequently, an overestimation of the impact of changes in foreign prices on the level of competitiveness (Bems and Johnson, 2017).

To our knowledge, no studies directly address the impact of undervaluation on GVC participation. However, a substantial body of literature explores the impact of GVC integration on the exchange rate elasticity of exports. For instance, Ahmed et al. (2016) use panel data for 46 countries spanning 1996-2012 and find that countries that are more integrated into GVCs experience a partial improvement in the competitiveness of the value of final goods exports following currency depreciation. They also observe that, on average, GVC participation reduces the RER elasticity of manufacturing exports by 22 percent. Similarly, Bang and Park (2018) use country-level data for three East Asian countries (China, Japan, and South Korea) and conclude that GVC participation diminishes the exchange rate elasticity of exports. They argue that the significance of this impact depends on the intensity of GVC integration as well as the country's position within the value chain. Moreover, Tan et al. (2019) find that a higher share of FVA embodied in exports completely offsets the negative impact of RER appreciation

on real gross exports. Additionally, a higher FVA share dampens the negative relationship between increased RER volatility and exports. Many studies also conclude that the exchange rate pass-through to export prices is weaker when countries are deeply integrated into GVCs and exported goods rely more intensively on foreign imported inputs (Greenaway et al., 2010; Berman et al., 2012; Amiti et al., 2014; Ollivaud et al., 2015; and Fauceglia et al., 2018). De Soyres et al. (2021) employ sectoral-level panel data from the World Input-Output Tables (WIOD) over the period 1995-2009 and test three main predictions. First, the higher the share of foreign value added in exports, the lower the response of export volumes to exchange rate fluctuations. Second, the higher the share of exports that return as imports, the lower the response of export volumes to exchange rate changes. Third, the higher the share of inputs to be re-exported, the higher the response of exports to the nominal effective exchange rate of its trading partner. The findings support these three predictions.

Considering the direct impact of RER appreciation on GVC participation, Cheng et al. (2016) use the OECD-WTO Trade in Value Added (TiVA) database and find that a real appreciation not only reduces the exports of domestic value added DVA, in line with conventional trade theory, but also decreases the imports of FVA, contradicting this theory. This finding aligns with the notion of complementarity between GVC-related FVA and DVA in production. Hence, exporting less DVA implies reduced demand for imported FVA. The magnitude of this response relies on the share of FVA in exports. A share of FVA in exports that exceeds 60 percent leads to a shift in the sign of import and export elasticities from negative to positive, indicating an increase in both DVA and FVA in response to currency appreciation.

The third strand of literature relevant to the research problem at hand is the literature that accounts for the conditional effect of RER given the quality of institutions and the extent of digitalization. When considering the quality of institutions, the literature shows strong evidence that the positive impact of undervaluation on trade flows or economic growth is accentuated when a country has weak institutions and suffers from market failures.[11] This can be attributed to two plausible explanations. First, according to Méon and Sekkat (2008), sophisticated goods are more relationship- and contract-intensive than primary ones. Weak institutions in a country impose implicit taxes on relationship- and contract-intensive exports compared to primary products. Therefore, a currency undervaluation helps compensate for implicit taxes which, in turn, promotes the manufactured and sophisticated exports. Second, Rodrik (2008) argues that poor economic institutions, which are more noticeable for developing countries, create a wedge between private and social returns, which is more severe in traded economic activities, especially in developing countries. This wedge leads to a huge misallocation of resources in favor of non-traded sectors and large dynamic distortions in the traded ones. Since traded sectors are more dynamic, a rise in the relative prices of traded to non-traded goods should lead to an enhancement of static efficiency and growth in a second-best fashion. Therefore, by offering an economy-wide subsidy to tradable sectors, undervaluation is expected to partially reduce the negative effect of weak economic institutions. Nevertheless, these arguments have

[11] See Rodrik (2008); Aghion et al. (2009); Freund and Pierola (2012); Elbadawi and Kaltani (2016); Combes et al. (2019); Elbadawi and Zaki (2021).

been rejected by Svensson (2003) and Brach and Naudé (2012). They argue that a currency undervaluation would lead to an increase in the costs of imported inputs required to produce sophisticated goods, such as machinery. In this case, an overvaluation of the national currency would reduce the costs of the imported inputs, consequently encouraging the diversification of exports.

As for access to telecommunication technology and digital adoption, numerous empirical studies provide evidence supporting their positive impact on export performance and GVC participation (Freund and Weinhold, 2002; Clarke, 2008; Kowalski et al., 2015; Fernandes et al., 2019; Cusolito et al., 2020; De Melo and Solleder, 2022a, b), especially for developing countries (Clarke and Wallsten, 2006). Beyond the advantages of accessing knowledge, these technologies facilitate the coordination of complex production processes that are spread across different geographical locations. Furthermore, telecommunications play a vital role in enabling firms to outsource intricate production activities across borders. While the existing literature lacks evidence regarding the impact of undervaluation on GVC participation when accounting for the degree of digitalization, it is reasonable to expect that the positive impact of undervaluation is amplified with better Internet accessibility. Internet use reduces transaction costs and minimizes information asymmetries, creating an optimal condition for production regardless of the institutional quality. Therefore, the advantages conferred by undervaluation are likely to have a more pronounced impact with better access to the Internet.

Against this backdrop, this paper contributes to the existing literature in three aspects. First, unlike most studies focusing on the impact of RER undervaluation on traditional trade, our paper delves into the impact on both forward and backward GVC participation. Second, we explore how this impact is contingent upon additional factors, namely the quality of institutions and the level of digitalization. Third, we examine how the aforementioned impact varies depending on a country's position within the value chain, distinguishing between upstream and downstream countries.

3. Data

In this section, we provide an overview of the construction of the RER undervaluation index. We also describe the GVC indicators obtained from the UNCTAD-EORA dataset, along with the other variables considered in the analysis. Moreover, we present some stylized facts and an initial assessment of the association between RER undervaluation and GVC participation.[12]

3.1 Real Exchange Rate Misalignment

Following Rodrik (2008), the concept of RER that we adopt is derived from the principle of purchasing power parity that provides an approximate measure of unit costs across countries. Therefore, RER is measured as a domestic price level adjusted for the Balassa-Samuelson effect (see Appendix B). The main advantage of this index is its comparability between

[12] A comprehensive overview of the definitions, sources of all the variables, and the corresponding summary statistics are presented in Appendix A.

countries and over time, since it adjusts the relative price of tradables to non-tradables to the level of development as proxied by income per capita.

To allow for comparability between countries with different income levels, we classify the countries covered by our sample into four income groups following the World Bank classification (see Appendix C). Table 1 shows that almost 49 percent and 75 percent of low-income/low-middle-income and upper-middle-income countries, respectively, have an undervalued RER. However, this is the case for only 30 percent of high-income countries. Overall, almost 48 percent of the countries covered by the sample have an undervalued RER. These patterns corroborate the arguments of Steinberg (2016) discussed above.

Table 1. Descriptive Statistics of RER Undervaluation (Log Units) 1995-2018

	Obs	Mean	Std. Dev.	Min	Max	Undervaluation	Overvaluation
Low/Low-Middle-Income	1458	0.018	0.394	-1.47	1.28	708	750
Upper-Middle-Income	931	0.169	0.241	-0.44	1.40	694	237
High-Income	1346	-0.137	0.397	-1.04	1.25	408	938
All	3735	6.44e-10	0.381	-1.47	1.40	1810	1925

Source: Authors' own calculations.

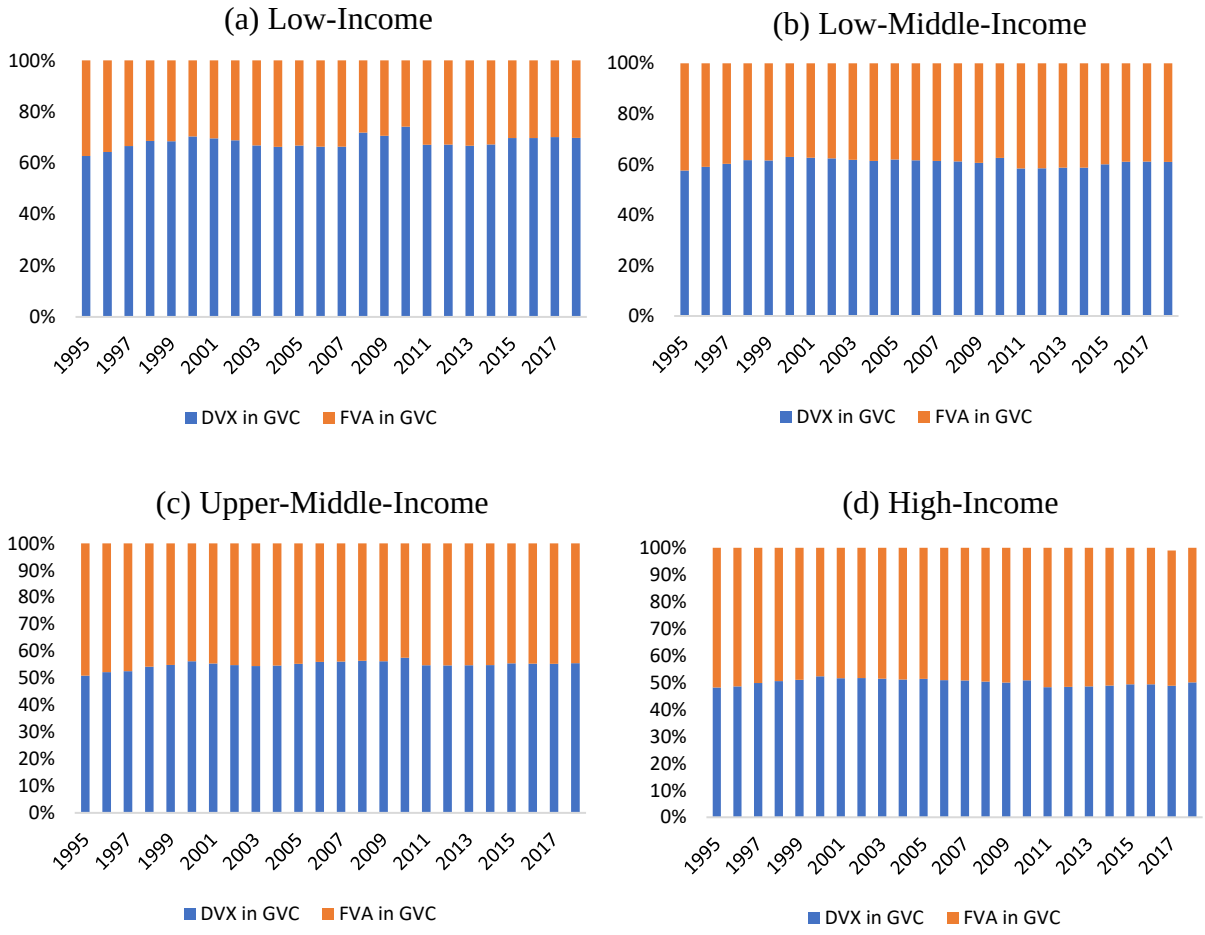
3.2 GVC Indicators: Forward and Backward Linkages

To assess the impact of undervaluation on GVC participation, we use the UNCTAD-EORA Global Supply Chain database on backward and forward linkages (Casella et al., 2019). As mentioned earlier, this dataset provides the key GVC indicators: FVA embodied in a country's exports and domestic value added (DVX) embodied in foreign countries' exports. Both are generated from the EORA Multi-Region Input-Output tables (MRIOs) for 143 countries over the period 1995-2018.

Figure 1 illustrates the share of domestic and foreign value-added components in GVCs for the four income groups. Two observations are worth mentioning. First, the higher the income level, the lower the domestic value-added content in the final GVC product. Second, low-income countries rely more on their domestic value added to produce a final GVC product. In contrast, high-income countries rely more on foreign intermediate inputs in their production. This goes in line with the findings of Bems and Johnson (2017), who argue that large exporting sectors are also large importers. Hence, producing and exporting more domestic value added increases the derived demand for imported intermediate inputs in foreign value added.

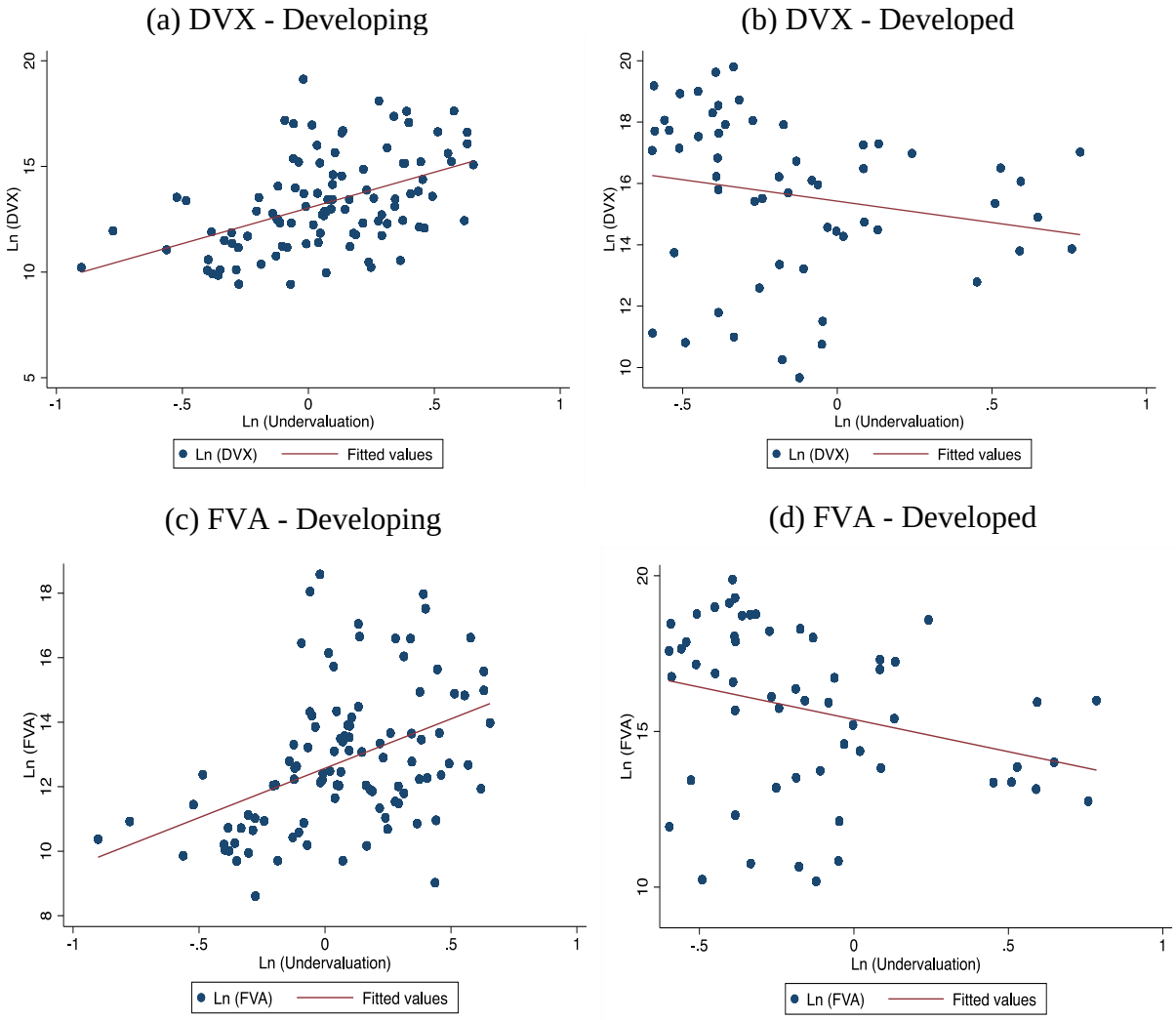
Figure 2 shows the association between RER undervaluation and the domestic value added (DVX) of a country embodied in the exports of other countries (Figure 2a and b), and the foreign value added (FVA embodied in the exports of a specific country (Figure 2c and d). In both cases, GVC participation is positively correlated with undervaluation in developing countries, but not in developed ones.

Figure 1. The Share of Domestic and Foreign Value-Added Components in GVC
(1995-2018)



Source: Constructed by the authors using UNCTAD-EORA dataset.

Figure 2. The Relation Between GVC Participation and RER Undervaluation



Note: Positive (negative) values of Ln (undervaluation) correspond to RER undervaluation (overvaluation). The graph is averaged over the period 1995-2018.

3.3 Other Controls

As previously mentioned, we are interested in assessing the marginal contribution of RER undervaluation while accounting for the effects of institutions and digitalization, the two controls that dominate the analysis of GVC literature. We expect that, in line with the burgeoning literature on trade and institutions, undervaluation might be an effective policy instrument when institutions are deficient. Moreover, with the Fourth Industrial Revolution and the automation of different tasks, digitalization matters greatly as a determinant of GVC participation, and thus might amplify the impact of undervaluation.

Regarding the data sources, we include two variables in our analysis to measure institutions. First, we utilize the Government Effectiveness Index from the World Governance Indicators (WGI), which reflects the quality of public and civil services as well as their independence from political pressures. Second, we include the financial institutions efficiency index from the Financial Development Index database provided by the International Monetary Fund (IMF).

This index encompasses various metrics such as banking sector net interest margin, lending-deposits spread, non-interest income to total income, overhead costs to total assets, return on assets, and return on equity.

On another note, the widespread utilization of the Internet in business operations is expected to promote GVC participation through different channels. First, it offers producers the ability to communicate with their customers, suppliers, distributors, and workers regardless of their geographic location (Clarke, 2008; Hagsten and Kotnik, 2017). Second, the Internet facilitates access to faster and more accurate information about various economic agents and market conditions, enabling firms to expand internationally (Mostafa et al., 2005). Third, the use of the Internet reduces the cost linked to finding an expensive intermediary who plays a crucial role in establishing trade relations (Fernandes et al., 2019). Lastly, access to the Internet enables swift cross-border interactions among firms and provides a cost-effective means of participating in global markets (Kim, 2020). To gauge the extent of digitalization, we employ the proportion of individuals within the total population using the Internet from the WDI.

4. Empirical Strategy and Findings

4.1 Empirical Setup

Our analysis is conducted in two main steps. First, we test the stationarity as well as the existence of a long-term relationship between the variables. Second, we consider the relationship between RER undervaluation and GVC participation.

We test the stationarity of the series relying on three main unit-root tests[13] (Harris and Tzavalis, 1999; Choi, 2001; Im et al., 2003). The tests confirm that some variables are stationary, and the others are integrated of order one I(1). Two panel cointegration tests are then performed to check the existence of a long-run relationship between the variables (Kao, 1999; Pedroni, 1999, 2004). The results confirm the existence of a long-run relationship between the variables (see Appendix D). Hence, cointegration methods that fit for non-stationary and cointegrated series are used.

To reduce the bias of standard ordinary least squares (OLS) in regressions with non-stationary variables, a Dynamic OLS (DOLS) model is estimated. DOLS is a cointegration method appropriate for non-stationary but cointegrated series (Nouira et al., 2011; Fišera and Horváth, 2022). This parametric approach relies on the inclusion of lags and leads of explanatory variables in the regression. Hence, it accounts for potential endogeneities among explanatory variables. It should also cleanse the error term from correlation and heteroskedasticity, in addition to addressing the problem of different orders of integration (Kao and Chiang, 2001; Mark and Sul, 2003).

[13] The different tests and the corresponding null and alternative hypotheses are reported in Appendix D.

We posit the following RER undervaluation-focused model for GVC participation:

$$Ln\ (GVC_{it}) = \alpha_0 + \alpha_1\ Ln\ (Undervaluation_{it}) + \alpha_2\ \eta_{it} + \delta_i + \mu_t + \tau_{it} \quad (1)$$

In (1), $Ln\ (GVC_{it})$ is the GVC participation index of country i at year t measured through the the value added in exports with outputs that are produced by foreign industries (backward participation, FVA) and the value added that is embodied in the exports of other countries (forward linkages, DVX). $Ln\ (Undervaluation_{it})$ represents RER undervaluation estimated as in Rodrik (2008). η_{it} is a vector of covariates that includes the following variables. First, the real GDP per capita (in log) is a proxy for the level of development. Second, the total value of natural resource rents (in log) accounts for the size of country's endowments. A higher level of rents is generally seen as a factor reducing economic diversification due to the Dutch disease or the curse of raw materials. Third, a weighted mean of applied tariff faced by a country and applied by its trade partners (forward linkage) and imposed by a country on its imports (backward linkage) is included to control for trade openness (in log)[14]. δ_i and μ_t denote country and year fixed effects respectively. τ_{it} is the disturbance term.

Next, we consider an extended model where ζ_{it} is a vector of variables reflecting the quality of institutions proxied by the government effectiveness index and financial institutions efficiency index, and the level of digitalization measured by the log of the share of the population using the Internet.

$$Ln\ (GVC_{it}) = \alpha_0 + \alpha_1\ Ln\ (Undervaluation_{it}) + \alpha_2\ \eta_{it} + \alpha_3\ \zeta_{it} + \delta_i + \mu_t + \tau_{it} \quad (2)$$

4.2 Baseline Regressions

Looking at the nexus between RER undervaluation and GVC participation, Table 2 reports the results for both the forward (columns a-c) and backward linkages (columns d-f).

First, we find that the coefficient of undervaluation is positive and highly significant for both the forward and backward linkages. The estimated elasticity of exports to exchange rate aligns closely with the elasticities reported by Berman et al. (2012), Fitzgerald and Haller (2018), and Fontagné et al. (2018), who find that the elasticity of export volumes to exchange rate ranges from 0.5 to 0.8, close to our own estimate. The results of the backward linkage may appear contradictory when compared to traditional trade theory, according to which undervaluation lowers imports, as their prices in domestic currency become more expensive. However, the latter result is consistent with the notion that GVC-related domestic and foreign value added are complements in the supply chain. Hence, producing and exporting more DVX increases the derived demand for imported FVA, especially for countries that export final goods that rely more on imported intermediate inputs. Notably, as we incorporate controls for the quality of institutions (columns b-c and e-f), we observe a steady increase in the undervaluation coefficient. This compellingly demonstrates the pivotal role of institutions and Internet usage in amplifying the impact of undervaluation. For the interaction between the income level and RER undervaluation, we find negative and highly significant coefficients, corroborating the

[14] Following Fontagné et al. (2015), we include ln ($tariff_{it}$ +1) to take into account the case of zero tariffs.

earlier findings of Rodrik (2008) in that RER undervaluation is particularly important for developing countries.

Considering the quality of institutions,[15] recent literature highlights the importance of institutional quality in various aspects of economic performance, including international trade. While numerous studies[16] demonstrate that higher institutional quality positively impacts exports' performance, this influence varies across commodities and may differ between low value added (i.e., raw materials), manufactured, and higher value added products (Méon and Sekkat, 2008). Instead, there is a dearth of literature on the role of institutions in the GVC context. In our analysis, we find that the coefficient of financial efficiency is positive and highly significant for both the forward and backward linkages. Clearly, at least through the opportunity to access domestic bank credit at a reasonable interest rate, a financial system appropriately assessing and managing risks greatly contributes to supporting a wider participation in GVCs. As per the government effectiveness estimate, it does not have a significant impact on the forward linkage. However, it significantly decreases the foreign value added in exports. A potential reason we can put forward (yet with no possibility to test in our empirical context) relates to the type of exported products (manufactured, low value added, or high value added). As per the interaction with undervaluation, the coefficients exhibit negative and highly significant effects. However, for the backward linkage and the interaction of undervaluation with financial efficiency index, no significant impact is detected. These findings align with the argument that RER undervaluation is unlikely to be effective nor necessary for promoting exports in economies with developed institutions. Instead, it becomes a counter-productive policy instrument for GVC promotion, as first-best solutions already exist.

Finally, to capture the aspects related to connectivity and the use of technology, we control for the number of individuals using the Internet (percentage of the population). The findings show that the coefficient of Internet usage is significant only for the backward linkage, lending support to the role of Internet access in the promotion of GVC participation, as previously mentioned. The results are consistent with the findings of Gopalan et al. (2022), who find that access to the Internet plays a crucial role in deepening firms' integration into GVCs. As per the interaction with RER misalignment, the coefficient is positive and highly significant for both the forward and backward linkages. Therefore, Internet usage can be perceived as a catalyst that magnifies the positive impact of RER misalignment.

As per the income level, the higher the income level, the higher the domestic and foreign value-added components. More developed countries tend to engage in both purchasing and selling a higher proportion of their gross exports as intermediate goods. Regarding natural resource rents, countries where rents are abundant are less likely to engage in forward as well as backward linkages. This negative impact can be explained by the fact that oil and other natural

[15] The regressions are done using alternative indicators for the quality of institutions and digitalization using the International Country Risk Guide (ICRG) and WDI datasets. The results are available upon request.
[16] See Anderson and Marcouiller (2002); Borrmann et al. (2006); Soeng and Cuyvers (2018); Karam and Zaki (2019).

resource products are found on the periphery of the product space, which limits the capacity of natural resource-dependent economies to produce new products and undergo structural transformation. Instead, economies with a large manufacturing base are found in the denser part of the product space (Hausmann and Klinger, 2006). When considering the impact of tariffs, backward participation is expected to be more sensitive to the country's own tariff policy as it encompasses imports into the country levying the tariff. Conversely, forward participation involves producers who face tariffs imposed on their exports. Thus, a distinction is made between the tariffs faced by a country on its exports (forward linkage) and the tariffs imposed by a country on its imports (backward linkage). The findings provide evidence that tariffs significantly decrease both forward and backward participation in GVCs, which is consistent with the findings of Kowalski et al. (2015). Tariffs, particularly those imposed on intermediate inputs, hinder a country's ability to access foreign inputs, increase costs, and ultimately impede the growth and development of downstream industries. Following this result, trade liberalization is an important determinant of GVC participation. Thus, recent protectionist measures in various countries can affect the insertion of developing countries into GVCs and reinforce global fragmentation.

Table 2. GVC Participation and RER Undervaluation – Baseline Regressions

	Forward Linkage			Backward Linkage		
	(a)	(b)	(c)	(d)	(e)	(f)
[1] Ln (Undervaluation)	0.180***	0.233***	0.449***	0.372***	0.175***	0.578***
	(0.046)	(0.043)	(0.061)	(0.050)	(0.016)	(0.049)
[2] Ln (GDPPC)	0.638***	0.595***	0.540***	0.632***	0.560***	0.518***
	(0.008)	(0.009)	(0.009)	(0.008)	(0.003)	(0.007)
[1] * [2]	-0.069***	-0.072***	-0.114***	-0.058***	-0.033***	-0.121***
	(0.005)	(0.005)	(0.007)	(0.006)	(0.002)	(0.006)
Ln (Tariff +1)	-0.034***	-0.030***	-0.017***	-0.046***	-0.026***	-0.024***
	(0.003)	(0.003)	(0.003)	(0.004)	(0.001)	(0.003)
Ln (Rents)	-0.006***	-0.006***	-0.005***	-0.004***	-0.004***	-0.002***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.0004)	(0.001)
[3] Government Effectiveness		-0.002	-0.027***		-0.031***	-0.050***
		(0.006)	(0.005)		(0.002)	(0.004)
[4] Financial Development		0.218***	0.217***		0.112***	0.144***
		(0.017)	(0.016)		(0.006)	(0.013)
[5] Ln (Internet Usage)		-0.001	-0.018***		0.053***	0.044***
		(0.002)	(0.002)		(0.001)	(0.002)
[1] * [3]			-0.091***			-0.023***
			(0.011)			(0.008)
[1] * [4]			-0.271***			-0.008
			(0.039)			(0.031)
[1] * [5]			0.140***			0.132***
			(0.003)			(0.002)
Country and Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	Yes	Yes	Yes	Yes	Yes	Yes
Mean of Dependent Variable	14.831	14.831	14.831	14.597	14.597	14.597
Observations	2,649	2,649	2,649	2,649	2,649	2,649

Rescaled standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

4.3 Instrumental Variable Approach

As previously mentioned, GVCs can affect the exchange rate. This is why we control for the potential endogeneity of RER undervaluation following an instrumental variable (IV) approach.

For the forward linkage, we use two different instruments. The first one is the RER undervaluation of the country's main trade partner. Cheng et al. (2016) argue that when a country has a limited DVA contribution to the final GVC product, any change in its RER should have a minor impact on the overall competitiveness of the entire supply chain. Therefore, the response in terms of DVA and FVA to its own RER undervaluation will be muted. Conversely, countries with substantial DVA contribution experience significant competitiveness effects on the entire supply chain when their RER changes, leading to spillover effects on other participants. Consequently, a country with a small DVA contribution can benefit when a supply-chain partner with a large DVA contribution undergoes depreciation, even if the small DVA-contributing country's own RER is appreciating. Second, we use a "leave-one-out mean" measure of undervaluation calculated over a set of countries that share country i's main characteristics at year t excluding the i^{th} country's RER undervaluation. The idea is inspired from Autor et al. (2013). To match each country with the countries that have the same characteristics, we follow two steps. First, we calculate propensity scores for each country i at year t based on a set of characteristics: the GDP per capita, tariffs imposed, tariffs faced, domestic value added, foreign value added, rents, quality of institutions, level of financial development, and degree of digitalization. Second, we estimate an average for the RER undervaluation over the blocks constructed upon the estimated scores.[17] By doing so, we draw information from countries that are homogenous enough to draw inferences on the relation between RER undervaluation and GVC participation. This leave-one-out mean instrument has been widely used in the literature (Alby et al., 2013; Clarke et al., 2015; Dovis and Zaki, 2020; Cette et al., 2022; Gopalan et al., 2022).

As per the backward linkage, we use the previous leave-one-out mean calculated over a set of countries that share country i's main characteristics at year t excluding the i^{th} country's RER undervaluation. Moreover, we use a leave-one-out mean over region. This measure refers to the instrument for the i^{th} country at year t constructed as the region-year average of RER undervaluation while excluding the i^{th} country's RER undervaluation. However, we do not make use of the RER undervaluation of the main trade partner as it directly impacts the foreign value added of the country. Thus, it violates the exclusion restriction.

Therefore, the endogeneity problem is tackled following a Two-Stage Least Squares (2SLS) technique. The first stage predicts RER undervaluation as follows:

$$Ln\ (Undervaluation_{it}) = \chi_{it}\ \beta_1 + \eta_{it}\ \beta_2 + \zeta_{it}\ \beta_3 + \delta_i + \mu_t + \in_{it}\ (3)$$

[17] A comprehensive description of blocks is available upon request.

Where $Ln\,(Undervaluation_{it})$ is RER undervaluation suspected to be endogenous. χ_{it} is a vector that compiles a set of instruments that varies according to the GVC participation indicator (forward and backward linkages). η_{it} and ζ_{it} represent the vector of control variables and the vector that compiles variables related to the quality of institutions, the level of financial development and the degree of digitalization. $\in_{it}$ is the error term. The instruments appear to satisfy the relevance condition as shown by the positive and significant coefficient of the instruments in the first stage regressions.[18]

Table 3 reports the results of the 2SLS estimations.[19] The findings show that RER undervaluation exerts a positive and highly significant impact on both the forward and backward linkages. It is pertinent to note that, when considering endogeneity, the economic impact of RER undervaluation becomes even stronger, as it is shown with larger coefficients compared to the baseline estimates. Failing to account for endogeneity may result in underestimated coefficients.[20]

As per interactions, the coefficients of financial efficiency and Internet usage align with the baseline results for the forward linkage. However, the negative interaction with government effectiveness is no longer present. For the backward linkage, the coefficients for Internet usage and government effectiveness (column b) remain consistent with the baseline results while the one with the financial institutions' efficiency index is no longer statistically significant.

[18] The results of the first stage regressions as well as the endogeneity and validity tests are reported in Table A6 in Appendix E.

[19] We use alternative combinations of instruments, and the results are in line with those reported and are available upon request.

[20] We run panel fixed-effects regressions with Driscoll-Kraay (1998) robust standard errors that correct for spatial and serial cross-sectional dependence, the positive impact of RER undervaluation is still confirmed for both the domestic and foreign value-added components. Results are available upon request.

Table 3. GVC Participation and RER Undervaluation – 2SLS

	Forward Linkage	Backward Linkage
	(a)	(b)
[1] Ln (Undervaluation)	1.504**	1.661***
	(0.610)	(0.583)
[2] Ln (GDPPC)	0.648***	0.516***
	(0.0286)	(0.0341)
[1] * [2]	-0.215***	-0.241***
	(0.0710)	(0.0678)
Ln (Tariff +1)	-0.0124*	-0.0112
	(0.00742)	(0.0121)
Ln (Rents)	-0.008*	0.00232
	(0.00439)	(0.00503)
[3] Government Effectiveness	-0.001	-0.020
	(0.017)	(0.021)
[4] Financial Development	0.189***	0.151***
	(0.052)	(0.057)
[5] Ln (Internet Usage)	-0.033**	0.052***
	(0.012)	(0.011)
[1] * [3]	0.292***	-0.165*
	(0.102)	(0.0915)
[1] * [4]	-2.10***	0.359
	(0.349)	(0.344)
[1] * [5]	0.392***	0.167***
	(0.0462)	(0.0286)
Country and Year FE	Yes	Yes
Intercept	Yes	Yes
Mean of Dependent Variable	14.831	14.597
Inst 1: Leave-One-Out Mean by Region and Year	No	Yes
Inst 2: Leave-One-Out Mean by Common Characteristics	Yes	Yes
Inst 3: Undervaluation of Main Trade Partner	Yes	No
R-squared	0.164	0.298
Observations	2,629	2,652

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

4.4 GVC Position and RER Undervaluation

To comprehensively investigate the impact of undervaluation on GVC participation, it is crucial to consider countries' position within the value chain. While two countries may have identical participation indexes, their position within the value chain can differ significantly, with specialization in either downstream or upstream activities in the production process. To account for this distinction, we split the sample into two. Following the literature (Koopman et al., 2010; Ahmed et al., 2016; Banerjee and Zeman, 2022; Fišera and Horváth, 2022), a country is specializing in an upstream activity if the domestic value added is higher than the foreign value added. On the other hand, if a country is specializing in the advanced phases of production (downstream activities), it is more likely to import more intermediate inputs and consequently, exhibiting higher backward relative to forward linkages. Then, for each sub-sample, we run the regressions for the forward and backward linkages.

The results (see Table 4) show that undervaluation exerts a consistently positive and highly significant impact on the forward linkage, irrespective of a country's position within the value chain. Regarding the impact on the backward linkage, we find a strong negative impact for upstream countries, while the impact remains positive and highly significant for downstream countries. One possible explanation is that exports and imports are better cushioned and

protected from exchange rate changes in countries that are more downstream in the supply chain, i.e., that operates in a stage of production that is closer to the end consumer (Riad et al., 2012). This protection stems from their greater price flexibility advantage over upstream countries. To cope with currency fluctuations, countries involved in downstream activities can pass on a part of the cost increase or decrease on their customers or suppliers, thereby mitigating the impact on trade and reducing their vulnerability to currency volatility. This is further supported by the higher coefficient of undervaluation for downstream countries in both the forward and backward linkages.

Comparing these coefficients with those reported in our baseline regressions (Table 2, columns c and f), we observe that the coefficient of undervaluation is higher for both the forward and backward linkages in the context of downstream countries. In the case of upstream countries, we also observe a relatively higher coefficient in absolute value for the backward linkage, while a smaller one is found for the forward linkage.

As per different interactions, they consistently align with the baseline findings for the forward linkage, irrespective of a country's position within the value chain. Similarly, when considering upstream countries, the coefficients remain consistent for the backward linkage.

Table 4. GVC Position and RER Undervaluation

	Forward Linkage: DVX		Backward Linkage: FVA	
	(a) Upstream	(b) Downstream	(c) Upstream	(d) Downstream
[1] Ln (Undervaluation)	0.157*	0.695***	-0.814***	2.861***
	(0.086)	(0.149)	(0.098)	(0.239)
[2] Ln (GDPPC)	0.443***	0.459***	0.337***	0.585***
	(0.014)	(0.015)	(0.016)	(0.024)
[1] * [2]	-0.073***	-0.127***	0.067***	-0.430***
	(0.010)	(0.017)	(0.011)	(0.027)
Ln (Tariff +1)	-0.005	-0.001	-0.083***	0.109***
	(0.004)	(0.004)	(0.006)	(0.009)
Ln (Rents)	-0.003**	0.009***	0.010***	0.007**
	(0.002)	(0.002)	(0.002)	(0.003)
[3] Government Effectiveness	-0.055***	-0.052***	-0.068***	-0.027**
	(0.009)	(0.008)	(0.011)	(0.012)
[4] Financial Development	0.197***	0.201***	0.189***	-0.055
	(0.025)	(0.026)	(0.028)	(0.042)
[5] Ln (Internet Usage)	-0.012***	-0.024***	0.025***	0.053***
	(0.004)	(0.003)	(0.004)	(0.006)
[1] * [3]	-0.211***	-0.129***	-0.236***	0.247***
	(0.017)	(0.020)	(0.019)	(0.031)
[1] * [4]	-0.293***	-0.599***	-0.291***	0.461***
	(0.053)	(0.070)	(0.060)	(0.112)
[1] * [5]	0.118***	0.207***	0.120***	0.214***
	(0.005)	(0.008)	(0.005)	(0.012)
Country and Year FE	Yes	Yes	Yes	Yes
Intercept	Yes	Yes	Yes	Yes
Mean of Dependent Variable	14.831	14.831	14.597	14.597
Observations	1,431	1,215	1,431	1,215

Rescaled standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

5. Robustness Checks

In order to check the robustness of our results, we first examine whether the impact of RER misalignment is primarily driven by positive values (undervaluation) or negative ones (overvaluation). Additionally, we assess the extent of misalignment, irrespective of whether it is undervalued or overvalued. Second, we run the regressions separately for different income groups, low-income countries, low-middle-income countries, upper-middle-income countries, and high-income countries.

5.1 Undervaluation vs Overvaluation

In our baseline specification, where RER is represented with its sign, we show that the sign of the deviation from the equilibrium level matters. However, an additional empirical question is whether the magnitude of the effects really depends on the sign. For developing countries, Rodrik (2008) finds that the positive effect of an increase of undervaluation on economic growth is just as powerful as the negative growth effect of overvaluation. Therefore, we examine whether the impact of RER misalignment is predominantly driven by positive values (undervaluation) or remains consistent regardless of whether the RER is undervalued or overvalued. We investigate this question by employing two distinct variables, as indicated by equation (4):

$$Ln\,(GVC_{it}) = \gamma_1\,|Misalignment_{it}| + \gamma_2\,(Misalignment_{it} * Dummy_{it}) \qquad (4)$$

Where $|Misalignment_{it}|$ is the absolute value of misalignment and ($Misalignment_{it}{*}Dummy$) is the misalignment interacted with a dummy variable taking the value 1 if RER misalignment > 0 (undervaluation) and 0 if RER misalignment < 0 (overvaluation). The equation incorporates all the control variables, quality of institutions and access to Internet variables, and fixed effects, as mentioned in equation 3.

Including the absolute value of RER misalignment allows us to capture the magnitude of RER disequilibrium irrespective of notions of undervaluation or overvaluation. Regarding the interaction between RER misalignment and the dummy variable, three scenarios are possible for γ_2. First, the coefficient can be statistically insignificant, suggesting no discernible difference between undervaluation and overvaluation. Second, it can be significant and positive, indicating that the impact is predominantly influenced by RER undervaluation. Third, it can be significant and negative, suggesting that the impact is driven by RER overvaluation.

Table 5 presents the findings for the forward and backward linkages (columns a and b, respectively). The results show that irrespective of whether the RER is overvalued or undervalued, misalignment exerts a substantial and statistically significant effect on the increase of domestic value added. Additionally, we observe a comparatively less significant but still positive impact on the foreign value added.

Regarding the interaction between misalignment and the dummy for undervaluation (=1), we find a highly significant and positive coefficient for both the forward and backward linkages.

This implies that the positive impact is primarily driven by the undervaluation level.[21] As per the coefficients obtained from the interaction of undervaluation with the government effectiveness index, the financial institutions efficiency index, and the share of Internet users, they consistently align with the baseline results for the forward and backward linkages.

Compared to the previous results (columns c and d, Table 2), we observe a smaller coefficient of the absolute value of misalignment than what we get when both the positive and negative values of misalignment are considered. However, when the coefficient of misalignment interacts with a dummy variable representing undervaluation, we find a higher coefficient for the backward linkage relative to what we observe when we keep both the positive and negative values. This pattern does not hold for the forward linkage. Additionally, when analyzing the coefficients of the interaction with variables gauging institutional quality and the level of digitalization, values prove significantly higher than those obtained when considering both undervalued and overvalued RER.

Table 5. GVC Participation and RER Misalignment – Undervaluation vs Overvaluation

	(a) Forward Linkage	(b) Backward Linkage
| Misalignment |	0.281***	0.0271*
	(0.0124)	(0.0162)
Dummy (1= Undervaluation)	0.0254***	0.0278***
	(0.00357)	(0.00469)
[1] Misalignment * Dummy (1= Undervaluation)	0.356***	1.412***
	(0.0776)	(0.104)
[2] Ln (GDPPC)	0.651***	0.656***
	(0.00870)	(0.0114)
[1] * [2]	-0.140***	-0.206***
	(0.00875)	(0.0117)
Ln (Tariff +1)	-0.008***	-0.014***
	(0.002)	(0.004)
Ln (Rents)	-0.006***	-0.006***
	(0.001)	(0.001)
[1] * Government Effectiveness	-0.314***	-0.0857***
	(0.0160)	(0.0209)
[1] * Financial Development	-0.531***	-0.359***
	(0.0504)	(0.0663)
[1] * Ln (Internet Usage)	0.176***	0.143***
	(0.00397)	(0.00517)
Country and Year FE	Yes	Yes
Intercept and Controls	Yes	Yes
Mean of Dependent Variable	14.831	14.597
Observations	2,649	2,649
Difference T-test: Undervaluation Vs Overvaluation	-0.612***	

Rescaled standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

5.2 Undervaluation and GVC Participation - Income Level

Undervaluation can have different effects depending on the level of development. With this variation in mind, previous models are rerun by taking into account the criterion of per capita income level (Table 6). For upper-middle-income countries, the impact is found to be positive and highly significant for the forward linkage, while insignificant for the backward one.

[21] The T-test reported in the last row in Table 5 shows that the difference between RER undervaluation and RER overvaluation is highly significant.

However, for lower-middle-income and high-income countries, undervaluation exerts a significantly negative impact on both the forward and backward linkages. These findings support the idea of complementarity between GVC-related FVA and DVA in production, as both DVA and FVA consistently exhibit the same sign. This suggests that producing and exporting less (more) DVA leads to a decrease (increase) in demand for imported FVA. It is worth noting that these findings may be influenced by the large proportion of undervalued upper-middle-income countries, as indicated in Table 1. Moreover, these results may help explain the negative correlation between RER undervaluation and GVC participation observed in developed countries (Figure 3 b, d). Finally, for low-income countries, undervaluation turns out to be insignificant. This might be due to the fact that the positive impact of undervaluation is contingent upon many factors, such as the size of the manufacturing sector. These countries, being primarily commodity (unprocessed) exporters, do not have the ability to integrate into a GVC, even with an undervalued currency.

Table 6. GVC Participation and RER Undervaluation – by Income Level

Ln (DVA): Forward Linkage	(a) Low-Income	(b) Low-Middle-Income	(c) Upper-Middle-Income	(d) High-Income
[1] Ln (Undervaluation)	1.065	-0.625**	0.334***	-0.881***
	(0.758)	(0.264)	(0.0934)	(0.0170)
Ln (GDPPC)	-0.0307	0.254**	0.900***	0.530***
	(0.208)	(0.109)	(0.0250)	(0.00500)
Ln (Tariff +1)	0.0126	-0.0549*	0.00764	-0.0202***
	(0.0215)	(0.0296)	(0.00742)	(0.00165)
Ln (Rents)	-0.0673	-0.0182	0.000189	0.00162***
	(0.0664)	(0.0184)	(0.00511)	(0.000456)
[2] Government Effectiveness	0.334**	0.105	-0.186***	0.103***
	(0.143)	(0.0657)	(0.0167)	(0.00323)
[3] Financial Development	-0.470	0.807***	0.342***	-0.137***
	(0.397)	(0.194)	(0.0616)	(0.00987)
[4] Ln (Internet Usage)	0.0653	-0.0586*	0.0315***	0.112***
	(0.0585)	(0.0318)	(0.00913)	(0.00174)
[1] * [2]	0.555	0.0378	0.0419	-0.0515***
	(0.440)	(0.144)	(0.0484)	(0.00544)
[1] * [3]	-1.724	0.622	-1.489***	-0.750***
	(1.096)	(0.487)	(0.174)	(0.0233)
[1] * [4]	0.378***	0.0810**	0.0881***	0.250***
	(0.102)	(0.0334)	(0.0133)	(0.00219)
Ln (FVA): Backward Linkage	(a) Low-Income	(b) Low-Middle-Income	(c) Upper-Middle-Income	(d) High-Income
[1] Ln (Undervaluation)	0.386	-0.644***	-0.279	-0.666***
	(0.402)	(0.0940)	(0.471)	(0.0953)
Ln (GDPPC)	0.540***	0.485***	0.424***	0.776***
	(0.114)	(0.0372)	(0.122)	(0.0282)
Ln (Tariff +1)	-0.0458	-0.0451***	0.0304	-0.141***
	(0.0386)	(0.0101)	(0.0466)	(0.0145)
Ln (Rents)	-0.227***	-0.0112*	0.00539	-0.00324
	(0.0361)	(0.00626)	(0.0259)	(0.00269)
[2] Government Effectiveness	0.558***	-0.207***	-0.126	0.150***
	(0.0787)	(0.0224)	(0.0865)	(0.0182)
[3] Financial Development	0.367*	-0.209***	0.546*	-0.219***
	(0.219)	(0.0674)	(0.312)	(0.0553)
[4] Ln (Internet Usage)	-0.0199	-0.00940	0.0761*	0.223***
	(0.0315)	(0.0108)	(0.0462)	(0.00978)
[1] * [2]	1.249***	-0.0596	0.137	0.107***
	(0.224)	(0.0509)	(0.247)	(0.0308)
[1] * [3]	-0.448	0.781***	0.148	-1.170***
	(0.596)	(0.166)	(0.877)	(0.131)
[1] * [4]	0.383***	0.142***	0.0779	0.270***
	(0.0599)	(0.0114)	(0.0668)	(0.0122)
Observations	178	715	664	1,083

Rescaled standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
All regressions include an intercept and country and year fixed effects.

To sum up, undervaluation has a positive and highly significant impact on both the forward and backward linkages. By employing an IV approach to address potential endogeneity concerns of undervaluation, our results align with the baseline regressions, indicating a stronger coefficient for undervaluation. We ensure the robustness of our findings through additional checks, and these findings consistently align with the baseline results.

6. Conclusion and Policy Implications

The increasing fragmentation of production processes sheds light on new patterns of production and trade and, therefore, the need to understand how trade in value added and intermediate inputs responds to exchange rate undervaluation. This paper explores this question by using an adequate estimator and controlling for a set of potentially concomitant factors (e.g., the income level, the quality of institutions, and the degree of digitalization). We show that undervaluation has a positive impact on the forward and backward components of GVC participation, and particularly benefits countries with a higher level of digitization. An undervaluation strategy proves counterproductive for countries with strong institutions. These findings remain robust when we control for the potential endogeneity of RER undervaluation using an IV approach. Expanding our analysis to consider a country's position within the value chain, we consistently observe a positive impact of undervaluation on the forward linkage, regardless of a country's position. However, for the backward linkage, the impact remains positive and highly significant for downstream countries while becoming negative for upstream ones. This may be attributed to the cushioning effect that downstream countries have over upstream ones due to the price flexibility advantage. Results prove robust after investigating whether the impact of RER is primarily influenced by positive values (undervaluation) or negative ones (overvaluation) and after running the regressions by income level.

From a policy lens, undervaluation can act as a second-best solution to mitigate the economic cost of poor institutions and market failures that more specifically penalize the tradable sector and value-added exports. A first-best policy would consist of identifying specific market failures and implementing tailored solutions. However, undervaluation can be perceived as a substitute for a comprehensive industrial policy in the presence of a manufacturing sector that is able to export. Moreover, the paper emphasizes the idea that the impact of RER undervaluation on trade flows is not the same across countries. Many aspects, including the level of financial development, the quality of institutions, and the degree of digitalization, should be considered. Hence, to maintain the positive effect of RER undervaluation, the exchange rate policy should be coupled with other policies. Nonetheless, while this policy is doable in the short term, it is not sustainable in the long run and deeper reforms to improve institutions and have a higher level of digital transformation are needed.

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Appendix A: Variables Description

Table A2. Variables Definition

Variable	Definition	Source	Coverage
XR	Exchange rate, national currency/USD.	WDI	1995-2018
PPP	Purchasing power parity.	WDI	1995-2018
Ln (DVA)	Ln of the domestic value added of this country, which is embodied in the exports of other countries. This corresponds to the forward GVC participation component of the participation index.	UNCTAD-EORA	1995-2018
Ln (FVA)	Ln of the foreign value added which is embodied in this country's exports. This corresponds to the backward GVC participation component of the GVC participation index	UNCTAD-EORA	1995-2018
Ln (GDPPC)	Ln of the real GDP per capita, Constant 2015.	WDI	1995-2018
Ln (Tariff +1)	Ln of the weighted mean tariff rate (applied) +1 imposed on the exports of country i by its main trade partners for the case of DVX or the average tariff imposed by country i on the exports of other countries for the case of FVA.	WDI	1995-2018
Ln (Rents)	Ln of total natural resources rents value, which are the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents.	WDI	1995-2018
Gvt. Eff.	Government effectiveness reflects the quality of public and civil services and the degree of their independence from political pressures. The estimate ranges from -2.5 (weak) to 2.5 (strong) governance performance.	WGI	1995-2018
Ln (Internet Usage)	Ln of individuals using the Internet (percentage of the population).	WDI	1995-2018
Fin. Inst. Efficiency	Includes data on banking sector net interest margin, lending-deposits spread, non-interest income to total income, overhead costs to total assets, return on assets, and return on equity.	IMF	1995-2018

Table A3. Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Ln (DVA)	2652	14.831	2.521	9.018	20.342
Ln (FVA)	2652	14.597	2.63	8.321	20.59
Ln (Undervaluation)	2652	-.001	.354	-.986	1.251
Ln (GDPPC)	2652	8.831	1.427	5.614	11.63
Ln (Tariff_imposed +1)	2652	1.683	.736	0	5.023
Ln (Tariff_faced +1)	2652	.618	.763	0	3.385
Ln (Rents)	2652	20.036	3.932	0	27.178
Government Eff. Estimate	2652	.258	.941	-2.14	2.43
Financial Efficiency Index	2652	.569	.118	.093	.845
Ln (Internet Usage)	2652	2.973	1.308	0	4.612

Source: Authors' own calculations.

Appendix B: Real Exchange Rate Undervaluation Index

Following Rodrik (2008), the index of undervaluation is estimated following three steps. First, data from the WDI on exchange rates (XR) and purchasing power parity conversion factors (PPP) expressed as national currency units per US dollar and controls for price level differences with respect to the US economy from the WDI[22] are used to calculate a RER as follows:

$$Ln\,(RER_{it}) = Ln\left({XR_{it}}/{PPP_{it}}\right) \qquad (1)$$

Where i and t denote country and year, respectively. A RER value greater than one indicates that the currency is more depreciated than indicated by PPP. Nevertheless, through the Balassa-Samuelson effect, the relative prices of non-tradables tend to increase as countries become richer due to higher productivity in tradables. However, non-tradables are cheaper in poorer countries. Hence, in a second step, we account for this effect by regressing Ln (RER) on real gross domestic product per capita (GDPPC), supposed to proxy the productivity level, as follows:

$$Ln\,(RER_{it}) = \beta_0 + \beta_1\, Ln\,(RGDPPC_{it}) + f_t + \varepsilon_{it} \qquad (2)$$

Where f_t denotes year fixed effects and ε_{it} is the disturbance term. The regression (Table A1) yields an estimate beta ($\hat{B}_1 = -0.25$ with a high t-statistic of around 48.31) close to the beta ($\hat{\beta} = -0.24$) estimated by Rodrik (2008). This result suggests a strong estimated Balassa-Samuelson effect as it shows that an increase of income by 10 percent leads to a decrease of RER by 2.5 percent (Table A1). As a final step, RER undervaluation is estimated as the difference between the actual RER and the predicted one as follows:

$$Ln\,(Undervaluation_{it}) = Ln\,(RER_{it}) - Ln\,(\widehat{RER_{it}}) \qquad (3)$$

Where $Ln\,(\widehat{RER_{it}})$ is the predicted RER from equation (2). A positive value corresponds to RER undervaluation and a negative one corresponds to overvaluation. Figure A1 depicts the distribution of the undervaluation measure which is centered at zero and has a standard deviation of 0.38.

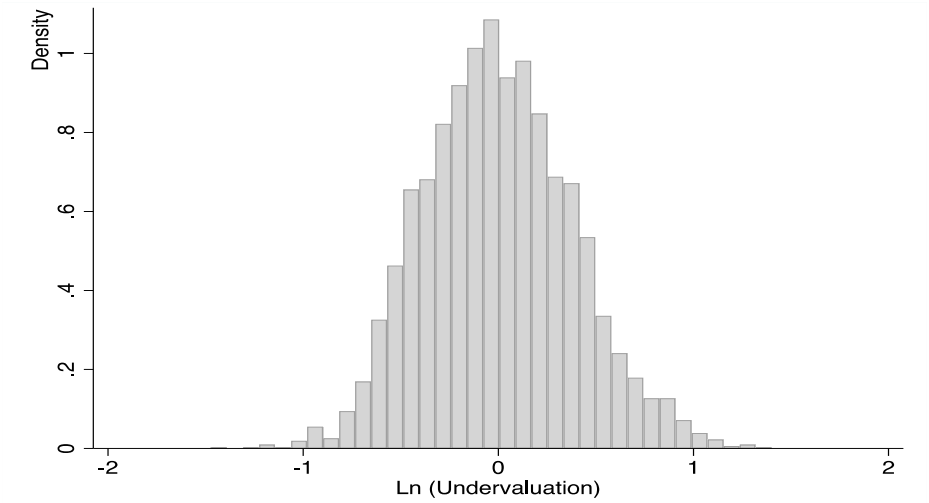
Table A1. RER Adjusted for Balassa-Samuelson Effect

	Ln (RER)
Ln (GDPPC)	-0.249***
	(0.005)
Constant	3.038***
	(0.048)
Year FE	Yes
Observations	3,735
R-squared	0.434

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

[22] Following Rodrik (2008), we estimate the RER using data from the Penn Worlds Table version 7.1 and the results are in line with our findings using the WDI.

Figure A1. Distribution of the Undervaluation Measure Across Countries (1995-2018)



Source: Authors' own calculations.
Note: Positive (negative) values correspond to RER undervaluation (overvaluation).

Appendix C: Countries in the Sample

Low-Income	Upper-Middle-Income	High-Income
Burundi	Argentina - TFYR Macedonia	Antigua – Malta
Central African Republic	Armenia - Thailand	Aruba – Netherlands
Gambia	Azerbaijan - Turkey	Australia – New Zealand
Madagascar	Bosnia and Herzegovina	Austria – Norway
Malawi	Botswana	Bahamas – Oman
Mali	Brazil	Bahrain – Poland
Mozambique	Bulgaria	Barbados – Portugal
Niger	China	Belgium – Qatar
Rwanda	Colombia	Bermuda - Seychelles
Sierra Leone	Costa Rica	Brunei Darussalam – Singapore
Uganda	Dominican Republic	Canada – Slovak Republic
Low-Middle-Income	Ecuador	Chile – Slovenia
Algeria - Gaza Strip	Fiji	Croatia – South Korea
Angola - Ghana	Gabon	Cyprus – Spain
Bangladesh - Haiti	Georgia	Czech Republic – Sweden
Bhutan - Honduras	Guatemala	Denmark – Trinidad and Tobago
Bolivia - India	Jamaica	Estonia – United Arab Emirates
Cambodia - Indonesia	Jordan	Finland – United Kingdom
Cameroon - Iran	Kazakhstan	France – United States of America
Cape Verde - Kenya	Lebanon	Germany - Uruguay
Côte d'Ivoire - Kyrgyzstan	Malaysia	Greece
Egypt - Lao PDR	Maldives	Hong Kong
El Salvador - Lesotho	Mauritius	Hungary
Mauritania - Mongolia	Mexico	Iceland
Morocco - Myanmar	Montenegro	Ireland
Nepal - Nicaragua	Namibia	Israel
Nigeria - Pakistan	Panama	Italy
Philippines - Sao Tome and Principe	Paraguay	Japan
Senegal - Sri Lanka	Peru	Kuwait
Swaziland - Tajikistan	Romania	Latvia
Tanzania - Togo	Russia	Lithuania
Tunisia – Ukraine - Uzbekistan	South Africa	Luxembourg
Vietnam - Zambia	Suriname	Macao SAR

Source: Authors' own elaboration following the World Bank online classification.

Appendix D: Unit-root and Cointegration Tests

To test for the stationarity of the series, we rely on three main unit-root tests.

The first is the Im-Pesaran-Shin test (Im et al., 2003), which tests the null hypothesis (all panels contain unit roots) against the alternative hypothesis (some panels are stationary).

The second is the Harris-Tzavalis test (Harris and Tzavalis, 1999), which tests a more flexible null hypothesis (panels contain unit roots) against the same alternative hypothesis of the latter.

The third is the Fisher test (Choi, 2001), which tests the same null hypothesis of the Im-Pesaran-Shin test but a broader alternative hypothesis (at least one panel is stationary).

Table A4 shows that the results of the three tests are in line as they confirm that the components of GVC, exchange rate undervaluation, and GDPPC are I(1), i.e., integrated of order one, and tariffs, financial development, and digitalization indicators are stationary.

Table A4. Unit-root Tests

	Ln (DVA)		Ln (FVA)		Ln (Undervaluation)	Ln (GDPPC)	
Test		1st diff.		1st diff.			1st diff.
Fisher Unit-Root Test							
H_0: All panels contain unit roots							
H_a: At least one panel is stationary							
Inverse chi-squared	1.000	0.000	1.000	0.000	0.000	0.551	0.000
Inverse normal	0.999	0.000	1.000	0.000	0.000	1.000	0.000
Inverse logit	0.991	0.000	1.000	0.000	0.000	1.000	0.000
Modified inv. Chi-squared	1.000	0.000	1.000	0.000	0.000	0.561	0.000
Im-Pesaran-Shin Test							
H_0: All panels contain unit roots							
H_a: Some panels are stationary							
Z-t-tilde-bar	0.969	0.000	1.000	0.000	-	-	-
Harris-Tzavalis Test							
H_0: Panels contain unit roots							
H_a: Some panels are stationary							
rho	1.000	0.000	1.000	0.000	-	-	-

	Ln (Tariffs)		Ln (Rents)		Ln (Int Usage)	Fin Dev	Gvt. Eff.	
				1st diff.				1st diff.
Fisher Unit-Root Test								
H_0: All panels contain unit roots								
H_a: At least one panel is stationary								
Inverse chi-squared		0.000	0.2629	0.000	0.000	0.000	0.4485	0.000
Inverse normal		0.000	0.0021	0.000	0.000	0.000	0.4517	0.000
Inverse logit		0.000	0.0031	0.000	0.000	0.000	0.4293	0.000
Modified inv. Chi-squared		0.000	0.2682	0.000	0.000	0.000	0.4586	0.000
Im-Pesaran-Shin Test								
H_0: All panels contain unit roots								
H_a: Some panels are stationary								
Z-t-tilde-bar		-	-	-	-	0.000	0.3728	0.000
Harris-Tzavalis Test								
H_0: Panels contain unit roots								
H_a: Some panels are stationary								
rho		-	-	-	-	0.000	0.0087	0.000

Note: The table reports the p-values for each test.

Some p-values cannot be estimated for Im-Pesaran-Shin and Harris-Tzavalis because they require strongly balanced data.

Table A5. Panel Cointegration Tests

Test	(a) Forward Linkage (DVA) P-value
Kao Test for Cointegration	
H_0: No cointegration	
H_a: All panels are cointegrated	
Modified Dickey-Fuller t	0.0012
Augmented Dickey-Fuller t	0.0001
Pedroni Test	
H_0: No cointegration	
H_a: All panels are cointegrated	
Modified Phillips-Perron t	0.0000
Phillips-Perron t	0.0000
Augmented Dickey-Fuller t	0.0000
Test	(b) Backward Linkage (FVA) P-value
Kao Test for Cointegration	
H_0: No cointegration	
H_a: All panels are cointegrated	
Modified Dickey-Fuller t	0.0000
Augmented Dickey-Fuller t	0.0000
Pedroni Test	
H_0: No cointegration	
H_a: All panels are cointegrated	
Modified Phillips-Perron t	0.0000
Phillips-Perron t	0.0008
Augmented Dickey-Fuller t	0.0175

Note: The table reports the p-values for each test.

Appendix E: Robustness Checks

Table A6. Instrumental Variable Approach – First Stage

	Forward Linkage	Backward Linkage
Ln (Undervaluation)	(1)	(2)
Leave-One-Out Mean by Region and Year	-	0.851***
		(0.0435)
Ln (Undervaluation_Partner)	0.0876***	-
	(0.0142)	
Leave-One-Out Mean by Common Characteristics	2.789***	2.372***
	(0.523)	(0.492)
Ln (Tariff +1)	0.00884	-0.0340***
	(0.00661)	(0.00869)
Ln (Rents)	0.00982***	0.0107***
	(0.00368)	(0.00348)
Ln (GDPPC)	0.0181	0.0106
	(0.0251)	(0.0234)
Government Effectiveness	0.0182	-0.00180
	(0.0167)	(0.0159)
Financial Development	-0.190***	-0.225***
	(0.0441)	(0.0414)
Ln (Internet Usage)	-0.0690***	-0.0479***
	(0.00712)	(0.00685)
Country and Year FE	Yes	Yes
Intercept	Yes	Yes
Observations	2,629	2,652
Endogeneity Test		
H0: Variables are Exogenous		
Durbin (score) chi2 (1)	(0.0000)	(0.0002)
Wu-Hausman F (1,2620)	(0.0000)	(0.0002)
Weak Identification Test		
Cragg-Donald Wald F Statistic	34.70	206.3
Overidentification Test		
Sargan Statistic	0.5054	0.4790

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Note: We have two different first stages for the backward and forward linkages as tariffs are not the same for both. For the endogeneity test, p-values are reported in parentheses.