Global Value Chains and Intellectual Property Right in Agricultural Trade

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Abstract

This paper examines the impact of intellectual property rights (IPR)-related trade policy on agri-food global value chains (GVCs). The study uses IPR provisions in regional trade agreements (RTAs) as a proxy for IPR-related trade policy. The empirical specification follows a gravity model, and the Pseudo Poisson Maximum Likelihood method is employed. The paper analyzes the overall effect of IPR provisions in RTAs on average GVC trade in the agriculture and food sectors. We further explore the trade effects of IPR provisions based on their specific characteristics, utilizing the deep trade agreement data published by the World Bank. Finally, the paper investigates the effects of IPR provisions by income pair group. The empirical results indicate that average bilateral agricultural GVC trade participation decreases between members with RTAs that include IPR provisions compared to those without. However, the effects vary by the type of IPR provisions. The results suggest that an interactive effect between the two types of IPR provisions is crucial for enhancing agricultural and food GVC trade, whereas single-type IPR provisions have a negative effect. The effects are more significant in the agriculture sector compared to the food sector. Moreover, the study finds heterogeneous effects across countries' income levels.

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1 Introduction

There has been broad interest and growth in scholarly investigations of the relationship between intellectual property rights (IPR) and international trade, more recently, specific inquiries on its effects of RTAs (Awokuse and Yin, 2010; Kucik, 2012; Maskus and Ridley, 2021). Intellectual property can take various forms, such as patents, copyrights, trademarks, trade secrets, and geographical indicators. These are important because they allow creators to safeguard their work from unauthorized use by third parties and ensure they receive a return on their investment in developing their ideas or inventions. Strong IPR protection provides important benefits, such as promoting new technology, innovation development, and transfer, which can facilitate improved product quality, higher productivity, and profitability

This increasing emphasis on IPR and its effects was motivated by two key developments. First, although the United States began raising concerns about the implications of weak IPR protection as a trade negotiation concern under Section 301 of the Trade Act 1974, it became an issue of greater global concern after the enactment of a special provision in the US Trade Act of 1988 which linked American trade policy to the prevailing IPR regimes in bilateral trading partner nations. Second, the establishment of a multilateral World Trade Organization's (WTO) Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs) in 1994 increased interest in seeking better understanding of IPR protection regimes could be used a form of non-tariff trade barrier. Although there were prevailing intellectual property standards, they were weak and lacking trade dispute resolution mechanisms (Maskus, 2000; Gutowski, 1999; Braga et al., 2000).

IPRs have expanded beyond the industrial sector to encompass a broader range of sectors. One of the key developments that paved the way for an expansion of IPR was the technological developments in the area of biotechnology and food science (Eaton and Graff, 2014). Patents are commonly recognized as the predominant type of IPR for patentable biotechnological procedures, plants, and animals utilized in their production. Patents can also be used to protect food products or processes, such as a new method of producing a particular ingredient. Trademarks protect the branding and identity of a food product, such as the name or logo of a particular product or company. Geographical indication identifies a product as originating from a particular geographic region, where a certain quality, reputation, or characteristic of the product is attributable to that specific place of origin. Examples of geographical indications include Champagne, Darjeeling tea, and Colombian coffee. Trade secrets protect confidential information related to the production or formulation of food products, such as the parental line of hybrid seed or

crops and secret recipes for beverages.

In recent decades, Park (2008) notes that the requirement of including IPR provisions has increased as the cases of international and bilateral trade agreements have expanded in recent years. Correspondingly, there has been a growing number of analytical studies that explicitly investigated the impact of IPR provisions on internationa trade and RTAs. Several empirical studies found that strengthening IPRs after implementing TRIPS resulted in an increase in the export of IP-intensive goods and benefits both emerging and developed countries (Ivus, 2010; Delgado et al., 2013; Maskus and Ridley, 2016). More recent studies address the implications of IPR provisions in regional trade agreements and investigate how they affect international trade. Relative to the WTO TRIPS, IPR provisions in regional trade agreements are characterized by broader and more stringent commitments.

There are few empirical studies regarding the effect of IPR provisions in RTAs on trade. They support the idea that IPR provisions have a positive trade effect on technology (or intellectual property, knowledge)-intensive goods, but the effects are heterogeneous and dynamic, depending on the context (Maskus and Ridley, 2016, 2019, 2021; Campi and Dueñas, 2019). Some studies criticque the common assumption regarding the interest of developing countries in IPR by showing that a high number of RTAs between developing countries involve IPR provisions in their agreements (Valdés and McCann, 2014).

Previous research has shown mixed results, and these studies have not specifically taken into account IPR provisions within RTAs. Given that IPR protection has expanded beyond industrial sectors to encompass a broader range of information, materials, and products relevant to agriculture and food, it is important to conduct more empirical tests to examine the impact of RTAs with IPR provisions on agriculture and food trade. In this context, our study focuses on the characteristics of IPR provisions in RTAs and explores their impact on agriculture and food trade based on these characteristics

While previous studies acknowledge the possibility that the impact of IPR protection on trade and FDI may vary by product sectors and by the level of economic development in trading partner countries (Maskus and Penubarti, 1995; Smith, 1999; Awokuse and Yin, 2010; Awokuse and Gu, 2015), most of the focus has been limited to the effect of IPR on industrial production because of the technology intensive components in the intermediate and final products. The few existing studies are often based on case study, conceptual study on lawsuits, and systematic reviews of legal documents. The empirical studies find an insignificant impact of IPR protection on the seed trade. However, the relatively limited empirical evidence exists on the impact of IPR regimes on agrifood trade flows

is concerning given the transformation of the sector into more complex and vertically integrated entities with growing similarities to industrial manufacturing and distribution firms (Awokuse et al., 2012; Awokuse and Yin, 2010).

This study addresses a gap in the literature by focusing on the interactions between agrifood global value chains, intellectual property rights, and international trade. For example, food processing firms exhibit vertical specialization and make differentiated products which generates trade in intermediate goods with different degrees of differentiated good with embedded technologies and innovations. According to research by the OECD (2020) and Salvatici (2020), significant portion of agrifood tradenow consists of highly process and differentiated food products that is part of global value chains. Food pro duction is increasingly ocurring across multiple countries and relying on materials sourced from all over the world. GVCs refer to all the activities and services involved in converting raw materials into the final product delivered to the consumer, including production, marketing, and logistics. While GVC-related trade in the agriculture and food sector may be lagging behind that of manufactured goods, it is crucial for countries to understand the new connections and opportunities presented by agri-food GVCs as they seek alternative paths for economic growth, participate in regional trade initiatives, and pursue further multilateral trade regulation reforms (OECD, 2020; Bellemare et al., 2022).

We use GVC-related trade data from the World Integrated Trade Solution and apply the empirical gravity model specification. We employ the Pseudo Poisson Maximum Likelihood method for the estimation. We first examine the overall effect of IPR provisions in RTAs on average GVC trade in the agriculture and food sector. We find that the average bilateral agricultural GVC trade participation decreases between members with RTAs that have IPR provisions relative to those without IPR provisions. However, the IPR provisions do not significantly affect food GVC trade.

To further explore the trade effect of IPR provisions based on their specific characteristics, we use the deep trade agreement data published by the World Bank. This data enable us to distinguish between the "WTO-plus" and "WTO-extra" features of IPR provisions, where the former covers what is required by the WTO and includes additional procedural rules for effective implementation, while the latter mandates compliance with additional IP-related treaties to extend the IP protection system beyond WTO rules. We hypothesize that the impact of these two features may differ and find that an interactive effect between the two types of IPR provisions is important to enhance agricultural and food GVC trade, while single-type IPR provisions have a negative effect. The effects are more significant in the agriculture sector compared to the food sector.

In addition, we also analyze the effects of IPR provisions by income pair group. The

impact of these commitments will depend on the level of economic development of the country as it requires the support of the domestic system to effectively implement the agreement. Our result indicates that the impact of IPR provisions on agricultural and food GVC links varies depending on the specific features of the IPR provision and the development level of the countries involved in the GVC. First, we show that WTO-extra type provisions (extensive rule beyond the WTO) as part of a package with WTO-plus provisions (rules deepen the WTO commitment) may facilitate trade between countries with similar income levels. Second, the commitment to WTO-plus type provisions between high and low-income group countries may offer developing economies a tool for implementing domestic reforms and facilitate connections between developed and developing countries in GVCs. Third, the result from pairing the low-income group with the higher-income group may imply that strengthening IPR in the destination country may serve as a trade barrier in the agriculture sector.

This paper contributes to several literature strands. First, it adds to the literature on global value chains and trade policy. The GVC has garnered significant attention in economic research due to its impact on economic development. However, the literature on the implications of trade policies, such as tariffs, quantitative restrictions, or regulatory standards, on the rise of GVCs is relatively underdeveloped (Antràs, 2020). Antràs and Staiger (2012) presents a theoretical model that examines the interaction between trade agreements and GVCs, arguing that trade agreements need to reflect member-specific interests to facilitate economic integration in the GVC era. Empirical studies that investigate related questions suggest that deeper and more integrated regional trade agreements increase GVC links between member countries (Orefice and Rocha, 2014; Laget et al., 2020). In the field of agricultural economics, Balié et al. (2019) specifically looks at the agriculture and food GVC and demonstrates that regional trade agreements promote bilateral GVC participation by shifting trade regimes associated with regional trade agreements. Our study complements Balié et al. (2019) by focusing on the potential impact of heterogeneous IPR provisions in RTAs.

Second, this paper contributes to the literature on intellectual property in agriculture. As we reviewed in the earlier part of the Introduction, empirical evidence of the trade effects of IPR in agriculture and food trade is relatively scarce. While some studies have found an insignificant impact of IPR protection on seed trade in the US and EU countries, others have shown mixed results depending on the income level of the destination countries. At the bilateral level, some studies have found negative trade effects of stronger IPR protection on agriculture and food exports. Our study complements these analyses by explicitly taking into account countries' membership in regional trade agreements and

focusing on GVC-related trade. Therefore, our study provides complementary evidence to understand the role of engaging in regional trade agreements on GVC links.

The paper is organized as follows. Section 2 introduces the additional backgrounds and data. In Sections 3 to 5, we present the empirical specification and estimation results. Specifically, Section 3 investigates contemporaneous trade effects of intellectual property right provisions and the dynamic effects on agri-food GVCs. Section 4 analyzes the interactive effects between different types of intellectual property rights provisions. In Section 5, we examine the heterogeneous effects across the income level of exporting and importing nations. Section 6 concludes.

2 Background and Data

2.1 Intellectual Property Rights in Regional Trade Agreement

This study focuses on the heterogeneous effect of IPR provisions in regional trade agreements depending on their type. We use the 'deep trade agreement data' from the World Bank constructed by Hofmann et al. (2017) to identify which types of IPR provisions are included in the specific regional trade agreement. Regional trade agreements consist of multiple chapters (policy area) such as tariff, export restriction, services, technical barriers of trade, sanitary and phytosanitary, intellectual property rights, etc. Hofmann et al. (2017) defined 52 policy areas within regional trade agreements, and further divided these provisions into two types of categories: "WTO plus" and "WTO extra". "WTO plus" type provisions reaffirm existing commitments under the WTO and, in some cases, there are additional obligations that may require more implementation procedural rules, transparency, and enforcement (Mattoo et al., 2020). In contrast, "WTO extra" provisions relate to policy areas that are not currently governed by the WTO. This refers to obligations that are "qualitatively new" and pertain to policy instruments that have not previously been regulated by the WTO (Horn et al., 2010).

First, for instance, policies regarding environmental protection, labor markets, or competition are not covered by the WTO, so such policy areas would be classified as "WTO extra". Second, they categorize several provisions under the same policy into "WTO plus" and "WTO extra". The chapter on intellectual property rights falls into the second case because some provisions are in relation to the commitments that have been made within the WTO TRIPs, but some are not. Specifically, the rule they classify as "WTO extra" type IPR is to check whether the IPR provisions require accession to international treaties not referenced in the WTO TRIPs explicitly. According to the Mattoo et al. (2020) and Valdés

and McCann (2014), these international treaties are including treaties administered by the World Intellectual Property Organization (WIPO) and the Union for the Protection of New Varieties of Plants (UPOV) Convention of 1991. For example, IPR provisions in ASEAN-Australia-New Zealand Free Trade Area (AANZFTA) agreement required members to access and ratify several WIPO treaties and UPOV conventions which are not required in the boundary of WTO TRIPs.

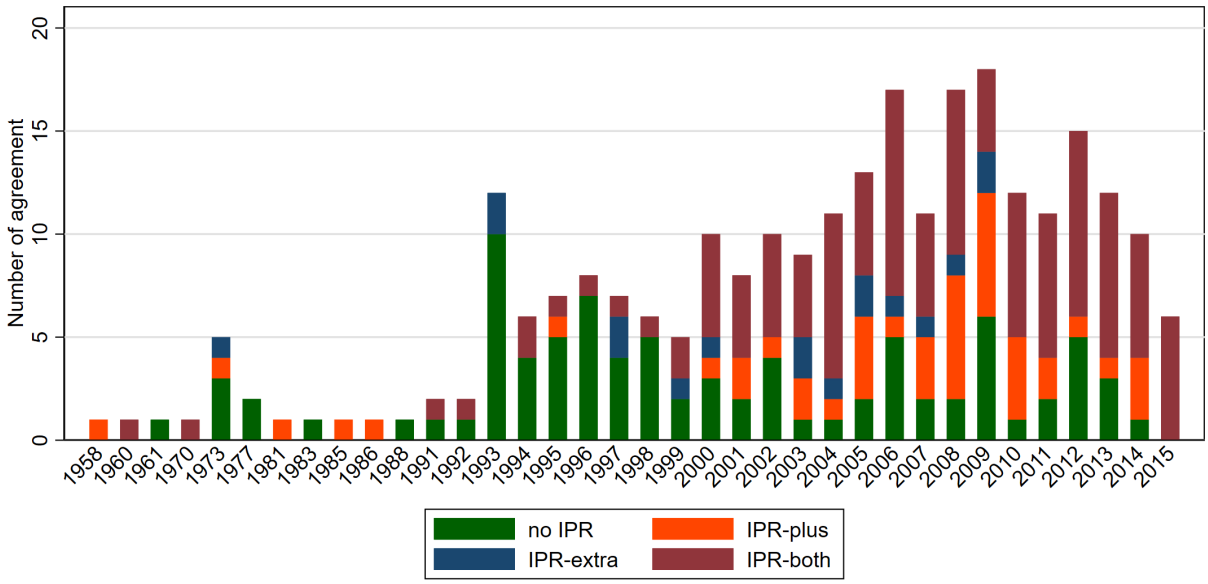


Figure 1: Evolution of RTA with IPR provisions, 1958-2015

Note: The Y-axis represents the number of agreements that enter into force in a given year and the X-axis lists the corresponding years.

Figure 1 displays the trend of RTAs with IPR provisions between 1958 and 2015, using data from Hofmann et al. (2017)'s database. It shows a significant rise in the number of RTAs that include IPR provisions over time. Prior to the launch of the WTO TRIPS agreement in 1995, only a few RTAs, such as the North American Free Trade Agreement, included IPR chapters, which played a role in establishing the TRIPS Agreement (Mattoo et al., 2020). Since then, the inclusion of IPR provisions in RTAs has become increasingly common. As of 2015, out of the 261 regional trade agreements that were implemented between 1958 and 2015, 174 (67%) contained IPR provisions. Of those 174 agreements, 113 (65%) included both types of IPR provisions, while 44 included WTO-Plus type provisions, and the remaining 17 included WTO-extra type provisions. The trend of RTAs with both types of IPR provisions also showed a steady increase from 2000. This indicates that as economies become more integrated and interconnected, the protection of IPR becomes more crucial for market access, investment, and multinational firms' outsourcing and offshoring decisions. Figure 2 describes the linkages between two countries that have signed

a regional trade agreement with intellectual property right provisions.

Our sample includes 189 countries and 224 agreements that are effective from 1990-2015 in our sample. County pairs are not perfectly symmetric as unique exporter countries are 169 but the number of importers is 189. When the country pair has more than one effective trade agreement during the period of this study, we take the latest agreement they signed in. In the case of the European Union (EU) enlargement, the Hofmann et al. (2017) account for it as a seperate agreement therefore we treated them as a separate trade agreements [1]. We exclude 132 bilateral pairs overall time period due to the case that countries withdrew from the following three trade agreements: The Andean Community (CAN), the Treaty on a Free Trade Area between members of the Commonwealth of Independent States (CIS), and Common Market for Eastern and Southern Africa (COMESA). For example, Angola joined COMESA in 1994 and left in 2007, so we removed observations of trade between Angola and the rest of the COMESA members.

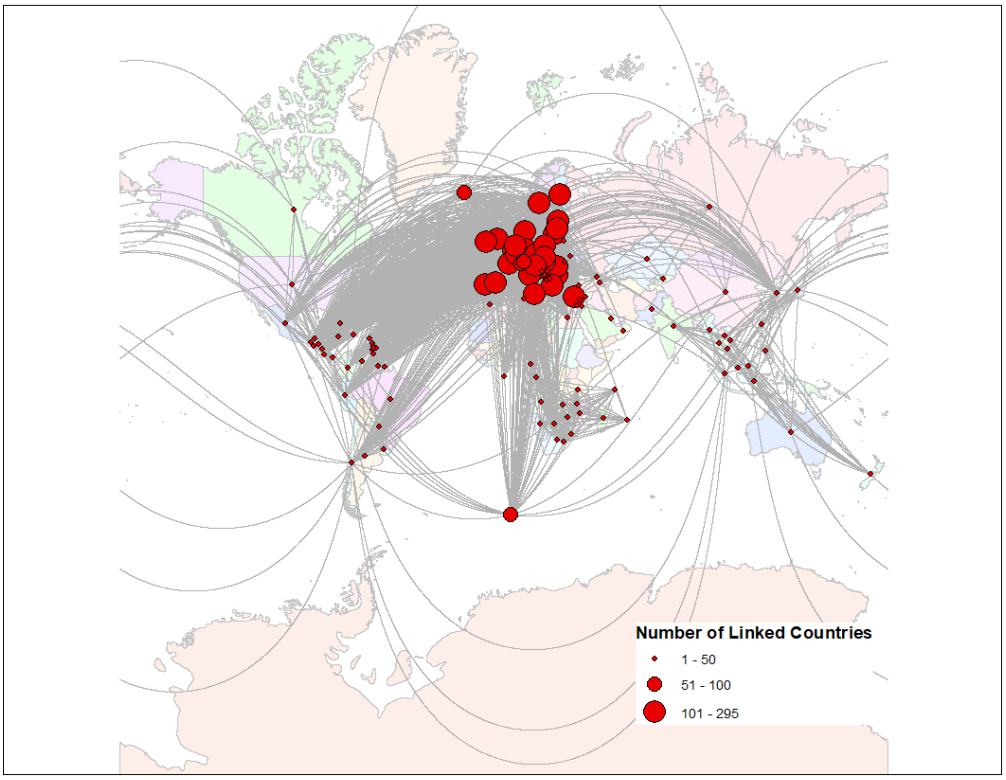


Figure 2: Linkage with IPR provisions in the RTA they signed, 1958-2015

Note: The diagram shows the connections between two countries that have signed a regional trade agreement with intellectual property right provisions. The red circle indicates the number of countries linked in the agreement.

[1] EU-12, 15, 25, 27 and 28

2.2 Agri-food Global Value Chains (GVCs)

We employ a GVC-related trade database provided by World Integrated Trade Solution (WITS). This data is computed following the methodology studied in Borin and Mancini (2019) and Borin et al. (2021) using EORA26 MRIO. They decomposed the value-added across the different bilateral and sectoral trade flows then enable to study GVC participation at the country and disaggregated sector level. Among 26 sectors in EORA26 MRIO, we use agriculture and food and beverage sector data.

Building on seminal contribution of Hummels et al. (2001), Johnson and Noguera (2012) and Koopman et al. (2014), Borin and Mancini (2019) and Borin et al. (2021) define GVC-related as follows. GVC-related trade (GVC_{sr}) can be measured by excluding from the country's gross exports (E_{sr}) to country r the domestic value-added exported by each sector n that is absorbed directly by country r, Traditional trade ($DAVAX_{sr}$).

$$GVC_{sr} = E_{sr} - DAVAX_{sr}$$

Therefore, by the above definition, GVC-related trade includes all trade values that have crossed at least two international borders. From this perspective, GVC-related trade can be a sufficient view for an exported good to be part of an international production network.

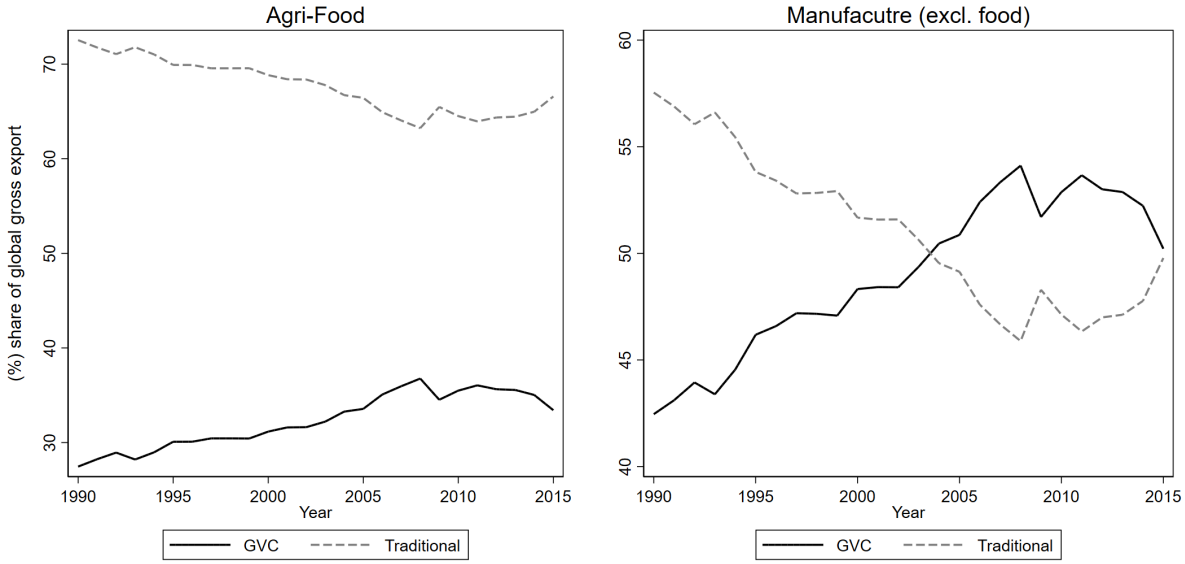


Figure 3: GVC-related % share of gross export at the global level, 1990-2015

Note: The Y-axis represents % share of gross export. We follow the sector classification of EORA MRIO26. Agri-Food is sum of Agriculture and Food (including Beverage) sector and manufacture includes 8 manufacturing sector. (Source: Borin et al. (2021) EORA MRIO26)

The GVC-related share of gross export in the agriculture and food sector has been increasing from 1990 until the late 2000s as the global economy integrated, however, it has stagnated and decreased since then. These trends are found in the manufacturing sector as well. This trend is due to macroeconomic factors such as globalization in the 1990s and financial crisis in 2008. Compared to the manufacturing sector, the GVC-related share of gross export is relatively lower but still more than 30% of gross exports appear to be GVC-related (See Figure 3).

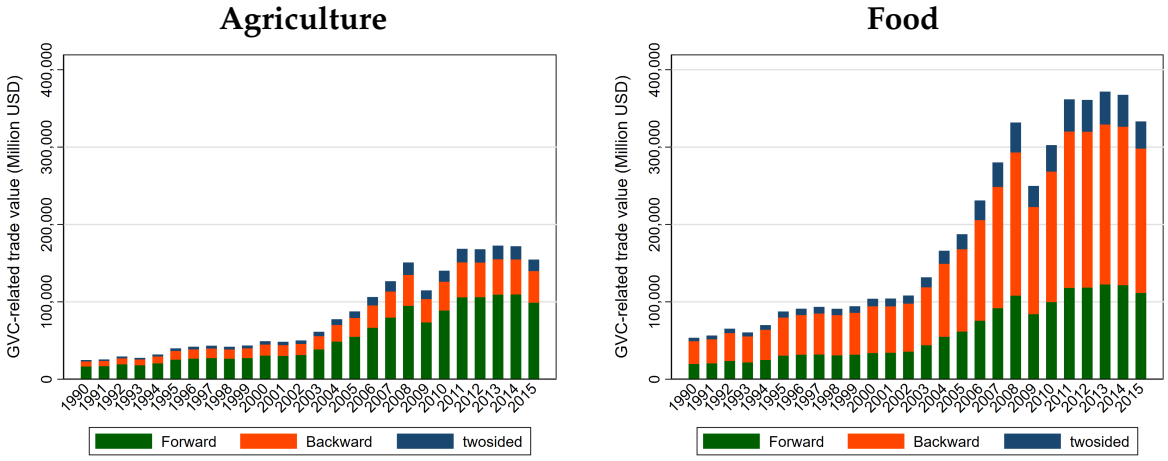


Figure 4: GVC-related trade in Agriculture and Food sector at the global level

Note: This figure displays the global trend of GVC-related trade in the Agriculture and Food sector, including beverages, from 1990 to 2015. The values on the Y-axis are expressed in millions of US dollars, while the X-axis represents the year (Source: Borin et al. (2021) EORA MRIO26)).

We further decompose GVC-related trade value into three types of GVC participation components following Borin et al. (2021): forward, backward and two-sided. This decomposition is based on (i) whether the value-added is domestic of foreign contents and (ii) whether the value-added is absorbed in the importing country r. Illustration of this decomposition is provided in the Appendix (Figure A4).

$$GVC_{sr} = Forward_{sr} + Backward_{sr} + twosided_{sr}$$

$Forward_{sr}$ consists of domestic value-added of exporting country r but $Backward_{sr}$ and $twosided_{sr}$ consist of foreign value added that is embedded in the country s's export. Precisely, $Forward_{sr}$ can be defined as the difference between the entire domestic value-added that is exported to importing country r and the one that is directly absorbed by r. This value represents the pure forward linkage trade between two countries. $Backward_{sr}$ can be defined as the import content of exporting country s's exports absorbed by the importing country r and $twosided_{sr}$ can be the one that is re-exported by r (Borin and

Mancini, 2019; Borin et al., 2021).

Appendix Table A1 reports summary statics for the GVC trade values in our sample. In the agriculture sector, the GVC forward trade is the most relevant component in total agricultural GVC trade as it takes up about 70% of total GVC trade. GVC backward trade accounts for about 20% and two-sided trade are the remaining 10%. On contrary, GVC backward trade accounts for about 56% of total food GVC trade and GVC forward trade takes up 33%. Over time, the value of agriculture and food GVC trade has increased, but the relative percentages of each component have remained constant in both sectors (See Figure 4). In our research, we focus on the impact of IPR provisions on both the forward and backward segments of GVCs, not only on total GVC, as these two segments make up over 90% of the overall GVC trade.

2.3 Multidimensional effect of IPR on trade

The effect of IPR on trade varies depending on the circumstances. Weak IPR protection can distort trade by incentivizing domestic companies to replicate foreign properties and products at a lower cost, leading to the replacement of imports with locally produced imitations (Maskus, 2000). Additionally, weak border enforcement can indirectly subsidize the exports of counterfeit products, potentially increasing their trade (Maskus, 2000).

However, the impact of strengthening IPR on trade is theoretically ambiguous. The first strand focuses on the trade effects of IPR from the perspective of importing market conditions (Maskus and Penubarti, 1995; Smith, 1999; Co, 2004; Falvey et al., 2009; Awokuse and Yin, 2010). The seminar paper by (Maskus and Penubarti, 1995) proposes three channels for the trade effects of IPR. The first channel is the market expansion effect, which occurs when foreign rights-holders can more easily protect their IPRs, leading to an increase in their market share. The second channel is the market power effect, which arises when strengthened IPRs allow rights-holders to engage in monopolistic behavior, restricting sales and raising prices in destination markets. This can results in a decrease of trade volume from such firms. The third channel is the cost reduction effect, which occurs when firms save on the cost of imitation deterrence activities as the importing country secures stronger protection for imported products. Building on these three channels, Smith (1999); Co (2004); Falvey et al. (2009); Awokuse and Yin (2010) consider the threat or capability of imitation and argue that countries without the ability to imitate new products do not pose a competitive threat to foreign IP developers, particularly for technology-intensive manufacturing goods. At the same time, foreign firm could adjust their entry mode in response to IPR policies in importing countries (Smith, 2001; Awokuse

and Gu, 2015). For example, stronger IPR protection confer a location advantage and can provide benefits such as increased affiliate sales (through foreign direct investment (FDI)) and licenses compared to exports (Smith, 2001). This advantage arises when it is more cost-effective to produce goods in the foreign country than to export them. However, as stronger IPR makes the market more appealing, any type of market entry could potentially increase in the destination country (Maskus and Ridley, 2019), making it difficult to generalize the trade-offs.

Second strand of literature focuses on the trade effects of IPR from the perspective of exporting capacity (Branstetter et al., 2006; Yang and Maskus, 2009; Branstetter et al., 2011; He and Maskus, 2012; Briggs and Park, 2014; Maskus and Yang, 2018; Lai et al., 2020). They view the primary channel through which domestic patent protection may affect industrial development as inducing more inward technology transfer via trade, FDI, and licensing of IPR. In turn, stronger IPR could expand export capacity in countries that absorb and deploy foreign technical information. Furthermore, Shin et al. (2016) argue that the effects are asymmetric depending on the nation's development status.

With this complex framework, any primary trade effects could be magnified as domestic IPR policy reform interacts with the implementation of trade agreement. Regional trade agreements (with IPR provisions) increase IPRs protection to the unilateral minimum level of global standard or above it as the commitment is a key driver of the domestic policy reform (Park, 2008; Campi and Nuvolari, 2021).

3 Effects of IPR-provisions in RTA on Agri-food GVC trade

3.1 Empirical Strategy

3.1.1 Baseline specification

In this paper, we follow the standard gravity specification well-established by Anderson (1979), Bergstrand (1985), Eaton and Kortum (2002), Anderson and van Wincoop (2003, 2004), Baier and Bergstrand (2007), and used as a workhorse to examine the determinant of trade flows (Yotov et al., 2016). We simply introduce the general version of the structural gravity model borrowing the notations from Baier et al. (2019). Let X_{ij} denotes the value of exports from an exporting country i to an importing country j, then the gravity equation is

$$X_{ij} = \frac{A_i w_i^{-\theta} \tau_{ij}^{-\theta}}{\sum_l A_l w_l^{-\theta} \tau_{lj}^{-\theta}} E_j \tag{1}$$

where E_j is the expenditure by purchasers in country j on goods from all origin, τ_{ij} is the trade cost ("iceberge" trade cost) between country i and j, w_i is the wage in country i, A_i is the quality of production technologies in country i, and θ is the constant trade elasticity ($\theta > 1$). The summation term in the denominator can be expressed in a compact form, $P_j^{-\theta}$, which represents an aggregate measure of all bilateral trade costs faced by consumers in the importing country (Anderson and van Wincoop, 2003).

$$X_{ij} = \frac{A_i w_i^{-\theta} \tau_{ij}^{-\theta}}{P_j^{-\theta}} E_j \tag{2}$$

For the panel econometric implementation, we can write Equation (2) with a time subscript t and error term $\varepsilon_{ij,t}$ in exponential form to ease the further derivation (Baier et al., 2019; Baier and Bergstrand, 2007).

$$X_{ij,t} = exp\big[lnA_{i,t} w_{i,t}^{-\theta} + ln\frac{E_{j,t}}{P_{j,t}^{-\theta}} + ln\tau_{ij,t}^{-\theta}\big] \times \varepsilon_{ij,t} \tag{3}$$

The standard procedure to infer the effects of trade policy(e.g. formation of regional trade agreement) on bilateral trade flows typically involves accounting for the presence of such policy using a fixed effect. This fixed effect is interpreted as being part of the unobservable trade costs, represented as $\tau_{ij,t}$ in the structural gravity equation.

$$ln\tau_{ij,t}^{-\theta} = \alpha Z_{ij} + \beta RTA_{ij,t} \tag{4}$$

Here, $RTA_{ij,t}$ is an indicator variable for the regional trade agreement between country i and j at time t. Z_{ij} can include traditional gravity variables such as geographical distance, colonial ties, contiguity, common language and etc. Recent literature has incorporated bilateral dummies (ϕ_{ij}) to address potential endogeneity issues in trade agreements. Then, any of the time-invariant standard gravity variables will be dropped due to the perfect collinearity.

The econometric specification of gravity is completed by substituting Equation (4) to (3) and the baseline specification for estimating the average effect of RTA on trade becomes

$$X_{ij,t} = exp[\beta RTA_{ij,t} + \delta_{i,t} + \eta_{j,t} + \phi_{ij}] \times \varepsilon_{ij,t} \tag{5}$$

where δ_{it} and η_{jt} denotes the exporter-time and importer-time dummy variables to absorb the terms $lnA_{i,t} w_{i,t}^{-\theta}$ and $ln\frac{E_{j,t}}{P_{j,t}^{-\theta}}$ in Equation (3) which are unobservables. These two fixed effects explicitly account for the time-varying multilateral price factors in the structural

gravity model. ϕ_{ij} denotes country-pair fixed effects (bilateral dummies).

This baseline specification relying on the three-way fixed effects allows us to estimate the most plausible average effect of a trade policy such as the formation of the trade agreement on a bilateral trade flow in the panel data setting (Baier and Bergstrand, 2007) and it has been widely used in recent trade field studies including Anderson and Yotov (2016), Yotov et al. (2016), Baier et al. (2019) and Balié et al. (2019).

3.1.2 Identifying the IPR provisions specific effects

Based on this, our specification to analyze the contemporaneous effect of IPR provision in regional trade agreement on the GVC-related agriculture and food trade can be expressed by using following equation:

$$X_{ij,t}^{p} = exp[\beta_1 RTA_{ij,t} + \beta_2 IPR_{ij,t} + \delta_{i,t} + \eta_{j,t} + \phi_{ij}] \times \varepsilon_{ij,t} \tag{6}$$

where dependent variable $X_{ij,t}$ is GVC-related trade between exporter *i* and importer *j* at time *t*. *p* refers to agriculture, food and total (agriculture + food). RTA capture the generic effect of the regional trade agreement on trade. $RTA_{ij,t}$ is 1 if country *i* and *j* has membership in any RTA at time t. $IPR_{ij,t}$ is 1 if the RTA between country *i* and *j* includes IPR provisions. This is identical to express $RTA_{ij,t} \cdot IPR_{ij,t}$ as IPR provision is a component of RTA. δ_{it} and η_{jt} denote the exporter-time and importer-time dummy variables and are theoretically motivated by the structural gravity model. We also include the set of country-pair fixed effects (bilateral dummies) ϕ_{ij} to control for the time-invariant trade cost between countries and the potential heterogeneity of trade policy variables (Anderson and Yotov, 2016).

We further investigate the dynamic and long-run effect of IPR provisions on GVC-related agriculture and food trade to account for the potential time lag in the effects of the regional trade agreement. The potential lag effect, called the "phase-in" effect, is suggested and documented by previous studies including Baier and Bergstrand (2007), Anderson and Yotov (2016), Franco-Bedoya and Frohm (2022) and Egger et al. (2022). The econometric specification includes the lag variables in Equation (4) and this is motivated by the institutional characteristics of regional trade agreement, which refers to the gradual implementation of its provisions over time. In many cases, the full impact of a trade agreement may not be felt immediately after its enactment, but rather over years as various provisions are gradually implemented. This can be due to a variety of factors, such as the need for regulatory changes, adjustments to trade policies, or delays in the adoption of new technologies. The full gravity equation for dynamic and long-run effects of IPR

provisions takes the following form:

$$X_{ij,t}^{p} = exp\Big[\sum_{k=0}^{10} \alpha_k RTA_{ij,t-k} + \sum_{k=0}^{10} \beta_k IPR_{ij,t-k}\Big] \times exp[\delta_{i,t} + \eta_{j,t} + \phi_{ij}] \times \varepsilon_{ij,t} \tag{7}$$

Dependent variables are Total GVC, GVC forward and backward trade for each sector (Agri-Food, Agriculture, and Food). The definition of explanatory variables is the same as variables used in Equation (6). The subscript $t-k$ indicates the lag variable and we consider 10 lag in the specification. Many studies estimating the trade policy affect to use the common practice of using interval years (e.g. 3 to 5 years) with panel data to adjust for the dynamic policy adjustment process (Baier and Bergstrand, 2007; Olivero and Yotov, 2012; Anderson and Yotov, 2016; Yotov et al., 2016; Baier et al., 2019). On the other hand, a recent study by Egger et al. (2022) documented potential systematic downward bias due to the unequal spacing of trade agreements from using interval year data compared to using consecutive year data. [2] Following the recent study, we use consecutive year data to gain the insightful diminishing effect of IPR provisions and include ten lags as phase-in periods are typically over five to ten years (Baier and Bergstrand, 2007).

We employ the Pseudo Poisson Maximum Likelihood (PPML) estimation method to account for heteroskedasticity and obtain the consistent estimator (Silva and Tenreyro, 2006) [3]. However, recent work by Weidner and Zylkin (2021) has shown that, in three-way gravity models, standard significance tests and confidence intervals may not be valid, as the asymptotic bias and standard deviation of the estimator decrease at the same rate. This is affected by the incidental parameter problems which can arise when the number of fixed effects is large relative to the number of observations. To address this issue, we follow Weidner and Zylkin (2021) and apply a remedy to all estimations in our paper to mitigate the bias in standard errors while still retaining the benefits of fixed effects estimation.

[2] We also conducted analyses using data with 4-year intervals following Anderson and Yotov (2016). We found that the overall results were similar between the interval and consecutive years, but the estimates were smaller when we used the 4-year intervals. Results from the 4-year interval data can be found in the Appendix C

[3] A consistent estimator is obtained when the conditional mean function is correctly specified and strict exogeneity holds.

3.2 Empirical results

3.2.1 Contemporaneous Effects

We begin by analyzing contemporaneous effects of Regional Trade Agreements (RTAs) and Intellectual Property Rights (IPRs) provisions specific effects on Global Value Chain (GVC) trade in the agriculture and food sectors. Table 1 presents the regression results of Equation (6)

The first three columns (Columns 1-3) show the estimated RTA effects on Agri-Food and the two sectors separately. The following three columns (Columns 4-6) add IPR provisions to the RTA effects. In Panel A, we find a positive and significant RTA effect on Agri-Food GVC trade (Column 1) and agriculture GVC trade (Column 2) but not on food GVC trade (Column 3). However, the IPR provision effect is insignificant for Agri-Food GVC trade (Column 4), but its impacts are negative, and the magnitude is -0.050 (Column 5). It means that bilateral agricultural GVC trade participation decreased by 4.8% ($(exp(-0.050) - 1) \times 100$) between the members with RTA with IPR provision relative to the RTA without IPR provision. RTA and IPR provisions have no significant effect on food GVC trade (Column 6). In Panels B and C, we analyze the impact of RTAs and IPR provisions on GVC forward and backward trade, respectively. The overall results are similar to Panel A. Still, we find a negative and significant impact of IPR provisions on bilateral agricultural GVC forward participation (6.3% decrease in Column 5). In contrast, both sectors have no significant effect on GVC backward trade.

In summary, our results indicate that an average bilateral Agricultural GVC trade participation decrease between the members with RTA with IPR provision relative to the RTA without IPR provisions. However, the inclusion of IPR provisions does not have a significant effect on an average bilateral food GVC trade.

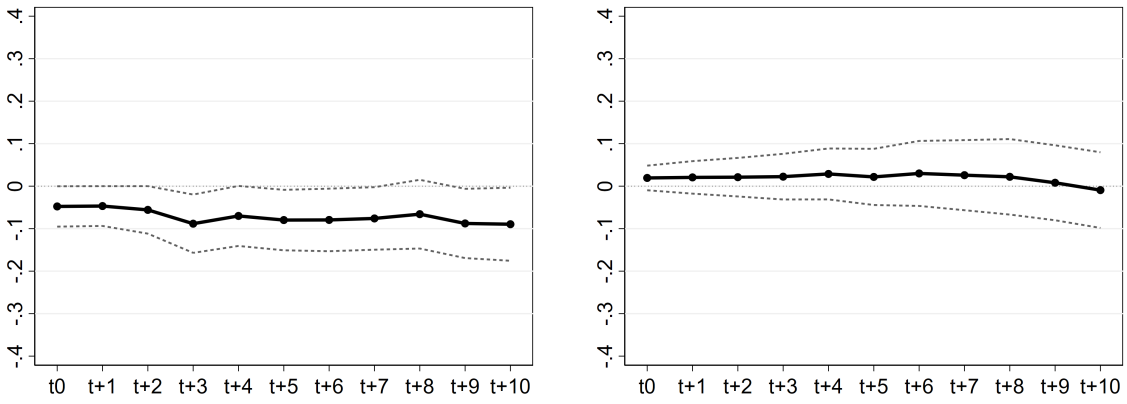
3.2.2 Dynamic and Long-Run effects

We further explore the long-run effects to account for the potential time lag in the effects of the regional trade agreement. The regression results using Equation (7) for the three dependent variables are presented in Appendix Table A3. Overall, RTAs have a positive effect, but the impact of IPR provisions varies over time. Most of the lag coefficients show a negative sign. To illustrate the accumulated short and long-run effects of IPR provisions on total GVC trade in the agriculture and food sectors, please refer to Figure 5. Meanwhile, Appendix Figure A1 depicts the effects on GVC forward and backward.

Table 1: Effects of IPR provision on agriculture and food GVC trade

	Agri-Food	Agriculture	Food	Agri-Food	Agriculture	Food
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Total GVC trade						
RTA(t)	0.025*	0.045*	0.012	0.021	0.082**	-0.004
	(0.011)	(0.018)	(0.009)	(0.016)	(0.025)	(0.017)
IPR(t)				0.005	-0.050+	0.020
				(0.016)	(0.026)	(0.016)
Obs.	748,457	748,298	748,539	748,457	748,298	748,539
Pseudo-R2	0.999	0.999	0.999	0.999	0.999	0.999
Panel B: Forward trade						
RTA(t)	0.040**	0.072**	0.010	0.050**	0.119**	-0.006
	(0.011)	(0.017)	(0.010)	(0.018)	(0.030)	(0.022)
IPR(t)				-0.014	-0.066*	0.020
				(0.017)	(0.028)	(0.021)
Obs.	745,481	745,774	745,163	745,481	745,774	745,163
Pseudo-R2	0.999	0.999	1.000	0.999	0.999	1.000
Panel B: Backward trade						
RTA(t)	0.018	0.026	0.022*	0.023	0.063*	0.015
	(0.013)	(0.018)	(0.011)	(0.017)	(0.029)	(0.015)
IPR(t)				-0.007	-0.047	0.009
				(0.018)	(0.031)	(0.015)
Obs.	748,818	748,800	748,799	748,818	748,800	748,799
Pseudo-R2	0.999	0.999	0.999	0.999	0.999	0.999

Note: Standard errors are clustered by country pair and reported in parentheses. The years in the data are from 1990 to 2015. All estimations are performed with exporter and importer time-varying fixed effects and bilateral dummies in Equation (6). Fixed effects estimates, including the constant, are omitted for brevity. All estimates are PPML estimator. In Panel A, we present the results for the regression analysis with total GVC trade as the dependent variable. Panels B and C, on the other hand, display the results when the dependent variables are GVC Forward and Backward trade, respectively. The results of the regression by sector, including agriculture, food, and agri-food (sum of agriculture and food), are presented in each column. We adjust for the (asymptotic) bias in the coefficient estimates as well as the standard errors by using the bias correction method suggested by Weidner and Zylkin (2021). The p-values read as follows: $+p < .10$,* $p < .05$,** $p < .01$.



(a) Agriculture

(b) Food

Figure 5: Impact of IPR provisions on GVC-related trade in agriculture and food

Note: These figures are a visualization of the short and long-run effect of IPR provisions on GVC-related trade. The Y-axis represents the proportionate change of average GVC-related export from country *i* to *j* when there are IPR provisions in the RTA. X-axis represents the event timeline. t0 means the year that RTA comes into force. The coefficients are obtained from the regression of Equation (7) and listed in the Appendix Table A3 column (2) and (3). Specifically, all of the lags, and current IPR estimates were added to provide the point estimates in the figure. Thus, for example, by construction '$t+1$' (associated with the sum of IPR_t and IPR_{t-1}), and '$t+10$' (associated with the sum of IPR_t, IPR_{t-1}, IPR_{t-2}, ..., and IPR_{t-10}). The dashed lines above and below the line connecting estimates indicate the upper and lower bound of 95% confidence intervals.

In the Agriculture sector, we observe a steadily decreasing pattern in the impact of IPR provisions until three years after the trade agreement takes effect. After that, only minor marginal effects are followed until the 8th year, with weak statistical significance. In contrast, we see a minor and increasing pattern in the Food sector until 7-8 years after the trade agreement comes into force, but these changes are not statistically significant. Moreover, these patterns hold for total GVC trade and for GVC forward and backward trade.

When we consider the total long-run effects of IPR provisions (as shown in Appendix Table A3, Total IPR row), calculated as the sum of coefficients on contemporaneous and all ten lag variables, we find statistically significant results at the 5% level only in the Agriculture sector for all three dependent variables. The total impact of IPR provisions on Agriculture GVC trade is -0.090 (standard error 0.044), indicating a 9.0% decrease in agricultural GVC trade participation during the 10 years of investigation in bilateral trade between members with RTAs that have IPR provisions, relative to those without such provisions. The total impact of IPR provisions on Agriculture GVC forward and backward trade is -10.6% (standard error 4.5) and -11% (standard error 5.3), respectively.

Our results indicate an average bilateral Agricultural GVC trade participation decrease between the members with RTA with IPR provision relative to the RTA without IPR provisions when we account for the phased-in effect of the trade agreement. However, the inclusion of IPR provisions does not significantly impact the average bilateral

food GVC trade in the long term.

4 WTO-plus versus WTO-Extra: Heterogeneous Treatment effect analysis

Recall that IPR provisions in regional trade agreements have two aspects, as described in Section 2.1. The WTO plus aspect covers what is required by WTO TRIPs but includes additional procedural rules for effective implementation, while the WTO extra aspect mandates compliance with additional IP-related treaties to extend the IP protection system beyond WTO TRIPs. We hypothesize that the impact of these two features of IPR provisions may differ because they involve different obligations and elements, and the way they affect the process of domestic policy reform will also vary. We also try to identify the source of the negative dominant impact of IPR provisions observed in Section 3 by examining the characteristics of these provisions. To do so, we conduct an empirical investigation to explore potential heterogeneity in the effects of IPR provisions across types of IPR provisions using the deep trade agreement data constructed by Hofmann et al. (2017). Our analysis follows the order of the previous section as outlined in Section 3.1. We first examine the contemporaneous effect and then proceed to investigate the long-run effect.

4.1 Empirical Strategy

We analyze the contemporaneous of WTO plus and extra type IPR provisions on GVC-related agriculture and food trade by using following equation:

$$\begin{aligned} X^{p}_{ij,t} = exp[\alpha RTA_{ij,t} + \beta_1 iprPlus_{ij,t} + \beta_2 iprExtra_{ij,t} + \beta_3 iprPlus * iprExtra_{ij,t}] \\ \times exp[\delta_{i,t} + \eta_{j,t} + \phi_{ij}] \times \varepsilon_{ij,t} \end{aligned} \tag{8}$$

where dependent variable $X_{ij,t}$ is GVC-related trade between exporter i and importer j at time t. p refers to agriculture, food and total (agriculture + food). RTA capture the generic effect of the regional trade agreement on trade. $RTA_{ij,t}$ is 1 if country i and j has membership in any RTA at time t. In this model, we want to identify the effect of the "WTO plus"($iprPlus$) and "WTO extra"($iprExtra$) type of IPR provision on trade and consider the interaction effect of two types. $iprPlus$ and $iprExtra$ are binary variable. 1 if the provision of IPR in RTA between country i and j has each characteristic and 0 otherwise. δ_{it} and η_{jt} denotes the exporter-time and importer-time dummy variables and

ϕ_{ij} denote country-pair fixed effects (bilateral dummies).

We analyze the dynamic and long-run effect of WTO plus and extra type IPR provisions on GVC-related agriculture and food trade by using the following equation:

$$\begin{aligned} X_{ij,t}^{p} =& exp\Big[\sum_{k=0}^{10} \alpha_k RTA_{ij,t-k}\Big] \\ &\times exp\Big[\sum_{k=0}^{10} \left(\gamma_{1,k} iprPlus_{ij,t-k} + \gamma_{2,k} iprPlus_{ij,t-k} + \gamma_{3,k} iprPlus_{ij,t-k} * iprExtra_{ij,t-k}\right)\Big] \\ &\times exp[\delta_{i,t} + \eta_{j,t} + \phi_{ij}] \times \varepsilon_{ij,t} \end{aligned} \tag{9}$$

The variables used in this equation are the same as those in the Equation (8). The subscript $t-k$ indicates the lag variable and we consider 10 lag in the specification. The theoretical framework for this specification is provided in an earlier section of the text (see Section 3.1.2)

4.2 Estimation results

4.2.1 Contemporaneous Effects

In this section, we investigate whether the impact of IPR provisions on agriculture and food GVC trade differs based on the specific characteristics of these provisions. The result shows that the interaction term between WTO-plus and extra-type provisions has a statistically significant and positive effect on trade, while single-type variables have a negative effect (see Table 2). The effects are more significant in agriculture than in food, and this pattern is consistent across all three dependent variables: total GVC, GVC forward, and backward trade. However, the current model does not fully explain the variation in food sector GVC trade, as demonstrated in Panel C. We examine the marginal effect of each provision, as the interaction term plays a role. We compute the proportional change in GVC trade and present it in Table 3.

Table 2: Effects of WTO plus and WTO extra type of IPR provisions on GVC trade in Agriculture and Food sector

	Total GVC		GVC Forward		GVC Backward	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Agri-Food Total						
RTA(t)	0.021	0.017	0.050**	0.047**	0.023	0.019
	(0.016)	(0.016)	(0.018)	(0.018)	(0.017)	(0.017)
IPR(t)	0.005		-0.014		-0.007	
	(0.016)		(0.017)		(0.018)	
iprPlus(t)		-0.030		-0.070**		-0.048*
		(0.019)		(0.022)		(0.020)
iprExtra(t)		-0.070		-0.060		-0.090
		(0.053)		(0.057)		(0.065)
iprPlus(t)*iprExtra(t)		0.131*		0.141*		0.166*
		(0.057)		(0.061)		(0.066)
Obs.	748,457	748,457	745,481	745,481	748,818	748,818
Pseudo-R2	0.999	0.999	0.999	0.999	0.999	0.999
Panel B: Agriculture						
RTA(t)	0.082**	0.062*	0.119**	0.104**	0.063*	0.044
	(0.025)	(0.026)	(0.030)	(0.028)	(0.029)	(0.027)
IPR(t)	-0.050^{+}		-0.066*		-0.047	
	(0.026)		(0.028)		(0.031)	
iprPlus(t)		-0.149**		-0.181**		-0.154**
		(0.033)		(0.038)		(0.034)
iprExtra(t)		-0.166^{+}		-0.130^{+}		-0.136*
		(0.086)		(0.068)		(0.058)
iprPlus(t)*iprExtra(t)		0.344**		0.313**		0.319**
		(0.094)		(0.081)		(0.064)
Obs.	748,298	748,298	745,774	745,774	748,800	748,800
Pseudo-R2	0.999	0.999	0.999	0.999	0.999	0.999
Panel C: Food						
RTA(t)	-0.004	-0.006	-0.006	-0.007	0.015	0.013
	(0.017)	(0.018)	(0.022)	(0.022)	(0.015)	(0.015)
IPR(t)	0.020		0.020		0.009	
	(0.016)		(0.021)		(0.015)	
iprPlus(t)		0.002		0.005		-0.029
		(0.021)		(0.024)		(0.019)
iprExtra(t)		-0.017		0.021		-0.030
		(0.041)		(0.070)		(0.056)
iprPlus(t)*iprExtra(t)		0.048		-0.002		0.087
		(0.046)		(0.071)		(0.058)
Obs.	748,539	748,539	745,163	745,163	748,799	748,799
Pseudo-R2	0.999	0.999	1.000	1.000	0.999	0.999

Note: Standard errors are clustered by country pair and reported in parentheses. The years in the data are from 1990 to 2015. All estimations are performed with exporter and importer time-varying fixed effects and bilateral dummies in Equation (8). Fixed effect estimates, including the constant, are omitted for brevity. All estimates are PPML estimator. Panel A reports the result for agriculture and food sector together. Panel B and C report results for agriculture and food separately. Each column lists the result of regression by dependent variables that are Total GVC, GVC Forward and Backward trade, respectively. We adjust for the (asymptotic) bias in the coefficient estimates as well as the standard errors by using the bias correction method suggested by Weidner and Zylkin (2021). The p-values read as follows: $+p < .10$,* $p < .05$,** $p < .01$.

Table 3: Marginal effect of "WTO plus" and "WTO extra" IPR provisions on GVC trade

	Agri-Food			Agriculture			Food		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent variable	Total	Forward	Backward	Total	Forward	Backward	Total	Forward	Backward
Proportional change in average dependent variable when Δx = 1									
x = iprExtra | iprPlus = 1	0.063**	0.084**	0.079**	0.195**	0.201**	0.201**	0.031^{+}	0.019	0.059**
	(0.016)	(0.019)	(0.015)	(0.037)	(0.043)	(0.033)	(0.016)	(0.013)	(0.015)
x = iprExtra | iprPlus = 0	-0.068	-0.058	-0.086	-0.153*	-0.121*	-0.127*	-0.017	0.021	-0.029
	(0.049)	(0.053)	(0.059)	(0.073)	(0.060)	(0.051)	(0.041)	(0.071)	(0.054)
x = iprPlus | iprExtra = 1	0.107^{+}	0.074	0.125^{+}	0.216^{+}	0.141^{+}	0.179**	0.051	0.003	0.060
	(0.061)	(0.063)	(0.076)	(0.115)	(0.086)	(0.066)	(0.043)	(0.066)	(0.062)
x = iprPlus | iprExtra = 0	-0.029	-0.067**	-0.047*	-0.138**	-0.165**	-0.143**	0.002	0.005	-0.028
	(0.019)	(0.020)	(0.019)	(0.029)	(0.031)	(0.029)	(0.021)	(0.024)	(0.018)

Note: Columns represent each model by sector and dependent variable. Total, Forward and Backward means Total GVC, GVC Forward and Backward, respectively. All estimates are result for the nonlinear combination of PPML estimates obtained in Table 2 column (2), (4) and (6) to present the proportional change in dependent variable when variable x changes from 0 to 1. Specifically, "**x = iprExtra** | iprPlus = 1" can read as the proportional change in average dependent variable when iprExtra changes from 0 to 1 when iprPlus = 1 (and RTA = 1). This implies the incremental effect of having both type of provisions compared to having plus type of provision. Column (1) is corresponding to the Table 2-Panel A-Column (2) and the first estimate (0.063) is calculated by $\frac{exp(0.062-0.149+0.344-0.166)-exp(0.062-0.149)}{exp(0.062-0.149)} = exp(0.344-0.166)-1$. The interpretation is that the average bilateral Total GVC trade in Agfood sector increase by 6.3% between country i and j if they have both type of IPR provisions compared to have plus type of provision in their regional trade agreement. The rest of estimates are also calculated and interpreted in similar way. Standard errors are in parentheses and the p-values read as follows: $+p < .10$,* $p < .05$,** $p < .01$.

The results shown in Table 3, columns (1) to (3), are for the aggregated Agri-Food sector. The result on total GVC trade indicates that, on average, bilateral total Agri-Food GVC trade increases by 6.3% between countries *i* and *j* when both types of IPR provisions are present in their regional trade agreement, compared to the case where only the WTO-plus type provision is present (See column 1, **x = iprExtra** | iprPlus = 1). Additionally, bilateral total Agri-food GVC trade increases by 10.7% between countries *i* and *j* when both types of IPR provisions are present, compared to when only the extra-type provision is present in the RTA. However, our findings suggest that having only extra or plus-type provisions in an RTA does not have a significant effect on GVC trade compared to the case without any IPR provisions (refer to column (1) **x = iprExtra** | iprPlus = 0 and **x = iprPlus** | iprExtra = 0). The results on GVC forward show that the inclusion of extra-type provisions in addition to WTO-plus provisions has a positive and significant incremental effect on Agri-Food GVC forward trade (8.4% increase), while the effect of including WTO-plus provisions in addition to extra-type provisions is not significant. In the case of GVC backward trade, the inclusion of extra-type provisions in addition to WTO-plus provisions has an incremental effect of 7.9% and the inclusion of WTO-plus provisions in addition to extra-type provisions has an incremental effect of 12.5%

Next, we examine the results separately for the agriculture and food sectors. The results shown in Table 3, columns (4) to (6), are for the Agriculture sector. The result on total

GVC trade indicates that, on average, bilateral total Agriculture GVC trade increases by 19.5% between countries i and j when both types of IPR provisions are present in their regional trade agreement, compared to the case where only the WTO-plus type provision is present (See column 4, **x = iprExtra** | iprPlus = 1). Additionally, bilateral total Agriculture GVC trade increases by 21.6% between countries i and j when both types of IPR provisions are present, compared to when only the provision is included in the RTA.

However, our findings suggest that having only extra or plus-type provisions in a negative and statistically significant effect on GVC trade compared to the case without any IPR provisions (15.3% and 13.8% decrease, refer to column (4) **x = iprExtra** | iprPlus = 0 and **x = iprPlus** | iprExtra = 0). The results on GVC forward (column (5)) indicate that incorporating extra-type provisions in addition to WTO-plus provisions has a statistically significant and positive impact on Agriculture GVC forward trade (20.1% increase). Similarly, including WTO-plus provisions in combination with extra-type provisions also has a positive effect on Agri-Food GVC forward trade, leading to a 14.1% increase. In the case of GVC backward trade, the inclusion of extra-type provisions in addition to WTO-plus provisions has an incremental effect of 20.1% and the inclusion of WTO-plus provisions in addition to extra-type provisions has an incremental effect of 17.9%. Having only WTO-extra or plus type provisions has a negative and statistically significant effect on Agriculture GVC forward and backward compared to the case without any IPR provisions (refer to column (5)-(6) **x = iprExtra** | iprPlus = 0 and **x = iprPlus** | iprExtra = 0).

The results shown in Table 3, columns (7) to (9), are for the Food sector. In the Food sector, the current model does not fully explain the variation in the GVC trade compared to the agriculture sector. However, we find that including extra provisions has a statistically significant impact on total GVC trade and GVC backward trade in the Food sector. The observed marginal effects are 3.1% and 5.9%, respectively, suggesting a notable increase in trade as a result of the incorporation of WTO-extra provisions.

Our results indicate that an interactive effect between two types of IPR provisions is important to enhance the agricultural and food GVC trade between the members with RTA including IPR commitments. Our results show that having a single type of IPR provision may not have a desirable effect on the GVC links.

4.2.2 Dynamic and Long-Run effects

In previous regression, we've seen a positive incremental effect between WTO-plus and extra-type provisions. The dynamic model regression shows a consistent result with our previous finding. The patterns of effects are similar across total GVC, GVC forward, and backward trade. Here we discuss the results for each sector separately.

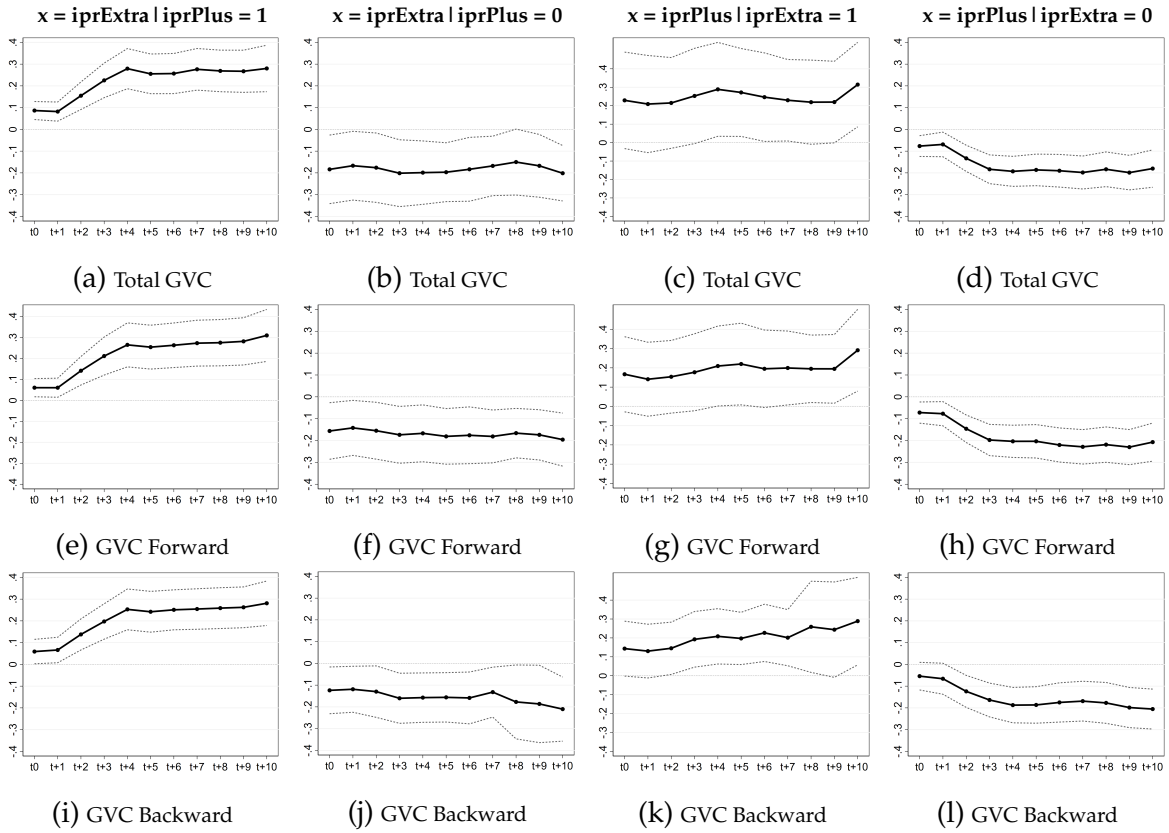


Figure 6: The marginal effect of WTO plus and extra type provision on Total GVC, GVC forward and backward trade in the Agriculture sector

Note: These figures are visualization of the marginal effect of WTO plus and extra type IPR provisions on total GVC (first row), GVC Forward (Second row) and GVC Backward (Third row) in the Agriculture sector. The Y-axis represents the proportionate change of average GVC-related export from country *i* to *j* given RTA =1 and iprPlus = 1. The X-axis represents the event timeline. t0 means the year that RTA was entered into force. The coefficients are obtained from the regression of Equation (8). Specifically, all of the lags, and current IPR estimates were added to provide the point estimates in the figure. Thus, for example, by construction '$t+1$' (associated with the sum of $iprExtra_t$, $iprPlus_t * iprExtra_t$, $iprExtra_{t-1}$, $iprPlus_{t-1} * iprExtra_{t-1}$), and '$t+10$' (associated with the sum of $iprExtra_t$, $iprPlus_t * iprExtra_t$, $iprExtra_{t-1}$, $iprPlus_{t-1} * iprExtra_{t-1}$, ..., and $iprExtra_{t-10}$, $iprPlus_{t-10} * iprExtra_{t-10}$,$iprExtra_{t-10}$, $iprPlus_{t-10} * iprExtra_{t-10}$). The dashed lines above and below the line connecting estimates indicate the upper and lower bound of 95% confidence intervals. For brevity, tables are included in the appendix.

The Appendix Table A4 columns (2), (5), and (8) report the regression results for the Agriculture sector. In terms of total long-run effects, bilateral total Agriculture GVC trade increases by 28% between countries *i* and *j* when both types of IPR provisions are present, compared to when only the WTO-extra provision is present in the RTA during the period of investigation (10 years) (See column (2), **x = iprExtra** | iprPlus = 1). Similarly, bilateral total Agriculture GVC trade increases by 31.4% between countries *i* and *j* when both types of IPR provisions are present, compared to when only the WTO-plus provision is present in the RTA (See column (2), **x = iprPlus** | iprExtra = 1). However, our findings suggest that having only extra or plus-type provisions shows a negative and statistically significant effect on GVC trade compared to the case without any IPR provisions (20.2% and 18.0% decrease, refer to column (2) **x = iprExtra** | iprPlus = 0 and **x = iprPlus** | iprExtra = 0).

The results on GVC forward (column (5)) indicate that incorporating extra-type provisions in addition to WTO-plus provisions has a statistically significant and positive impact on Agriculture GVC forward trade (31% increase). Similarly, including WTO-plus provisions in combination with extra-type provisions also has a positive effect on Agriculture GVC forward trade, leading to a 29.2% increase. In the case of GVC backward trade, the inclusion of extra-type provisions in addition to WTO-plus provisions has an incremental effect of 28.1% and the inclusion of WTO-plus provisions in addition to extra-type provisions has an incremental effect of 28.9%. Similar to the contemporaneous effect, we observe that having only WTO-extra or plus type provisions has a statistically significant and negative long-run effect on Agriculture GVC forward and backward compared to the case without any IPR provisions (refer to column (5) and (8) **x = iprExtra** | iprPlus = 0 and **x = iprPlus** | iprExtra = 0).

Figure 6 displays estimated short- and long-term impacts of WTO-plus and extra-type provisions on total GVC trade, as well as forward and backward GVC trade in the Agriculture sector. When a country has both types of IPR provisions, the trade-enhancing effect of the provisions is greater than when the RTA includes only a single type of IPR provision. The growth pattern of incremental effects of WTO-extra and plus type provisions differs over the event time. The incremental effects of WTO-extra type provisions increase until approximately 4 years after the trade agreement is implemented (as seen in Figures 6a, 6e, and 6e). In contrast, the incremental effects of WTO-plus type provisions seem larger than that of WTO-extra type but the marginal growth in changes are relatively small and statistically less significant (as observed in Figures 6c, 6g, and 6g).

After 4-5 years, the effects of extra-type provisions appear to reach their full potential, while the effects of plus-type provisions show a slight decrease, although this change is relatively small. Similar patterns are observed across total GVC, GVC forward, and backward trade.

The Appendix Table A4 columns (3), (6), and (9) report the regression result for the Food sector. As we recall the contemporaneous effects, the IPR provisions in the Food sector are less attributable to the variation in GVC trade compared to the Agriculture sector but we observed the inclusion of WTO-extra provisions in addition to the WTO-plus provisions has positive trade effects on Total GVC and GVC backward trade. This hold in the long-run effect view, but we additionally observe the positive effect on GVC forward trade when we account for the dynamic effects of the trade agreement. The results show that including WTO-extra provisions in addition to WTO-plus provisions has a statistically significant incremental impact on total GVC, GVC forward and backward trade in the Food sector. The observed marginal effects are 5.1%, 4.5%, and 8.4% respec-

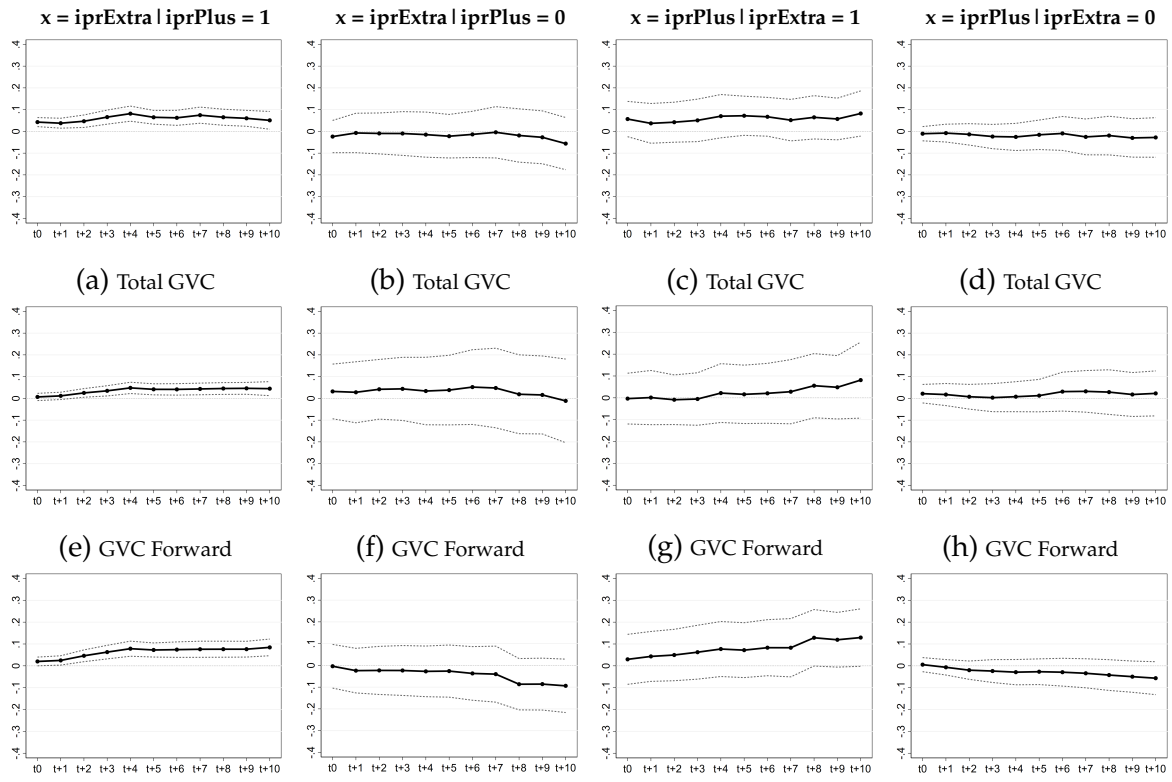


Figure 7: Marginal effect of WTO plus and extra type provision on Total GVC, GVC forward and backward trade in the Food sector

Note: These figures are visualization of the marginal effect of WTO plus and extra type IPR provisions on totoa GVC (first row), GVC Forward (Second row) and GVC Backward (Third row) in the Agriculture sector. The Y-axis represents the proportionate change of average GVC-related export from country *i* to *j* given RTA =1 and iprPlus = 1. The X-axis represents the event timeline. t0 means the year that RTA was entry into force. The coefficients are obtained from the regression of Equation (9). Specifically, all of the lags, and current IPR estimates were added to provide the point estimates in the figure. Thus, for example, by construction '$t+1$' (associated with the sum of $iprExtra_t$, $iprPlus_t * iprExtra_t$, $iprExtra_{t-1}$, $iprPlus_{t-1} * iprExtra_{t-1}$), and '$t+10$' (associated with the sum of $iprExtra_t$, $iprPlus_t * iprExtra_t$, $iprExtra_{t-1}$, $iprPlus_{t-1} * iprExtra_{t-1}$, ..., and $iprExtra_{t-10}$, $iprPlus_{t-10} * iprExtra_{t-10}$,$iprExtra_{t-10}$, $iprPlus_{t-10} * iprExtra_{t-10}$). The dashed lines above and below the line connecting estimates indicate the upper and lower bound of 95% confidence intervals.For the brevity, tables are included in the appendix.

tively, suggesting a modest increase in trade as a result of the incorporation of WTO-extra provisions. Furthermore, we can observe the incremental long-run effect of WTO-plus provisions on GVC backward trade.

Figure 7 displays estimated short- and long-term impacts of WTO-plus and extra-type provisions on total GVC trade, as well as forward and backward GVC trade in the Food sector. When a country has both types of IPR provisions, the trade-enhancing effect of the provisions is greater than when the RTA includes only a single type of IPR provision. The growth pattern of incremental effects of WTO-extra and plus type provisions differs over the event time. The incremental effects of WTO-extra type provisions increase until approximately 4 years after the trade agreement is implemented (as seen in Figure 7a, 7e, and 7e). In contrast, the incremental effects of WTO-plus type provisions seem larger than that of WTO-extra type but the marginal growth in changes are relatively small and statistically less significant (as observed in Figures 7c, 7g, and 7g). Finally, our results indicate that including only WTO-extra or WTO-plus type provisions in a trade agreement does not have a significant long-run effect on trade, compared to agreements without any IPR provisions.

In summary, our findings suggest that an interactive effect between two types of IPR provisions is crucial for enhancing agricultural and food GVC trade among members with RTAs that include IPR commitments, accounting for phased-in effects. We observe that a single type of IPR provision may not have a desirable impact on strengthening GVC links. Furthermore, the effects of IPR provisions appear to reach their full potential after 4-5 years. The incremental effects of WTO-extra and plus type provisions exhibit different growth patterns over time. WTO-extra type provisions demonstrate increasing effects until around 4 years after implementation, while the effects of WTO-plus type provisions are more significant but exhibit relatively smaller and statistically less significant changes in growth.

5 Treatment Heterogeneity

As we introduced background in the Section 2.1, the justification and intention of IPR provisions in the trade agreement are debatable. The inclusion of IPR provisions in trade agreements may be due to external pressure for stronger IPR protection or internal needs to leverage domestic IPR reform. However, the impact of these commitments will depend on the level of economic development of the country as it requires the support of the domestic system to effectively implement the agreement.

In other words, whether a country is pressured by external forces or internally mo-

tivated to include IPR provisions in trade agreements, the success of the agreement will depend on the country's ability to enforce those provisions within its domestic legal and institutional frameworks. A developing country may struggle to implement IPR commitments without significant reforms to its legal and institutional systems, while a developed country may have a more established framework to support IPR enforcement. Therefore, it is important to consider the development level of trading partners to examine the IPR provisions effects. To do so, we focus on the heterogeneous contemporaneous effects of "WTO plus" and "WTO extra" type provisions across countries with different levels of development.

We classified countries into three income-level categories using the World Bank Analytic Classification as given for the year 1995: High, Middle (including upper-middle and lower-middle), and Low-income economies. We then split the sample into nine groups based on the exporter-importer income pairs and run separate regressions using the Equation (8) in Section 4.1. The results are presented in Table 4 and each row mean the result of the regression for each group. For example, the "Low $\rightarrow$ Middle" group represents the sub-sample where the exporting country is a Low-income economy and the importing country is a Middle-income economy.

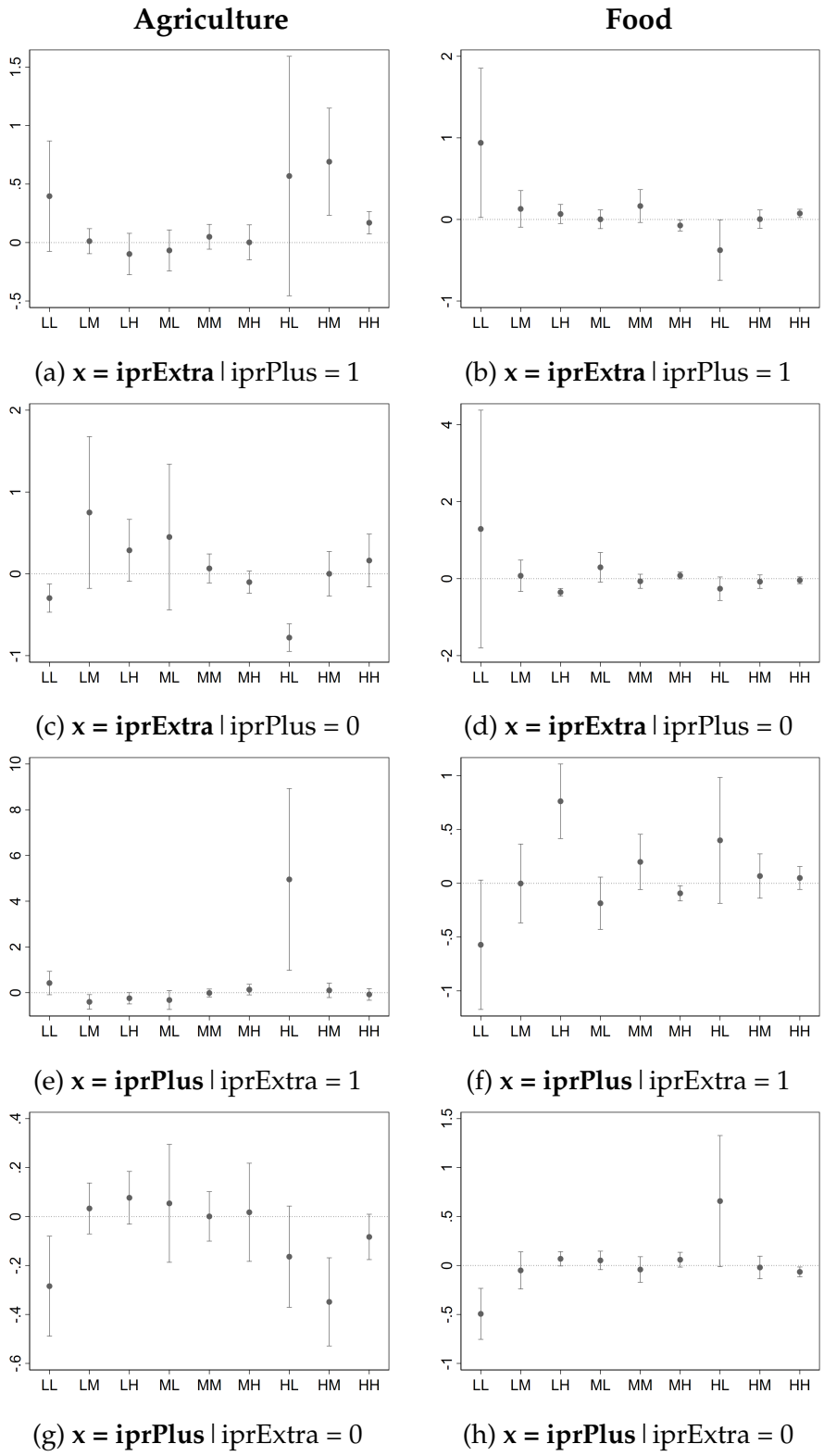
Our results indicate that the effect of IPR provisions varies across income pairs. Specifically, we find that IPR variables are significantly related to GVC trade in the agricultural sector when exporter countries are low or high-income economies, but the effects are insignificant when the exporting country is a middle-income economy. In the food sector, we observe that IPR effects are significantly related to the GVC trade of high-income countries (See Table 4).

Table 4: Effects of WTO plus and extra type provision on agriculture and food GVC trade by income pair

	Dependent variable: Total GVC				
	(1) RTA(t)	(2) IPR-Plus(t)	(3) IPR-Extra(t)	(4) IPR-Plus(t)*IPR-Extra(t)	Obs.
Panel A: Agriculture					
Low → Low	0.164**	-0.335*	-0.352**	0.686**	73742
	(0.054)	(0.146)	(0.125)	(0.132)	
Low → Middle	0.011	0.033	0.559*	-0.548*	99339
	(0.028)	(0.051)	(0.270)	(0.277)	
Low → High	-0.016	0.074	0.253+	-0.356*	60390
	(0.055)	(0.051)	(0.150)	(0.177)	
Middle → Low	0.045	0.053	0.372	-0.441	106146
	(0.078)	(0.117)	(0.313)	(0.340)	
Middle → Middle	0.084*	0.001	0.064	-0.016	139433
	(0.033)	(0.052)	(0.085)	(0.105)	
Middle → High	0.052	0.017	-0.107	0.109	83529
	(0.084)	(0.101)	(0.077)	(0.112)	
High → Low	-0.305	-0.179	-1.512**	1.963**	54145
	(0.219)	(0.126)	(0.389)	(0.359)	
High → Middle	0.114*	-0.429**	0.001	0.525*	71872
	(0.054)	(0.141)	(0.139)	(0.222)	
High → High	-0.013	-0.087+	0.151	0.006	37514
	(0.034)	(0.052)	(0.142)	(0.150)	
Panel B: Food					
Low → Low	0.606**	-0.681**	0.829	-0.166	73742
	(0.213)	(0.263)	(0.687)	(0.667)	
Low → Middle	-0.020	-0.051	0.072	0.050	99406
	(0.073)	(0.102)	(0.193)	(0.214)	
Low → High	0.003	0.066+	-0.436**	0.501**	60390
	(0.039)	(0.035)	(0.078)	(0.113)	
Middle → Low	0.073*	0.051	0.258+	-0.256	106155
	(0.036)	(0.046)	(0.152)	(0.163)	
Middle → Middle	0.125**	-0.042	-0.071	0.223+	139552
	(0.039)	(0.070)	(0.100)	(0.132)	
Middle → High	0.003	0.058	0.079+	-0.155**	83529
	(0.020)	(0.036)	(0.042)	(0.056)	
High → Low	0.005	0.506*	-0.303	-0.170	54150
	(0.145)	(0.206)	(0.210)	(0.293)	
High → Middle	0.041+	-0.020	-0.082	0.086	71914
	(0.023)	(0.060)	(0.097)	(0.120)	
High → High	-0.005	-0.067*	-0.044	0.116*	37514
	(0.017)	(0.027)	(0.047)	(0.053)	

Note: Columns represent subsample regression by income pair. Dependent variables is Total GVC trade. All estimations are performed with exporter and importer time-varying fixed effects and bilateral dummies in Equation (8). Fixed effects estimates, including the constant, are omitted for brevity. All estimates are PPML estimator. Panel A and B reports the regression result for the agriculture and food sector, respectively. Each row in the panel shows the result for the each corresponding income pair group in the first column. We pair the exporter and importer country using the three income level (High, middle and low). For example, "Low → Middle" means that exporter is Low income and importer is Middle level income country. Standard errors are clustered by country pair and reported in parentheses. We adjust for the (asymptotic) bias in the coefficient estimates as well as the standard errors by using the bias correction method suggested by Weidner and Zylkin (2021). The p-values read as follows: $+p < .10$,* $p < .05$,** $p < .01$.

As the interaction term plays a role, we examine the marginal effect of each provision. We calculate the proportional change in Total GVC trade in each sector and report in Table 5 and Figure 8. The results shown in Table 5 Panel A are for the Agriculture sector.



(a) **x = iprExtra** | iprPlus = 1 (b) **x = iprExtra** | iprPlus = 1

(c) **x = iprExtra** | iprPlus = 0 (d) **x = iprExtra** | iprPlus = 0

(e) **x = iprPlus** | iprExtra = 1 (f) **x = iprPlus** | iprExtra = 1

(g) **x = iprPlus** | iprExtra = 0 (h) **x = iprPlus** | iprExtra = 0

Figure 8: Marginal effect of "WTO plus" and "WTO extra" IPR provisions on total GVC trade in Agriculture and Food sector by income pair

Note: Y-axis presents the magnitude of proportional change. X-axis presents the income pair. For instant, "LH" stands for that exporter country is Low-income and importer country is High-income economy. All point estimates are presented in Table 5 and vertical line across the point indicates the 95% interval.

Table 5: Marginal effect of "WTO plus" and "WTO extra" IPR provisions on total GVC trade in Agriculture and Food sector by income pair

	Dependent variable: Total GVC								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Income pair	LL	LM	LH	ML	MM	MH	HL	HM	HH
Proportional change in average dependent variable when Δx = 1									
Panel A: Agriculure									
x = iprExtra | iprPlus = 1	0.397^{+}	0.012	-0.098	-0.067	0.049	0.002	0.569	0.691**	0.170**
	(0.241)	(0.055)	(0.090)	(0.090)	(0.054)	(0.076)	(0.522)	(0.234)	(0.049)
x = iprExtra | iprPlus = 0	-0.296**	0.750	0.287	0.450	0.066	-0.102	-0.780**	0.001	0.163
	(0.088)	(0.473)	(0.193)	(0.454)	(0.090)	(0.069)	(0.086)	(0.139)	(0.165)
x = iprPlus | iprExtra = 1	0.421	-0.402*	-0.245^{+}	-0.322	-0.015	0.134	4.952*	0.101	-0.078
	(0.260)	(0.162)	(0.126)	(0.211)	(0.088)	(0.118)	(2.028)	(0.160)	(0.130)
x = iprPlus | iprExtra = 0	-0.284**	0.033	0.077	0.054	0.001	0.017	-0.164	-0.349**	-0.083^{+}
	(0.104)	(0.053)	(0.055)	(0.123)	(0.052)	(0.102)	(0.106)	(0.092)	(0.047)
Panel B: Food									
x = iprExtra | iprPlus = 1	0.939*	0.130	0.067	0.002	0.165	-0.074*	-0.377*	0.004	0.074**
	(0.467)	(0.114)	(0.060)	(0.058)	(0.103)	(0.035)	(0.189)	(0.057)	(0.026)
x = iprExtra | iprPlus = 0	1.290	0.075	-0.353**	0.294	-0.069	0.082^{+}	-0.261^{+}	-0.078	-0.043
	(1.574)	(0.208)	(0.051)	(0.196)	(0.093)	(0.045)	(0.155)	(0.089)	(0.045)
x = iprPlus | iprExtra = 1	-0.571^{+}	-0.002	0.763**	-0.185	0.199	-0.093*	0.399	0.068	0.050
	(0.307)	(0.187)	(0.177)	(0.124)	(0.131)	(0.036)	(0.299)	(0.105)	(0.054)
x = iprPlus | iprExtra = 0	-0.494**	-0.050	0.068^{+}	0.052	-0.041	0.059	0.658^{+}	-0.020	-0.065*
	(0.133)	(0.097)	(0.037)	(0.048)	(0.067)	(0.039)	(0.342)	(0.059)	(0.026)

Note: All estimates are result for the nonlinear combination of PPML estimates obtained in Table 4 to present the proportional change in dependent variable when variable x changes from 0 to 1. Specifically, "**x = iprExtra** | iprPlus = 1" can read as the proportional change in average dependent variable when iprExtra changes from 0 to 1 when iprPlus = 1 (and RTA = 1). This implies the incremental effect of having both type of provisions compared to having plus type of provision. Each Columns are corresponding to the rows of Table 4, for example, "LL" matches to "Low → Low" and the estimate (0.397) is calculated by $\frac{exp(0.164-0.335-0.352+0.686)-exp(0.164-0.335)}{exp(0.164-0.335)} = exp(-0.352+0.686)-1$. The interpretation is that the average bilateral Total GVC trade in Agriculture sector increase by 39.7% between country *i* and *j* if they have both type of IPR provisions compared to have plus type of provision in their regional trade agreement. The rest of estimates are also calculated and interpreted in similar way. Standard errors are in parentheses and the p-values read as follows: $+p < .10$,* $p < .05$,** $p < .01$.

Column 1 indicates the result When the exporting and importing countries are both Low-income economies. We find that the impact of the incremental effect of WTO-extra type provision compared to plus type is an average increase of 39.7% in GVC exports to Low income (Column 1). That is, commitment in both types of IPR provisions is beneficial for the agricultural GVC link between low-income countries, compared to the case where they only include the WTO-plus type provision in the agreement (See row **x = iprExtra** | iprPlus = 1). Similar to the findings from full sample regression analysis, having only WTO-extra or plus type provisions has a negative and statistically significant effect on Agriculture GVC trade between low-income countries compared to the case without any IPR provisions (refer rows **x = iprExtra** | iprPlus = 0 and **x = iprPlus** | iprExtra = 0). However, the results from pairing the low-income group with the higher-income group (Columns 2,3) reveal a different pattern. We find that the inclusion of WTO-plus type provision has a negative impact on GVC links compared to the case where members only

include WTO-extra type provision in the agreement. This is the unique result that we observe in this subsample regression.

When the exporting country is a Middle-income economy, the GVC trade does not show a statistically significant response to the IPR provisions. When the exporting country is a high-income economy, the incremental effect of plus type provision in addition to extra type provision is 495% when the partner country is a low-income country. the incremental effect of plus type in addition to extra type is insignificant when the importer is in the middle or high-income group. On the other hand, the incremental effect of extra type provision in addition to plus is positive and significant when importers are from a middle or high-income country. This may imply that WTO-extra-type provisions may facilitate trade between countries with similar income levels but may not be as effective in facilitating connections between high-income and low-income countries.

The results shown in Table 5 Panel B are for the Food sector. Column 1 indicates the result When the exporting and importing countries are both Low-income economies. We find that the impact of the incremental effect of WTO-extra type provision compared to plus type is an average increase of 93.9% in GVC exports to Low income (Column 1). That is, commitment in both types of IPR provisions is beneficial for the agricultural GVC link between low-income countries, compared to the case where they only include the WTO-plus type provision in the agreement (See row **x = iprExtra** | iprPlus = 1). However, commitment to both types of IPR provisions has negative effects on the Food GVC link between low-income countries, compared to the case where they only include the WTO-extra type provision in the agreement. We find the positive incremental effect of plus-type provision when the importer is a high-income country which is in contrast to the result we observed in the agriculture sector.

In our study, we found that the impact of IPR provisions on exports from Middle income-level economies to high-income group countries is statistically significant. However, we also observed an unexpected result where having only WTO-extra type provisions led to an increase in GVC exports to high-income group countries, while the effect of having both types of provisions was negative. This finding is unique because our previous full-sample analysis had shown the opposite result.

Lastly, for High income-level economies, our study found that having only WTO-plus type provisions led to an increase in GVC exports to low-income group countries. However, having only WTO-extra type provisions alongside WTO-plus type shows a negative effect on GVC exports to low-income group countries. In contrast, having only WTO-extra type provisions alongside WTO-plus type show a positive effect on GVC exports to low-income group countries.

The regression results of GVC forward and backward trade are reported in Appendix Table A5 to A8 and Appendix Figure A2 and A3. Results appear in line with those of Table 4 and 5, but the effects are more prominent in the agriculture sector for GVC forward trade and the food sector for GVC backward trade

The regression results of GVC forward and backward trade are reported in Appendix Table A5 to A8 and Appendix Figure A2 and A3. Results appear in line with those of Table 4 and 5 but the effects are more prominent in the agriculture sector for GVC forward trade and the food sector for GVC backward trade

We summarize our main findings as follows. First, WTO-extra provisions as part of a package with WTO-plus provisions may promote trade between countries with similar income levels, as we find a positive trade effect among similar income pairs. Second, our results from pairing low-income countries with higher income countries suggest that strengthening IPR in the destination country may serve as a trade barrier in the agriculture sector, reducing exports from developing nations. Countries with emerging technological capabilities may be particularly affected by recent tightening of IP laws and policies, hindering their export growth (Shin et al., 2016). Third, our study finds a substantial incremental effect of WTO-plus type provisions in the agriculture sector when high-income countries export to low-income countries. Additionally, having only WTO-plus type provisions leads to an increase in food GVC exports from high-income to low-income countries. If we recall that WTO-plus type provisions include more procedural rules to aid in the implementation of the provisions, it is plausible to suggest that commitments made through WTO-plus type provisions have provided developing economies with a tool for implementing domestic reforms (Laget et al., 2020). This, in turn, may have facilitated connections between developed and developing countries in GVCs. Finally, we acknowledge that the unique results found in various income group pairings in our study should be interpreted with caution and may be subject to limitations. Nonetheless, our findings suggest that the impact of IPR provisions on agriculture and food GVC links may vary depending on the specific features of the IPR provision and the development level of the countries involved in the GVC.

6 Conclusion

This paper examines the impact of intellectual property rights (IPR) on the agri-food global value chain (GVC) with a focus on the effect of IPR-related trade policies within regional trade agreements (RTAs). The study employs GVC-related trade data from the World Integrated Trade Solution and utilizes the empirical gravity model specification. The Pseudo Poisson Maximum Likelihood method was applied for the estimation. Initially, the study investigates the overall effect of IPR provisions in RTAs on average GVC trade in the agriculture and food sector. The results suggest that bilateral agricultural GVC trade participation decreases on average between members with IPR provisions in RTAs compared to those without IPR provisions. In contrast, the provisions do not significantly impact the food GVC trade.

Further, we analyze trade effect of IPR provisions based on their specific characteristics, utilizing the deep trade agreement data published by the World Bank. This data allows us to classify the IPR provisions into "WTO-plus" and "WTO-extra" aspects of IPR provisions. The former pertains to what is mandated by the World Trade Organization (WTO) and includes supplementary procedural regulations, while the latter requires adherence to extra IP-related treaties to expand the IP protection system beyond WTO regulations. The study finds that an interactive effect between the two types of IPR provisions is necessary to enhance agricultural and food GVC trade. In contrast, single-type IPR provisions have a negative effect, with more significant effects in the agriculture sector than in the food sector.

Moreover, the effects of IPR provisions are analyzed by income pair group. The study finds that the impact of IPR provisions on agricultural and food GVC links varies based on the specific features of the IPR provision and the development level of the countries involved in the GVC. The study shows that WTO-extra type provisions as part of a package with WTO-plus provisions may facilitate trade between countries with similar income levels. The commitment to WTO-plus type provisions between high and low-income group countries may offer developing economies a tool for implementing domestic reforms and facilitate connections between developed and developing countries in GVCs. However, pairing the low-income group with the higher-income group suggests that strengthening IPR in the destination country may act as a trade barrier in the agriculture sector.

However, our study has some limitations that need to be taken into account. Firstly, we were unable to identify the effect of particular IPR provisions by IP types (for example, whether the provision is related to patent, trademark, or others) due to the data

limitation. Secondly, we did not fully consider the potential interactions between IPR provisions and other regulatory issues such as investment rules, services liberalization, or other regulations that apply to agriculture and food GVC. As a result, we may have overlooked the complementary effects that may exist between IPR standards and other regulations. To provide a more comprehensive understanding of the impact of international IPR rules on the agricultural and food sectors, future research should attempt to address these limitations. By doing so, it can better elucidate the interplay between IPR rules and other regulations, and their implications for the agricultural and food global value chain to derive policy implication.

Our study sheds light on the relationship between IPR rules and the agricultural and food GVC, and suggests a promising avenues for future research. One such direction is to investigate the impact of IPR rules on agriculture and food GVC-related trade at a more granular level, using firm-level data. Specifically, further studies could explore to what extent firms adjust their trade patterns of final goods versus intermediates in response to changes in IPR rules implemented through trade agreement across different countries. Such questions are challenging to answer using country-level data alone, but they can be addressed with firm-level data.

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Appendix

A Table

A.1 Descriptive Data

Table A1: Summary statistics: GVC trade

	Mean (USD)	Standard Deviation (USD)	Minimum (USD)	Maximum (USD)	Observation
[Panel A] Total GVC					
Sector: Agri-Food					
1990-1994	3,149,183	42,871,241	9	2,694,898,315	138,518
1995-1999	4,548,244	60,386,965	8	4,116,006,958	145,057
2000-2004	6,145,542	80,669,733	383	5,665,218,994	144,393
2005-2009	12,559,658	158,418,242	407	11,573,003,174	146,079
2010-2015	17,191,809	201,604,753	874	12,516,756,348	174,488
Sector: Agriculture					
1990-1994	986,333	13,767,114	18	954,671,326	138,391
1995-1999	1,431,846	19,372,177	71	1,477,732,788	145,025
2000-2004	1,946,035	26,193,598	189	2,061,080,566	144,393
2005-2009	3,924,630	51,268,401	202	4,086,175,049	146,079
2010-2015	5,430,252	66,513,138	436	4,422,694,824	174,488
Sector: Food					
1990-1994	2,162,654	30,459,060	3	1,887,885,620	138,590
1995-1999	3,116,499	42,800,125	16	2,638,274,170	145,067
2000-2004	4,199,507	56,959,332	193	3,980,680,664	144,393
2005-2009	8,635,028	112,021,241	205	7,647,906,250	146,079
2010-2015	11,761,557	141,622,928	437	8,238,237,305	174,488
[Panel B] GVC Forward					
Sector: Agri-Food					
1990-1994	1,435,347	22,967,896	51	2,114,972,656	138,297
1995-1999	1,980,081	29,668,374	6	2,536,664,978	144,468
2000-2004	2,612,074	37,709,696	80	3,996,443,604	143,681
2005-2009	5,324,526	75,569,274	8	7,690,652,344	145,366
2010-2015	7,343,471	97,220,597	24	8,348,848,145	173,748
Sector: Agriculture					
1990-1994	649,987	9,772,039	31	841,854,126	138,259
1995-1999	906,426	12,701,732	0	1,026,168,701	144,799
2000-2004	1,223,036	16,766,756	47	1,683,114,990	143,681
2005-2009	2,480,062	33,930,194	9	3,216,046,875	145,367
2010-2015	3,453,247	44,506,382	20	3,494,906,738	173,748
Sector: Food					
1990-1994	785,284	13,927,261	20	1,273,118,530	138,347
1995-1999	1,072,998	17,805,840	6	1,518,266,235	144,277
2000-2004	1,389,038	22,071,391	33	2,313,328,613	143,681
2005-2009	2,847,916	43,811,154	11	4,474,605,469	145,189
2010-2015	3,890,223	55,686,015	4	4,853,941,406	173,748
[Panel C] GVC Backward					
Sector: Agri-Food					
1990-1994	1,451,174	20,233,873	12	1,757,041,931	138,843
1995-1999	2,172,746	31,546,341	10	3,290,458,984	145,093
2000-2004	2,955,714	42,714,280	6	4,385,737,305	144,393
2005-2009	5,890,691	76,912,880	4	7,153,536,377	146,079
2010-2015	7,991,429	95,599,976	4	7,367,205,322	174,488
Sector: Agriculture					
1990-1994	260,679	4,343,925	5	598,271,667	138,825
1995-1999	406,140	7,477,631	4	1,111,580,811	145,093
2000-2004	550,245	10,140,070	2	1,505,023,926	144,393
2005-2009	1,052,684	16,997,581	2	2,428,709,229	146,079
2010-2015	1,437,296	21,097,369	2	2,497,237,061	174,488
Sector: Food					
1990-1994	1,190,692	16,663,693	7	1,174,421,509	138,824
1995-1999	1,766,606	25,316,154	6	2,178,878,174	145,093
2000-2004	2,405,469	34,282,270	3	2,880,713,379	144,393
2005-2009	4,838,007	63,113,605	2	4,724,827,148	146,079
2010-2015	6,554,133	78,533,467	2	4,869,968,262	174,488

Table A2: Summary statistics: RTA and IPR variables by income pair

	Mean	Standard Deviation	Minimum	Maximum	Observation
Income pair: High-High					
RTA	0.2874	0.4525	0	1	37,514
IPR	0.2442	0.4296	0	1	37,514
IPR-Plus	0.2363	0.4248	0	1	37,514
IPR-Extra	0.1844	0.3878	0	1	37,514
IPR-both	0.1765	0.3813	0	1	37,514
Income pair: High-Middle					
RTA	0.1416	0.3487	0	1	71,916
IPR	0.1161	0.3204	0	1	71,916
IPR-Plus	0.1090	0.3116	0	1	71,916
IPR-Extra	0.1100	0.3128	0	1	71,916
IPR-both	0.1028	0.3037	0	1	71,916
Income pair: High-Low					
RTA	0.0248	0.1555	0	1	54,154
IPR	0.0162	0.1262	0	1	54,154
IPR-Plus	0.0145	0.1197	0	1	54,154
IPR-Extra	0.0139	0.1170	0	1	54,154
IPR-both	0.0122	0.1100	0	1	54,154
Income pair: Middle-High					
RTA	0.1219	0.3272	0	1	83,535
IPR	0.1000	0.3000	0	1	83,535
IPR-Plus	0.0938	0.2916	0	1	83,535
IPR-Extra	0.0947	0.2928	0	1	83,535
IPR-both	0.0885	0.2840	0	1	83,535
Income pair: Middle-Middle					
RTA	0.0994	0.2992	0	1	139,538
IPR	0.0605	0.2383	0	1	139,538
IPR-Plus	0.0543	0.2265	0	1	139,538
IPR-Extra	0.0561	0.2301	0	1	139,538
IPR-both	0.0499	0.2178	0	1	139,538
Income pair: Middle-Low					
RTA	0.0444	0.2059	0	1	106,171
IPR	0.0159	0.1252	0	1	106,171
IPR-Plus	0.0141	0.1179	0	1	106,171
IPR-Extra	0.0069	0.0825	0	1	106,171
IPR-both	0.0050	0.0707	0	1	106,171
Income pair: Low-High					
RTA	0.0222	0.1475	0	1	60,397
IPR	0.0145	0.1196	0	1	60,397
IPR-Plus	0.0130	0.1134	0	1	60,397
IPR-Extra	0.0125	0.1109	0	1	60,397
IPR-both	0.0110	0.1042	0	1	60,397
Income pair: Low-Middle					
RTA	0.0473	0.2123	0	1	99,397
IPR	0.0170	0.1293	0	1	99,397
IPR-Plus	0.0151	0.1218	0	1	99,397
IPR-Extra	0.0073	0.0853	0	1	99,397
IPR-both	0.0054	0.0730	0	1	99,397
Income pair: Low-Low					
RTA	0.1086	0.3111	0	1	73,751
IPR	0.0113	0.1057	0	1	73,751
IPR-Plus	0.0107	0.1028	0	1	73,751
IPR-Extra	0.0012	0.0341	0	1	73,751
IPR-both	0.0005	0.0233	0	1	73,751

A.2 Dynamic effect

Table A3: Long-run effect of IPR provisions on agriculture and food GVC-related trade.

	Dep: Total GVC			Dep: GVC Forward			Dep: GVC Backward		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Total	Agr.	Food	Total	Agr.	Food	Total	Agr.	Food
RTA(t)	0.022^{+}	0.074**	-0.004	0.037*	0.085**	-0.012	0.020^{+}	0.060**	0.008
	(0.012)	(0.017)	(0.014)	(0.015)	(0.018)	(0.019)	(0.012)	(0.019)	(0.011)
RTA(t-1)	0.006	0.008	0.003	0.010	0.016	0.005	0.008	0.008	0.011^{+}
	(0.007)	(0.013)	(0.006)	(0.008)	(0.013)	(0.006)	(0.009)	(0.012)	(0.006)
RTA(t-2)	0.001	0.014	-0.001	0.005	0.022**	-0.006	-0.000	0.006	-0.002
	(0.006)	(0.009)	(0.005)	(0.005)	(0.009)	(0.005)	(0.007)	(0.011)	(0.006)
RTA(t-3)	0.010^{+}	0.034**	-0.001	0.016**	0.034**	-0.006	0.009	0.030*	-0.002
	(0.006)	(0.009)	(0.007)	(0.006)	(0.010)	(0.007)	(0.008)	(0.012)	(0.007)
RTA(t-4)	-0.001	-0.002	-0.000	0.005	0.004	0.002	-0.000	-0.002	0.001
	(0.006)	(0.007)	(0.006)	(0.005)	(0.006)	(0.005)	(0.004)	(0.006)	(0.004)
RTA(t-5)	0.005	0.014^{+}	0.002	0.014**	0.027**	0.002	0.011*	0.015^{+}	0.008*
	(0.005)	(0.008)	(0.005)	(0.004)	(0.007)	(0.005)	(0.004)	(0.008)	(0.004)
RTA(t-6)	-0.014*	-0.014	-0.010	-0.014^{+}	-0.011	-0.018*	-0.005	-0.008	-0.004
	(0.007)	(0.009)	(0.007)	(0.007)	(0.010)	(0.009)	(0.005)	(0.011)	(0.004)
RTA(t-7)	-0.001	-0.005	-0.001	0.005	0.009^{+}	-0.003	-0.001	-0.016*	0.002
	(0.004)	(0.005)	(0.005)	(0.004)	(0.005)	(0.005)	(0.004)	(0.007)	(0.003)
RTA(t-8)	-0.003	-0.014^{+}	0.005	0.003	-0.004	0.006	0.003	-0.001	0.009^{+}
	(0.007)	(0.008)	(0.006)	(0.006)	(0.007)	(0.005)	(0.006)	(0.008)	(0.005)
RTA(t-9)	0.009*	0.013*	0.006	0.008^{+}	0.014*	0.006	0.004	0.016^{+}	0.001
	(0.004)	(0.007)	(0.004)	(0.004)	(0.007)	(0.004)	(0.005)	(0.009)	(0.004)
RTA(t-10)	0.040**	0.030^{+}	0.030*	0.025*	0.023	0.025*	0.031*	0.028	0.018
	(0.012)	(0.017)	(0.012)	(0.012)	(0.017)	(0.011)	(0.014)	(0.019)	(0.014)
IPR(t)	-0.001	-0.049^{+}	0.019	-0.010	-0.048*	0.027	-0.000	-0.041	0.017
	(0.015)	(0.025)	(0.014)	(0.016)	(0.022)	(0.020)	(0.016)	(0.026)	(0.012)
IPR(t-1)	0.001	0.001	0.001	-0.004	-0.009	-0.002	-0.010	-0.012	-0.011^{+}
	(0.007)	(0.012)	(0.007)	(0.007)	(0.012)	(0.006)	(0.008)	(0.011)	(0.007)
IPR(t-2)	-0.001	-0.010	0.000	-0.003	-0.015^{+}	0.004	-0.000	-0.004	0.004
	(0.005)	(0.008)	(0.005)	(0.005)	(0.008)	(0.006)	(0.006)	(0.010)	(0.006)
IPR(t-3)	-0.009	-0.035**	0.001	-0.015*	-0.031**	0.002	-0.006	-0.026*	0.005
	(0.007)	(0.011)	(0.006)	(0.006)	(0.011)	(0.007)	(0.008)	(0.012)	(0.006)
IPR(t-4)	0.010	0.020*	0.006	0.012	0.022*	0.011^{+}	0.003	0.007	0.003
	(0.007)	(0.009)	(0.006)	(0.008)	(0.010)	(0.006)	(0.004)	(0.006)	(0.004)
IPR(t-5)	-0.008	-0.010	-0.007	-0.007	-0.014	-0.001	-0.008^{+}	-0.008	-0.004
	(0.005)	(0.010)	(0.005)	(0.005)	(0.009)	(0.005)	(0.004)	(0.008)	(0.004)
IPR(t-6)	0.010	0.000	0.008	-0.001	-0.017	0.015	0.000	0.016	-0.004
	(0.008)	(0.014)	(0.007)	(0.010)	(0.015)	(0.010)	(0.006)	(0.016)	(0.005)
IPR(t-7)	-0.004	0.004	-0.004	-0.005	-0.006	0.001	-0.003	0.012	-0.004
	(0.005)	(0.007)	(0.005)	(0.004)	(0.006)	(0.004)	(0.005)	(0.010)	(0.004)
IPR(t-8)	0.002	0.011	-0.004	0.000	0.010	-0.005	-0.007	-0.009	-0.011^{+}
	(0.007)	(0.009)	(0.006)	(0.007)	(0.008)	(0.005)	(0.007)	(0.010)	(0.006)
IPR(t-9)	-0.017**	-0.024**	-0.014**	-0.014**	-0.017*	-0.011**	-0.013**	-0.028**	-0.009^{+}
	(0.004)	(0.007)	(0.005)	(0.004)	(0.007)	(0.004)	(0.005)	(0.009)	(0.005)
IPR(t-10)	-0.022^{+}	-0.002	-0.017	-0.002	0.013	-0.003	-0.026^{+}	-0.024	-0.013
	(0.013)	(0.019)	(0.013)	(0.013)	(0.019)	(0.013)	(0.014)	(0.021)	(0.013)
Total IPR	-0.039	-0.090*	-0.009	-0.048	-0.106*	0.038	-0.066	-0.110*	-0.026
	(0.038)	(0.044)	(0.045)	(0.037)	(0.045)	(0.054)	(0.041)	(0.053)	(0.040)
Obs.	731,328	731,172	731,405	728,377	728,666	728,061	731,659	731,641	731,642

Pseudo R2	0.999	0.999	0.999	0.999	0.999	1.000	0.999	0.999	0.999

Note: All estimations are performed with exporter and importer time-varying fixed effects and bilateral dummies in Equation (7). Fixed effects estimates, including the constant, are omitted for brevity. All estimates are PPML estimator. Column headers denote the dependent variable (Total GVC, GVC Forward and Backward) and sectors (Agriculture and Food). Estimates for $RTA(t-k)$ are partial effect of generic regional trade agreement on Traditional trade and GVC-related trade. Estimates for $IPR(t-k)$ indicate the partial effect of intellectual property right (IPR) provisions in the regional trade agreement. t-1 to t-10 denotes the lag variables. Estimates for Total IPR effect at the bottom are associated with the sum of current and all lag variables $IPR(t)$, $IPR(t-1)$, $IPR(t-2)$, ..., and $IPR(t-10)$. This is the long-run effect of IPR provisions on three GVC trade values. Standard errors are clustered by country pair and reported in parentheses. We adjust for the (asymptotic) bias in the coefficient estimates as well as the standard errors by using the bias correction method suggested by Weidner and Zylkin (2021). The p-values read as follows: $^{+}p < .10$,* $p < .05$,** $p < .01$.

Table A4: Long-run effect of WTO plus and extra type IPR provisions on agriculture and food GVC-related trade.

	Dep: Total GVC			Dep: GVC Forward			Dep: GVC Backward		
	(1) Total	(2) Agr.	(3) Food	(4) Total	(5) Agr.	(6) Food	(7) Total	(8) Agr.	(9) Food
RTA(t)	0.012	0.048*	-0.009	0.031*	0.071**	-0.013	0.008	0.037*	0.003
	(0.013)	(0.020)	(0.014)	(0.014)	(0.019)	(0.019)	(0.013)	(0.017)	(0.014)
RTA(t-1)	0.010	0.008	0.006	0.010	0.014	0.004	0.011	0.006	0.010
	(0.006)	(0.011)	(0.006)	(0.007)	(0.011)	(0.007)	(0.008)	(0.012)	(0.007)
RTA(t-2)	0.003	0.024^{+}	-0.002	0.005	0.025*	-0.005	0.002	0.015	-0.001
	(0.006)	(0.014)	(0.005)	(0.006)	(0.011)	(0.004)	(0.008)	(0.017)	(0.006)
RTA(t-3)	0.005	0.015^{+}	-0.003	0.011*	0.020*	-0.007	0.004	0.013	-0.004
	(0.005)	(0.008)	(0.007)	(0.005)	(0.009)	(0.007)	(0.007)	(0.011)	(0.007)
RTA(t-4)	0.002	0.003	0.001	0.006	0.006	0.002	0.002	0.002	0.002
	(0.006)	(0.007)	(0.006)	(0.005)	(0.006)	(0.005)	(0.004)	(0.005)	(0.004)
RTA(t-5)	0.003	0.013*	-0.000	0.011*	0.022**	0.001	0.011*	0.015^{+}	0.008*
	(0.005)	(0.007)	(0.005)	(0.004)	(0.006)	(0.005)	(0.004)	(0.009)	(0.004)
RTA(t-6)	-0.006	-0.003	-0.005	-0.008	-0.003	-0.017^{+}	-0.000	-0.002	-0.002
	(0.007)	(0.009)	(0.007)	(0.007)	(0.010)	(0.009)	(0.005)	(0.010)	(0.005)
RTA(t-7)	0.001	-0.004	0.000	0.005	0.010^{+}	-0.004	-0.001	-0.015**	0.001
	(0.004)	(0.005)	(0.005)	(0.004)	(0.006)	(0.005)	(0.004)	(0.006)	(0.003)
RTA(t-8)	-0.002	-0.012	0.006	0.003	-0.004	0.007	0.008^{+}	0.007	0.012*
	(0.006)	(0.008)	(0.006)	(0.005)	(0.007)	(0.005)	(0.005)	(0.008)	(0.005)
RTA(t-9)	0.007	0.009	0.005	0.005	0.009	0.004	0.002	0.010	-0.001
	(0.004)	(0.006)	(0.005)	(0.004)	(0.007)	(0.004)	(0.006)	(0.007)	(0.005)
RTA(t-10)	0.021^{+}	0.002	0.016	0.010	0.000	0.020^{+}	0.018	0.004	0.008
	(0.012)	(0.015)	(0.012)	(0.012)	(0.016)	(0.011)	(0.014)	(0.019)	(0.014)
IPR-Plus(t)	-0.024	-0.080**	-0.011	-0.015	-0.075**	0.021	0.003	-0.056	0.005
	(0.016)	(0.026)	(0.017)	(0.018)	(0.027)	(0.021)	(0.018)	(0.034)	(0.016)
IPR-Plus(t-1)	0.002	0.008	0.003	-0.007	-0.006	-0.004	-0.016*	-0.013	-0.012^{+}
	(0.007)	(0.010)	(0.007)	(0.006)	(0.009)	(0.006)	(0.008)	(0.011)	(0.007)
IPR-Plus(t-2)	-0.022**	-0.071**	-0.006	-0.039**	-0.078**	-0.010^{+}	-0.024**	-0.064**	-0.013^{+}
	(0.007)	(0.016)	(0.007)	(0.008)	(0.014)	(0.006)	(0.009)	(0.018)	(0.008)
IPR-Plus(t-3)	-0.026**	-0.060**	-0.010	-0.036**	-0.062**	-0.004	-0.016*	-0.046**	-0.004
	(0.006)	(0.011)	(0.007)	(0.007)	(0.012)	(0.007)	(0.008)	(0.014)	(0.008)
IPR-Plus(t-4)	-0.004	-0.012	-0.002	-0.003	-0.008	0.004	-0.009^{+}	-0.029**	-0.005
	(0.008)	(0.011)	(0.007)	(0.008)	(0.012)	(0.007)	(0.006)	(0.009)	(0.006)
IPR-Plus(t-5)	0.010	0.008	0.010	-0.002	0.000	0.005	0.000	0.001	0.002

	(0.007)	(0.011)	(0.007)	(0.007)	(0.010)	(0.005)	(0.005)	(0.010)	(0.005)
IPR-Plus(t-6)	0.007	-0.005	0.006	-0.001	-0.021	0.018^{+}	-0.001	0.014	-0.002
	(0.009)	(0.015)	(0.008)	(0.011)	(0.016)	(0.011)	(0.007)	(0.018)	(0.006)
IPR-Plus(t-7)	-0.020**	-0.010^{+}	-0.016**	-0.007	-0.011^{+}	0.001	-0.006	0.007	-0.005
	(0.005)	(0.006)	(0.005)	(0.004)	(0.006)	(0.004)	(0.004)	(0.007)	(0.003)
IPR-Plus(t-8)	0.012*	0.018*	0.006	0.002	0.013^{+}	-0.003	-0.008^{+}	-0.010	-0.008^{+}
	(0.005)	(0.008)	(0.005)	(0.005)	(0.007)	(0.005)	(0.005)	(0.009)	(0.005)
IPR-Plus(t-9)	-0.015**	-0.019**	-0.011*	-0.012*	-0.015^{+}	-0.011*	-0.013*	-0.026**	-0.008
	(0.005)	(0.007)	(0.005)	(0.005)	(0.008)	(0.005)	(0.007)	(0.008)	(0.006)
IPR-Plus(t-10)	0.001	0.023	0.002	0.015	0.029	0.005	-0.015	-0.009	-0.007
	(0.013)	(0.019)	(0.012)	(0.013)	(0.020)	(0.013)	(0.012)	(0.020)	(0.012)
IPR-Extra(t)	-0.090^{+}	-0.203*	-0.024	-0.081	-0.170*	0.031	-0.070	-0.132*	-0.004
	(0.049)	(0.099)	(0.039)	(0.061)	(0.078)	(0.062)	(0.066)	(0.063)	(0.051)
IPR-Extra(t-1)	0.015	0.020^{+}	0.017	0.006	0.017	-0.004	-0.010	0.006	-0.020*
	(0.010)	(0.012)	(0.012)	(0.012)	(0.010)	(0.012)	(0.014)	(0.014)	(0.009)
IPR-Extra(t-2)	-0.004	-0.011	-0.002	-0.000	-0.015	0.013	-0.004	-0.012	0.001
	(0.009)	(0.011)	(0.011)	(0.007)	(0.011)	(0.010)	(0.009)	(0.012)	(0.008)
IPR-Extra(t-3)	-0.006	-0.031**	-0.000	-0.005	-0.022*	0.002	-0.014	-0.036*	-0.000
	(0.009)	(0.010)	(0.008)	(0.007)	(0.010)	(0.008)	(0.010)	(0.018)	(0.008)
IPR-Extra(t-4)	-0.005	0.003	-0.005	-0.003	0.008	-0.010	-0.006	0.004	-0.004
	(0.008)	(0.010)	(0.009)	(0.007)	(0.008)	(0.008)	(0.004)	(0.008)	(0.005)
IPR-Extra(t-5)	-0.007	0.002	-0.007	-0.009	-0.017*	0.004	-0.005	0.001	0.001
	(0.009)	(0.011)	(0.010)	(0.006)	(0.008)	(0.007)	(0.007)	(0.006)	(0.004)
IPR-Extra(t-6)	0.014	0.017	0.008	0.008	0.006	0.013	-0.009^{+}	-0.003	-0.011*
	(0.011)	(0.013)	(0.009)	(0.006)	(0.008)	(0.009)	(0.005)	(0.010)	(0.005)
IPR-Extra(t-7)	0.017^{+}	0.019	0.010	-0.004	-0.006	-0.004	0.007	0.031	-0.003
	(0.009)	(0.018)	(0.008)	(0.009)	(0.015)	(0.009)	(0.010)	(0.028)	(0.005)
IPR-Extra(t-8)	0.008	0.021	-0.015	0.000	0.018	-0.028*	-0.038^{+}	-0.053	-0.049**
	(0.018)	(0.025)	(0.017)	(0.025)	(0.027)	(0.013)	(0.021)	(0.060)	(0.017)
IPR-Extra(t-9)	-0.012	-0.021^{+}	-0.009	-0.004	-0.010	-0.003	-0.003	-0.011	0.001
	(0.009)	(0.011)	(0.007)	(0.005)	(0.011)	(0.004)	(0.006)	(0.012)	(0.005)
IPR-Extra(t-10)	-0.044^{+}	-0.042	-0.030	-0.027	-0.027	-0.027	-0.023	-0.030	-0.009
	(0.024)	(0.026)	(0.025)	(0.017)	(0.022)	(0.019)	(0.017)	(0.035)	(0.017)
IPR-Plus*IPR-Extra(t)	0.135**	0.286**	0.066	0.099	0.229**	-0.025	0.089	0.190**	0.024
	(0.050)	(0.101)	(0.041)	(0.063)	(0.083)	(0.064)	(0.066)	(0.068)	(0.052)
IPR-Plus*IPR-Extra(t-1)	-0.019^{+}	-0.025*	-0.022^{+}	-0.002	-0.017	0.009	0.017	0.001	0.025**
	(0.010)	(0.011)	(0.013)	(0.013)	(0.010)	(0.012)	(0.014)	(0.014)	(0.009)
IPR-Plus*IPR-Extra(t-2)	0.028*	0.076**	0.011	0.041**	0.089**	-0.000	0.031**	0.077**	0.020^{+}
	(0.011)	(0.017)	(0.013)	(0.010)	(0.017)	(0.011)	(0.010)	(0.018)	(0.010)
IPR-Plus*IPR-Extra(t-3)	0.035**	0.090**	0.018^{+}	0.038**	0.082**	0.008	0.037**	0.087**	0.016^{+}
	(0.011)	(0.014)	(0.009)	(0.009)	(0.014)	(0.010)	(0.011)	(0.021)	(0.009)
IPR-Plus*IPR-Extra(t-4)	0.027**	0.040**	0.020^{+}	0.026**	0.035**	0.023*	0.025**	0.042**	0.019*
	(0.010)	(0.013)	(0.011)	(0.009)	(0.013)	(0.010)	(0.006)	(0.012)	(0.008)
IPR-Plus*IPR-Extra(t-5)	-0.009	-0.021	-0.008	0.008	0.008	-0.011	-0.003	-0.010	-0.007
	(0.011)	(0.014)	(0.012)	(0.008)	(0.011)	(0.008)	(0.008)	(0.009)	(0.006)
IPR-Plus*IPR-Extra(t-6)	-0.017	-0.015	-0.011	-0.007	0.001	-0.013	0.013*	0.010	0.013*
	(0.012)	(0.014)	(0.010)	(0.007)	(0.011)	(0.009)	(0.006)	(0.013)	(0.006)
IPR-Plus*IPR-Extra(t-7)	-0.002	-0.003	0.002	0.008	0.014	0.006	-0.006	-0.028	0.005
	(0.009)	(0.019)	(0.008)	(0.009)	(0.015)	(0.009)	(0.010)	(0.028)	(0.006)
IPR-Plus*IPR-Extra(t-8)	-0.018	-0.027	0.006	0.000	-0.017	0.030*	0.039^{+}	0.057	0.050**
	(0.019)	(0.025)	(0.017)	(0.025)	(0.027)	(0.013)	(0.021)	(0.060)	(0.017)
IPR-Plus*IPR-Extra(t-9)	0.009	0.019	0.004	0.005	0.015	0.004	0.004	0.014	-0.000
	(0.010)	(0.012)	(0.007)	(0.005)	(0.011)	(0.004)	(0.006)	(0.012)	(0.006)
IPR-Plus*IPR-Extra(t-10)	0.036	0.052^{+}	0.021	0.028	0.049^{+}	0.026	0.029^{+}	0.044	0.016

	(0.024)	(0.029)	(0.025)	(0.017)	(0.025)	(0.019)	(0.018)	(0.036)	(0.017)
Proportional change in average dependent variable when Δx = 1									
x = iprExtra | iprPlus = 1	0.095**	0.280**	0.051*	0.133**	0.310**	0.045**	0.108**	0.281**	0.084**
	(0.022)	(0.054)	(0.021)	(0.026)	(0.063)	(0.016)	(0.022)	(0.052)	(0.019)
x = iprExtra | iprPlus = 0	-0.108*	-0.202**	-0.056	-0.113^{+}	-0.196**	-0.012	-0.160**	-0.210**	-0.094
	(0.052)	(0.065)	(0.061)	(0.067)	(0.062)	(0.098)	(0.061)	(0.075)	(0.063)
x = iprPlus | iprExtra = 1	0.135*	0.314**	0.082	0.150^{+}	0.292**	0.081	0.187*	0.289*	0.129^{+}
	(0.059)	(0.117)	(0.053)	(0.084)	(0.108)	(0.089)	(0.076)	(0.118)	(0.067)
x = iprPlus | iprExtra = 0	-0.076*	-0.180**	-0.028	-0.099**	-0.207**	0.023	-0.100**	-0.205**	-0.056
	(0.038)	(0.044)	(0.046)	(0.036)	(0.044)	(0.053)	(0.038)	(0.047)	(0.038)
Obs.	731,328	731,172	731,405	728,377	728,666	728,061	731,659	731,641	731,642
Pseudo R2	0.999	0.999	0.999	0.999	0.999	1.000	0.999	0.999	0.999

Note: All estimations are performed with exporter and importer time-varying fixed effects and bilateral dummies in Equation (9). Fixed effects estimates, including the constant, are omitted for brevity. All estimates are PPML estimator. Column headers denote the dependent variable (Total GVC, GVC Forward and Backward) and sectors (Agriculture and Food). Estimates for $RTA(t-k)$ are partial effect of generic regional trade agreement on Traditional trade and GVC-related trade. Estimates for $IPR-type(t-k)$ where type $\in$ (Plus, Extra) indicate the partial effect of each type of IPR provisions in the regional trade agreement and we have interaction terms. t-1 to t-10 denotes the lag variables of IPR-type. Standard errors are clustered by country pair and reported in parentheses. We adjust for the (asymptotic) bias in the coefficient estimates as well as the standard errors by using the bias correction method suggested by Weidner and Zylkin (2021). Four estimates at the bottom are associated with the marginal effect of each type of provision when other conditions are fixed. For exampple, "**x = iprExtra** | iprPlus = 1" can read as the proportional change in average dependent variable when iprExtra changes from 0 to 1 when iprPlus = 1 (and RTA = 1). This implies the incremental effect of having both type of provisions compared to having plus type of provision. The p-values read as follows: $+p < .10$,* $p < .05$,** $p < .01$.

A.3 by income group - forward and backward

Table A5: Effects of WTO plus and extra type provision on agriculture and food GVC Forward trade by income group

	Dependent variable: GVC Forward				
	(1) RTA(t)	(2) IPR-Plus(t)	(3) IPR-Extra(t)	(4) IPR-Plus(t)*IPR-Extra(t)	Obs.
Panel A: Agriculture					
Low → Low	0.169**	-0.315*	-0.344**	0.651**	73517
	(0.056)	(0.136)	(0.123)	(0.143)	
Low → Middle	0.011	0.026	0.532*	-0.514*	99020
	(0.025)	(0.038)	(0.249)	(0.253)	
Low → High	-0.060	0.071	0.362*	-0.340^{+}	60185
	(0.051)	(0.057)	(0.167)	(0.185)	
Middle → Low	0.140	-0.083	0.285	-0.268	105642
	(0.093)	(0.145)	(0.344)	(0.381)	
Middle → Middle	0.081*	-0.002	0.092	-0.062	138690
	(0.034)	(0.051)	(0.103)	(0.121)	
Middle → High	0.060	-0.055	-0.086	0.142	83133
	(0.103)	(0.120)	(0.089)	(0.138)	
High → Low	-0.130	-0.096	-1.509**	1.794**	54142
	(0.176)	(0.161)	(0.533)	(0.525)	
High → Middle	0.085	-0.326**	0.168	0.314^{+}	71802
	(0.066)	(0.115)	(0.124)	(0.180)	
High → High	0.002	-0.092	0.088	0.060	37514
	(0.038)	(0.057)	(0.117)	(0.128)	
Panel B: Food					
Low → Low	0.491**	-0.380^{+}	0.924	-0.557	73517
	(0.190)	(0.208)	(0.609)	(0.587)	
Low → Middle	-0.030	-0.108	0.322^{+}	-0.181	99032
	(0.045)	(0.103)	(0.195)	(0.217)	
Low → High	-0.010	0.110**	-0.244**	0.158**	60185
	(0.036)	(0.031)	(0.043)	(0.042)	
Middle → Low	0.058^{+}	0.060	0.236*	-0.238^{+}	105417
	(0.032)	(0.045)	(0.105)	(0.124)	
Middle → Middle	0.102**	-0.039	0.068	0.083	138423
	(0.029)	(0.066)	(0.091)	(0.128)	
Middle → High	-0.010	0.065	0.175^{+}	-0.246*	82957
	(0.028)	(0.041)	(0.101)	(0.109)	
High → Low	-0.078	0.342**	-0.118	0.006	54142
	(0.068)	(0.131)	(0.135)	(0.179)	
High → Middle	0.050**	-0.032	0.086^{+}	-0.065	71861
	(0.013)	(0.052)	(0.051)	(0.081)	
High → High	0.016	-0.085**	0.127	-0.054	37514
	(0.021)	(0.030)	(0.100)	(0.103)	

Note: All estimations are performed with exporter and importer time-varying fixed effects and bilateral dummies in Equation (8). Fixed effects estimates, including the constant, are omitted for brevity. All estimates are PPML estimator. Panel A and B reports the regression result for the agriculture and food sector, respectively. Each row in the panel shows the result for the each corresponding income pair group in the first column. We pair the exporter and importer country using the three income level (High, middle and low). For example, "Low → Middle" means that exporter is Low income and importer is Middle level income country. Standard errors are clustered by country pair and reported in parentheses. We adjust for the (asymptotic) bias in the coefficient estimates as well as the standard errors by using the bias correction method suggested by Weidner and Zylkin (2021). The p-values read as follows: $+p < .10$,* $p < .05$,** $p < .01$.

Table A6: Marginal effect of "WTO plus" and "WTO extra" IPR provisions on total GVC Forward trade in Agriculture and Food sector by income pair

	Dependent variable: GVC Forward								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Income pair	LL	LM	LH	ML	MM	MH	HL	HM	HH
Proportional change in average dependent variable when Δx = 1									
Panel A: Agriculure									
x = iprExtra | iprPlus = 1	0.359	0.018	0.023	0.017	0.030	0.058	0.329	0.620**	0.160**
	(0.236)	(0.042)	(0.112)	(0.117)	(0.053)	(0.101)	(0.333)	(0.162)	(0.047)
x = iprExtra | iprPlus = 0	-0.291**	0.703+	0.437+	0.330	0.096	-0.082	-0.779**	0.183	0.092
	(0.087)	(0.424)	(0.240)	(0.457)	(0.113)	(0.082)	(0.118)	(0.146)	(0.128)
x = iprPlus | iprExtra = 1	0.400	-0.386*	-0.235+	-0.296	-0.062	0.092	4.462	-0.011	-0.032
	(0.266)	(0.154)	(0.135)	(0.239)	(0.101)	(0.141)	(2.747)	(0.132)	(0.106)
x = iprPlus | iprExtra = 0	-0.270**	0.027	0.074	-0.079	-0.002	-0.053	-0.092	-0.278**	-0.088+
	(0.099)	(0.039)	(0.061)	(0.134)	(0.051)	(0.114)	(0.146)	(0.083)	(0.052)
Panel B: Food									
x = iprExtra | iprPlus = 1	0.443+	0.151	-0.082**	-0.002	0.163	-0.068*	-0.106	0.021	0.076**
	(0.267)	(0.115)	(0.031)	(0.051)	(0.108)	(0.034)	(0.116)	(0.053)	(0.026)
x = iprExtra | iprPlus = 0	1.518	0.380	-0.217**	0.266*	0.071	0.192	-0.111	0.090	0.136
	(1.534)	(0.269)	(0.034)	(0.133)	(0.097)	(0.120)	(0.120)	(0.056)	(0.113)
x = iprPlus | iprExtra = 1	-0.608*	-0.251+	0.308**	-0.163+	0.045	-0.166*	0.415*	-0.092+	-0.129
	(0.247)	(0.145)	(0.052)	(0.091)	(0.109)	(0.073)	(0.200)	(0.048)	(0.089)
x = iprPlus | iprExtra = 0	-0.316*	-0.102	0.116**	0.062	-0.038	0.067	0.407*	-0.031	-0.081**
	(0.143)	(0.092)	(0.034)	(0.047)	(0.064)	(0.044)	(0.184)	(0.051)	(0.027)

Note: All estimates are result for the nonlinear combination of PPML estimates obtained in Table A5 to present the proportional change in dependent variable when variable x changes from 0 to 1. Specifically, "**x = iprExtra** | iprPlus = 1" can read as the proportional change in average dependent variable when iprExtra changes from 0 to 1 when iprPlus = 1 (and RTA = 1). This implies the incremental effect of having both type of provisions compared to having plus type of provision. Each Columns are corresponding to the rows of Table 4, for example, "LL" matches to "Low → Low" and the estimate (0.359) is calculated by $\frac{exp(0.169-0.315-0.344+0.651)-exp(0.169-0.315)}{exp(0.169-0.315)} = exp(-0.344+0.651)-1$. The interpretation is that the average bilateral Total GVC trade in Agriculture sector increase by 35.9% between country *i* and *j* if they have both type of IPR provisions compared to have plus type of provision in their regional trade agreement. The rest of estimates are also calculated and interpreted in similar way. Standard errors are in parentheses and the p-values read as follows: $+p < .10$,* $p < .05$,** $p < .01$.

Table A7: Effects of WTO plus and extra type provision on agriculture and food GVC Backward trade by income group

	Dependent variable: GVC Backward				
	(1) RTA(t)	(2) IPR-Plus(t)	(3) IPR-Extra(t)	(4) IPR-Plus(t)*IPR-Extra(t)	Obs.
Panel A: Agriculture					
Low → Low	0.198**	-0.360*	-0.237^{+}	0.528**	73793
	(0.066)	(0.182)	(0.142)	(0.154)	
Low → Middle	0.044	-0.001	0.656	-0.627	99480
	(0.050)	(0.122)	(0.524)	(0.539)	
Low → High	-0.040	0.046	0.153	-0.305^{+}	60390
	(0.074)	(0.087)	(0.127)	(0.159)	
Middle → Low	0.028	0.038	0.279	-0.302	106220
	(0.055)	(0.074)	(0.253)	(0.268)	
Middle → Middle	0.084*	-0.019	0.021	0.050	139593
	(0.038)	(0.062)	(0.065)	(0.093)	
Middle → High	0.101^{+}	0.060	-0.012	-0.019	83529
	(0.053)	(0.090)	(0.061)	(0.107)	
High → Low	-0.414	-0.136^{+}	-1.276**	1.791**	54178
	(0.293)	(0.071)	(0.360)	(0.320)	
High → Middle	0.107^{+}	-0.481*	-0.098	0.595*	71914
	(0.056)	(0.205)	(0.159)	(0.279)	
High → High	-0.002	-0.115*	0.331*	-0.142	37514
	(0.037)	(0.050)	(0.157)	(0.163)	
Panel B: Food					
Low → Low	0.606**	-0.730**	0.988	-0.415	73793
	(0.229)	(0.276)	(0.784)	(0.762)	
Low → Middle	0.019	0.006	-0.196	0.264	99470
	(0.090)	(0.109)	(0.372)	(0.395)	
Low → High	-0.028	-0.024	-0.489**	0.565**	60390
	(0.046)	(0.046)	(0.124)	(0.163)	
Middle → Low	0.105**	-0.023	0.166	-0.076	106220
	(0.038)	(0.045)	(0.177)	(0.184)	
Middle → Middle	0.123**	-0.045	-0.137	0.289*	139593
	(0.045)	(0.075)	(0.114)	(0.143)	
Middle → High	0.039^{+}	0.048^{+}	0.068*	-0.137**	83529
	(0.021)	(0.028)	(0.034)	(0.050)	
High → Low	0.024	0.582**	-0.343	-0.225	54178
	(0.171)	(0.223)	(0.234)	(0.320)	
High → Middle	0.001	0.008	-0.093	0.098	71923
	(0.018)	(0.064)	(0.131)	(0.152)	
High → High	0.006	-0.091**	-0.027	0.131**	37514
	(0.016)	(0.026)	(0.032)	(0.038)	

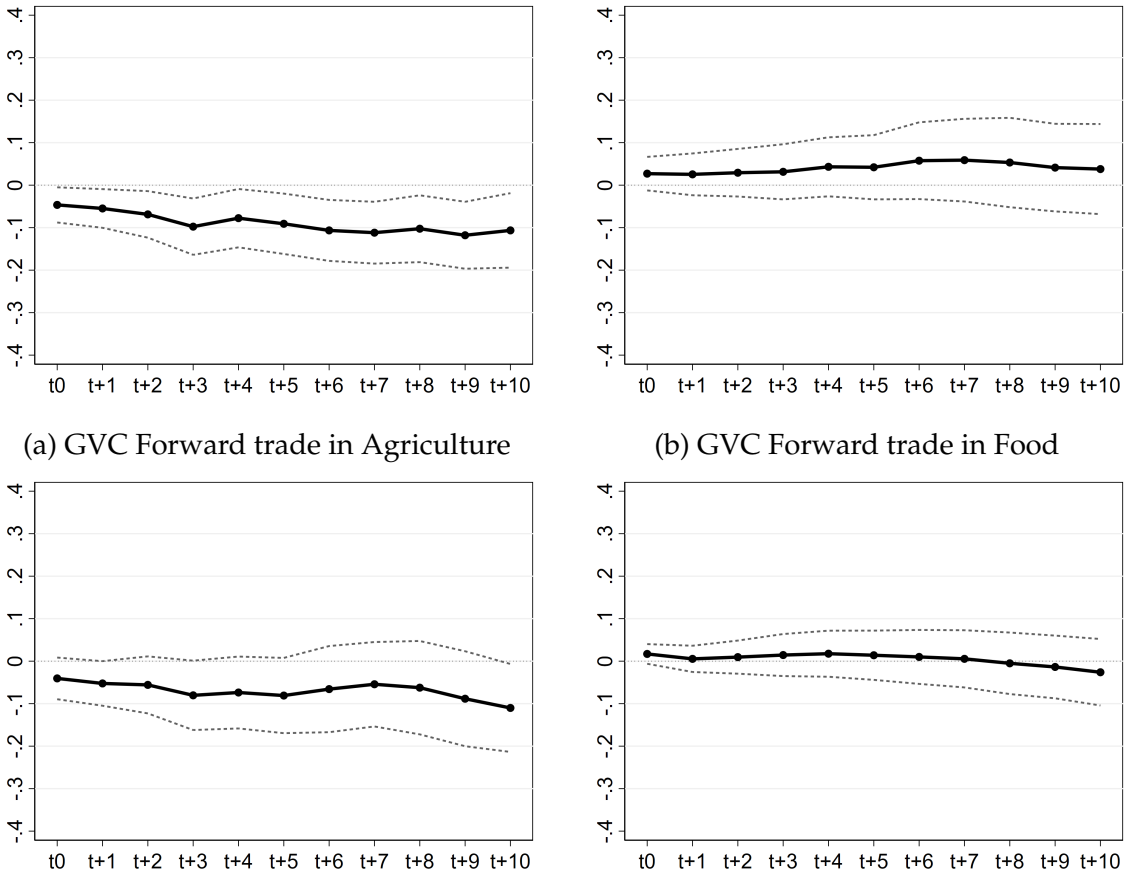
Note: All estimations are performed with exporter and importer time-varying fixed effects and bilateral dummies in Equation (8). Fixed effects estimates, including the constant, are omitted for brevity. All estimates are PPML estimator. Panel A and B reports the regression result for the agriculture and food sector, respectively. Each row in the panel shows the result for the each corresponding income pair group in the first column. We pair the exporter and importer country using the three income level (High, middle and low). For example, "Low → Middle" means that exporter is Low income and importer is Middle level income country. Standard errors are clustered by country pair and reported in parentheses. We adjust for the (asymptotic) bias in the coefficient estimates as well as the standard errors by using the bias correction method suggested by Weidner and Zylkin (2021). The p-values read as follows: $+p < .10$,* $p < .05$,** $p < .01$.

Table A8: Marginal effect of "WTO plus" and "WTO extra" IPR provisions on GVC Backward trade in Agriculture and Food sector by income pair

	Dependent variable: GVC Backward								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Income pair	LL	LM	LH	ML	MM	MH	HL	HM	HH
Proportional change in average dependent variable when Δx = 1									
Panel A: Agriculure									
x = iprExtra | iprPlus = 1	0.338	0.030	-0.141	-0.023	0.073	-0.031	0.673	0.644^{+}	0.208**
	(0.283)	(0.117)	(0.086)	(0.067)	(0.067)	(0.075)	(0.674)	(0.336)	(0.051)
x = iprExtra | iprPlus = 0	-0.211^{+}	0.927	0.165	0.322	0.022	-0.012	-0.721**	-0.093	0.392^{+}
	(0.112)	(1.009)	(0.148)	(0.335)	(0.066)	(0.060)	(0.101)	(0.144)	(0.218)
x = iprPlus | iprExtra = 1	0.183	-0.466^{+}	-0.228*	-0.233	0.031	0.042	4.231**	0.120	-0.227^{+}
	(0.236)	(0.279)	(0.097)	(0.194)	(0.073)	(0.076)	(1.635)	(0.180)	(0.130)
x = iprPlus | iprExtra = 0	-0.303*	-0.001	0.047	0.038	-0.019	0.062	-0.127*	-0.382**	-0.109*
	(0.127)	(0.121)	(0.091)	(0.077)	(0.061)	(0.096)	(0.062)	(0.127)	(0.044)
Panel B: Food									
x = iprExtra | iprPlus = 1	0.772	0.070	0.079	0.094	0.164	-0.067**	-0.433*	0.004	0.110**
	(0.472)	(0.120)	(0.097)	(0.067)	(0.105)	(0.023)	(0.200)	(0.062)	(0.027)
x = iprExtra | iprPlus = 0	1.685	-0.178	-0.387**	0.180	-0.128	0.071*	-0.290^{+}	-0.089	-0.027
	(2.104)	(0.305)	(0.076)	(0.209)	(0.099)	(0.036)	(0.166)	(0.119)	(0.031)
x = iprPlus | iprExtra = 1	-0.682**	0.309	0.717**	-0.094	0.277^{+}	-0.086**	0.430	0.112	0.041
	(0.262)	(0.484)	(0.253)	(0.159)	(0.156)	(0.033)	(0.339)	(0.149)	(0.038)
x = iprPlus | iprExtra = 0	-0.518**	0.006	-0.024	-0.023	-0.044	0.049^{+}	0.790*	0.008	-0.087**
	(0.133)	(0.110)	(0.045)	(0.044)	(0.072)	(0.029)	(0.399)	(0.064)	(0.024)

Note: All estimates are result for the nonlinear combination of PPML estimates obtained in Table A7 to present the proportional change in dependent variable when variable x changes from 0 to 1. Specifically, "**x = iprExtra** | iprPlus = 1" can read as the proportional change in average dependent variable when iprExtra changes from 0 to 1 when iprPlus = 1 (and RTA = 1). This implies the incremental effect of having both type of provisions compared to having plus type of provision. Each Columns are corresponding to the rows of Table 4, for example, "LL" matches to "Low → Low" and the estimate (0.338) is calculated by $\frac{exp(0.198-0.360-0.237+0.528)-exp(0.198-0.360)}{exp(0.198-0.360)} = exp(-0.237+0.528)-1$. The interpretation is that the average bilateral Total GVC trade in Agriculture sector increase by 35.9% between country *i* and *j* if they have both type of IPR provisions compared to have plus type of provision in their regional trade agreement. The rest of estimates are also calculated and interpreted in similar way. Standard errors are in parentheses and the p-values read as follows: $+p < .10$,* $p < .05$,** $p < .01$.

B Figures



(a) GVC Forward trade in Agriculture

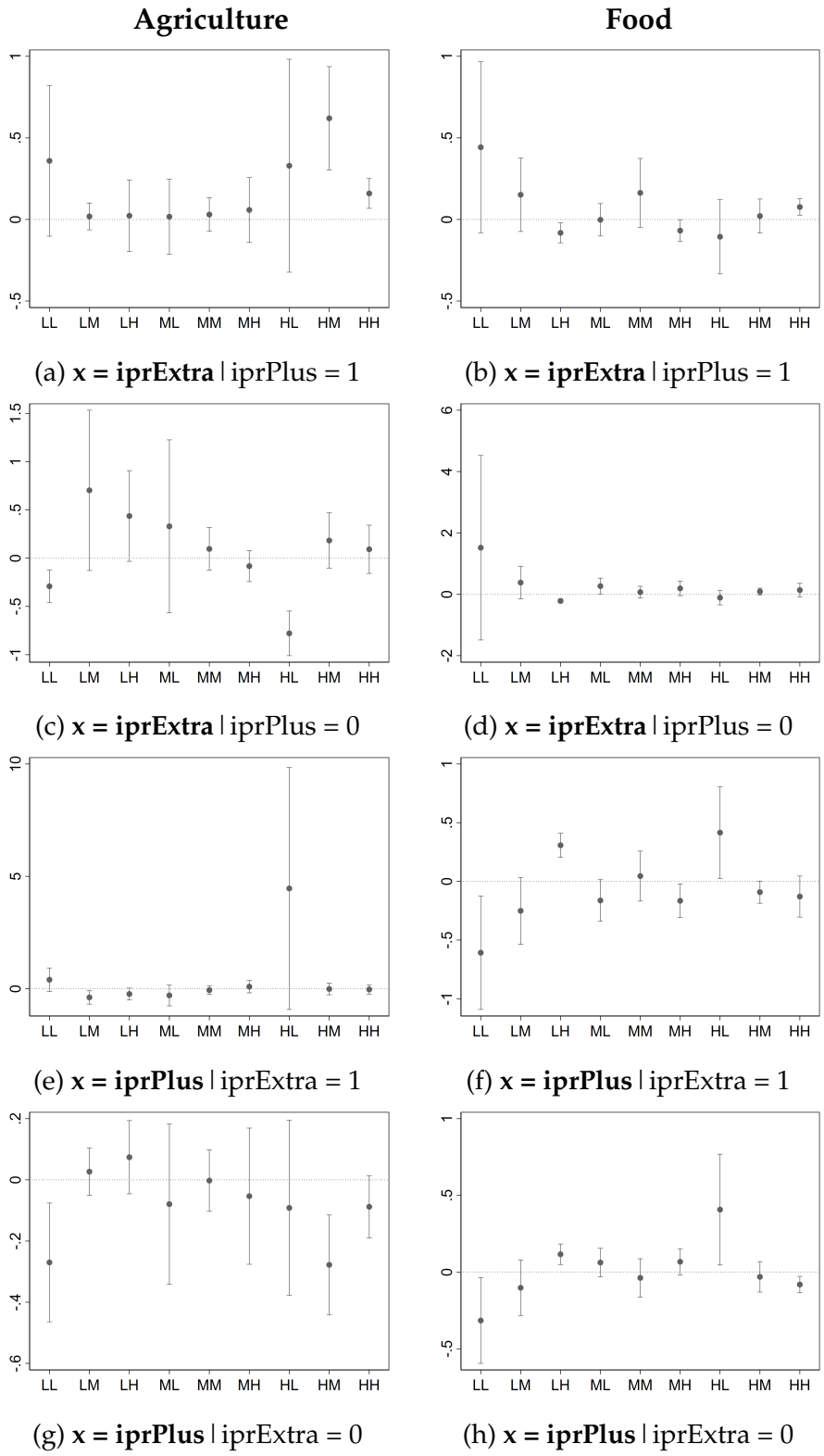
(b) GVC Forward trade in Food

(c) GVC Backward trade in Agriculture

(d) GVC Backward trade in Food

Figure A1: Impact of IPR provision on GVC participation

Note: Note: These figures are visualization of the short and long-run effect of IPR provisions on GVC Forward and Backward trade). The Y-axis represents the proportionate change of average GVC Forward ((a), (b)) and Backward ((c), (d)) export from country i to j when there is IPR provisions in the RTA. X-axis represents the event timeline. t0 means the year that RTA comes into force. The coefficients are obtained from the regression of Equation (7) and listed in the Appendix Table A3 Specifically, all of the lags, and current IPR estimates were added to provide the point estimates in the figure. Thus, for example, by construction '$t+1$' (associated with the sum of IPR_t and IPR_{t-1}), and '$t+10$' (associated with the sum of IPR_t, IPR_{t-1}, IPR_{t-2}, ..., and IPR_{t-10}). The dashed lines above and below the line connecting estimates indicate the upper and lower bound of 95% confidence intervals. Standard errors are clustered by symmetric country-pair and reported in parentheses. We adjust for the (asymptotic) bias in the coefficient estimates as well as the standard errors by using the bias correction method suggested by Weidner and Zylkin (2021). Label next to the plot means p-values and they read as follows: $+p < .10$,* $p < .05$,** $p < .01$. For the brevity, tables are included in the appendix.



(a) **x = iprExtra** | iprPlus = 1 (b) **x = iprExtra** | iprPlus = 1

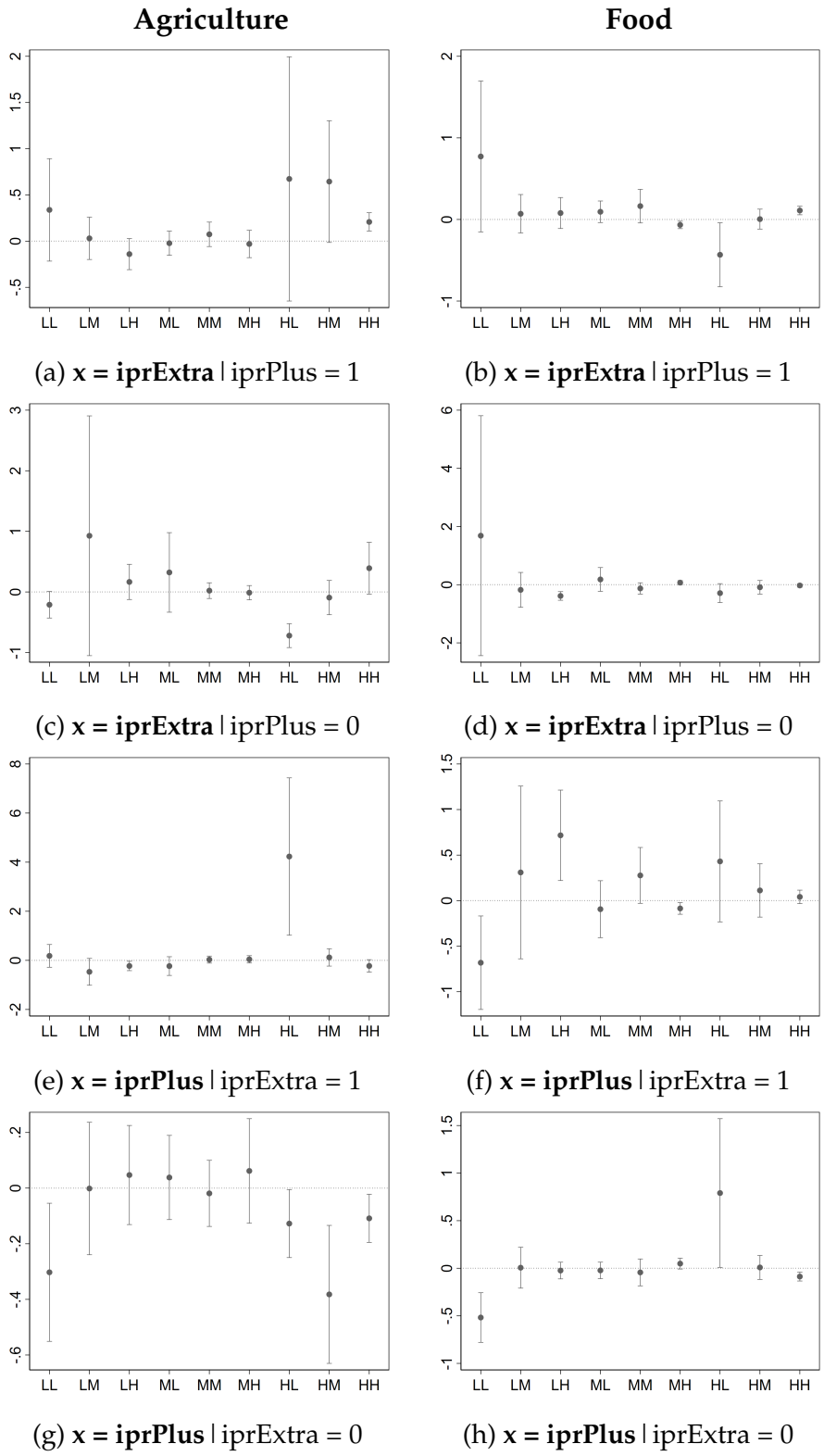
(c) **x = iprExtra** | iprPlus = 0 (d) **x = iprExtra** | iprPlus = 0

(e) **x = iprPlus** | iprExtra = 1 (f) **x = iprPlus** | iprExtra = 1

(g) **x = iprPlus** | iprExtra = 0 (h) **x = iprPlus** | iprExtra = 0

Figure A2: Marginal effect of "WTO plus" and "WTO extra" IPR provisions on GVC Forward trade in Agriculture and Food sector by income pair

Note: Y-axis presents the magnitude of proportional change. X-axis presents the income pair. For instant, "LH" stands for that exporter country is Low-income and importer country is High-income economy. All point estimates are presented in the Appendix Table A6 and vertical line across the point indicates the 95% interval.



(a) **x = iprExtra** | iprPlus = 1 (b) **x = iprExtra** | iprPlus = 1

(c) **x = iprExtra** | iprPlus = 0 (d) **x = iprExtra** | iprPlus = 0

(e) **x = iprPlus** | iprExtra = 1 (f) **x = iprPlus** | iprExtra = 1

(g) **x = iprPlus** | iprExtra = 0 (h) **x = iprPlus** | iprExtra = 0

Figure A3: Marginal effect of "WTO plus" and "WTO extra" IPR provisions on GVC Backward trade in Agriculture and Food sector by income pair

Note: Y-axis presents the magnitude of proportional change. X-axis presents the income pair. For instant, "LH" stands for that exporter country is Low-income and importer country is High-income economy. All point estimates are presented in the Appendix Table A8 and vertical line across the point indicates the 95% interval.

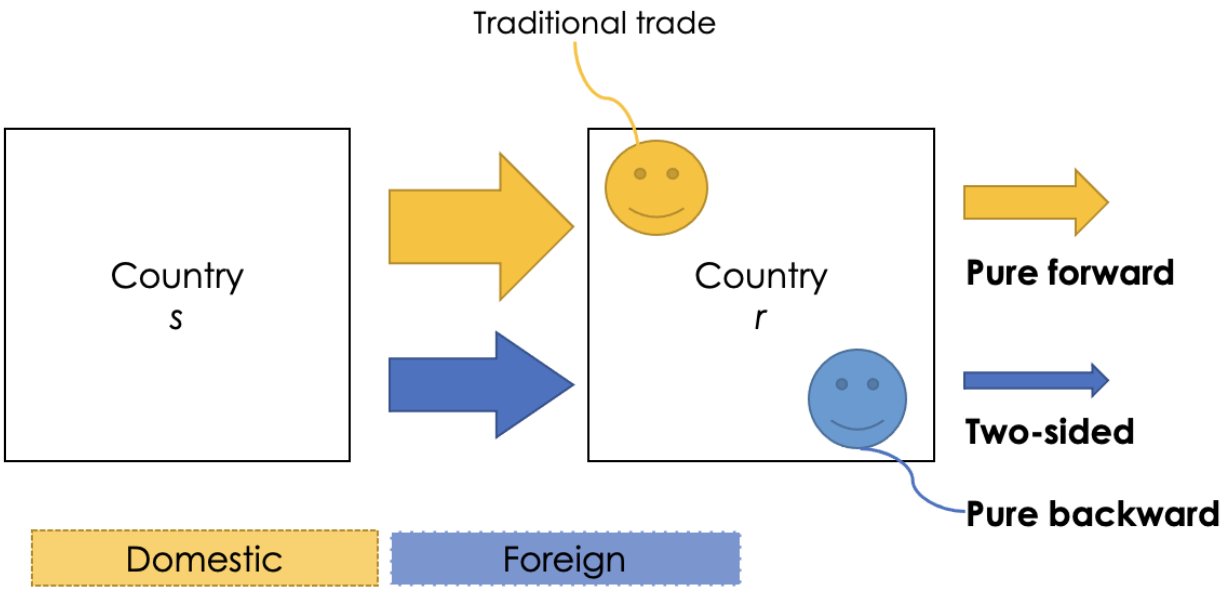


Figure A4: Illustration of GVC decomposition

Note: Author's description based on the Borin et al. (2021)

C Robustness check: 4-year interval data

Table A9: Effects of IPR provision on agriculture and food GVC trade (using 4-year interval data)

	Agri-Food	Agriculture	Food	Agri-Food	Agriculture	Food
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Total GVC trade						
RTA(t)	0.040*	0.008	0.022*	0.070**	-0.012	0.012
	(0.017)	(0.010)	(0.010)	(0.026)	(0.019)	(0.017)
IPR(t)				-0.041^{+}	0.024	0.013
				(0.024)	(0.018)	(0.017)
Obs.	202,250	202,319	202,289	202,250	202,319	202,289
Pseudo-R2	0.999	0.999	0.999	0.999	0.999	0.999
Panel B: Forward trade						
RTA(t)	0.066**	0.010	0.037**	0.107**	-0.012	0.041*
	(0.017)	(0.011)	(0.011)	(0.030)	(0.024)	(0.019)
IPR(t)				-0.058*	0.028	-0.005
				(0.028)	(0.025)	(0.018)
Obs.	201,581	201,417	201,583	201,581	201,417	201,583
Pseudo-R2	0.999	1.000	0.999	0.999	1.000	0.999
Panel B: Backward trade						
RTA(t)	0.028	0.017	0.015	0.057*	0.007	0.014
	(0.017)	(0.012)	(0.012)	(0.026)	(0.017)	(0.018)
IPR(t)				-0.036	0.013	0.001
				(0.027)	(0.017)	(0.018)
Obs.	202,562	202,562	202,562	202,562	202,562	202,562
Pseudo-R2	0.999	0.999	0.999	0.999	0.999	0.999

Note: Standard errors are clustered by country pair and reported in parentheses. The years in the data are from 1991, 1995, 1999, 2003, 2007, 2011, 2015. All estimations are performed with exporter and importer time-varying fixed effects and bilateral dummies in equation (1). Fixed effects estimates, including the constant, are omitted for brevity. All estimates are PPML estimator. Panel A reports the result when the dependent variable is total GVC trade. Panel B and C report results when the dependent variables are GVC Forward and Backward trade, respectively. Each column lists the result of regression by sector, agriculture, food, and agri-food (sum of agriculture and food). We adjust for the (asymptotic) bias in the coefficient estimates as well as the standard errors by using the bias correction method suggested by Weidner and Zylkin (2021). The p-values read as follows: $+p < .10$,* $p < .05$,** $p < .01$.

Table A10: Effects of WTO plus and WTO extra type of IPR provisions on GVC trade in Agriculture and Food sector (using 4-year interval data)

	Total GVC		GVC Forward		GVC Backward	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Agri-Food Total						
RTA(t)	0.012	0.004	0.041*	0.035^{+}	0.014	0.004
	(0.017)	(0.018)	(0.019)	(0.020)	(0.018)	(0.020)
IPR(t)	0.013		-0.005		0.001	
	(0.017)		(0.018)		(0.018)	
iprPlus(t)		-0.011		-0.057*		-0.037^{+}
		(0.022)		(0.024)		(0.022)
iprExtra(t)		-0.059		-0.057		-0.082
		(0.041)		(0.052)		(0.054)
iprPlus(t)*iprExtra(t)		0.111*		0.138*		0.159**
		(0.045)		(0.057)		(0.056)
Obs.	202,289	202,289	201,583	201,583	202,562	202,562
Pseudo-R2	0.999	0.999	0.999	0.999	0.999	0.999
Panel B: Agriculture						
RTA(t)	0.070**	0.048^{+}	0.107**	0.090**	0.057*	0.038
	(0.026)	(0.028)	(0.030)	(0.030)	(0.026)	(0.026)
IPR(t)	-0.041^{+}		-0.058*		-0.036	
	(0.024)		(0.028)		(0.027)	
iprPlus(t)		-0.144**		-0.180**		-0.164**
		(0.036)		(0.040)		(0.036)
iprExtra(t)		-0.124*		-0.101*		-0.083^{+}
		(0.054)		(0.046)		(0.045)
iprPlus(t)*iprExtra(t)		0.302**		0.291**		0.278**
		(0.066)		(0.063)		(0.053)
Obs.	202,250	202,250	201,581	201,581	202,562	202,562
Pseudo-R2	0.999	0.999	0.999	0.999	0.999	0.999
Panel C: Food						
RTA(t)	-0.012	-0.016	-0.012	-0.013	0.007	0.000
	(0.019)	(0.020)	(0.024)	(0.025)	(0.017)	(0.018)
IPR(t)	0.024		0.028		0.013	
	(0.018)		(0.025)		(0.017)	
iprPlus(t)		0.021		0.024		-0.016
		(0.023)		(0.027)		(0.021)
iprExtra(t)		-0.032		-0.008		-0.047
		(0.047)		(0.081)		(0.059)
iprPlus(t)*iprExtra(t)		0.051		0.018		0.103^{+}
		(0.051)		(0.082)		(0.061)
Obs.	202,319	202,319	201,417	201,417	202,562	202,562
Pseudo-R2	0.999	0.999	1.000	1.000	0.999	0.999

Note: Standard errors are clustered by country pair and reported in parentheses. The years in the data are from 1991, 1995, 1999, 2003, 2007, 2011, 2015. All estimations are performed with exporter and importer time-varying fixed effects and bilateral dummies in equation (1). Fixed effects estimates, including the constant, are omitted for brevity. All estimates are PPML estimator. Panel A reports the result when the dependent variable is total GVC trade. Panel B and C report results when the dependent variables are GVC Forward and Backward trade, respectively. Each column lists the result of regression by sector, agriculture, food, and agri-food (sum of agriculture and food). We adjust for the (asymptotic) bias in the coefficient estimates as well as the standard errors by using the bias correction method suggested by Weidner and Zylkin (2021). The p-values read as follows: $+p < .10$,* $p < .05$,** $p < .01$.

Table A11: Long-run effect of IPR provisions on agriculture and food GVC-related trade (using 4-year interval data)

	Dep: Total GVC			Dep: GVC Forward			Dep: GVC Backward		
	Agri-food	Agriculture	Food	Agri-food	Agriculture	Food	Agri-food	Agriculture	Food
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
RTA(t)	0.012	0.073**	-0.014	0.038*	0.100**	-0.017	0.010	0.058*	0.001
	(0.017)	(0.024)	(0.020)	(0.019)	(0.028)	(0.026)	(0.018)	(0.025)	(0.017)
RTA(t-1)	-0.005	0.012	-0.008	0.014	0.043**	-0.018	0.006	0.013	0.006
	(0.014)	(0.017)	(0.015)	(0.011)	(0.015)	(0.016)	(0.014)	(0.019)	(0.012)
RTA(t-2)	0.016	-0.002	0.020	0.012	0.015	0.007	0.024*	0.017	0.022*
	(0.013)	(0.019)	(0.012)	(0.015)	(0.020)	(0.016)	(0.011)	(0.018)	(0.011)
IPR(t)	0.009	-0.051*	0.026	-0.008	-0.062*	0.035	0.003	-0.043	0.017
	(0.018)	(0.024)	(0.020)	(0.019)	(0.026)	(0.028)	(0.019)	(0.028)	(0.017)
IPR(t-1)	0.009	0.008	0.004	0.001	-0.014	0.018	-0.008	0.002	-0.008
	(0.013)	(0.018)	(0.014)	(0.012)	(0.017)	(0.015)	(0.013)	(0.019)	(0.012)
IPR(t-2)	-0.030*	-0.008	-0.030*	-0.011	-0.001	-0.004	-0.035**	-0.034^{+}	-0.031**
	(0.014)	(0.020)	(0.014)	(0.016)	(0.022)	(0.017)	(0.011)	(0.020)	(0.012)
Total IPR	-0.012	-0.049	-0.001	-0.018	-0.074^{+}	0.050	-0.040	-0.073^{+}	-0.022
	(0.034)	(0.040)	(0.040)	(0.035)	(0.042)	(0.054)	(0.031)	(0.039)	(0.032)
Obs.	200,554	200,515	200,582	199,848	199,846	199,685	200,806	200,806	200,806
Pseudo R2	0.999	0.999	0.999	0.999	0.999	1.000	0.999	0.999	0.999

Note: All estimations are performed with exporter and importer time-varying fixed effects and bilateral dummies in Equation (7). The years in the data are from 1991, 1995, 1999, 2003, 2007, 2011, 2015. Fixed effects estimates, including the constant, are omitted for brevity. All estimates are PPML estimator. Column headers denote the dependent variable (Total GVC, GVC Forward and Backward) and sectors (Agriculture and Food). Estimates for $RTA(t-k)$ are partial effect of generic regional trade agreement on Traditional trade and GVC-related trade. Estimates for $IPR(t-k)$ indicate the partial effect of intellectual property right (IPR) provisions in the regional trade agreement. t-1 to t-2 denotes the lag variables. Estimates for Total IPR effect at the bottom are associated with the sum of current and all lag variables $IPR(t)$, $IPR(t-1)$, $IPR(t-2)$. This is the long-run effect of IPR provisions on three GVC trade values. Standard errors are clustered by country pair and reported in parentheses. We adjust for the (asymptotic) bias in the coefficient estimates as well as the standard errors by using the bias correction method suggested by Weidner and Zylkin (2021). The p-values read as follows: $+p < .10$,* $p < .05$,** $p < .01$

Table A12: Long-run effect of WTO plus and extra type IPR provisions on agriculture and food GVC-related trade (using 4-year interval data)

	Dep: Total GVC			Dep: GVC Forward			Dep: GVC Backward		
	(1) Total	(2) Agr.	(3) Food	(4) Total	(5) Agr.	(6) Food	(7) Total	(8) Agr.	(9) Food
RTA(t)	0.001	0.045	-0.021	0.030	0.081**	-0.020	-0.005	0.034	-0.008
	(0.019)	(0.029)	(0.021)	(0.021)	(0.029)	(0.027)	(0.020)	(0.025)	(0.020)
RTA(t-1)	0.003	0.023	-0.002	0.015	0.043**	-0.018	0.017	0.024	0.013
	(0.014)	(0.015)	(0.016)	(0.011)	(0.015)	(0.017)	(0.014)	(0.018)	(0.014)
RTA(t-2)	0.012	-0.015	0.017	0.002	0.000	0.002	0.024*	0.005	0.021^{+}
	(0.012)	(0.018)	(0.013)	(0.015)	(0.019)	(0.017)	(0.011)	(0.019)	(0.012)
IPR-Plus(t)	-0.044*	-0.177**	-0.008	-0.081**	-0.201**	0.007	-0.038	-0.165**	-0.021
	(0.022)	(0.038)	(0.023)	(0.025)	(0.040)	(0.029)	(0.023)	(0.039)	(0.022)
IPR-Plus(t-1)	0.002	-0.009	0.003	-0.005	-0.023	0.020	-0.019	-0.028	-0.011
	(0.015)	(0.018)	(0.016)	(0.013)	(0.017)	(0.016)	(0.014)	(0.020)	(0.015)

IPR-Plus(t-2)	0.009	0.042^{+}	0.006	0.020	0.034	0.022	-0.031*	-0.016	-0.026^{+}
	(0.016)	(0.024)	(0.016)	(0.019)	(0.025)	(0.020)	(0.012)	(0.023)	(0.013)
IPR-Extra(t)	-0.065	-0.161*	-0.026	-0.070	-0.135*	0.008	-0.081	-0.113*	-0.040
	(0.046)	(0.072)	(0.051)	(0.047)	(0.054)	(0.075)	(0.054)	(0.052)	(0.057)
IPR-Extra(t-1)	0.015	0.042	0.005	0.005	0.002	0.015	-0.019	0.027	-0.019
	(0.014)	(0.032)	(0.015)	(0.022)	(0.028)	(0.024)	(0.013)	(0.042)	(0.014)
IPR-Extra(t-2)	-0.054	-0.047	-0.064^{+}	-0.038	-0.040	-0.054^{+}	-0.061**	-0.067^{+}	-0.064**
	(0.042)	(0.038)	(0.038)	(0.040)	(0.052)	(0.030)	(0.024)	(0.035)	(0.022)
IPR-Plus*IPR-Extra(t)	0.148**	0.357**	0.079	0.171**	0.333**	0.031	0.160**	0.295**	0.103^{+}
	(0.050)	(0.080)	(0.055)	(0.052)	(0.069)	(0.077)	(0.055)	(0.060)	(0.059)
IPR-Plus*IPR-Extra(t-1)	-0.002	-0.006	-0.001	0.018	0.041	-0.010	0.035*	0.018	0.029^{+}
	(0.016)	(0.035)	(0.018)	(0.023)	(0.030)	(0.025)	(0.015)	(0.044)	(0.016)
IPR-Plus*IPR-Extra(t-2)	0.014	0.017	0.028	0.021	0.039	0.036	0.065**	0.075*	0.069**
	(0.042)	(0.039)	(0.039)	(0.041)	(0.053)	(0.030)	(0.025)	(0.036)	(0.023)
Proportional change in average dependent variable when Δx = 1									
x = iprExtra | iprPlus = 1	0.057**	0.224**	0.021	0.111**	0.270**	0.027	0.103**	0.265**	0.081**
	(0.021)	(0.050)	(0.020)	(0.026)	(0.059)	(0.017)	(0.017)	(0.045)	(0.016)
x = iprExtra | iprPlus = 0	-0.100^{+}	-0.153**	-0.081	-0.098	-0.159*	-0.030	-0.148**	-0.142*	-0.116^{+}
	(0.054)	(0.048)	(0.068)	(0.075)	(0.062)	(0.112)	(0.052)	(0.059)	(0.063)
x = iprPlus | iprExtra = 1	0.137*	0.251**	0.113	0.154	0.248*	0.112	0.186**	0.195*	0.154^{+}
	(0.064)	(0.085)	(0.072)	(0.094)	(0.100)	(0.109)	(0.072)	(0.078)	(0.079)
x = iprPlus | iprExtra = 0	-0.032	-0.135**	0.001	-0.064^{+}	-0.174**	0.050	-0.085**	-0.189**	-0.056^{+}
	(0.036)	(0.045)	(0.042)	(0.036)	(0.045)	(0.055)	(0.031)	(0.039)	(0.032)
Obs.	200,554	200,515	200,582	199,848	199,846	199,685	200,806	200,806	200,806
Pseudo R2	0.999	0.999	0.999	0.999	0.999	1.000	0.999	0.999	0.999

Note: All estimations are performed with exporter and importer time-varying fixed effects and bilateral dummies in Equation (9). The years in the data are from 1991, 1995, 1999, 2003, 2007, 2011, 2015. Fixed effects estimates, including the constant, are omitted for brevity. All estimates are PPML estimator. Column headers denote the dependent variable (Total GVC, GVC Forward and Backward) and sectors (Agriculture and Food). Estimates for $RTA(t-k)$ are partial effect of generic regional trade agreement on Traditional trade and GVC-related trade. Estimates for $IPRtype(t-k)$ where type $\in$ (Plus, Extra) indicate the partial effect of each type of IPR provisions in the regional trade agreement and we have interaction terms. t-1 to t-2 denotes the lag variables of IPR-type. Standard errors are clustered by country pair and reported in parentheses. We adjust for the (asymptotic) bias in the coefficient estimates as well as the standard errors by using the bias correction method suggested by Weidner and Zylkin (2021). Four estimates at the bottom are associated with the marginal effect of each type of provision when other conditions are fixed. For exampple, "**x = iprExtra** | iprPlus = 1" can read as the proportional change in average dependent variable when iprExtra changes from 0 to 1 when iprPlus = 1 (and RTA = 1). This implies the incremental effect of having both type of provisions compared to having plus type of provision. The p-values read as follows: $+p < .10$,* $p < .05$,** $p < .01$.

Table A13: Marginal effect of "WTO plus" and "WTO extra" IPR provisions on total GVC trade in Agriculture and Food sector by income pair (using 4-year interval data)

	Dependent variable: Total GVC								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Income pair	LL	LM	LH	ML	MM	MH	HL	HM	HH
Proportional change in average dependent variable when Δx = 1									
Panel A: Agriculure									
x = iprExtra | iprPlus = 1	0.443^{+}	0.031	-0.114	-0.064	0.034	0.010	0.592	0.691**	0.175**
	(0.251)	(0.067)	(0.083)	(0.092)	(0.054)	(0.078)	(0.549)	(0.234)	(0.050)
x = iprExtra | iprPlus = 0	-0.246*	0.888^{+}	0.201	0.441	0.038	-0.067	-0.757**	-0.011	0.142
	(0.113)	(0.499)	(0.176)	(0.468)	(0.086)	(0.049)	(0.103)	(0.118)	(0.146)
x = iprPlus | iprExtra = 1	0.327	-0.434**	-0.196	-0.322	0.006	0.097	4.022*	0.103	-0.064
	(0.267)	(0.151)	(0.131)	(0.219)	(0.087)	(0.111)	(1.828)	(0.141)	(0.118)
x = iprPlus | iprExtra = 0	-0.307**	0.037	0.090	0.044	0.010	0.014	-0.233^{+}	-0.355**	-0.090^{+}
	(0.105)	(0.058)	(0.055)	(0.117)	(0.053)	(0.104)	(0.123)	(0.092)	(0.050)
Panel B: Food									
x = iprExtra | iprPlus = 1	1.038*	0.156	0.014	-0.042	0.161^{+}	-0.060*	-0.389*	0.012	0.067*
	(0.454)	(0.128)	(0.057)	(0.055)	(0.097)	(0.026)	(0.171)	(0.059)	(0.027)
x = iprExtra | iprPlus = 0	1.429	0.253	-0.392**	0.128	-0.080	0.052	-0.259	-0.080	-0.033
	(1.559)	(0.341)	(0.045)	(0.179)	(0.094)	(0.033)	(0.164)	(0.085)	(0.036)
x = iprPlus | iprExtra = 1	-0.603*	-0.141	0.980**	-0.093	0.235^{+}	-0.074*	0.302	0.078	0.049
	(0.265)	(0.229)	(0.200)	(0.143)	(0.137)	(0.036)	(0.248)	(0.104)	(0.047)
x = iprPlus | iprExtra = 0	-0.527**	-0.068	0.187*	0.068	-0.021	0.037	0.579^{+}	-0.021	-0.049^{+}
	(0.111)	(0.105)	(0.072)	(0.055)	(0.066)	(0.029)	(0.325)	(0.061)	(0.029)

Note: The years in the data are from 1991, 1995, 1999, 2003, 2007, 2011, 2015. Please refer Table 5 note for details. Standard errors are in parentheses and the p-values read as follows: $+p < .10$,* $p < .05$,** $p < .01$. Results for GVC forward and Backward are not included in the manuscript.