# Rules of Origin and Auto-Parts Trade

Chenying Yang\*

Singapore Management University

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#### Abstract

Recent decades have witnessed the growing importance of trade in intermediate goods and pursuit of free trade agreements (FTAs). They distort firms' sourcing decisions internationally through preferential tariffs and rules of origin (RoOs), a set of criteria that define the origin of a product to qualify for preferential access. The paper distinguishes trade diversion through RoOs from tariff reduction on intermediate goods, focusing on the automotive industry. Car assemblers' decisions of how much to acquire from which supplier are modeled for every auto part. With the derived gravity trade equation, the estimation identifies significant diversion in intermediate sourcing and the effect is nonlinear with respect to the restrictiveness of RoOs. The shift from foreign to regional inputs exhibits a humped shape and it peaks when the required minimum FTA content is between 50% and 60%. Impacts of RoOs are further decomposed to four channels: export destinations of final goods, magnitude of preferential treatments, price and cost penalty of intermediate goods. Results show that the RoO effects are stronger when car exports are mainly intra-FTA. However, there are mixed forces driving the effects of preferential tariff margins of cars and values of parts.

Keywords: Rules of Origin, intermediate inputs sourcing, RTA, automotive.

<sup>\*</sup>Please send any comments to cyyang@smu.edu.sg

# **1** Introduction

Since 2016, a set of free trade agreements have drawn unprecedented attention led by the formation, renegotiation, or separation of some world's largest free-trade areas, namely the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), the United States-Mexico-Canada Agreement (USMCA), the Regional Comprehensive Economic Partnership (RCEP), and the EU-UK Trade and Cooperation Agreement (TCA). Unlike the trade deals in earlier years, tariffs as well as non-tariff barriers have already been largely eliminated between the member states of these agreements. Hence, only a few additional tariff cuts are expected. Governments instead has been wrestling with how to determine whether a product is eligible for preferential treatment in an agreement, especially when it comes to sensitive sectors, such as the auto industry. CPTPP adopted a generous rule of regional value content (RVC) on duty-free vehicles at 45%, which means that automobiles need to be manufactured using at least 45% of content created intra-FTA. There has been vigorous opposition in some member countries, such as Canada, arguing that the liberal rule contradicts what is demanded by the US in USMCA, an increasingly stricter standard from 62.5% to 75%. In Asia, RCEP consolidates various rules in the existing five "ASEAN+1" agreements. Firms no longer need to reformulate the production to comply with different rules, and instead they manufacture products to qualify a single set of RCEP criteria, which is fairly low at 40%. As for the EU-UK trade deal, there has been back and forth negotiations on the content rule of electric vehicles.

Debate over these trade agreements sheds light on a commercial policy instrument which used to be less transparent: rules of origin (RoOs). It functions as a set of criteria to determine the origin of products and whether products can be granted preferential tariff treatment. Complementary to the preferential terms among FTA members, RoOs are designed to curb exports from third countries to transship goods to the FTA through the member with the lowest external tariff (trade deflection).<sup>1</sup> As such, researchers historically regard RoOs as a "supportive" role for regional integration. Nevertheless, with the dramatic growth of intermediate goods trade which accounts for almost two thirds of international trade (Johnson and Noguera, 2012), the production chain of final goods evolves to be an increasingly sophisticated network across industries and geographical locations. A commonly cited case is Apple iPod in Dedrick et al. (2010), whose production involves memory chips from South Korea, battery from Japan, controller chip from the US and assembly in China. The answer to where a final product originates is thus no longer straightforward. In this

<sup>&</sup>lt;sup>0</sup>For example, USMCA is a substitute of the already in-forced NAFTA. EU-UK TCA substitutes the terms in European Union before Brexit. Except for the country pairs Japan-China and Japan-South Korea, trade agreements for all bilateral links between RCEP countries already exist.

<sup>&</sup>lt;sup>1</sup>In this paper, I define that trade diversion occurs when an importer chooses a less efficient source because of regional preferences, whereas trade deflection occurs when tariffs in one destination cause the exporter to send her goods to a different destination.

context, rules of origin reshape firms' input allocation by defining a product's "nationality".

Rules of origin distort sourcing decisions beyond the traditional trade diversion effects of preferential tariffs.<sup>2</sup> If RoOs are not too liberal to leave firms unconstrained, a final good producer faces a dichotomy. On one hand, she can enjoy the low tariff when exporting final goods to the trade bloc in exchange for procuring a required share of inputs within the region which could be less cost-effective sources. On the other hand, she can source from the cheapest input suppliers anywhere but lose the origin status and pay MFN tariffs when crossing partners' borders. Exporters choose whether to comply with the rules or not. For compliers, RoOs divert trade of intermediate inputs to the free trade region even without tariff reduction for inputs. Prices of traded goods will rise if the increase in production costs over compensates the savings on tariff payment. For non-compliers, there could be other margins of firm adjustment, such as reorganizing export or relocating production to countries with laxer requirements. Either way, a restrictive RoO could backfire when consumers substitute away from higher priced goods or more firms defy the rules and move out of the region.

I develop a theoretical model to analyze firm's decisions on where and how much to source each input facing the rules of origin constraint in a multi-country and multi-product world. The key focus of this model is to incorporate RoO as implicit costs of importing intermediates from countries outside the free trade region. Built upon Antràs and Chor (2013) and Antras et al. (2017), the model allows marginal products of different inputs in producing the final good to vary but is silent on the extensive margin decisions on offshoring which is the focus in Antras et al. (2017). Having different marginal product of inputs helps to build a micro foundation featuring heterogeneity in intermediate imports along the product dimension. The model yields a gravity trade equation for every intermediate goods, and guides the estimation to be tractable.

Legal complexity and inconformity of rules of origin presents a major empirical challenge in studying their effects.<sup>3</sup> The practice with regard to RoOs varies across trade deals and industries, with some defined in terms of change in tariff headings, some the regional value content (RVC) criterion and yet others manufacturing procedure requirement. For this reason, the existing empirical papers on RoOs have focused on a single trade agreement (Anson et al. 2005, Conconi et al. 2018 and Head et al. 2021 on NAFTA, Sytsma 2019 on EU Generalized System of Preferences, Demidova et al. 2012 and Cherkashin et al. 2015 on preferences given by the US and EU to Bangladesh). To accommodate the lack of uniformity in rules across sectors, they either use a synthetic index approach as in Estevadeordal (2000) or count the number of linked final goods that are subject to

<sup>&</sup>lt;sup>2</sup>See Caliendo and Parro (2015), Amiti and Konings (2007), and Bas and Strauss-Kahn (2015) for studying effects of tariff liberalization.

<sup>&</sup>lt;sup>3</sup>Rules of origin are very detailed in regional trade agreements. For example, NAFTA's annex on rules of origins is close to 200 pages.

RoOs like Conconi et al. (2018), or else exploit an event study.<sup>4</sup> This paper differs in focusing on a single industry, the automotive, where global sourcing is prevalent and, most importantly, regional value content criterion is consistently applied by different free trade agreements. It allows me to rank FTAs according to the regulated share of value originating from member states out of the value of a car as a measure of RoO restrictiveness. Using observed RVC thresholds avoids measurement error in self-constructed indices, and is consistent with the way my framework and other theoretical papers have modeled RoOs.

Leveraging the derived gravity equation on trade in intermediates and variation in local content requirements across FTAs, I first unpack the effects of free trade agreements on intermediate goods trade to two distinct channels: preferential intermediate tariffs and rules of origin on final outputs. I collect detailed RoO requirement on the automotive industry for 104 FTAs that have once been in-forced since 1993 to 2020. These agreements cover 40 major economies and 52 HS6-digit auto parts. Results show that RoOs indeed facilitate trade diversion. A 10% increase in the regional value content requirement of exported cars would increase 9.4% of intermediate trade within the FTA. Furthermore, the degree of trade diverted is hump shaped with respect to the restrictiveness of RoOs. As the content rule goes beyond 65%, the average shift of foreign sourced inputs to regionally sourced ones is smaller than FTAs with less than 50% RVC, suggesting a negative price effect or firm exit. The trade diversion effect peaks when approaching a 60% content rule.

Beyond the trade diversion effects of RoOs, the paper further explores firms' heterogeneous responses to RoO changes. Specifically, I test whether export destinations of cars, the magnitude of preferential benefits, prices and cost penalty of different car parts would vary the results. When the majority of foreign consumers are intra-FTA, car exporters are more likely to comply with the rules. The estimates indeed show complementarity between the share of intra-FTA car export and RVC. Higher preferential margin in car exports facilitates stronger intermediate trade diversion when the increase in cost of meeting the RoO is not as high. As for different auto parts, the results suggest that firms reorganize cheaper parts internally due to smaller cost benefit forgone.

This paper adds to a growing body of literature on rules of origin. Much interest on earlier works has been on theory (Krishna and Krueger, 1995; Krueger, 1997; Falvey and Reed, 2002; Krishna, 2005; Ju and Krishna, 2005; Krishna, 2015). Recently, empirical studies start to rise. The most closely related paper is Conconi et al. (2018) in which they use difference-in-difference to show RoOs reduce the growth rate of imports of intermediate goods from third countries to Mexico relative to NAFTA partners by around 45%. Anson et al. (2005) also document negative impact

<sup>&</sup>lt;sup>4</sup>The index constructed by Estevadeordal (2000) and also used in Anson et al. (2005) measures the restrictiveness of preferential rules of origin from 1 being the least restrictive to 7 being the most restrictive. It is based on the type of rules implemented, technical rule being the most restrictive practice, followed by value content and lastly change in tariff classifications. Conconi et al. (2018) consider the input-output linkage in counting the number of sourcing restrictions that affect intermediate goods in each sector.

of RoOs on imports and that the compliance costs of NAFTA RoOs on Mexican exporters amount to 47% of the preferential margin. Sytsma (2019) finds the RoO in EU to Bangladesh textile exporters cuts three-fourths of the preferential margin. Several other papers provide evidences that liberalising rules of origin increases export (Andersson, 2016; Tanaka, 2021; De Melo and Portugal-Perez, 2014). The most recent study by Head et al. (2021) focuses on the auto industry as well. They establish a RoO Laffer curve where production of car parts within USMCA first expands and then contracts with increasing content requirement, taking into account adjustment on firm types (compliant-unconstrained, compliant-constrained, and non-compliant) and relocation of assemblers. Their theory is corroborated by some of the empirical results in this paper.

The paper continues as follows. I first adapt the existing model to include rules of origin as a form of trade frictions. Derived from the model, trade elasticities can be estimated separating the effects of RoOs from others in a FTA. Refinements are then performed to test for any heterogeneous effects related to export decisions and intermediate goods characteristics.

## 2 A Model of Global Sourcing under Rules of Origin

I develop a multi-country and multi-product sourcing model that characterizes how much and where final good producers import every intermediate inputs. Geography is categorized by countries where intermediate suppliers locate, final good producers locate, and markets where final goods are sold. To study rules of origin, I restrict the second and third type of locations to the same set which is bonded by a free trade agreement, whereas locations of intermediates can be global. Compliers of RoOs are constraint in sourcing from countries outside of the FTA region as if a hypothetical tariff on intermediates is imposed between FTA members and other countries.

### 2.1 Consumer preferences and demand

Consider a free trade bloc  $\mathcal{N}$  consisting of countries where individuals have common preferences. For model tractability, I let trade in cars entails zero costs among FTA member countries and assume away any frictions including distances, and thus, there is no price arbitrage. It allows me to model aggregated demand for the entire bloc instead of each country. A representative consumer in  $\mathcal{N}$  values the consumption of different varieties of cars from a set  $\Omega$  according to a standard constant elasticity of substitution (CES) aggregator

$$U = \left(\int_{\omega \in \Omega} (\varphi_{\omega} \tilde{q}_{\omega})^{\rho} d\omega\right)^{1/\rho}, \ \rho \in (0, 1),$$
(1)

where  $\varphi_{\omega}$  represents the quality of variety  $\omega$  perceived by all consumers in the bloc and  $\tilde{q}_{\omega}$  is its consumption in physical units. Denote E as the total expenditure on the automotive industry summing across the member countries. Maximizing utility subject to the budget constraint  $\int_{\omega \in \Omega} p_{\omega} \tilde{q}_{\omega} d\omega = E$  gives rise to the following demand featuring a constant price elasticity for variety  $\omega$ :

$$q_{\omega} = A_{\omega} p_{\omega}^{-\frac{1}{1-\rho}},\tag{2}$$

where  $q_{\omega} \equiv \varphi_{\omega} \tilde{q}_{\omega}$  is the quality-adjusted output. The variety-specific demand shifter,  $A_{\omega} = E \left(P^{\rho} \varphi_{\omega}\right)^{1/(1-\rho)}$ , depends on the industry-wide demand for the set of countries and consumers' taste towards the variety of car. I assume firms treat  $A_{\omega}$  as exogenous. P is the standard price index accounting for the taste differences across varieties available to these markets.

#### 2.2 Firm's problem conditional on sourcing location

Each differentiated variety is produced by a single car manufacturer who locates at  $\ell \in \mathcal{N}$  within the bloc. Firms are then also indexed by  $\omega$ . They are heterogeneously defined by their core productivity  $\delta_{\omega}$ . Production of final car varieties requires assembly of a continuum bundle of intermediates, denoted by j on an unit interval. Firms decide how much and where to procure parts given the demand of its variety within the trade bloc characterized by equation (2). Sourcing of parts, however, is not restricted to the member countries only, but a broader set  $\mathcal{I}$ . I leave firms' export decisions to markets outside of the trade bloc and the joint determination of both exports and imports for future extensions. Instead, I focus on the group of firms who are always constrained by rules of origin and choose to comply, named "compliant-constrained" in Head et al. (2021).

Intermediates are produced by competitive parts suppliers from a country set  $\mathcal{I}$  where each supplier is denoted by ji where  $i \in \mathcal{I}$ . A part supplier engages either in a relationship-specific production or in an outside option with value zero. Since every part is fully customized to a variety of car, neither can parts suppliers resell to alternative buyers. In a case where contracts between car assemblers and parts suppliers are perfectly enforceable and complete, assemblers make an offer to pay  $p_j$  in exchange for  $x_j$  amount of compatible inputs j for each part. Suppose the optimal sourcing strategy is  $\{i^*(j), \forall j \in [0, 1]\}$ , the quality-adjusted volume of a car variety  $\omega$  follows a CES production function,

$$q_{\omega} = \delta_{\omega} \left( \int_0^1 (\psi_j x_{j(i^*)\omega})^{\alpha} dj \right)^{1/\alpha}, \tag{3}$$

where  $\psi_j$  captures the marginal product of different car parts which is non-negative and continuously differentiable.<sup>5</sup> Intermediate inputs are combined with a symmetric elasticity of substitution

<sup>&</sup>lt;sup>5</sup>Another way is to ignore substitutability and model a Leontieff production function which is a special case of the CES specification.

equal to  $1/(1 - \alpha)$  where  $\alpha \in (0, 1)$ . They are imperfectly substitutable along the quality dimension, but not the engineering process. For example, an assembler may compensate inferior wheels with leather seats cover to meet the same level of quality perceived by consumers.

With complete control over the investments and prices of all components, a car manufacturer maximizes his profits by offering the optimal contract such that only the lowest cost parts suppliers  $\{i^*(j), \forall j \in [0, 1]\}$  would participate. Mathematically,

$$\max_{\{x_{j\omega}, p_{j\omega}\}_{j\in[0,1]}} \pi_{\omega} = A_{\omega}^{1-\rho} \delta_{\omega}^{\rho} \left( \int_{0}^{1} (\psi_{j} x_{j\omega})^{\alpha} dj \right)^{\rho/\alpha} - \int_{0}^{1} p_{j\omega} x_{j\omega} dj$$
s.t.  $p_{j\omega} x_{j\omega} - c_{j(i^{*})\omega} x_{j\omega} \ge 0.$ 
(4)

Part j supplier in country  $i^*$  incurs unit cost  $c_{j(i^*)\omega}$ . I show in Appendix that solving this problem delivers the optimal amount of input j, pricing, and associated firm profits to be

$$x_{j\omega}^{*} = \frac{A_{\omega}}{\psi_{j}} \left(\rho \delta_{\omega}^{\rho}\right)^{\frac{1}{1-\rho}} \left(v_{j\omega}^{*}\right)^{\frac{1}{1-\alpha}} V_{\omega}^{\frac{\rho-\alpha}{(1-\alpha)(1-\rho)}}$$

$$p_{j\omega}^{*} = c_{j(i^{*})\omega}$$

$$\pi_{\omega}^{*} = (1-\rho) A_{\omega} \left(\rho \delta_{\omega} V_{\omega}\right)^{\frac{\rho}{1-\rho}},$$
(5)

where  $v_{j\omega}^* = \psi_j / c_{j(i^*)\omega}$  indicates the marginal product per unit of cost and  $V_\omega = \left[ \int_0^1 (v_{j\omega}^*)^{\frac{\alpha}{1-\alpha}} dj \right]^{\frac{1-\alpha}{\alpha}}$  is an aggregator of cost-adjusted quality of all intermediates. The discussion of whether the qualityadjusted investment on inputs are complements or substitutes depending on the relative size of  $\alpha$  and  $\rho$  follows similar rationale in Antràs and Chor (2013) and Alfaro et al. (2019). When  $\rho$  is smaller than  $\alpha$  and demand of a final car is more elastic, any additional investment on quality improvement of a particular part can significantly reduce that of other parts, making them substitutes in quality terms. The suppliers' participation constraint is binding for the lowest cost parts producers, which leaves them with the same payoff as the outside option at zero. Car assemblers extract all the rents.

Now let's characterize the marginal cost of part j supplier from country i shipping to assembler  $\omega$  at  $\ell$ ,

$$c_{ji\omega\ell} = \frac{w_i}{z_{ji\omega}} \tau_{ji\ell} r_{i\ell} d_{i\ell},\tag{6}$$

where  $w_i$  is a composite index of wages and material prices for car parts production in sourcing country *i*. Delivery of car parts is subject to a set of trade frictions from *i* to  $\ell$ , namely *ad-valorem* tariffs on parts  $\tau_{ji\ell} = 1 + t_{ji\ell}$ , non-price factors such as distance that shifts transportation cost  $d_{i\ell}$ , and implicit costs on parts due to rules of origin placed on final cars  $r_{i\ell}$ . For RoO compliers who find the rules to be binding,  $r_{i\ell} > 1$  if the part is sourced outside the region, i.e.  $i \notin \mathcal{N}$ , and  $r_{i\ell} = 1$  otherwise. There could be other groups of firms who never find RoOs binding and those who choose not to abide the rule, in either case  $r_{i\ell} = 1$  regardless whether county *i* belongs to the region  $\mathcal{N}$  or not. Modeling the endogeneity of  $r_{i\ell}$  which depends on firm-level decisions and identifying marginal switchers would further complicate the model and require more disaggregated data in estimation.<sup>6</sup> With limited data, I keep the model parsimonious but bear in mind that firms' heterogeneous responses to RoOs are embedded in  $r_{i\ell}$  which will be investigated empirically in Section 4.

Another caveat is that firms may progressively source parts within the FTA region until the minimum requirement is met. The effective RoO constraint on different parts would then vary depending on their relative value in a car and foreign-cost advantages, although technically, a lump-sum content threshold is imposed without specification to parts. Diverting high value and high foreign advantaged parts increases the likelihood of a firm to meet the RoO, but at the same time imposes greater cost penalty to the firm. Solving which part is shifted to domestic sourcing and which part remains foreign is a complicated combinatorial problem. Nevertheless, I extend  $r_{i\ell}$  to  $r_{ji\ell}$  in the empirical section and investigate whether there is systematic trade diversion pattern across parts.

Productivities of the compatible inputs,  $z_{ji\omega}$ , are supplier-assembler specific. I treat productivities of part j from country i for a car assembler  $\omega$  as independent draws from the Fréchet distribution with CDF,  $\exp(-z^{-\theta})$ . Hence, the marginal product per unit cost of a part,  $v_{ji\omega} = \psi_j/c_{ji\omega\ell}$ , is distributed as

$$\Pr\left(v_{ji\omega} \le v\right) = \exp(-\phi_{ji\ell}v^{-\theta}),\tag{7}$$

where  $\phi_{ji\ell} = \psi_j^{\theta} (w_i \tau_{ji\ell} r_{i\ell} d_{i\ell})^{-\theta}$  indicates country *i*'s potential in supplying part *j* to country  $\ell$ . The shape parameter  $\theta$  governs the force of competitive advantage across suppliers from different countries for a specific part. The lower the  $\theta$ , the higher the variability of productivities. Note that different car manufacturers who assemble their respective varieties at the same location would expect identically distributed parts suppliers.

#### 2.3 Sourcing decisions

Based on equation (5), car manufactures choose the optimal part supplier who offers the lowest price of the part or equivalently the highest value per unit cost from the set of countries  $\mathcal{I}$ .<sup>7</sup> With equation (7) and properties of the Fréchet distribution, the distribution of value per unit cost for

<sup>&</sup>lt;sup>6</sup>The recent study by Head et al. (2021) makes theoretical contribution in modeling these margins.

<sup>&</sup>lt;sup>7</sup>Implicitly, I assume all countries from the set  $\mathcal{I}$  are capable of producing compatible inputs for every variety of car. Relaxation of this assumption will not affect the model structure. A gravity-type trade equation which is essential for the empirical estimation still holds.

parts that are actually procured by car assemblers at  $\ell$  is

$$\Pr(v_{j\omega}^* \le v) = 1 - \exp(-\Phi_{j\ell}v^{-\theta}),\tag{8}$$

where  $\Phi_{j\ell} = \sum_{k \in \mathcal{I}} \phi_{jk\ell}$  is the sourcing capability of a country  $\ell$  for a part j. The probability that  $i^*$  is selected for part j used in cars assembled at  $\ell$  equals to

$$\Pr(\arg\max_{i\in\mathcal{I}}v_{ji\omega}=i^*)=\frac{\phi_{ji^*\ell}}{\Phi_{j\ell}}.$$
(9)

It can also be interpreted as the share of assemblers in  $\ell$  that source from part supplier  $ji^*$  since ex-ante assemblers are identical in how they perceive the parts suppliers. More assemblers choose parts suppliers from  $i^*$  if they have low costs to serve  $\ell$  relative to others. Specifically, when RoOs are effective which means  $r_{i\ell} > r_{k\ell}$  for  $i \notin \mathcal{N}$  and  $k \in \mathcal{N}$ , sourcing within the FTA region has competitive advantage against sourcing outside, holding other cost factors equal. Following Eaton and Kortum (2002), another implication about the Fréchet distributed productivities is that the distribution of value per unit cost for part j that country  $\ell$  sources from a particular country is independent of the sourcing country's identity and equals to the distribution in (8). Consequently, the share of assemblers in  $\ell$  that source from  $ji^*$  is also the corresponding expenditure share.

### 2.4 Aggregation and gravity

From the optimal sourcing decisions of inputs in equation (5), the shipping flow of part j from the lowest-cost supplier to a car assembler  $\omega$  in value term is

$$X_{j\omega} = \rho^{\frac{1}{1-\rho}} E P^{\frac{\rho}{1-\rho}} (\varphi_{\omega} \delta_{\omega}^{\rho})^{\frac{1}{1-\rho}} (v_{j\omega}^*)^{\frac{\alpha}{1-\alpha}} V_{\omega}^{\frac{\rho-\alpha}{(1-\alpha)(1-\rho)}}.$$
(10)

To get the expected trade flow of part j from a country  $i^*$  to country  $\ell$ , I need to aggregate the above taking into account the measure of heterogeneous firms in  $\ell$ , their associated cost distributions when  $i^*$  is the source country, and the probability of choosing country  $i^*$ . Now, let's tackle each of the components.

I assume free entry for car manufacturers with entry cost  $F_{\ell}$  for every  $\ell \in \mathcal{N}$ . Equation (10) reveals that the preference-based  $\varphi_{\omega}$  and cost-based  $\delta_{\omega}$  are isomorphic in trade. Therefore, instead of separately specifying each variable, I assume the composite  $\varphi_{\omega}\delta_{\omega}^{\rho}$  is drawn from a Pareto distribution with shape parameter  $\eta$  where  $\eta > 1/(1-\rho)$ . Free entry condition and variable profit

in equation (5) give rise to the entrant's lowest productivity and quality cutoff being

$$\left(\underline{\varphi_{\omega}}\delta_{\omega}^{\rho}\right)^{\frac{1}{1-\rho}} = \frac{F_{\ell}}{(1-\rho)\rho^{\frac{\rho}{1-\rho}}EP^{\frac{\rho}{1-\rho}}V_{\omega}^{\frac{\rho}{1-\rho}}}.$$
(11)

Firms which above the threshold enter and actively source inputs from all potential suppliers since there is no fixed costs of importing.

Aggregating the variety-specific part usage in (10) to country  $\ell$  where assembly of a set  $\Omega_{\ell}$  varieties is processed, I obtain

$$X_{j\ell} = \kappa F_{\ell} \Omega_{\ell} \left(\frac{\Phi_{j\ell}}{\Phi_{\ell}}\right)^{\frac{\alpha}{(1-\alpha)\theta}},\tag{12}$$

where constant is  $\kappa = \frac{\eta\rho}{\eta(1-\rho)-1}$ , and  $\Phi_{\ell} = \left(\int_{0}^{1} \Phi_{j\ell}^{\frac{\alpha}{(1-\alpha)\theta}} dj\right)^{\frac{(1-\alpha)\theta}{\alpha}}$  is a sourcing capability index of country  $\ell$  across all the parts. The equation implies that if a part is higher value-added to the final car and also enjoys cost advantage among all the potential suppliers, it will be used more in producing the quality-adjusted final output relative to other parts. The relative difference is governed by the degree of substitution across parts and productivity dispersion across suppliers. The derivation is presented in the Appendix, which takes advantage of the setting where the cost distribution of parts that are actually sourced by a country is the same regardless of the identity of firms (varieties).

Combined with the sourcing probability in equation (9), export from country  $i^*$  to  $\ell$  for part j is

$$X_{ji^*\ell} = \kappa \underbrace{F_\ell \Omega_\ell \Phi_\ell^{-\frac{\alpha}{(1-\alpha)\theta}} \Phi_{j\ell}^{\frac{\alpha}{(1-\alpha)\theta}-1}}_{\text{dest., part-dest}} \underbrace{\psi_j^\theta w_{i^*}^{-\theta}}_{\text{part, orig.}} \underbrace{(r_{i^*\ell} d_{i^*\ell})^{-\theta}}_{\text{orig-dest}} \underbrace{\tau_{ji^*\ell}^{-\theta}}_{\text{part-orig-dest}}.$$
(13)

The model yields a gravity trade equation at product level aggregating from firms' decisions. Trade in intermediate inputs rises with the marginal product of a car part and measure of assemblers, and decreases with the cost of parts production and trade frictions between the country pair for the input. Due to the substitutability across intermediate inputs introduced in the model, country  $\ell$ 's sourcing capability of other parts also affects trade negatively. Depending on the relative size of  $\alpha$  versus  $\theta$ , the effect of sourcing capability of country  $\ell$  for part j is ambiguous. If intermediate inputs are less substitutable (small  $\alpha$ ) and input producers from different countries are less dispersed (high  $\theta$ ), then increase in  $\Phi_{j\ell}$  due to improvement in supply by other origins will reduce sourcing of the part from  $i^*$  because business stolen by part suppliers from other origins dominates expansion of the market for part j. The trade elasticity remains  $-\theta$  as in Antras et al. (2017) when the extensive margin in sourcing is suppressed and all firms are capable of sourcing inputs from all countries. Although this paper does not intend to structurally recover all the model primitives for counterfactual analysis, the gravity equation provides a powerful guidance for understanding trade flows of intermediate inputs and estimating trade elasticities. Once observed variables measuring each type of frictions are introduced, namely tariffs, rules of origin restrictiveness and non-price factors, I can apply the empirical counterpart of equation (13) to disentangle each of their effects on trade.

As an extension of the benchmark model, I have mentioned in Section 2.2 that the effective RoO friction when sourcing outside of the trade bloc could vary by parts if there is systematic differences in which part to be shifted inwards first and which part to be always left out. The extension will not change much of the deviation except that I replace  $r_{i^*ell}$  with  $r_{ji^*\ell}$ , and the gravity equation becomes

$$X_{ji^*\ell} = \kappa \underbrace{F_{\ell}\Omega_{\ell}\Phi_{\ell}^{-\frac{\alpha}{(1-\alpha)\theta}}\Phi_{j\ell}^{\frac{\alpha}{(1-\alpha)\theta}-1}}_{\text{dest., part-dest}}\underbrace{\psi_{j}^{\theta}w_{i^*}}_{\text{part, orig. orig-dest}}\underbrace{d_{i^*\ell}^{-\theta}}_{\text{orig-dest}}\underbrace{(r_{ji^*\ell}\tau_{ji^*\ell})^{-\theta}}_{\text{part-orig-dest}}.$$
(14)

I will provide more details in Section 3.3 about constructing the proxy for  $r_{ji\ell}$ , and compare empirical results in equation (14) to (13).

# **3** Data and Variables

#### 3.1 FTAs and RoOs

Rules of origin are critical components in free trade agreements. In this paper, I study a period from 1993 to 2020 covering 104 FTAs and 40 major car and parts production countries, namely the U.S., Canada, Mexico, Brazil, China, Japan, South Korea, Thailand, India, 28 EU countries, Iceland, Norway, and Turkey. These countries in total accounts for more than 91% of the passenger vehicle production over the years according to The International Organization of Motor Vehicle Manufacturers, also known as OICA. The free trade agreements are either still active in 2020 or once have been active during the studied time period. Information on each FTA such as years of entry into force and deactivation, parties involved, RoO provisions is collected from the Rules of Origin Facilitator based on databases in the International Trade Centre.

The restrictiveness of rules of origin in this paper is measured using a defined regional value content percentage such that exports can only be treated with preferential terms if such percentage is reached. Concentrating on a single industry, the automotive, allows me to exploit the observed thresholds rather than relying on self-constructed approximations. One may raise concern on whether RVC is sufficient to represent the stringency of rules of origin. RVC rules are normally used in combination with change of tariff classifications which requires any non-originating input must be classified in a different product category with the final good. For example, consider a

passenger vehicle falling under HS sub-heading 8703.21-8703.90. USMCA rules of origin require the following:

"A change to a passenger vehicle of subheading 8703.21 through 8703.90 from any other heading, provided there is a regional value content of not less than 75 percent under the net cost method"

The first part means that non-originating input in a passenger car requires a HS heading change, i.e. not coming from heading 8703 ("motor cars & vehicles for transporting persons"). The second part imposes additional constraint which the cost of inputs sourced within USMCA has to be at least 75% of the total net cost for a final car. Considering car parts that are mostly under the heading of 8708 ("parts & access for motor vehicles") and 8407 ("spark-ignition reciprocating or rotary internal combustion piston engines") and none under the same heading with passenger cars, the change of classification restriction will not be binding. What matters for the sourcing of car parts is mainly the RVC threshold.<sup>8</sup> In general, the fact that change of classification rule is unbinding in the automotive industry applies to other trade agreements as well, which makes RVC a valid measurement for RoO stringency.

How regional value content is calculated goes further in details. Generally two methods are used, transaction value or net cost. The former is calculated as one minus the share of non-originating materials' value in adjusted price of the good. The latter replaces transaction price to net cost of the good and is calculated by subtracting value of non-originating materials over total net cost of the good.<sup>9</sup> Checking the consistency in value-added calculation across the FTAs in my sample, I find that most of the agreements provide the transaction value calculation for cars. In the case that multiple methods are provided with slightly different threshold, I choose the more stringent content rule as baseline and use others as robustness checks.

A list of free trade agreements in my sample and their respective value content rules on the automotive industry is presented in Table 1. RVC ranges from 35% to 75%, but many are concentrated at 60% due to Pan-Euro-Mediterranean Convention, a harmonising initiative of preferential rules of origin among the European countries. The lack of variation poses a threat in the identification of RVC effect, which I have carefully dealt with in the empirical section. One caveat is that one country pair could be linked through more than one FTAs in the same year, for example, Canada and Mexico are members of NAFTA/USMCA and CPTPP, and Japan and Mexico are

<sup>&</sup>lt;sup>8</sup>The replacement of NAFTA with USMCA also introduces new regulation on labor value content that requires a minimum content to be made by workers earning at least US\$16 per hour, as well as 70% of steel and aluminum used in car production must originate within the region. Since these two requirements are not commonly used across FTAs, I ignore clauses other than RVC but acknowledge that my measurement of stringency could be at the lower bound.

<sup>&</sup>lt;sup>9</sup>As global value chain becomes more fragmented, production of non-originating intermediates could involve the use of originating materials as inputs. One caveat is that the value flow back home through imported foreign intermediates is not counted as intra-FTA. Therefore, from the global value chain perspective, RoOs are more restrictive than it appears to be.

members of their own FTA and CPTPP. In this case, I assume that the lower RVC is considered in firms' decisions because it is less costly for firms to meet the RoOs. As robustness checks, I also use the higher RVC and average RVC weighted by export share of cars to member countries.

FTA Name	Car RVC (%)
India - South Korea	35
India - Japan	35
ASEAN - India	35
ASEAN - Japan	40
Japan - Thailand	40
ASEAN - China	40
EFTA-Mexico	40
ASEAN - South Korea	45
Canada - South Korea	45
Canada - US (CUSFTA)	50
China - Iceland	50
EFTA - Canada	50
EU - Canada	50
CPTPP	55
EFTA - South Korea	55
EU - South Korea	55
South Korea - Turkey	55
South Korea - US	55
China - South Korea	60
EU - Japan	60
EU - Mexico	60
Pan-Euro-Mediterranean Cumulation System / PEM Convention	60
North American Free Trade Agreement (NAFTA)	62.5
Japan - Mexico	65
US - Mexico - Canada Agreement (USMCA)	75

Table 1: Description statistics on FTA and RVC

Note: Pan-Euro-Mediterranean cumulation system is based on a network of Free Trade Agreements having identical origin protocols with contracting parties including EU, EFTA, Turkey, and participants in the Barcelona Process, and others. 80 other FTAs are part of PEM Convention and not separately listed above. In NAFTA, the RVC for light vehicles was first set to be 50% during 1994-1998, and then modified to be 56% in 1998-2002 before reaching 62.5%.

### 3.2 Tariff and trade

To estimate the gravity equation of trade in intermediate inputs in (13), I collect trade and tariff data for HS6-digit car parts from UN Comtrade and the World Integrated Trade Solution (WITS). 52 categories are identified for car parts including engine, transmission, brake system, steering and suspension components, axle, electrical equipments, body and chassis. Final good is restricted to passenger cars.

Figure 1 reports the applied tariff distributions of cars and car parts across the country pairs in 1993 and 2020, excluding a large number of zero tariffs. Effectively applied tariffs would be the MFN rates if a country pair does not form FTA and preferential tariffs otherwise. Variation in tariffs takes into account the phase-out schedule and other forms of regional trade agreement. As in panel (a), China has 190% tariff on passenger cars in 1993 before joining the WTO, which subsequently drops to 15% by 2020. In 2020, India replaces China as having the highest tariff, 125%, for cars, followed by Thailand at 75%. Countries such as the US and Canada have low rate at about 2.5% to 6%. Japan has zero tariff for cars although the high automobile standards impede foreign cars from stepping into the market. Car parts generally face lower tariffs compared to what are imposed on finished cars due to tariff escalation. China had high tariff on auto parts at 85% in 1993 and reduced it to 10% or less in 2020. Thailand and India are at the top tier of countries which set high MFN rates on parts at 60% - 80% in 1993 and 20% - 30% in 2020. Tariffs on parts in the US, Canada and Japan are largely approaching zero.



Figure 1: Distribution of effectively applied tariff

Figure 2 shows preferential margins defined as the difference between the MFN and preferential tariffs. They are not as dispersed but highly concentrated at 10% in 2020 and also at 6% in 1993, conforming with the fact that most MFN tariffs on passenger cars are at these two rates as presented in Figure 1, panel (a).<sup>10</sup> Countries that are located at the thin right tail are India, Mexico and a few small European economies who witness substantial tariff decline after forming FTAs.

Although the model does not explicitly solve firms' decisions on export of cars, equation (10) incorporates the market demand within FTA in determining import of intermediates at the firm level. When market demand is higher within the FTA, firms are more likely to obey the rules of

<sup>&</sup>lt;sup>10</sup>Figure 1, panel (a) and Figure 2 are not exactly the same because the difference between MFN and each year's phase-out tariff is included when plotting Figure 2.

Figure 2: Distribution of preferential margin on passenger car



Figure 3: Distribution of cars export share within FTA and CU



origin and source pars internally. In the empirical section, I construct the share of intra-FTA trade over total export of cars to test the hypothesis.<sup>11</sup> Figure 3 shows the distribution of export share of cars within FTAs only and within FTA and customs union (CU). We see that more than 70% of the country-year observations export at least 80% cars to FTA or CU partners, driven primarily by the EU and NAFTA countries. Excluding customs union, we still have 22% of the country-years export 80% and above within the FTAs, which makes RoO a relevant consideration for firms. On the other hand, Asian economies, such as China, India and Thailand, export significant number of cars to countries outside the FTA region. The variation helps to identify heterogeneous effects of rules of origin for firms with different export targets.

<sup>&</sup>lt;sup>11</sup>Production of cars that serves the domestic market (i.e. trade with itself) is not included in the measurement because it is not subject to RoOs.

### 3.3 Part-level data

To test for any heterogeneity in effects of RoO by parts using equation (14), I introduce prices and cost penalty for different auto parts to be interacted with the RVC in the analysis. Price is computed at the origin-product level using the value traded with the US divided by the corresponding physical volume based on the primary quantity unit measured at HS10 digit before averaging to HS6.<sup>12</sup> Cost penalty is measured as the difference between average price from any potential suppliers and the average price from FTA partners, weighted by the importing share of parts from different suppliers.

Figure 4 panel (a) shows that most parts cost below \$500, before jumping to thousand-dollar engines, transmissions and starter motors. Brake system and spark plugs are the least costly parts when assembling a car.<sup>13</sup> Panel (b) visualizes tariffs across parts averaging over country pairs and years. Compared to Figure 1, much of the variation in tariffs of auto parts stems from country pairs and years instead of the product dimension.

Figure 4: Heterogeneity in car parts



(a) Unit price

(b) Applied tariff<sup>14</sup>

### 3.4 Bilateral accessibility

The last set of data needed for estimating the gravity equation are the standard explanatory variables, including distances, whether two countries are adjacent or share a common language, as non-price cost shifters. These variables have been shown in past literature to matter for trade flows.

<sup>&</sup>lt;sup>12</sup>Due to missing data across years, I suppress the time variation of parts' prices. The category of car parts also shrinks from 52 to 36.

<sup>&</sup>lt;sup>13</sup>Price for spark plugs are denoted at 6 units to fit a common car's usage.

<sup>&</sup>lt;sup>14</sup>Average applied tariffs exclude zero-tariff observations to be comparable with Figure 1.

Another variable controlled for is customs union (CU). Unlike FTAs, member states in a CU would have a common external tariff in which case trade deflection is eliminated. Therefore, the rationale for having rules of origin is largely weakened, which is why RoOs are typically absent from CU arrangements.<sup>15</sup> For the whole sample, about 35% of observations are part of a CU, 22% forms FTAs, 1% forms PSAs, and the rest do not have any regional trade agreements. I include a customs union dummy in the following regression analysis to avoid omitted variable bias.

## 4 Empirical Analysis

The primary goal of this paper is to verify whether rules of origin create trade diversion in intermediate goods from non-FTA countries to member states. With time dimension added, I specify the implicit trade friction from RoOs as a function of observables between country *i* and  $\ell$ , denoted  $\mathbf{R}_{i\ell t}$ . It includes indicators of whether the two countries belong to a customs union or connected by a free trade agreement, and interactions with the regional value content requirements. The nonprice trade costs are a function of distance, and a time-invariant vector of dummies describing the bilateral relationship, denoted  $\mathbf{D}_{i\ell}$ . Ad-valorem tariff for part *j* is  $\tau_{ji\ell t}$ . Explicitly, they are

$$r_{i\ell t} = \exp(\mathbf{R}'_{i\ell t}\beta^r), \ d_{i\ell} = \exp(\mathbf{D}'_{i\ell}\beta^d), \ \tau_{ji\ell t} = 1 + t_{ji\ell t},$$

where  $\beta^r$  and  $\beta^d$  are vectors of trade cost parameters.

The gravity trade equation (13) describing product trade flow between countries can be transformed to its estimable form,

$$\frac{X_{ji\ell t}}{X_{j\ell t}} = \exp\left[\mathrm{FE}_{j\ell t} + \mathrm{FE}_{jit} - \theta \mathbf{R}'_{i\ell t} \beta^r - \theta \mathbf{D}'_{i\ell} \beta^d - \theta \ln(1 + t_{ji\ell t}) + \epsilon_{ji\ell t}\right],\tag{15}$$

where the importer-part-year fixed effect is  $FE_{j\ell t} = -\ln(\Phi_{j\ell t})$ , the exporter-part-year fixed effect is  $FE_{jit} = \theta \ln(\psi_{jt}/w_{it})$ .<sup>16</sup> The equation is estimated using Poisson Pseudo Maximum Likelihood (PPML) due to the consistency it delivers under very general conditions and its capability of incorporating zeros as clearly explained in Silva and Tenreyro (2006) and Head and Mayer (2014). I replace the dependent variable from the level of trade to the share of trade such that less importance is given to large levels of trade and also governing the dependent variable to be between zero and one in a Poisson regression.

There are two caveats about the data. One is that the production data for HS6-digit car parts

<sup>&</sup>lt;sup>15</sup>See Georges (2008) for the effects of removing RoO by a hypothetical move from NAFTA to CU. They also mentioned that the European Commission set preferential RoOs for exceptions to the principle of free circulation.

<sup>&</sup>lt;sup>16</sup>The time-specific  $\psi_{jt}$  reflects that the marginal product of a part could vary across years due to technological improvement.

across countries and years is not readily available, which means the intra-national trade is missing from the panel. It could cause biases in the estimation of the effect of distance on trade when internal distances are not accounted for. What's more concerning is that the impact of FTAs can be downward biased when FTAs divert trade from domestic to foreign sales.<sup>17</sup> However, our target of interest, the effect of RoO restriction, may survive the problem because the use of content from a country itself or its FTA partners is treated the same to meet the rule. So there is no further distortion between intermediate trade diverted to the importer itself or other FTA members.<sup>18</sup> The other is that as mentioned in Section 3.1, RVC thresholds are highly concentrated at 60% due to the common practice in Pan-European-Mediterranean (PEM) Convention, causing a collinearity problem when both RVC and the FTA dummy are included in a regression. To separately identify the effects of rules of origin, I exclude the FTAs under the PEM Convention.

Table 2 reports the main results. For all columns, estimates on the standard gravity variables have the expected direction and similar magnitude to what have been found in the literature. Customs union has a significant effect on intermediates trade. Using the mean coefficient at 0.643, it implies that CU increases trade of car parts by 90 percent on average.<sup>19</sup> Other FTAs increase trade by around 84 percent based on the coefficient in column (1). The trade elasticity  $-\theta$  identified through tariffs variation is at -3, slightly lower than the -5 benchmark in Head and Mayer 2014. It suggests that part suppliers are quite heterogeneous from one another.

Now, let's focus on our parameter of interest, the effect of RoOs. Given that 80 out of 104 FTAs are under the umbrella of Pan-European-Mediterranean Convention, column (2) presents the results which validates the existence of the collinearity problem. Excluding these FTAs, column (3) shows that a 10 percentage point increase in regional value content divert more than 9% of intermediates import from third countries to the FTA. The effect is almost half of that of a direct tariff cut on intermediate goods. It supports the argument that firms would reallocate more inputs intra-FTA to satisfy the tightened content rule and maintain the originating status of their final output.

To further decompose the effects of RoO, I run column (4) where there are four groups of FTAs defined by their respective RVC level. Figure 5 visualizes the coefficients, their confidence intervals and effects on intermediates trade. We observe a hump shaped relationship between the

<sup>&</sup>lt;sup>17</sup>See Yotov et al. (2016), chapter 1 for more discussion on including intra-national and international trade in the estimation of structural gravity.

<sup>&</sup>lt;sup>18</sup>This production sharing across countries within a FTA is called cumulation rules. They define the geographic area from which inputs can be sourced without losing its originating status. It can follow full cumulation, diagonal cumulation, or bilateral cumulation. Full cumulation is more flexible because it allows to use inputs from a third country outside of the FTA although only the further processing added by member countries can accumulate to the regional value content. Diagonal or bilateral cumulation does not allow inputs outside and can only be applied to goods originating in an FTA member country and further processed in another member country.

<sup>&</sup>lt;sup>19</sup>For an indicator variable, the effect is interpreted as  $\exp(0.643) - 1 \approx 0.9$ .

Dep. Var	import share <i>jilt</i> , PPML					
	(1)	(2)	(3)	(4)		
In dist <sub>il</sub>	$-0.907^{a}$	-0.906 <sup>a</sup>	$-0.923^{a}$	$-0.923^{a}$		
	(0.072)	(0.072)	(0.068)	(0.070)		
contiguity <sub>il</sub>	$0.292^{b}$	$0.291^{b}$	$0.246^{b}$	$0.273^{b}$		
	(0.115)	(0.116)	(0.114)	(0.115)		
$language_{i\ell}$	$0.271^{c}$	$0.270^{c}$	$0.274^{c}$	$0.276^{c}$		
	(0.148)	(0.148)	(0.147)	(0.149)		
$\mathrm{CU}_{i\ell t}$	$0.692^{a}$	$0.703^{a}$	$0.506^{a}$	$0.671^{a}$		
	(0.156)	(0.158)	(0.180)	(0.161)		
ln (1+parts tariff <sub><i>jilt</i></sub> )	$-2.823^{a}$	$-2.876^{a}$	$-2.279^{b}$	$-2.576^{b}$		
	(1.041)	(1.063)	(1.046)	(1.061)		
$FTA_{i\ell t}$	$0.609^{a}$	0.365	$0.381^{a}$			
	(0.114)	(0.685)	(0.129)			
$\text{FTA}_{i\ell t}  imes  ext{RVC}_{i\ell t}$		0.434				
		(1.175)				
Non-PEM $FTA_{i\ell t} \times RVC_{i\ell t}$			$0.939^{a}$			
			(0.271)			
$\text{FTA}_{i\ell t}  imes 1(\text{RVC}_{i\ell t} < 50\%)$				$0.529^{c}$		
				(0.311)		
$\text{FTA}_{i\ell t} \times 1(50\% \leq \text{RVC}_{i\ell t} < 60\%)$				$0.932^{a}$		
				(0.159)		
$\text{FTA}_{i\ell t} \times 1(60\% \leq \text{RVC}_{i\ell t} < 65\%)$				$0.552^{a}$		
				(0.122)		
$\text{FTA}_{i\ell t}  imes 1(\text{RVC}_{i\ell t} \geq 65\%)$				$0.434^{b}$		
				(0.213)		
Observations	2137960	2137960	2137960	2137960		
$\mathbb{R}^2$	0.703	0.703	0.704	0.703		

Table 2: Baseline results

The parts are defined at HS 6-digit level and their exports in US dollar current value. It includes international trade flow between 40 countries from 1993 to 2020, but not intra-nation due to missing parts production data. All columns include origin-product-year and destination-product-year fixed effects. Standard errors are clustered at country pair (non-directional) level in parenthesis. Significance levels:  $^{c}$  p<0.1,  $^{b}$  p<0.05,  $^{a}$  p<0.01.

amount of trade diverted and RoO restrictiveness. Imports of intermediates from FTA partners is 70% larger than imports from countries outside when RVC is below 50%. The impact is equivalent to removing 23% of the *ad-valorem* tariff.<sup>20</sup> As the RVC is higher, more are diverted to the FTA until the effect peaks at 60% RVC. FTAs with the regional value content between 50% and 60% has the same effect as removing 44% of the *ad-valorem* tariff. However, beyond 60%, the effect

<sup>&</sup>lt;sup>20</sup>The effect is calculated by  $(\exp(0.529) - 1) \times 100\% \approx 69.7\%$  and tariff equivalent as  $(\exp(0.529/2.576) - 1) \times 100\% \approx 22.79\%$ .

declines. When requiring more than 65% of the originating inputs, FTA is weaker on facilitating regional trade than if the requirement is below 50%. Although the endogenous adjustment of firms is not explicitly modeled in the previous theoretical section, the empirical results are a mix of intensive and extensive margins. When the RVC rule is higher than 60%, compilers have to raise the price to compensate the increasing input costs, and thus driving consumers away to other substitutes. The high RVC also tightens the selection of firms and creates more non-compilers or non-exporters. The results resonate with the Laffer curve modeled in Head et al. (2021) where stricter content requirements initially expand production but eventually contract it. Instead of performing a simulation exercise, I show the nonlinear effects of RoO with real data.





As an extension of our baseline results, I further investigate what channels contribute to the RoO effects and whether there is any heterogeneity depending on firms' export status and parts imported. Building on the preferred estimates in column (3) of Table 2, I interact the regional value content with four more variables, namely the share of export within the FTA, the preferential margin on cars exporting to FTA partners, the average price of every auto parts, and the cost penalty when sourcing intra-FTA.

First, when the FTA member countries are important markets for car exporters at country  $\ell$ , firms would benefit from complying the rules and obtaining the preferential treatment. Hence, greater proportion of intra-FTA trade in final goods implies more firms would become compliers

Dep. Var	import share <sub><i>iilt</i></sub> , PPML				
	(1)	(2)	(3)	(4)	(5)
ln dist <sub>il</sub>	$-0.895^{a}$	$-0.924^{a}$	$-0.885^{a}$	$-0.858^{a}$	$-0.849^{a}$
	(0.069)	(0.068)	(0.070)	(0.069)	(0.070)
contiguity <sub>il</sub>	$0.220^{c}$	$0.246^{b}$	$0.272^{b}$	$0.241^{b}$	$0.233^{c}$
	(0.114)	(0.114)	(0.119)	(0.119)	(0.120)
$language_{i\ell}$	$0.279^{c}$	$0.274^{c}$	$0.284^{c}$	$0.298^{c}$	$0.296^{c}$
	(0.149)	(0.147)	(0.150)	(0.156)	(0.158)
$\mathrm{CU}_{i\ell t}$	$0.579^{a}$	$0.509^{a}$	$0.558^{a}$	0.619 <sup>a</sup>	$0.646^{a}$
	(0.178)	(0.181)	(0.186)	(0.176)	(0.177)
ln (1+parts tariff <sub><i>jilt</i></sub> )	-0.614	$-2.307^{b}$	$-2.188^{b}$	$-2.206^{c}$	-1.389
	(1.071)	(1.049)	(1.109)	(1.322)	(1.428)
$FTA_{i\ell t}$	$0.246^{c}$	$0.394^{a}$	$0.373^{a}$	$0.651^{a}$	$0.558^{a}$
	(0.126)	(0.129)	(0.133)	(0.163)	(0.156)
Non-PEM $FTA_{i\ell t} \times RVC_{i\ell t}$	$0.513^{c}$	$0.905^{a}$	$1.735^{a}$	$1.281^{a}$	0.398
	(0.268)	(0.276)	(0.385)	(0.419)	(0.428)
export share <sub>FTA(i)<math>\ell t</math></sub>	$0.065^{b}$				0.037
	(0.030)				(0.033)
tariff margin <sub>FTA(i)<math>\ell t</math></sub>		-0.250			-0.322
		(0.561)			(0.666)
$cost penalty_{FTA(i)\ell jt}$				$-0.088^{a}$	$-0.081^{a}$
				(0.029)	(0.030)
Non-PEM FTA <sub><i>i</i><math>\ell t</math> × RVC<sub><i>i</i><math>\ell t</math> × export share<sub>FTA</sub>(<i>i</i>)<math>\ell t</math></sub></sub>	$1.050^{a}$				$0.774^{a}$
	(0.191)				(0.225)
Non-PEM FTA <sub><i>i</i><math>\ell t</math> × RVC<sub><i>i</i><math>\ell t</math> × tariff margin<sub>FTA</sub>(<i>i</i>)<math>\ell t</math></sub></sub>		0.658			3.591 <sup>c</sup>
		(2.340)			(2.001)
Non-PEM FTA <sub><i>ilt</i></sub> × RVC <sub><i>ilt</i></sub> × ln (part price <sub><i>j</i></sub> )			$-0.117^{a}$		0.024
			(0.041)		(0.130)
Non-PEM FTA <sub><i>i</i><math>\ell t</math> × RVC<sub><i>i</i><math>\ell t</math> × cost penalty<sub>FTA</sub>(<i>i</i>)<math>\ell j t</math></sub></sub>				0.007	0.046
				(0.063)	(0.108)
Observations	2137960	2137960	1483109	1374806	1374806
$\mathbb{R}^2$	0.706	0.704	0.705	0.716	0.716

Table 3: Heterogeneous RoO effects

All columns include origin-product-year and destination-product-year fixed effects. Standard errors are clustered at country pair (non-directional) level in parenthesis. Subscript  $FTA(i)\ell$  refer to the FTAs that country *i* and  $\ell$  share. *export share*<sub>FTA(i)\ellt</sub> is country  $\ell$ 's share of car export to the FTA partners over  $\ell$ 's total car export. *tariff margin*<sub>FTA(i)ℓt</sub> = ln(1 + MFN tariff<sub>FTA(i)ℓt</sub> - pref tariff<sub>FTA(i)ℓt</sub>) is the preferential margin on country  $\ell$ 's car when exporting to these FTA partners. *cost penalty*<sub>FTA(i)ℓj</sub> is the logarithm of the difference between the average parts' price from FTA partners and that from any potential origins, weighted by the bilateral parts' exports.

Significance levels:  $^{c}$  p<0.1,  $^{b}$  p<0.05,  $^{a}$  p<0.01.

and import more intermediates regionally when increasing RVC. Complementarity between the content rule and the share of intra-FTA export shown in column (1), Table 3, verifies my hypothesis. One may be concerned about the consumers' taste preference towards final cars that assembled using domestic parts. Hence, I include the intra-FTA export share of cars by itself and separately identify the home preference effect and RoO effect.

The second refinement focuses on preferential tariff margin of exporting final goods. Car

exporters incline to abide by the rules when the benefit from a higher tariff margin dominates the cost of sourcing from inefficient suppliers. Therefore, there could be stronger trade diversion effect of RoO with higher preferential margin on car exports. In column (2), the coefficient of the interaction term is positive although not significant. The insignificant result stems from the nonlinear effect of the final good's tariff margin on intermediate trade diversion. When RVC is relatively low, higher tariff margin generates stronger diversion with increasing RVC because the savings on tariff payment outweigh the marginal cost increase from stricter RVC. Suggested by Figure 5, the cost of meeting RVC is convex. As RVC rises, the same amount of increase in tariff margin cannot compensate the increasing marginal cost of complying the rule, and result in no further trade diversion.

Lastly, equation (14) sets the foundation for testing whether RoOs have the same effect on different car parts. Observing column (3), I find that countries divert more cheaper parts with higher RVC. Low price parts typically do not have sticky long-term contract between assemblers and parts suppliers, and hence are more flexible in reorganizing the production. Moreover, the cost penalty associated with switching expensive parts can be high compared to cheaper parts. In column (5) when cost penalty is controlled, I observe no systematic difference in trade diversion across parts, which corroborates the second explanation. In column (4), I test for the cost penalty effect alone, and find no significant effect. Firms, on one hand, pursue cost saving sourcing decisions as shown by the negative effect of cost rising in FTA countries. On the other hand, higher FTA cost implies a higher likelihood of fulfilling the RoO requirement.

The last column in Table 3 combines all three forces. In general, results stay consistent with those from separately added variables. The effect of export share of cars to FTA members remains to be positive and significant. Estimation of the tariff margin effect is more precise when I control for the cost penalty when sourcing internally. In addition, with modifiers to the RoO effects, the interaction of FTA and RVC loses its explanatory power although the sign is still as expected.

# **5** Conclusions

This paper opens up the RTA black-box by separating the effects of tariff reduction from rules of origin. Specifically, I estimate the distortive effect of rules of origin on intermediate goods trade by exploring a particular dimension of sourcing restrictions, regional value content. A clear takeaway from results by applying the framework to the automotive industry is that car assemblers do reformulate sources of parts when facing more restrictive rules of origin. A 10 percentage point increase in regional value content diverts 9.4% of intermediates import from third countries to the FTA. However, the effect is not linear but following a humped shape. The increase in import of intermediates within a FTA first rises with more restrictive content rules but eventually falls down

when more firms becoming RoO defiers or reducing their production.

Going beyond the main effects of RoOs, I test four channels in which RoO takes effect heterogeneously: the share of export to FTA region in total export of final goods, preferential margin of final goods subsidized by FTA members, and the unit price and cost penalty of intermediates. Car exporters who target FTA markets find RoOs matter, and thus trade diversion is stronger with larger intra-FTA car export. The other channels, preferential margin on cars export and parts' characteristics, exhibit mixed results. More disaggregated firm-level data is necessary to identify different forces.

Theoretically, I build a multi-country and multi-product sourcing model to study where and how many inputs firms import. Rules of origin is incorporated in the framework as a *ad-valorem* trade costs on intermediates. It derives a gravity trade equation at product level that becomes handy in estimation. This is not a full-fleshed characterization of RoOs since I do not model export decisions of firms and firms' choices of whether to comply with the rules of not. There should be future attempts on adding these elements to the model and estimate it structurally with finer data.

It would also be interesting to study the RoO effects along the entire value chain. When goods cross borders multiple times in a fragmented production process, trade costs can accumulate and compound before the goods are sold for final consumption. Therefore, production which is labeled non-originating can be very costly. The aspects of global value chain provide a full agenda for future research.

Despite having limitations, this paper contributes to the existing literature by examining the effect of rules of origin across a wide span of trade agreements. It also provides guidance for policy makers in setting the optimal regional value content threshold by providing evidences on its nonlinearity. This paper serves as an exploration of the optimal RVC, while leaving future work to build upon.

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# Appendix

### A Derivation of firm's conditional inputs sourcing

In this Appendix, I provide more details on assembler's behavior conditional on sourcing location. Notice first that by solving first order condition of equation (4), I obtain the following optimal decision of parts quantity:

$$x_{j\omega}^* = \left\{ A_{\omega}^{1-\rho} \theta_{\omega}^{\rho} \rho \left[ \int_0^1 (\psi_j x_{j\omega}^*)^{\alpha} dj \right]^{\frac{\rho}{\alpha} - 1} \frac{\psi_j^{\alpha}}{c_{j(i^*)\omega}} \right\}^{\frac{1}{1-\alpha}}.$$
 (A-1)

Let  $Z_{j\omega}^* = \int_0^1 (\psi_j x_{j\omega}^*)^{\alpha} dj$ . Plugging this expression into the above  $x_{j\omega}^*$  and transform it into a function of  $Z_{j\omega}^*$  delivers the following,

$$Z_{j\omega}^* = \int_0^1 \psi_j^\alpha \left( A_\omega^{1-\rho} \theta_\omega^\rho \rho(Z_{j\omega}^*)^{\frac{\rho}{\alpha}-1} \frac{\psi_j^\alpha}{c_{j(i^*)\omega}} \right)^{\frac{\alpha}{1-\alpha}} dj.$$

Solving this equation, it's straightforward to verify

$$Z_{j\omega}^* = \rho^{\frac{\alpha}{1-\rho}} A_{\omega}^{\alpha} \theta_{\omega}^{\frac{\alpha\rho}{1-\rho}} \left[ \int_0^1 \left( \frac{\psi_j}{c_{j(i^*)\omega}} \right)^{\frac{\alpha}{1-\alpha}} dj \right]^{\frac{1-\alpha}{1-\rho}}.$$
 (A-2)

Lastly, substitute (A-2) back to (A-1), from which we can conclude the optimal  $x_{j\omega}^*$  is given by equation (5).

### **B** Derivation of country-level sourcing decisions

From equation (10), I need to integrate it to the country level over a set of varieties. Denote  $u = \varphi_{\omega} \delta^{\rho}_{\omega}$  and  $\underline{u}$  is the corresponding lower bound. Notice that the distribution of  $v_{j\omega}$  and  $V_{\omega}$  is invariant to  $\omega$ , therefore integration of these variables can be replaced by the integration over v, multiplied by the measure  $\Omega_{\ell}$ . G(v) is the distribution in equation (8). G(u) is the Pareto

distribution with shape parameter  $\eta$ . Then, we have

$$X_{j\ell} = \rho^{\frac{1}{1-\rho}} EP^{\frac{\rho}{1-\rho}} \int_{\omega \in \Omega_{\ell}} (\varphi_{\omega} \delta_{\omega}^{\rho})^{\frac{1}{1-\rho}} (v_{j\omega}^{*})^{\frac{\alpha}{1-\alpha}} V_{\omega}^{\frac{\rho-\alpha}{(1-\alpha)(1-\rho)}} d\omega$$

$$= \rho^{\frac{1}{1-\rho}} EP^{\frac{\rho}{1-\rho}} \left( \int_{\underline{u}}^{\infty} u^{\frac{1}{1-\rho}} dG(u) \right) \times \Omega_{\ell} \times \int_{\omega \in \Omega_{\ell}} (v_{j\omega}^{*})^{\frac{\alpha}{1-\alpha}} V_{\omega}^{\frac{\rho-\alpha}{(1-\alpha)(1-\rho)}} d\omega$$

$$= \frac{\eta\rho}{\eta(1-\rho)-1} F_{\ell} \Omega_{\ell} \int_{\omega \in \Omega_{\ell}} (v_{j\omega}^{*})^{\frac{\alpha}{1-\alpha}} V_{\omega}^{-\frac{\alpha}{(1-\alpha)}} d\omega$$

$$= \frac{\eta\rho}{\eta(1-\rho)-1} F_{\ell} \Omega_{\ell} \left( \int_{0}^{\infty} v^{\frac{\alpha}{1-\alpha}} dG(v) \right) \times \left[ \int_{0}^{1} \int_{0}^{\infty} v^{\frac{\alpha}{1-\alpha}} dG(v) dj \right]^{-1}.$$
(A-3)

Using the derived distribution of v, we have

$$\int_{0}^{\infty} v^{\frac{\alpha}{1-\alpha}} dG(v) = \Gamma\left(1 - \frac{\alpha}{(1-\alpha)\theta}\right) \Phi_{j\ell}^{\frac{\alpha}{(1-\alpha)\theta}}.$$
 (A-4)

Therefore, substituting (A-4) back to (A-3) obtains equation (12).