On GVCs and Innovation: What is at Stake?

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Abstract

This paper empirically investigates the impact of global value chains (GVCs) participation on countries' innovation performance. Highlighting the learning effect of foreign knowledge embedded in imported intermediate goods counters the argument that GVCs participation is biased towards developed countries with skilled labor abundance. We construct the foreign knowledge weighted GVCs index by merging the EORA26 and R&D. Results show a positive and significant effect of the GVCs index on innovation measured by resident patent per capita. Likewise, we show that the quality of institutions, intellectual property agreements, competition policy and trade policy constitute a pile of interfering preconditions in the nexus between GVCs participation and innovation. In particular, our results show that non-tariff trade costs negatively interact with GVCs participation as well as with intellectual property agreements while the latter interacts positively with the competition index. Our results remain robust when we use an instrumental variable approach to control for the endogeneity between GVCs and innovation and when we use alternative measure for our two variables of interest.

Keywords: Global Value Chains; innovation; R&D; technological change
JEL Classification: F(14); O(31)

1. Introduction

In recent years, the mounting trend of global value chains (GVCs) participation has slowed due to lowered global investments accompanied with the absence of major liberalization initiatives (World Bank, 2020). The "slowbalization" wave is further augmented with the aftermath of the COVID-19 pandemic crisis witnessing deliberate decoupling to unbind the interdependence between industries and countries and therefore prevent the domino effect stirring in crises (Coveri et al., 2020). In this respect, studying the benefits of outsourcing at the country level is crucial to scrutinizing the tradeoff of "reshoring" activities. Beside the conventional theories emphasizing the gains of GVCs participation in terms of trade (Feenstra and Hanson, 1996; Grossman and Rossi-Hansberg, 2008; Baldwin, 2013), trade in value added is indeed advantageous in other facets. This paper studies the impact of GVCs participation on innovation.

Similar to the reviewed nexus between trade in final goods and innovation (Keller, 2004; Alessandria et al., 2021; Ackigit and Melitz, 2021), GVCs participation is ordinary to have a knowledge driven effect. Backward participation linkages to GVCs transmit embedded foreign knowledge to destination countries that can be signaled by countries' innovation performance over time. During the years from 1995 till 2003, foreign knowledge enhanced productivity growth by 0.4% and the former led to more than doubling domestic productivity in developing countries from the year 2004 to 2014 (Aslam et al., 2018). Undeniably, the gains of international fragmentation of production in terms of technological spillovers are still subject to empirical exploration. Our study highlights the impact of backward linkages to GVCs participation on innovation through a quantitative model. Results emphasize the potential prospect for developing countries in realizing innovation driven economic growth[1].

Using the simple[2] offshoring definition, we synthesize the gains of GVCs participation in terms of innovation by empirically estimating the impact of foreign knowledge weighted GVCs on resident patent per capita. Auxiliary interfering factors in the GVCs learning effect are empirically explored namely business environment, institutions, world trade organization (WTO) membership, intellectual property (IP) agreements, trade policy and competition policy. Indeed, foreign knowledge spillovers are particularly central for developing countries disadvantaged in technology production. On a flipside however, the learning effect of GVCs participation is constrained with prevalent mitigating conditions. First, developing countries are underprivileged with rule of law as a subfactor of institutions' quality. Second, strengthening IP rights through trade related aspects of intellectual property rights (TRIPS)[3] deep trade agreement is argued to be biased towards higher income countries exporting technology. Third, unapt non-tariff trade costs in developing countries discourages foreign exporters of technology (UNCTAD, 2022) and consequently hinders foreign knowledge spillovers. Fourth, lax competition policy disincentivizes innovation (Goto, 2009). Disentangling the impact of the stated preconditions is crucial to pledging the learning effect of

[1] Economic growth is either factor driven, investment driven, or innovation driven (Raghupathi and Raghupathi, 2019). The share of innovation driven growth accounts to more than 50% of economic growth drivers (OECD, 2005; Kayal, 2008).

[2] The simple definition is limited to intermediate goods' crossing borders at least once. The complex definition of vertical specialization guarantees the reexporting of intermediate imports.

[3] Article 31 in the amended agreement provides WTO members with special licenses to produce and export medicines to other members having insufficient domestic production.

GVCs participation. We contribute to the existing literature by studying the multifactorial mitigating dynamism which is novel to the empirically reviewed nexus between GVCs and innovation. The evidence-based policies provided by this paper paves to the ninth global goal[4] of the United Nations sustainable development goals (SDGs) intended to be achieved by the year 2030.

This paper is composed of six sections structured as follows: Section 2 presents a review of literature on GVCs and innovation. Section 3 presents stylized facts and data trends in different income groups within the time frame from 1990 till 2019. Section 4 presents the econometric specification and data description. Section 5 presents the empirical results of the effect of foreign knowledge weighted GVCs on resident patent per capita in a panel of 83 countries over a time span of 30 years. Section 6 concludes and offers policy implication to the end of fostering innovation particularly in lower-middle income countries.

2. Literature Review

The effect of foreign knowledge weighted GVCs on domestic innovation is addressed by blending two strands of literature. The first strand summarizes the association between GVCs and domestic innovation, whereas the second strand is related to measuring knowledge spillovers and endogenizing innovation.

Within the international economics literature, a wide strand focuses on value creation through trade in intermediate goods (Johnson and Noguera, 2012; Antràs and Chor, 2013; Castellani et al., 2015; Aichele and Heiland, 2018; Lee and Yi, 2018;). Beside the decrease in marginal cost resulting from specialization, increased production due to GVCs participation can be rationalized by increased productivity due to the technological change channeled through imports of intermediate goods (Grossman and Helpman, 1991; Schmidt, 1997; Kasahara and Rodrigue, 2008). Despite the conventional concern of the possible adverse effect of GVCs participation on developing countries in terms of the relative wages of low skilled labor (Kaplinsky, 2000; Rodrik 2018), a number of optimistic studies emphasize that intermediaries' trade generates learning and innovation activities (Schmitz and Knorringa, 2000; Gereffi et al., 2005; Giuliani et al., 2005) leading to technological change. Notably, the transfer of technological knowledge through GVCs is governed by the nature of the relationship and the distance among GVCs participants (OECD, 2017).

GVCs participation can play a crucial role in international knowledge and innovation sharing. Indeed, the industry's performance in GVCs enhances innovation (OECD, 2013 a and b) since the quality of products is deliberately upgraded to face the demand of foreign supply chains. However, the estimated positive impact depends chiefly on absorptive capacities (Corrado et al., 2013). Primarily, developing countries' GVCs participation is deterred by a handful of obstacles rooted in persistent preconditions and strategic behavior (Bell and Albu, 1999; Schmitz, 2004). Likewise, a noteworthy stream in literature argues that the degree of upgrading in GVCs is endogenous to the nature of home institutions (Werner, 2012; Barrientos et al., 2016; Pipkin and Fuentes, 2017; Kano and Tsang, 2020), and the business environment (Dovis and Zaki, 2020). Arguably, the mitigating effect of weak institutions can eventually be alleviated by gaining knowledge through enhanced GVCs participation (Kano, 2018). Fortunately, digitalization has recently facilitated

[4] SDG 9 aims at building resilient infrastructure, promoting industrialization, and fostering innovation.

GVCs participation particularly in developing countries facing high trade costs and prohibitive conditions (World Bank, 2020).

Importing intermediate goods is a channel for technological change due to the potential for foreign knowledge spillovers (Keller, 2002; Keller, 2004). Although knowledge is tacit and difficult to measure, imported value added embed spillovers that can be mirrored in foreign R&D stock endowed in partner countries exporting intermediate goods (Coe and Helpman, 1995; Maskell and Malmberg, 1999; Cowan and Jonard, 2004; Zhang, 2020). Empirically, a rich strand of literature examined international knowledge diffusion across countries (Coe and Helpmann, 1995; Eaton and Kortum, 1999; Gong and Keller, 2003; Keller, 2004; Bottazzi and Peri, 2007; Coe et al., 2009; Bloom et al., 2013; Malerba et al., 2013; Bloom et al., 2016). While few results imply a negative short-run effect of GVCs participation on innovation in countries with low absorptive capacity (Pietrobelli, 2008; Farole and Winkler, 2014), the effect is nevertheless open for empirical investigation. Recently, the nexus between GVCs and innovation is empirically tested using various cross-sectional regressions for 74 developing countries (Gehl Sampath and Vallejo, 2018). Results show that innovation interacts with GVCs to foster learning and technological upgrading at the country level. Similarly, the positive effect of GVCs participation on innovation is empirically recognized for European countries relying on the WIOD dataset (Tajoli and Fellice, 2018).

A comprehensive body of literature endogenized innovation using patent per capita (Scotchmer and Green, 1990; Horowitz and Lai, 1996; O'Donoghue and Zweimuller, 2004; Bottazzi and Perri, 2007; Bloom et al., 2013; Malerba et al., 2013; Tajoli and Fellice, 2018). According to the conceptual innovation framework, R&D personnel and R&D expenditures are inputs to innovation, whereas patenting is the indicator of knowledge creation (Raghupathi and Raghupathi, 2019). While patenting is a direct innovation measure, it is considered an underestimation for two reasons. First, several goods are unpatentable due to their intangible nature (Corrado et al., 2013). Second, although patenting is associated with higher firms' exports (Aghion et al, 2018), some inventors intentionally follow trade secrets' strategies as a substitute to patenting aiming at preserving their competitive advantage (Crass et al., 2019). Recent variations in domestic patenting activities across countries is justified by different level of development, size of country, and R&D (WIPO, 2021). Literature on trade and innovation highlight the correlation between trade policy and patents. Higher tariff rates for example, negatively affect patents for developed and developing countries alike (Vishwasrao et al., 2007). Likewise, the effect of non-tariff measures (NTMs) is of particular importance in countries of the South where infrastructure deficiency augments trade costs (Beghin et al., 2015). Indeed, a harmonized set of trade policy regulations minimizes mismatches leading to positive externalities' diffusion of GVCs in ICT goods (Ghodsi et al., 2021).

Although developing countries have a technological change opportunity by absorbing knowledge spillovers resulting from linking economies through GVCs integration (Mudambi, 2008), knowledge transmission is constrained by a pile of prevalent conditions (Ghallini and Wright, 1990). First, innovation catchup necessitates institutional change (Buckley et al., 2020). The share of locally sourced inputs through foreign investors is largest in countries with strong rule of law (Amendolagine et al., 2019). Second, appropriate IP rights orchestrate the positive effect of GVCs participation on innovation (Ali and Rouvinen, 2015). Equally relevant, adequate enforcement generates the externalities effect (Bennato and Giulietti, 2019). Third, oil dependence induces

mitigating conditions to innovation (Namazi and Mohamadi, 2018). Fourth, competition incentivizes innovation (Marshall and Parra, 2019) whilst competition legislation and effectiveness are middling in Arab countries (Youssef and Zaki, forthcoming).

In light of the summarized theoretical and empirical strands of literature, this paper contributes to the recognized research gap in two respects. First, our dataset includes central beneficiaries namely lower-middle and low-income countries that are excluded from previous studies despite their technological disadvantage. Second, our identification strategy incorporates the multifactorial dynamism interfering in the GVCs and innovation nexus which is novel to the literature.

3. Stylized Facts

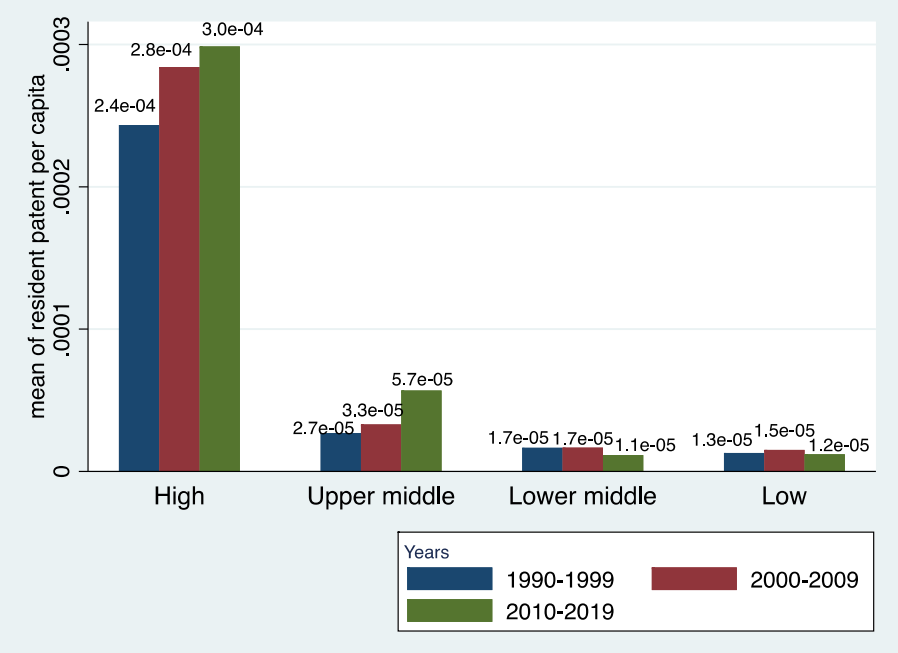
Testing the hypothesis that GVCs participation stimulates domestic innovation is grounded on three stylized facts. First, innovation is spatially concentrated. Second, imported value added embed foreign knowledge to destination countries. Third, a pile of mitigating conditions interferes in the knowledge spillover effect of GVCs. In this section, each stylized fact is synchronized with data demonstrations.

3.1 Innovation is spatially concentrated

Despite the free movement of factors of production, innovation is nevertheless clustered in high income countries (Marshall, 1890; Jaffe and Trajtenberg, 1999; Gassler and Nones, 2008). Figure 1 presents the vast discrepancies in domestic innovation measured by resident patent per capita between high income and subsequent income groups[5]. As shown, throughout the last three decades, high income countries are the front-runners of innovation with prolonged positive innovation growth rate across decades. Upper middle-income group has exceptionally experienced the highest growth rate percentage of 72% solely during the last decade compared to a 22.2% in the preceding decade. As an opposite pattern, both lower-middle and low-income groups experienced a negative innovation growth rate on average during the last decade compared to a stagnant innovation growth in lower-middle income group and a 15.3% increase in low-income group in the preceding decade.

[5] A list of countries with the corresponding income group is available in appendix 1.

Fig. *1* Resident patent per capita across income groups on average from the year 1990 till 2019



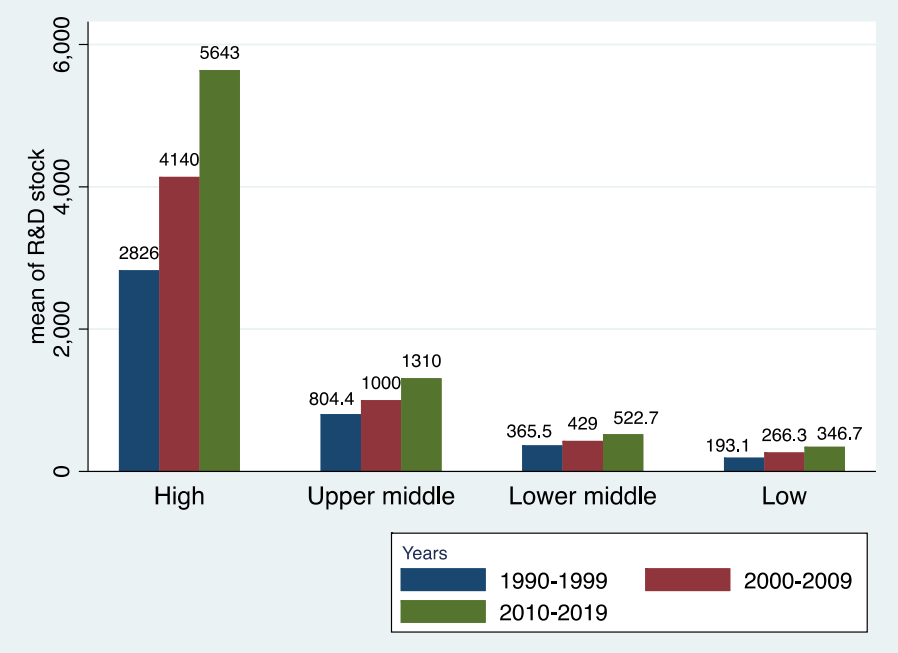
Source: Own construction based on WDI dataset using Stata

3.2 Imported value added embed foreign knowledge

Tacit knowledge embedded in imported intermediaries is a potential innovation channel for technology disadvantaged income groups. Although knowledge is intangible and difficult to measure, its foremost description that makes it measurable, is that it is embodied in human capital depicted in R&D stock. Knowledge spillovers to destination (importing) countries are signaled by R&D stock located in origin (exporting) countries. As shown in figure 2, during the previous decade, high income group is 4.3, 10.8, and 16.3 times richer in R&D stock on average than upper middle, lower-middle and low-income groups respectively. The discrepancies highlight the opportunity for developing countries to absorb foreign knowledge provided sufficient engagement in international production networks. Figure 3 presents the share of foreign knowledge weighted GVCs (GVCRD[6]) on average in different income groups from the year 1990 till 2019. Indeed, the less the countries' endowment in domestic R&D stock, the higher the foreign knowledge spillovers through GVCs participation. As shown in figure 3, GVCRD is highest at low-income group and decreases at higher levels of income.

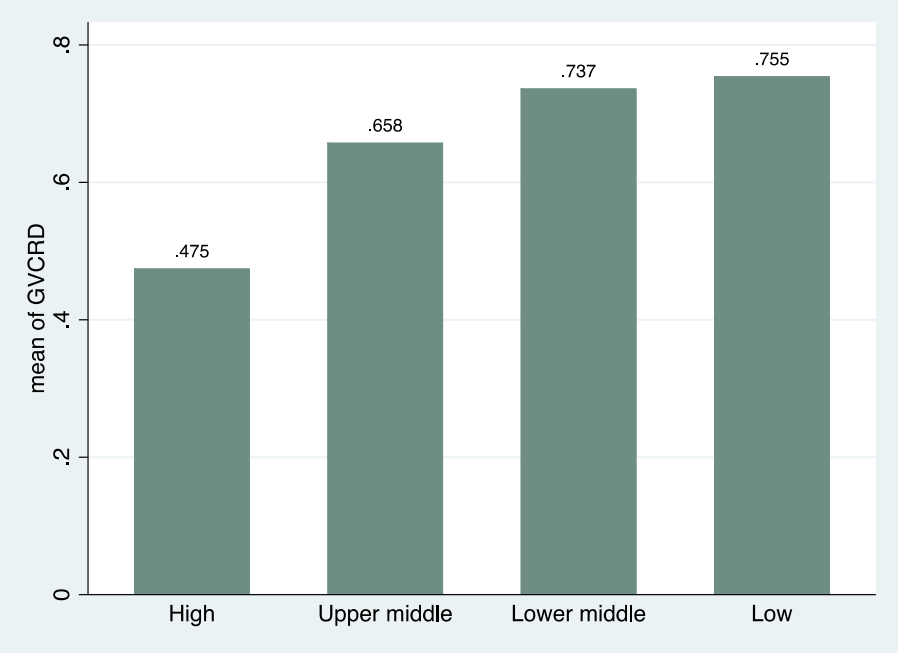
[6] Measurement details are provided in section 4.

Fig. 2 R&D stock (per million of the population) on average across income groups from the year 1990 till 2019



Source: Own construction based on WDI dataset

Fig.3 Share of foreign knowledge weighted GVC on average across income groups from the year 1990 till 2019



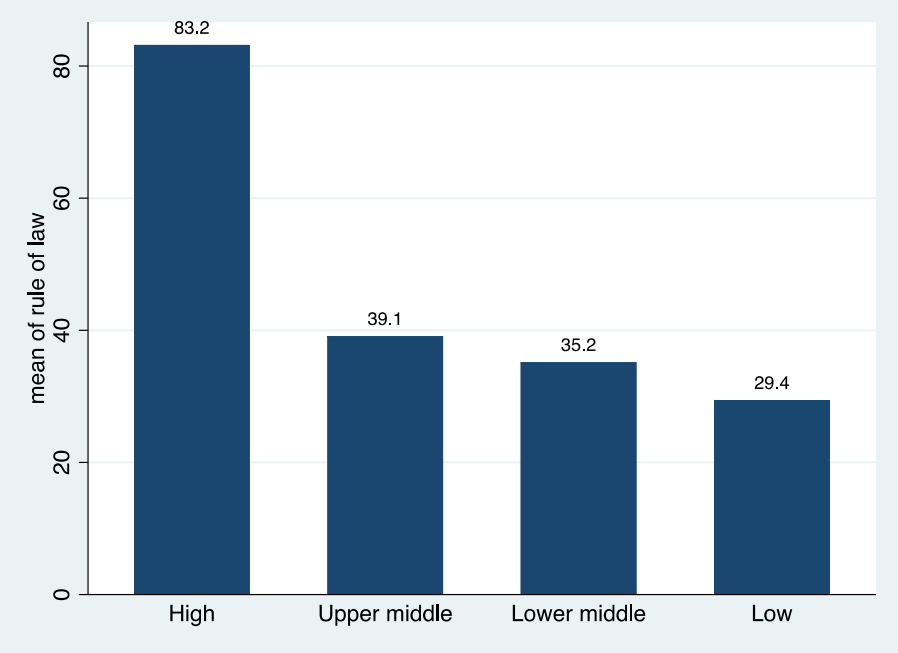
Own calculations based on merging EORA26 and WDI datasets

3.3 Knowledge spillovers' preconditions

As mentioned in section 2, a pile of conditions interferes in the nexus between GVCs and innovation including rule of law, IP agreements, trade policy and competition policy. Figure 4 presents rule of law on average at different income groups from the year 1990 till 2019. As

presented, rule of law is substantially higher on average in the high-income group compared to subsequent income groups.

Fig. 4 Rule of law across income groups on average from the year 1990 till 2019

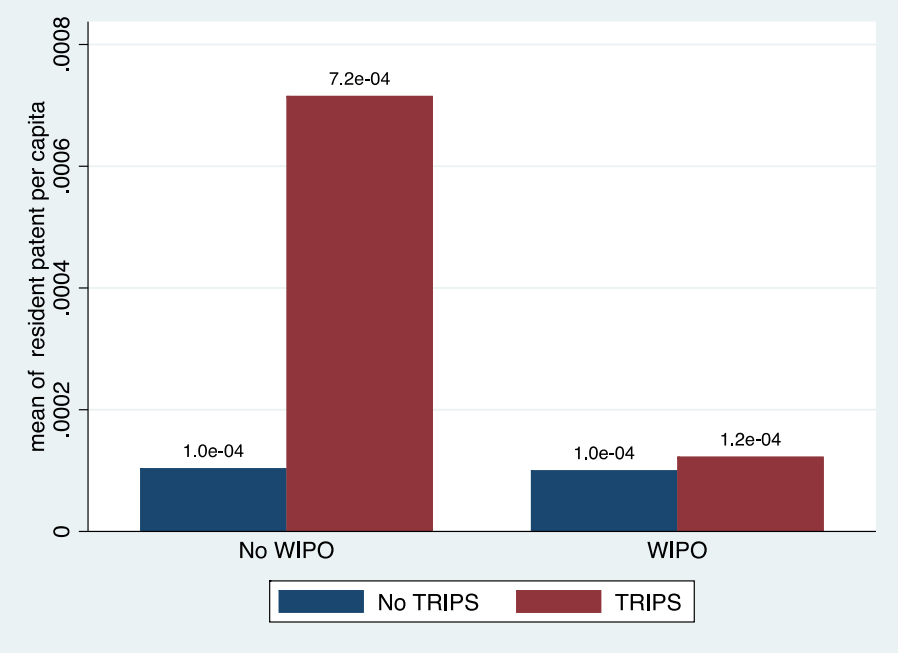


Source: Own calculations based on World Governance Indicators Datasets

Figure 5 presents resident patent per capita on average against two IP agreements namely world intellectual property organization (WIPO) and TRIPS deep trade agreement from the year 1990 till 2019. Data evidence conflicting trajectories of the two agreements in incentivizing innovation. As presented, countries involved in TRIPS exclusive of WIPO are achieving seven times higher resident patent per capita on average than countries involved in both WIPO and TRIPS. Figure 6 presents country average resident patent per capita against trade policy. Figure 6 a shows negative association between resident patent per capita and tariffs. Likewise, figure 6 b shows negative association between the former and non-tariff costs. Figure 7 presents country average resident patent per capita against competition proxied by the effectiveness of anti-monopoly law index showing a positive association between the two variables.

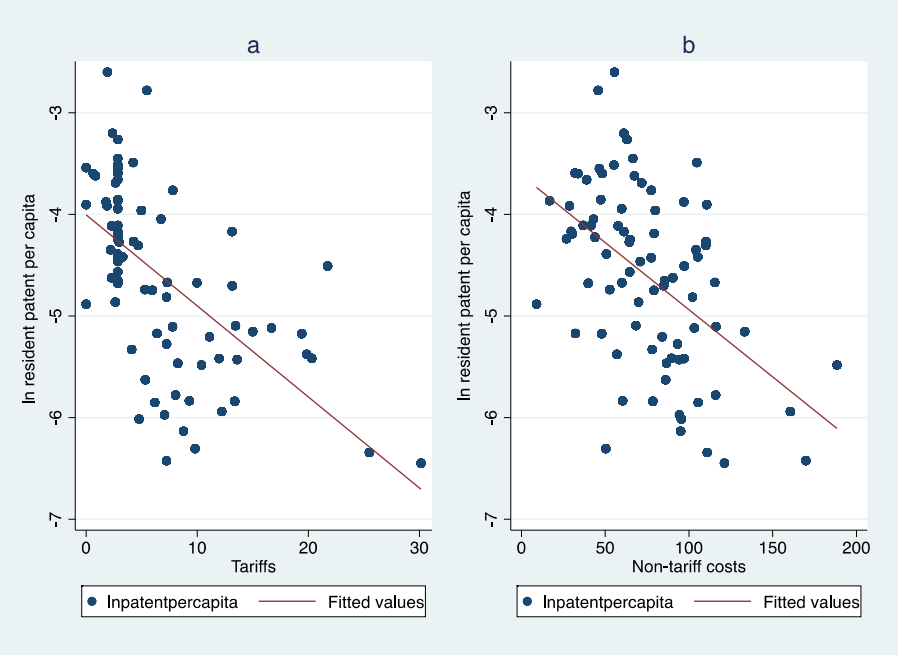
Data shows association between resident patent per capita and IP agreements, trade policy and competition, yet econometric modelling is necessary to capture the effect of each precondition on innovation along with its interaction with GVCs.

Fig. 5 Resident patent per capita against intellectual property rights agreements on average from the year 1990 till 2019



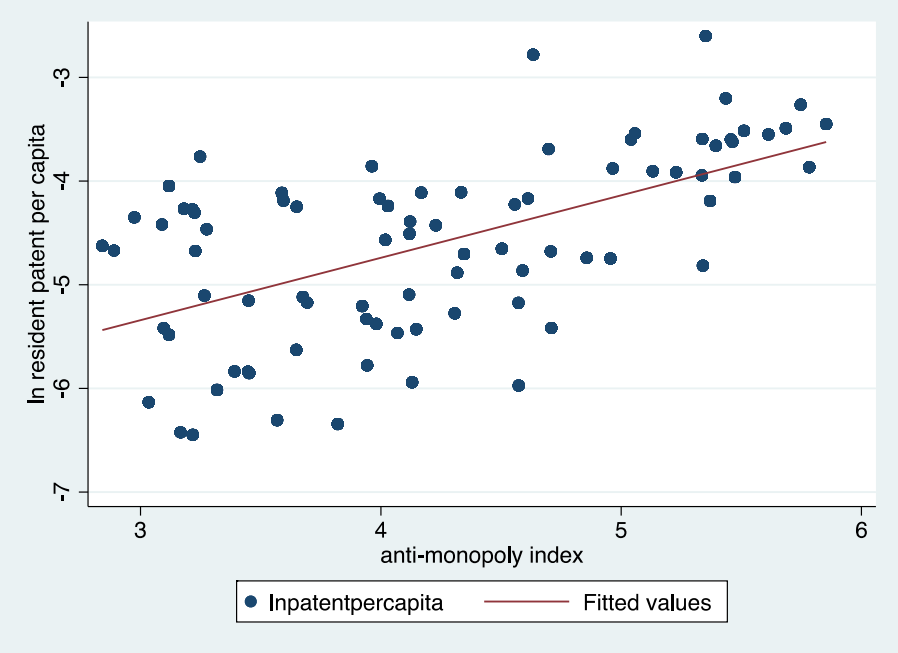
Source: Own calculations based on World Bank Deep Trade agreements' and WIPO Datasets

Fig. 6 Country average resident patent per capita against trade policy



Source: Own calculations based on WDI and ESCAP-World Bank Datasets

Fig. 7 Country average resident patent per capita against competition policy



Source: Own calculations based on WDI and Global Competitiveness World Economic Forum Datasets

4. Methodology and Data

Following Tajoli and Felice (2018), our econometric model estimates the effect of foreign knowledge weighted GVCs on resident patent per capita. From numerous GVCs definitions, the Feenstra and Hanson (1996) offshoring indicator[7] is used in measuring the variable of interest. To construct the variable of interest, the input output value added tables in EORA26 database[8] (Johnson, 2018; Lenzen et al., 2012 and 2013) is merged with R&D. The constructed variable of interest (GVCRD) is the share of foreign knowledge weighted value added absorbed in total knowledge weighted value added. Hence, for each destination (importer) country, value added imported from an origin country is multiplied by the corresponding R&D stock in the origin country. Then, the summation is divided by the total R&D weighted value added including the domestic value added.

Equation (1) presents the calculation of the share of foreign knowledge weighted GVCs.

$$\text{GVCRD}it = \frac{\sum_i^t VA\ ijt * RDjt}{(\sum_i^t VA\ ijt * RDjt) + (DVAit * RDit)} \qquad (1)$$

Where i is the destination (importing) country, j is the origin (exporter) country, t is time in years,

[7] Share of foreign value added absorbed through imported intermediate goods to the total value added of intermediate goods including the domestic value added.

[8] The database includes 189 countries from 1990 till 2019. All countries are aggregated to a common 26 sector classification.

VA is the imported value added, DVA is the domestic value added, and RD is the R&D stock[9].

Using fixed effects regression, our model aims at emphasizing the foreign learning effect of backward participation linkages to GVCs participation. Our contribution to the original model is twofold. First, we rely on a EAORA26 in constructing the share of foreign knowledge weighted GVCs indicator allowing for the inclusion of lower-middle and low-income countries. To our knowledge, this is the first paper using the EORA26 dataset in constructing a knowledge weighted GVCs measure. Second, we expand the identification to include interfering variables in the nexus between GVCs and innovation. In particular, we account for the interaction between domestic R&D stock and GVCs, business environment, WTO membership, the quality of institutions, IP agreements, trade costs and competition policy. Equation (2) presents the baseline model specification.

$$PAT_{it} = a_0 + a_1\, GVCRD_{it} + a_2\, X_{it} + u_i + \varepsilon_{it} \qquad (2)$$

Where,
PAT_{it} is the resident patent per capita in country i at year t and is expressed in logarithm.
$GVCRD_{it}$ is the share of foreign knowledge weighted GVCs in country i at year t.
X_{it} is a set of control variables including domestic R&D stock expressed in logarithm; GDP per capita controls for country's level of development and is expressed in logarithm; total population controls for the size of the country and is expressed in logarithm; tariffs[10] control for trade openness; oil exports as a percentage of merchandise exports controls for resource dependence; an interaction term between GVCRD and domestic R&D stock; WTO membership is a dummy variable equals to 1 if the country is a member of the WTO and 0 otherwise; time to enforce contracts controls for the business environment and is expressed in logarithm; and rule of law controls for the quality of institutions.
u_i is a time invariant fixed effects controlling for cross countries' unobserved heterogeneity.
ε_{it} is a residual error term.

Furthermore, the impact of IP agreements is addressed by adding WIPO membership and TRIPS deep trade agreement as explanatory variables to the baseline specification. In addition, the effect of non-tariff measures is addressed by adding non-tariff trade costs with the main trading partner as an explanatory variable to the baseline regression. Likewise, the effectiveness of the anti-monopoly law index is added as an explanatory variable to address the impact of competition policy on domestic innovation.

To untangle the heterogenous effect of foreign knowledge weighted GVCs in accordance with income groups, fixed effects regressions presented in equation 2 are repeated while interacting the variable of interest with the four income groups relying on the World Bank classification definition. Due to the expected endogeneity of GVCs[11], instrumental variables' fixed effects regressions are employed. To further ensure results' robustness, GVCRD and resident patent per

[9] Number of researchers working in R&D per million of the population.
[10] Applied weighted mean tariff rate on manufactured products.
[11] The relationship between GVCs and innovation is endogenous and mutually affecting (Pietrobelli and Rabellotti, 2011).

capita are alternated with a backward participation GVCs index from TiVA dataset and non-resident patent per capita consecutively.

Based on patents' data availability, our sample consists of 83 countries from the year 1990 till 2019. Data relies on the World Development indicators (WDI) dataset to measure the resident and non- resident patent[12] per capita. R&D stock is the number of researches working in R&D per million of the population relying on the WDI dataset. Similarly, GDP per capita (constant 2010 US$), tariffs on manufactured products, as well as oil exports as a percentage of merchandise exports rely on the WDI. Time to enforce contracts relies on the World Bank historical doing business dataset whereas rule of law relies on the World Bank World Governance Indicators dataset. WTO membership relies on WTO data. WIPO membership relies on WIPO dataset. TRIPS agreement relies on the World Bank Deep Trade Agreements dataset. Non-tariff measures are proxied by the comprehensive non-tariff indicator relying on the ESCAP-World Bank trade costs dataset. Competition is measured by the effectiveness of the anti-monopoly index relying on the Global Competitiveness World Economic Forum dataset. The alternative backward participation GVCs index is the share of foreign value added exported in total value-added exported relying on TiVA dataset for a sample of 57 countries from the year 1995 to 2018.

5. Empirical Results

Results of the effect of foreign knowledge weighted GVCs (GVCRD) on resident patent per capita are reported in tables 1 to 7. Column (1) shows that the main control variables have the expected signs. Column (2) presents the negative and significant interaction between domestic R&D stock and GVCRD. As domestic R&D stock increases, the impact of GVCRD on resident patent per capita becomes negative. The reason behind the negative interaction lies in the substitutability between foreign knowledge gained through GVCs participation and domestic R&D stock as inputs for domestic innovation. Column (3) shows that the effect of time to enforce contracts on domestic innovation is insignificant. Columns (4) and (5) synthesize the heterogeneous effect of WTO membership in varying income levels. Results reveal an unintended bias of WTO membership against low-income countries. As presented in column(5), interacting WTO membership with the sample of countries excluding low-income, results in a positive and significant effect on resident patent per capita while WTO membership for all countries has an opposing negative and significant effect. This heterogenous result supports the synthesis suggesting that enhanced international property rights imposed on WTO member countries transfers welfare from less developed (importers of technology) to the higher developed (exporters of technology) countries (Helpman 1993; McCalman 2002). Column (6) shows that the effect of rule of law on domestic innovation is positive and significant.

[12] Number of applications for process, design, and product.

Table 1 Baseline regression for the effect of GVCRD on resident patent per capita

	Dependent Variable: Log of Resident Patent per capita					
	(1)	(2)	(3)	(4)	(5)	(6)
GVCRD	.126	2.004***	1.981***	2.198***	2.075***	2.08***
	(.088)	(.2)	(.201)	(.207)	(.206)	(.206)
RD Stock	.05**	.141***	.139***	.164***	.151***	.157***
	(.022)	(.024)	(.024)	(.024)	(.024)	(.024)
GDP per capita	.298***	.252***	.265***	.341***	.344***	.251***
	(.063)	(.062)	(.063)	(.066)	(.065)	(.068)
Population	.243	.243	.242	.303**	.501***	.624***
	(.154)	(.15)	(.15)	(.15)	(.152)	(.154)
Tariffs	-.012***	-.011***	-.011***	-.011***	-.01***	-.01***
	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)
Fuel Exports	-.003***	-.003***	-.003***	-.003***	-.003***	-.003***
	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)
RD*GVCRD		-.482***	-.479***	-.515***	-.482***	-.482***
		(.046)	(.046)	(.047)	(.047)	(.047)
Time to Contracts			-.143	-.112	-.13	-.09
			(.133)	(.133)	(.132)	(.132)
WTO				-.074***	-.521***	-.509***
				(.018)	(.07)	(.07)
WTO*low-excluded					.469***	.454***
					(.071)	(.071)
Rule of Law						.004***
						(.001)
Constant	-7.818***	-9.51***	-9.134***	-10.212***	-11.448***	-12.366***
	(1.061)	(1.051)	(1.108)	(1.136)	(1.141)	(1.155)
No. of Observations	2490	2490	2490	2490	2490	2490
No. of Countries	83	83	83	83	83	83
R^2	.135	.173	.173	.179	.193	.2
Country FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Standard errors are in parentheses. Fixed effects are removed for brevity. ****p<.01, **p<.05, *p<.1*
R&D stock, GDP per capita, population, and time to enforce contracts are expressed in logarithm.

Table 2 presents the results of intellectual property rights agreements namely TRIPS deep trade and WIPO agreements. Column (1) presents the baseline results for comparison. Column (2) shows that TRIPS affects domestic innovation negatively. However, column (3) shows that TRIPS interaction with all countries excluding low income is positive and significant aligning with WTO membership results. Column (4) shows that WIPO exerts a positive and significant effect on resident patent per capita. Yet, as shown in column (5) when WIPO interacts with all countries excluding low-income, the significance vanishes. Column (6) shows that the interaction between GVCRD and TRIPS agreement is insignificant. Whereas column (7) shows that the interaction of the former with WIPO exerts a negative and significant effect on resident patent per capita. Column (8) shows that TRIPS and WIPO interact negatively. Although both agreements aim at incentivizing innovation, TRIPS is more effective for two reasons. First, TRIPS is a binding agreement unlike WIPO. Second, TRIPS provide flexibility of regulations to governments unlike WIPO providing a one size fits all regulations' system (McCalman, 2005). Empirical results show that the positive effect of TRIPS flexibilities is at risk under WIPO's rigid patent agenda.

Table 2 The effect of IP agreements on resident patent per capita

	Dependent Variable: Log of Resident Patent per capita							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GVCRD	2.08***	2.106***	2.118***	2.104***	2.104***	2.106***	2.05***	2.092***
	(.206)	(.206)	(.205)	(.205)	(.206)	(.207)	(.206)	(.206)
RD Stock	.157***	.164***	.169***	.165***	.165***	.165***	.155***	.161***
	(.024)	(.024)	(.024)	(.024)	(.024)	(.024)	(.024)	(.024)
GDP per capita	.251***	.294***	.287***	.281***	.281***	.28***	.267***	.262***
	(.068)	(.071)	(.071)	(.071)	(.071)	(.071)	(.071)	(.071)
Population	.624***	.648***	.697***	.564***	.564***	.564***	.57***	.561***
	(.154)	(.154)	(.155)	(.161)	(.161)	(.161)	(.161)	(.16)
Tariffs	-.01***	-.01***	-.01***	-.01***	-.01***	-.01***	-.01***	-.01***
	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)
Fuel Exports	-.003***	-.003***	-.004***	-.004***	-.004***	-.004***	-.004***	-.004***
	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)
RD*GVCRD	-.482***	-.485***	-.484***	-.481***	-.48***	-.482***	-.435***	-.438***
	(.047)	(.047)	(.047)	(.047)	(.047)	(.048)	(.048)	(.049)
Time to Contracts	-.09	-.098	-.074	-.051	-.051	-.051	-.052	-.094
	(.132)	(.132)	(.132)	(.132)	(.132)	(.132)	(.132)	(.132)
WTO	-.509***	-.511***	-.459***	-.444***	-.444***	-.445***	-.428***	-.434***
	(.07)	(.07)	(.072)	(.072)	(.072)	(.072)	(.072)	(.072)
WTO*low-excluded	.454***	.466***	.406***	.388***	.388***	.388***	.373***	.384***
	(.071)	(.071)	(.073)	(.074)	(.074)	(.074)	(.074)	(.074)
Rule of Law	.004***	.004***	.004***	.004***	.004***	.004***	.004***	.004***
	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)
TRIPS		-.04**	-.249***	-.251***	-.251***	-.256***	-.28***	-.192**
		(.019)	(.071)	(.07)	(.075)	(.083)	(.075)	(.094)
TRIPS*low-excluded			.224***	.214***	.215***	.215***	.256***	.234***
			(.073)	(.073)	(.077)	(.078)	(.078)	(.079)
WIPO				.066***	.068	.07	.156	.193*
				(.023)	(.1)	(.101)	(.102)	(.105)
WIPO*low-excluded					-.002	-.005	.079	.088
					(.102)	(.104)	(.104)	(.105)
TRIPS*GVCRD						.007		.062
						(.054)		(.056)
WIPO*GVCRD							-.246***	-.275***
							(.068)	(.072)
WIPO*TRIPS								-.13***
								(.038)
Constant	-12.366***	-12.725***	-13.124***	-12.206***	-12.206***	-12.207***	-12.101***	-11.997***
	(1.155)	(1.167)	(1.172)	(1.212)	(1.212)	(1.212)	(1.209)	(1.207)
No. of Observations	2490	2490	2490	2490	2490	2490	2490	2490
No. of Countries	83	83	83	83	83	83	83	83
R^2	.2	.201	.205	.207	.207	.207	.212	.216
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Standard errors are in parentheses. Fixed effects are removed for brevity. *** *p*<.01, ** *p*<.05, * *p*<.1
R&D stock, GDP per capita, population, and time to enforce contracts are expressed in logarithm.

Table 3 presents the results of the effect of trade policy on domestic innovation. Colum (1) presents the baseline results. As shown, tariffs exert a negative and significant effect on resident patent per capita. Column (2) shows that the time to enforce contracts exert a negative and significant effect when non-tariff measures (NTMs) are controlled for. Likewise, NTMs exert a negative and significant effect on resident patent per capita. Column (3) shows that NTMs interaction with GVCRD is negative and significant. As NTMs increase, the effect of GVCRD on domestic innovation becomes negative. Column (4) shows that TRIPS has an insignificant effect on resident patent per capita. Column (5) shows that the interaction between TRIPS and tariffs is insignificant. Column (6) shows a positive and significant effect of TRIPS whilst its interaction with NTMs exert a negative and significant effect on resident patent per capita. As NTMs increase, the impact of TRIPS on domestic innovation flips to negative. Column (7) shows that WIPO has an insignificant effect on resident patent per capita. Yet, columns (8) and (9) show that WIPO interacts negatively with tariff and NTMs respectively.

Table 4 presents the results of the effect of competition policy on domestic innovation. Column (1) presents the baseline results for comparison. Column (2) shows that the effectiveness of anti-monopoly law index is insignificant. However, as shown in column (3), when the squared term of the effectiveness of the anti-monopoly index is added, the level turns to positive and significant while the squared term is negative and significant. This result lines up with the theory of non-linear impact of competition on innovation in which the former exerts a nonmonotonic inverted U-shaped relationship with the latter (Aghion et al, 2005). Column (4) shows that the interaction between the effectiveness of anti-monopoly law and GVCRD is negative and significant. As competition increases, GVCRD exerts a negative and significant effect on resident patent per capita. Column (5) shows an insignificant effect of TRIPS. However, as presented in column (6), TRIPS and competition interact positively and significantly as both variables are complements to incentivizing innovation. Consequently, as competition increases, TRIPS effect flips to positive. Similarly, column (7) shows that WIPO exerts a negative and significant effect on innovation whereas column (8) shows that the interaction between WIPO and competition is positive and significant. Column (9) shows that the results are robust when all the variables are included in the same fixed effects regression.

Table 3 The effect of trade policy on resident patent per capita

	Dependent Variable: Log of Resident Patent per capita								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
GVCRD	2.08***	1.691***	2.651***	2.639***	2.625***	2.545***	2.599***	2.565***	2.565***
	(.206)	(.207)	(.338)	(.342)	(.342)	(.339)	(.341)	(.342)	(.342)
RD Stock	.157***	.122***	.117***	.117***	.121***	.106***	.118***	.109***	.109***
	(.024)	(.024)	(.024)	(.024)	(.024)	(.024)	(.024)	(.024)	(.024)
GDP per capita	.251***	.055	.104	.11	.11	.011	.106	.108	.108
	(.068)	(.075)	(.076)	(.08)	(.08)	(.081)	(.076)	(.076)	(.076)
Population	.624***	.704***	.614***	.621***	.623***	.874***	.663***	.701***	.701***
	(.154)	(.173)	(.174)	(.176)	(.176)	(.178)	(.18)	(.181)	(.181)
Tariffs	-.01***	-.016***	-.017***	-.017***	-.017***	-.017***	-.017***	-.017***	-.017***
	(.001)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)
Fuel Exports	-.003***	-.003***	-.003***	-.003***	-.003***	-.003***	-.003***	-.003***	-.003***
	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)
RD*GVCRD	-.482***	-.408***	-.453***	-.452***	-.449***	-.425***	-.448***	-.447***	-.447***
	(.047)	(.047)	(.048)	(.048)	(.048)	(.048)	(.048)	(.048)	(.048)
Time to Contracts	-.09	-.292**	-.313***	-.313***	-.305***	-.421***	-.324***	-.334***	-.334***
	(.132)	(.118)	(.118)	(.118)	(.118)	(.118)	(.119)	(.119)	(.119)
WTO	-.509***	-.951***	-.946***	-.948***	-.949***	-.987***	-.952***	-.943***	-.943***
	(.07)	(.088)	(.088)	(.088)	(.088)	(.088)	(.088)	(.088)	(.088)
WTO*low-excluded	.454***	1.031***	1.039***	1.041***	1.043***	1.087***	1.044***	1.036***	1.036***
	(.071)	(.092)	(.092)	(.092)	(.092)	(.092)	(.092)	(.092)	(.092)
Rule of Law	.004***	.003***	.003***	.003***	.003***	.003***	.003***	.003***	.003***
	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)
NTMs		-.002***	-.002***	-.002***	-.002***	-.003586	-.002***	-.001	-.001
		(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)
NTMs*GVCRD			-.011***	-.011***	-.011***	-.01***	-.01***	-.01***	-.01***
			(.003)	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)
TRIPS				-.005	-.03	.296***			
				(.022)	(.027)	(.05)			
TRIPS* Tariffs					.004				
					(.003)				
TRIPS*NTMs						-.004***			
						(.001)			
WIPO							-.026	.105	-.009
							(.025)	(.074)	(.027)
WIPO*Tariffs								-.002*	
								(.001)	
WIPO*NTMs									-.002*
									(.001)
Constant	-12.366***	-10.993***	-11.044***	-11.103***	-11.17***	-12.304***	-11.329***	-11.592***	-11.592***
	(1.155)	(1.261)	(1.257)	(1.284)	(1.285)	(1.283)	(1.286)	(1.293)	(1.293)
No. of Observations	2490	2050	2050	2050	2050	2050	2050	2050	2050
No. of Countries	83	82	82	82	82	82	82	82	82
R^2	.2	.23	.235	.235	.236	.252	.236	.237	.237
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Standard errors are in parentheses. Fixed effects are removed for brevity. ****p<.01, **p<.05, *p<.1*

R&D stock, GDP per capita, population, and time to enforce contracts are expressed in logarithm, NTMs are total trade costs with the main trade partner excluding tariffs.

Table 4 The effect of competition policy on resident patent per capita

	Dependent Variable: Log of Resident Patent per capita								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
GVCRD	2.08***	1.699***	1.635***	1.975***	1.963***	1.834***	1.995***	1.964***	1.863***
	(.206)	(.213)	(.212)	(.267)	(.267)	(.268)	(.267)	(.266)	(.267)
RD Stock	.157***	.129***	.123***	.116***	.116***	.11***	.119***	.114***	.11***
	(.024)	(.025)	(.025)	(.025)	(.025)	(.025)	(.025)	(.025)	(.025)
GDP per capita	.251***	.087	.19**	.185**	.232***	.268***	.196**	.172**	.238***
	(.068)	(.078)	(.079)	(.079)	(.084)	(.085)	(.079)	(.079)	(.085)
Population	.624***	.672***	.88***	.95***	.989***	.95***	1.059***	1.103***	1.078***
	(.154)	(.177)	(.18)	(.183)	(.184)	(.183)	(.188)	(.188)	(.188)
Tariffs	-.01***	-.016***	-.015***	-.015***	-.016***	-.015***	-.016***	-.016***	-.016***
	(.001)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)
Fuel Exports	-.003***	-.003***	-.003***	-.003***	-.003***	-.003***	-.003***	-.003***	-.003***
	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)
RD*GVCRD	-.482***	-.394***	-.364***	-.35***	-.35***	-.322***	-.343***	-.353***	-.332***
	(.047)	(.048)	(.048)	(.048)	(.048)	(.048)	(.048)	(.048)	(.048)
Time to Contracts	-.09	-.224*	-.125	-.084	-.092	-.098	-.102	-.126	-.129
	(.132)	(.12)	(.12)	(.122)	(.122)	(.122)	(.122)	(.122)	(.121)
WTO	-.509***	-1.004***	-1.024***	-1.014***	-1.028***	-1.022***	-1.027***	-1.043***	-1.045***
	(.07)	(.088)	(.088)	(.088)	(.088)	(.088)	(.088)	(.088)	(.088)
WTO*low-excluded	.454***	1.083***	1.094***	1.089***	1.103***	1.114***	1.101***	1.122***	1.135***
	(.071)	(.092)	(.092)	(.092)	(.092)	(.092)	(.092)	(.091)	(.092)
Rule of Law	.004***	.003***	.003***	.003***	.003***	.002***	.003***	.003***	.002***
	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)
Anti-Monopoly		.001	.868***	.822***	.837***	.627***	.852***	.591***	.493***
		(.016)	(.161)	(.163)	(.163)	(.169)	(.163)	(.171)	(.174)
(Anti-Monopoly)^2			-3.502***	-3.084***	-3.148***	-2.48***	-3.167***	-2.587***	-2.243***
			(.648)	(.678)	(.679)	(.693)	(.678)	(.686)	(.696)
Anti-Monopoly*GVCRD				-.106**	-.103**	-.099*	-.117**	-.088*	-.086*
				(.051)	(.051)	(.051)	(.051)	(.051)	(.051)
TRIPS					-.034	-.379***			-.28***
					(.021)	(.082)			(.086)
TRIPS*Anti-Monopoly						.083***			.06***
						(.019)			(.02)
WIPO							-.058**	-.57***	-.464***
							(.025)	(.112)	(.117)
WIPO*Anti-Monopoly								.128***	.104***
								(.027)	(.028)
Constant	-12.366***	-11.261***	-9.852***	-11***	-11.355***	-11.576***	-11.687***	-11.975***	-12.242***
	(1.155)	(1.278)	(1.295)	(1.407)	(1.424)	(1.418)	(1.437)	(1.431)	(1.437)
No. of Observations	2490	2075	2075	2075	2075	2075	2075	2075	2075
No. of Countries	83	83	83	83	83	83	83	83	83
R^2	.2	.217	.229	.231	.232	.239	.233	.241	.245
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Standard errors are in parentheses. Fixed effects are removed for brevity. *** $p<.01$, ** $p<.05$, * $p<.1$

R&D stock, GDP per capita, population, and time to enforce contracts are expressed in logarithm. Anti-Monopoly is effectiveness of the anti-monopoly law index.

Table 5 presents the results of GVCRD interaction with income groups to disentangle the effect of GVCs participation on domestic innovation in correspondence with varying income levels. Column (1) presents the baseline results. Column (2) shows that in reference to high income countries, GVCRD preserves the positive and significant effect on resident patent per capita, whereas it is insignificant in both upper-middle and low-income groups and exerts a positive and significant effect in lower-middle income group. The higher significance of the effect in lower-middle compared to upper-middle income group lines up with the theoretical foundation that countries at earlier stages of development benefit more from spillovers than developed countries (Aghion and Howitt, 2007). Whereas the insignificance for low-income group is due to the lesser absorptive capacity.

Table 5 The effect of GVCs on innovation in different income groups

	Dependent Variable: Log of Resident Patent per capita	
	(1)	(2)
GVCRD	2.08***	1.684***
	(.206)	(.331)
GVCRD*UpperMiddle		-.006
		(.216)
GVCRD*LowerMiddle		.681***
		(.228)
GVCRD*LowIncome		-.364
		(1.179)
RD Stock	.157***	.123***
	(.024)	(.026)
GDP per capita	.251***	.3***
	(.068)	(.069)
Population	.624***	.603***
	(.154)	(.156)
Tariffs	-.01***	-.01***
	(.001)	(.001)
Fuel Exports	-.003***	-.004***
	(.001)	(.001)
RD*GVCRD	-.482***	-.453***
	(.047)	(.052)
Time to Contracts	-.09	-.071
	(.132)	(.133)
WTO	-.509***	-.503***
	(.07)	(.07)
WTO*low-excluded	.454***	.458***
	(.071)	(.071)
Rule of Law	.004***	.004***
	(.001)	(.001)
Constant	-12.366***	-12.053***
	(1.155)	(1.182)
No. of Observations	2490	2490
No. of Countries	83	83
R^2	.2	.206
Country FE	Yes	Yes

Notes: Standard errors are in parentheses. Fixed effects are removed for brevity. *** $p<.01$, ** $p<.05$, * $p<.1$
R&D stock, GDP per capita, population, and time to enforce contracts are expressed in logarithm

Table 6 presents three robustness checks to the baseline regression results. Column (1) presents the baseline results for comparison. Column (2) shows the results of employing a fixed effects instrumental variables regression. The instruments used are the log of GDP per capita and rule of law of the main trading partner. The rationale is that as either GDP per capita or rule of law of the origin country (main trading partner) increases, the volume of intermediate goods' imports of

destination country increases leading to more knowledge spillovers. Indeed, results show robustness as the variable of interest exerts the same significant and positive effect when instrumental variables are employed. With the exception of GDP per capita, all control variables preserve the same significance and signs as the baseline results. Collinearity between GDP per capita of the country and its main trading partner is expected due to interdependence which explains the lost significance. Column (3) shows the results when an alternative backward GVCs index[13] from TiVA dataset is used. In this regression, R&D expenditure as a percentage of GDP is used instead of R&D stock. As presented, the GVCs index as well as all the explanatory variables preserve the same significance and signs as the baseline results. Finally, column (4) presents the results when the dependent variable is altered to a substitute of resident patent per capita. The sign of the variable of interest is inverted with preserved significance showing that an increase in GVCRD results in an increase in resident patent per capita mirrored in a decline in the non- resident patent per capita. Similarly, as domestic R&D stock increases, innovators shift from non-resident licenses to resident ones.

Table 6 Robustness check for the positive effect of GVCs. On domestic innovation

Dependent Variable:	log of Resident patent per capita			log of non-resident patent per capita
	Baseline	IV	TiVA	
	(1)	(2)	(3)	(4)
GVCRD/GVC	2.08***	2.433***	.036***	-1.238*
	(.206)	(.433)	(.005)	(.674)
RD Stock/exp	.157***	.367***	.949***	-.664***
	(.024)	(.063)	(.104)	(.079)
GDP per capita	.251***	-.079	.394***	-.616***
	(.068)	(.101)	(.087)	(.224)
Population	.624***	.544***	1.344***	2.947***
	(.154)	(.178)	(.179)	(.506)
Tariffs	-.01***	-.009***	-.021***	-.028***
	(.001)	(.001)	(.005)	(.004)
Fuel Exports	-.003***	-.002*	-.008***	0
	(.001)	(.001)	(.002)	(.003)
RD*GVCRD	-.482***		-.025***	-.272*
	(.047)		(.003)	(.153)
Time to Contracts	-.09	.256	-.196	-1.305***
	(.132)	(.172)	(.119)	(.432)
WTO	-.509***	-.667***	.17**	.266
	(.07)	(.083)	(.074)	(.229)
WTO*low-excluded	.454***	.554***		-.264
	(.071)	(.081)		(.232)
Rule of Law	.004***	.004***	.012***	.005
	(.001)	(.001)	(.003)	(.003)
Constant	-12.366***	-12.901***	-37.208***	-20.628***
	(1.155)	(1.399)	(3.074)	(3.791)
No. of Observations	2490	2490	1368	2490
No. of Countries	83	83	57	83
R^2	.2	.03	.369	.092
Country FE	Yes	Yes	Yes	Yes

Notes: Standard errors are in parentheses. Fixed effects are removed for brevity. *** *p<.01,* ** *p<.05,* * *p<.1* R&D stock, GDP per capita, population, and time to enforce contracts are expressed in logarithm. Instrumental variables: log of partner's GDP per capita and partner's rule of law. Variable of interest in TiVA dataset is the backwardness participation index.

[13] This is a more complex definition of GVC since it is a measure of the share of foreign value added that is exported whereas the simple definition is limited to the share of foreign value added absorbed.

Table 7 presents the results when all explanatory variables are added in the fixed effects regression against different datasets. Column (1) presents the results using EORA26 dataset. As shown, both the significance and the signs of all variables are preserved. Column (2) shows homogenous results using TiVA dataset. Notably, TiVA dataset excludes low-income countries clarifying the vanished bias of both WTO membership and TRIPS. Alternatively, unlike TRIPS, WIPO exerts a negative and significant effect on resident patent per capita. Likewise, NTMs is insignificant in TiVA dataset while competition maintains the same inverted U-shaped relationship.

Table 7 All explanatory variables against datasets

	Dependent Variable: Log of Resident Patent per capita	
	EORA26	TiVA
	(1)	(2)
GVCRD/GVC	1.66***	.041***
	(.209)	(.005)
RD Stock/exp	.13***	1***
	(.025)	(.102)
GDP per capita	.178**	.234**
	(.083)	(.095)
Population	1.124***	1.677***
	(.183)	(.192)
Tariffs	-.014***	-.019***
	(.002)	(.005)
Fuel Exports	-.004***	-.007***
	(.001)	(.002)
RD*GVC	-.374***	-.025***
	(.047)	(.003)
Time to Contracts	-.175	-.114
	(.119)	(.12)
WTO	-.984***	.169**
	(.087)	(.075)
WTO*low-excluded	1.046***	
	(.091)	
Rule of Law	.002*	.012***
	(.001)	(.003)
TRIPS	-.325***	.227***
	(.071)	(.052)
TRIPS*low-excluded	.339***	
	(.074)	
WIPO	-.054	-.187***
	(.116)	(.057)
WIPO*low-excluded	-.001	
	(.12)	
NTMs	-.002***	-.002
	(.001)	(.002)
Anti-Monopoly	1.007***	2.582***
	(.16)	(.528)
(Anti-Monopoly)^2	-4.027***	-10.089***
	(.64)	(2.272)
Constant	-10.774***	-32.204***
	(1.32)	(3.909)
No. of Observations	2050	1368
No. of Countries	82	57
R^2	.256	.405
Country FE	Yes	Yes

Notes: Standard errors are in parentheses. Fixed effects are removed for brevity. *** *p<.01,* ** *p<.05,* * *p<.1* R&D stock, GDP per capita, population, and time to enforce contracts are expressed in logarithm. NTMs are total trade costs with the main trade partner excluding tariffs. Anti-Monopoly is the effectiveness of the anti-monopoly law index.

In summary, empirical results show that backward participation linkages to GVCs have a positive and significant effect on resident patent per capita particularly in lower-middle income group. The quality of institutions matters to domestic innovation reflected in the persistent positive and significant effect of rule of law. In addition, TRIPS agreement is effective in incentivizing innovation unlike WIPO that exert an opposing trajectory. Likewise, both tariffs and NTMs exert a negative and significant effect on domestic innovation. In addition, the latter interacts negatively with TRIPS agreement. Although competition has a positive impact on domestic innovation and interacts positively with IP agreements, the former exerts a nonmonotonic inverted U-shaped relationship on resident patent per capita. Results remain robust when instrumental variables approach is employed and when alternative variables to the variables of interest are used.

6. Conclusion

This paper empirically emphasizes the significance of GVCs participation as a channel for fostering domestic innovation. The constructed foreign knowledge weighted GVCs index exerts a positive and significant effect on resident patent per capita. Results show that the quality of institutions, IP agreements, trade policy and competition policy matter for the effect of GVCs on innovation. In addition, results imply an unintended bias of WTO membership and TRIPS agreement against low-income countries. Furthermore, results show that both tariffs and NTMs exert a negative and significant effect on resident patent per capita. Meanwhile, the inverted U-shaped relationship between competition and innovation is empirically captured. Disentangling the effect of GVCs in accordance with the different income groups implies that foreign knowledge weighted GVCs is of particular importance to lower-middle income countries disadvantaged in technology production. On the other hand, results for low-income countries with miniature absorptive capacity show an insignificant impact. Finally, using instrumental variables' regressions, a backward GVCs participation index from TiVA dataset, and employing a substitute dependent variable ensure results' robustness.

This study contributes to the post COVID-19 controversial discourse on the trade-off of reshoring activities by evidencing the opportunity cost of decoupling in terms of domestic innovation. Empirical results suggest an externality learning effect of GVCs participation provided an unyielding convalescence of stacking preconditions. From a policy standpoint, the positive and significant effect of GVCs on innovation advocates encouraging backward linkages to GVCs particularly in lower-middle income countries. To this end, lowering unnecessary trade costs is key to encouraging foreign exporters of intermediate goods. In addition, policies targeting institutions' evolution and rule of law promotion are compulsory to fostering the foreign learning effect of GVCs participation. Moreover, negotiations of deep trade agreements involving property rights are central to guarantying unbiases against low-income countries disadvantaged in technology production. Finally, enhancing competition in countries with lax competition policy incentivizes innovation and complements the positive impact of IP agreements on domestic innovation. Yet, enforcing competition should be with caution due to the non-linearity of the effect. Clearly, our policy recommendations are directed towards developing countries with prevalent mitigating conditions.

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Appendix

Table 8 Dataset countries and income groups classification

	Country	Income Group		Country	Income Group
1	Algeria	Upper Middle	**43**	Lithuania	High
2	Argentina	Upper Middle	**44**	Luxembourg	High
3	Armenia	Upper Middle	**45**	Madagascar	Low
4	Australia	High	**46**	Malta	High
5	Austria	High	**47**	Malaysia	Upper Middle
6	Bangladesh	Lower Middle	**48**	Mexico	Upper Middle
7	Belarus	Upper Middle	**49**	Moldova	Lower Middle
8	Belgium	High	**50**	Monaco	High
9	Brazil	Upper Middle	**51**	Mongolia	Low
10	Bulgaria	Upper Middle	**52**	Morocco	Lower Middle
11	Canada	High	**53**	Netherlands	High
12	Chile	High	**54**	New Zealand	High
13	China	Upper Middle	**55**	Norway	High
14	Colombia	Upper Middle	**56**	Pakistan	Lower Middle
15	Costa Rica	Upper Middle	**57**	Peru	Upper Middle
16	Croatia	High	**58**	Philippines	Lower Middle
17	Cuba	Upper Middle	**59**	Poland	High
18	Czech Republic	High	**60**	Portugal	High
19	Denmark	High	**61**	Romania	Upper Middle
20	Ecuador	Upper Middle	**62**	Russian Federation	Upper Middle
21	Egypt	Lower Middle	**63**	Saudi Arabia	High
22	Finland	High	**64**	Singapore	High
23	France	High	**65**	Slovak Republic	High
24	Georgia	Upper Middle	**66**	South Africa	Upper Middle
25	Germany	High	**67**	Spain	High
26	Greece	High	**68**	Sri Lanka	Upper Middle
27	Guatemala	Upper Middle	**69**	Sweden	High
28	Hong Kong	High	**70**	Switzerland	High
29	Hungary	High	**71**	Syria	Low
30	Iceland	High	**72**	Tajikistan	Low
31	India	Lower Middle	**73**	Thailand	Upper Middle
32	Indonesia	Lower Middle	**74**	Tunisia	Lower Middle
33	Iran	High	**75**	Turkey	Upper Middle
34	Israel	High	**76**	Ukraine	Lower Middle
35	Italy	High	**77**	United Kingdom	High
36	Jamaica	Upper Middle	**78**	United States	High
37	Japan	High	**79**	Uruguay	High
38	Kazakhstan	Upper Middle	**80**	Uzbekistan	Lower Middle
39	Kenya	Lower Middle	**81**	Venezuela	Upper Middle
40	Korea	High	**82**	Vietnam	Lower Middle
41	Kyrgyz Republic	Lower Middle	**83**	Zambia	Lower Middle
42	Latvia	High			

Table 9 EORA26 sectors

1	Agriculture
2	Fishing
3	Mining and Quarrying
4	Food & Beverages
5	Textiles and Wearing Apparel
6	Wood and Paper
7	Petroleum, Chemical and Non-Metallic Mineral Products
8	Metal Products
9	Electrical and Machinery
10	Transport Equipment
11	Other Manufacturing
12	Recycling
13	Electricity, Gas and Water
14	Construction
15	Maintenance and Repair
16	Wholesale Trade
17	Retail Trade
18	Hotels and Restaurants
19	Transport
20	Post and Telecommunications
21	Financial Intermediation and Business Activities
22	Public Administration
23	Education, Health and Other Services
24	Private Households
25	Others
26	Re-export & Re-import

Table 10 Summary of descriptive statistics

Variable	No. of observations	Mean	Standard deviation	Minimum	Maximum
Resident Patents	2,490	13575.600	74315.920	1	1393815
GVCRD	2,490	0.591	0.295	0.018	1.000
R&D Stock	2,490	2380.033	5838.382	7.428	82512.410
GDP per capita	2,490	19861.370	25371.420	366.979	2.09e+05
Population	2,490	6.58e+07	1.89e+08	29433	1.40e+09
Tariffs (manufactured goods)	2,490	6.646	8.188	0	90.390
Fuel Exports as a % of merchandise exports	2,490	13.870	21.940	0	98.764
WTO membership	2,490	-	-	0	1
Rule of Law	2,490	58.653	28.706	0.469	100
Time to Enforce Contracts	2,490	596.070	323.853	120	1711
TRIPS	2,490	-	-	0	1
WIPO	2,490	-	-	0	1
NTMs	2,460	75.3684	33.4558	9.011269	188.4229
Effectiveness of anti-monopoly law index	2,075	4.231551	.9121709	2.309669	6.192313
Non-resident patents	2,490	6722.861	25449.31	1	336340
GVC (TiVA)	1,368	24.71323	11.55005	2.522	68.162