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Gravity with Multiple Tariff Schemes

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Keywords: Gravity; RTA; Preference margin
JEL classification: F15, F53

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Gravity with Multiple Tariff Schemes

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Abstract: This study contributes to the literature on gravity analysis by explicitly incorporating both most favored nation (MFN) rates and regional trade agreement (RTA) rates. Our gravity equation considers the fact that all exporters do not necessarily utilize RTA schemes, even when exporting to their RTA partners. We apply the tariff line–level data on worldwide trade to this gravity equation. As a result, we find a significantly negative coefficient for the (log) ratio of RTA rates to MFN rates. From the quantitative point of view, we show that in the first year of the Japan–Australia Economic Partnership (i.e., 2015), exports from Australia to Japan are expected to increase by 6% compared with the exports in 2014. Furthermore, it is shown that, based on the subsequent reduction in RTA rates, the magnitude of the trade-creation effect through tariff reductions gradually rises over time.

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1. Introduction

Many researchers have devoted their efforts towards the sophistication of gravity equations. The theoretical foundation has been established by Anderson (1979), Bergstrand (1985, 1989), Helpman and Krugman (1985), Deardorff (1998), Eaton and Kortum (2002), and Anderson and van Wincoop (2003). More recently, some studies, such as Chaney (2008) and Helpman, Melitz, and Rubinstein (2008), have developed gravity equations by allowing firm heterogeneity à la Melitz (2003). Most recently,

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Anderson et al. (2016) and Heid and Larch (2016) have respectively introduced scale effects in bilateral trade costs and labor market frictions into gravity equations and have proposed new "gravity with X" frameworks.

In this study, we contribute to this important literature in international trade by shedding light on regional trade agreement (RTA) rates. A tariff rate has been included into the gravity equations as only one of the components of trade costs. However, there are several types of tariff rates, so how alternative types of tariff rates should be treated in the gravity equations remains an open question. Specifically, there are not only general tariff rates such as most favored nation (MFN) rates, but also preferential rates such as RTA rates or unilateral preferential rates (e.g., generalized system of preferences [GSP]). Most of the studies introduce either MFN rates or applied tariff rates into the equation (e.g., Disdier et al., 2015). The former assumes that all exporters use MFN rates, even when exporting to their RTA partners, while the latter implies that all exporters use RTA rates when such rates are available. Obviously, both assumptions are not consistent with reality. For instance, Keck and Lendle (2012) show that the share of imports under RTA schemes in terms of total imports is below 100%, even for products with RTA rates that are lower than MFN rates.[1] Since the use of RTA schemes requires exporters to incur some costs, particularly costs to certify rules of origin, all exporters do not necessarily utilize RTA schemes, even when exporting to their RTA partners. Therefore, we need to specify the gravity equations carefully when RTA rates are available.

To do this, we derive a (product-level) gravity (-like) equation from a simple partial equilibrium model with multiple tariff schemes. The equation also incorporates firm heterogeneity in terms of the exporters' productivity. Following Demidova and Krishna (2008) and Cherkashin et al. (2015), we theoretically demonstrate that exporters with higher productivity tend to gain larger profits by utilizing an RTA tariff scheme, rather than an MFN tariff scheme. Naturally, a change in RTA tariff rates affects the so-called extensive and intensive margins. For instance, some exporters who utilize an MFN tariff scheme will switch to an RTA tariff scheme when RTA tariff rates decline (extensive margin), and they will generally export more under the RTA scheme than under the MFN scheme. Furthermore, existing RTA users will increase their trade when RTA rates decline (intensive margin). These effects through the intensive and extensive margins imply that the relatively low RTA rates will lead to greater trade of a

[1] Specifically, such a share of imports in Australia from the U.S. or Canada is approximately 50%. The share of European Union imports from Mexico is approximately 80%. A similar share can be found in the case of U.S. imports from Australia.

given product between two countries.

Using this theoretical model, we directly derive our gravity equation; that is, the equation on bilateral exports. Suppose that a given product is only traded under RTA schemes; namely, all exporters use RTA rates. Following the literature, this situation is called the "homogenous regime." In this case, the gravity equation only includes the RTA rates. Therefore, as in previous studies, the specification of introducing the applied tariff rates is theoretically supported. However, in the case of the "heterogeneous regime," where a product is traded under both MFN and RTA schemes, not only RTA rates but also MFN rates naturally appear in the gravity formulation. Namely, the theory-based gravity equation for a world with RTA schemes should include both MFN and RTA rates. The inclusion of MFN rates implies the possibility of yielding omitted-variable biases in the previous studies using applied tariff rates. We unify these gravity equations under two regimes by introducing the "tariff ratio," which is defined as the ratio of (one plus) RTA rates to (one plus) MFN rates. As a result, our gravity equation includes the (log) tariff ratio in addition to various kinds of fixed effects, which are generally used in gravity equations.

Furthermore, we apply the tariff line–level data on trade to this gravity equation. A challenging issue is that eligibility in RTAs is defined at each country's most detailed tariff line–level. Neither the Direction of Trade by the International Monetary Fund, nor the UN Comtrade by the United Nations provides such detailed trade data. Therefore, this study derives trade data from the World Trade Atlas (WTA) by the Global Trade Information Services (GTIS), in which trade data for a large number of countries are available at each country's detailed tariff line–level.[2] Specifically, we employ tariff line–level import data for 43 countries in our gravity estimations. The number of export countries is 181. The sample years are restricted from 2007 to 2011 in order to keep the version of a harmonized system (HS) consistent (i.e., HS2007). As a result, we find a significantly negative coefficient for the log of the tariff ratio, which is consistent with the above theoretical prediction.

Our estimates show one form of the trade-creation effects of RTAs. There are a large number of ex-post gravity studies on trade creation. Recent examples include Baier and Bergstrand (2007), Magee (2008), Caporale et al. (2009), Vicard (2009), Medvedev (2010), and Roy (2010). These studies introduce an RTA dummy variable, which takes the value one for RTA members, and interpret its coefficient as the

[2] Such data are also employed in Hayakawa et al. (2016), which regress RTA/MFN rates on trade values at a tariff line-level. However, the equation that they estimate is different from ours and it is not theoretically grounded.

trade-creation effects of RTAs. Cipollina and Salvatici (2010) conducted a meta-analysis of 85 studies, and concluded that trade-creation effects significantly exist. The approach using the RTA dummy identifies the total effects of RTAs, including both tariff reductions and the elimination of non-tariff barriers (NTBs). On the other hand, our estimates only capture the effects of tariff reductions through RTAs. Furthermore, by tracing the gradual reduction of RTA rates, we show the over-time effects of RTAs (i.e., the effects from their entry year to the last year of completing the scheduled tariff reductions). Such effects will be part of the lagged effects of RTAs shown in previous studies.

The rest of this study is organized as follows. Section 2 introduces our theoretical framework. We specify our estimation equation in Section 3. After explaining our data sources in Section 4, we report our estimation results in Section 5. Then, using these estimates in Section 6, we conduct a simple simulation analysis of the effects of the subsequent reduction in RTA rates on trade. Lastly, Section 7 concludes.

2. Theoretical Framework

In this section, we present a partial equilibrium model that incorporates alternative tariff schemes: MFN and RTA schemes. The structure of the model is the usual monopolistic competition framework. Regarding the exporters' choice of tariff schemes, we follow Demidova and Krishna (2008) and Cherkashin et al. (2015). The only difference from their models is that we explicitly consider that the existence of multiple products in each industry is consistent with our data structure. Nevertheless, it is still helpful to provide the theoretical model in order to demonstrate how it is connected to the data.

2.1. Representative Household

There are J countries in the economy. The representative household consumes final products from L industries. The utility function of the representative household in country j is given by

$$u_j = c_j = \prod_{l=1}^{L} [c_j(l)]^{\beta(l)}, \qquad \sum_{l=1}^{L} \beta(l) = 1.$$

$c_j(l)$ is the consumption index of products from industry l, and L is the number of industries. Each product is indexed by r and the number of products in industry l is represented by R_l. $c_j(l)$ is defined as

$$c_j(l) = \left(\sum_{r=1}^{R_l} \left[c_j(l,r)\right]^{\frac{\kappa-1}{\kappa}}\right)^{\frac{\kappa}{\kappa-1}}, \qquad 1 < \kappa < \infty,$$

where

$$c_j(l,r) = \left(\sum_{i=1}^{J} \int_{k\in\Omega_{ij}(l,r)} \left[c_{ij}(l,r,k)\right]^{\frac{\upsilon-1}{\upsilon}} dk\right)^{\frac{\upsilon}{\upsilon-1}}, \qquad 1 < \upsilon < \infty.$$

κ and υ represent the demand elasticity of products and varieties, respectively. Each variety k is assumed to be produced by one final-good producer. $\Omega_{ij}(l,r)$ is the set of varieties of product r in industry l purchased from country i by the representative household in country j. Cost minimization implies demand schedules

$$c_{ij}(l,r,k) = \left(\frac{p_{ij}(l,r,k)}{p_j(l,r)}\right)^{-\upsilon} c_j(l,r),$$

$$c_j(l,r) = \left(\frac{p_j(l,r)}{p_j(l)}\right)^{-\kappa} c_j(l), \text{and } c_j(l) = \beta(l)\left(\frac{p_j(l)}{P_j}\right)^{-1} c_j.$$

Price indices are defined in the following manner:

$$p_j(l,r) = \left(\sum_{i=1}^{J} \int_{k\in\Omega_{ij}(l,r)} \left[p_{ij}(l,r,k)\right]^{1-\upsilon} dk\right)^{\frac{1}{1-\upsilon}},$$

$$p_j(l) = \left(\sum_{r=1}^{R_l} \left[p_j(l,r)\right]^{1-\kappa}\right)^{\frac{1}{1-\kappa}}, \text{and } P_j = \sum_{l=1}^{L} \left[\frac{p_j(l)}{\beta(l)}\right]^{\beta_l}.$$

2.2. Final-good Producers

Final-good producers input the domestic labor force, produce outputs, and sell the outputs to domestic and foreign households. We assume that the production technology of each final-good producer k, that produces product r of industry l in country i, follows the simple linear function about the labor force given by

$$y_i(l,r,k) = \varphi(k) n_i(l,r,k),$$

where $\varphi(k)$ represents the firm-specific components of productivity and $n_i(l,r,k)$ is the labor input. We assume that $\varphi(k)$ follows the Pareto distribution, given by

$$G(\varphi) = 1 - \varphi^{-\alpha} \qquad \upsilon < \alpha,$$

and ranges in $[1,\infty)$. As a result of profit maximization, the mill price is derived as

$$\tilde{p}_i(k) = \frac{\upsilon}{\upsilon - 1}\frac{w_i}{\varphi(k)},$$

where w_i is the wage rate.

2.3. Choice of Tariff Schemes

We assume that final-good producers make the decisions on exports and tariff schemes. For simplicity, we do not assume any fixed costs of domestic supply without loss of generality. When exporting, firms can choose a tariff scheme, either an MFN scheme (*M*) or an RTA scheme (*R*). In any case, they need to pay fixed costs for exports, denoted by f_i.[3] Furthermore, when exporting under RTA schemes, they also need to incur additional fixed costs, such as documentation preparation costs, which are denoted by f_i^R. These two types of fixed costs are assumed to be export-country specific.[4]

The respective export prices under MFN and RTA schemes are given by

$$p_{ij}^{M}(l,r,k) = T_j(l,r)\tau_{ij}(l,r)\tilde{p}_i(k),$$
$$p_{ij}^{R}(l,r,k) = \mu_{ij}(l,r)T_j(l,r)\tau_{ij}(l)\tilde{p}_i(k).$$

τ_{ij} is the ice-berg physical transport costs ($\tau_{ij} > 1$) for exports from country i to country j. $T_j(l,r)$ is the per-unit MFN tariff ($T_j(l,r) > 1$) and $\mu_{ij}(l,r)$ is called the "tariff ratio," which is defined as the ratio of (one plus) RTA rates to (one plus) MFN rates ($1 > \mu_{ij}(l,r) > 0$).[5]

Under these settings, sales profits can be derived as follows:

$$\pi_{ij}^{M}(l,r,k) = \Phi(k)\left[T_j(l,r)\right]^{-\upsilon}\zeta_{ij}(l,r) - f_i,$$

[3] Following Helpman et al. (2004) and Helpman et al. (2008), we assume that exporters pay fixed costs for exports to each destination without considering the case where exporters deal with export processes for multiple destinations at the same time and save on the total fixed cost. In other words, the economies of scale are not considered for f_i. Also in terms of the fixed cost for RTA utilization, we assume a similar situation; i.e., exporters pay the fixed cost for RTA utilization for each transaction. Given that the model is static, mitigation of these fixed costs through the exporters' experiences is not considered. Investigating these possibilities would provide richer theoretical consequences, but we do not examine such cases in order to keep the model tractable and to obtain explicit gravity equations.

[4] Our gravity equation does not change, even if we assume that the production technology has a product-specific component of productivity, which is denoted by a_l ; i.e., $y_i(l,r,k) = a(l)\varphi(k)n_i(l,r,k)$. An alternative specification is to assume that the distribution of productivity is heterogeneous across products. Similarly, it is possible to assume that other parameters, including υ, f_i, and f_i^R, are product specific. These heterogeneity assumptions do not make any qualitative changes on our major results, although the estimated coefficients in the gravity equation become different across products.

[5] Although we assume that the use of RTA schemes does not require exporters to incur additional variable costs, it would be more natural to assume product-specific additional variable costs, which are based on the adjustment of inputs in order to comply with the rules of origin. However, our gravity equation does not change, unless such variable costs are country pair-product-specific. It should also be noted that multilateral and bilateral RTAs differ in terms of variable costs, as multilateral RTAs are supposed to impose lower additional variable costs than bilateral RTAs, as a result of the cumulation rules for multilateral RTAs. In our model, multilateral and bilateral RTAs are not differentiated, as we ignore the existence of these variable costs.

$$\pi_{ij}^R(l,r,k) = \Phi(k)\left[\mu_{ij}(l,r)T_j(l,r)\right]^{-\upsilon}\zeta_{ij}(l,r) - f_i - f_i^R,$$

where

$$\Phi(k) = [\varphi(k)]^{\upsilon-1},$$

$$\zeta_{ij}(l,r) = \left(\frac{\nu-1}{w_i}\right)^{\nu-1}\left(\frac{1}{\tau_{ij}(l,r)\nu}\right)^{\nu}\left(p_j(l,r)\right)^{\upsilon-\kappa}\left(p_j(l)\right)^{\kappa-1}\beta(l)P_jc_j.$$

Thus, sales profits are found to be increasing in $\varphi(k)$. Further, we obtain the following relation:

$$\pi_{ij}^R(l,r,k) - \pi_{ij}^M(l,r,k) = \Phi(k)[T_j(l,r)]^{-\upsilon}\zeta_{ij}(l,r)\left[\left(\frac{1}{\mu_{ij}(l,r)}\right)^{\nu} - 1\right] - f_i^R.$$

This implies that RTA is more beneficial than MFN for the more productive producers because the tariff rate is lower for RTA than for MFN.

Exporters optimally choose the tariff scheme that realizes the largest export profits. Thus, the optimization of exporters on the choice of tariff schemes is given by

$$\max\left\{0, \pi_{ij}^M(l,r,k), \pi_{ij}^R(l,r,k)\right\}.$$

We have three productivity thresholds. The first and second ones define the ranges of producers that gain positive profits by exporting under MFN and RTA, respectively. They are derived in the following manner:

$$\overline{\Phi}_{ij}^M(l,r) = \frac{f_i}{\zeta_{ij}(l,r)}[T_j(l,r)]^{\upsilon} \quad \text{and} \quad \overline{\Phi}_{ij}^R(l,r) = \frac{f_i + f_i^R}{\zeta_{ij}(l,r)}[\mu_{ij}(l,r)T_j(l,r)]^{\upsilon}.$$

On the choice of tariff scheme, we have the third threshold, as follows:

$$\overline{\Phi}_{ij}^{R>M}(l,r) = \frac{f_i^R}{\zeta_{ij}(l,r)}\left([\mu_{ij}(l,r)T_j(l,r)]^{-\upsilon} - [T_j(l,r)]^{-\upsilon}\right)^{-1}.$$

Thus, producers prefer RTA to MFN if $\overline{\Phi}_{ij}^{R>M}(l,r) < \Phi(k)$. A product is exported under multiple tariff schemes when $\overline{\Phi}_{ij}^R(l,r) > \overline{\Phi}_{ij}^M(l,r)$, which corresponds to the heterogeneous regime discussed in Demidova and Krishna (2008). We can rewrite this condition by

$$\left(1 + \frac{f_i^R}{f_i}\right)^{\frac{1}{\upsilon}} > \frac{1}{\mu_{ij}(l,r)}.$$

When this condition does not hold, product r in industry l is only exported under the RTA scheme. We call this the homogeneous regime.[6]

[6] Assuming an upper bound of productivity enables us to replicate products that are only traded under the MFN tariff scheme. We examine this case in Appendix A. Even if we assume an upper bound, our qualitative results are unchanged.

Figures 1 and 2 depict the exporters' choice of tariff scheme in terms of homogeneous and heterogeneous regimes, respectively. In the homogeneous regime, all of the exporters utilize the RTA tariff scheme. This case is more likely to happen when the fixed costs for RTA utilization are small relative to those for exports or when the tariff ratio is significantly low. In these cases, the relative attractiveness of RTA to MFN is high for exporters. As a result, all of the exporters become RTA users. In contrast, when the fixed costs for RTA utilization are high, relative to those for exports or when the tariff ratio is significantly high, some exporters will utilize the MFN tariff scheme.

=== Figures 1 & 2 ===

3. Empirical Specification

Based on the above theoretical framework, this section provides an estimable gravity equation. Specifically, we derive product-level bilateral exports. Since the theoretical formulation is different between the homogenous and heterogeneous regimes, we derive the exports for the two regimes separately and then unify them into one estimation equation.

3.1. Homogeneous Regime

For the various products that are only exported under the RTA scheme (i.e., those in the homogeneous regime), total exports ($Q_{ij}^A(l,r)$) are obtained in the following manner:

$$Q_{ij}^A(l,r) = Q_{ij}^R(l,r) = \int_{\left[\bar{\Phi}_{ij}^R(l,r)\right]^{\frac{1}{\upsilon-1}}}^{\infty} p_{ij}^R(l,r,k) c_{ij}^R(l,r,k) G(\varphi),$$

or

$$Q_{ij}^A(l,r)$$
$$= \xi b_i^A w_i^{-\alpha} \left[P_j c_j\right]^{\frac{\alpha}{\upsilon-1}} [\beta(l)]^{\frac{\alpha}{\upsilon-1}} \left[\tau_{ij}(l,r)\right]^{-\iota} \left[p_j(l,r)\right]^{\gamma} \left[p_j(l)\right]^{\gamma} \left[T_j(l,r)\right]^{-\iota} \left[\mu_{ij}(l,r)\right]^{-\iota}, \quad (1)$$

where

$$\xi \equiv \frac{\alpha}{\alpha-\upsilon+1}\left(\frac{1}{\upsilon}\right)^{\frac{\alpha-\upsilon+1}{\upsilon-1}}\left(\frac{\upsilon-1}{\upsilon}\right)^{\alpha} > 0, \qquad b_i^A \equiv \left[\frac{1}{f_i + f_i^R}\right]^{\frac{\alpha-\upsilon+1}{\upsilon-1}} > 0,$$

$$\iota \equiv \frac{\upsilon(\alpha-\upsilon+1)}{\upsilon-1} + \upsilon - 1 > 0, \qquad \gamma \equiv \frac{\alpha(\upsilon-\kappa)}{\upsilon-1}.$$

Some existing studies, such as Disdier et al. (2015), introduce RTA tariff rates (i.e., applied tariff rates) into a gravity equation. Such an equation appears when we rewrite equation (1) in the following manner:

$$Q_{ij}^{A}(l,r) = \xi b_i^A w_i^{-\alpha}\left[P_j c_j\right]^{\frac{\alpha}{\upsilon-1}}[\beta(l)]^{\frac{\alpha}{\upsilon-1}}\left[\tau_{ij}(l,r)\right]^{-\iota}\left[p_j(l,r)\right]^{\gamma}\left[p_j(l)\right]^{\gamma}\left[T_{ij}^{R}(l,r)\right]^{-\iota}.$$

Note that the RTA tariff rate $T_{ij}^{R}(l,r)$ is defined as $T_j^R(l,r) \equiv \mu_{ij}(l,r)T_j(l,r)$. This equation only includes the RTA rates, not the MFN rates, as all exporters utilize the RTA scheme in this homogeneous regime. It shows that exports become larger when RTA tariff rates become lower, as found in the existing studies. In short, the gravity equation used in the existing studies is nested within our framework as an extreme case, where the products are only traded under the RTA scheme.

Log linearization of (1) leads to

$$\ln Q_{ij}^{A}(l,r) = u_i + u_j + u_j(l) + u_j(l,r) + u(l) - \iota \ln \tau_{ij}(l,r) - \iota \ln \mu_{ij}(l,r), \qquad (2)$$

where

$$u_i \equiv \ln[\xi b_i^A w_i^{-\alpha}], \qquad u_j \equiv \frac{\alpha}{\upsilon-1}\ln P_j + \frac{\alpha}{\upsilon-1}\ln c_j, \qquad u_j(l) \equiv \gamma \ln p_j(l),$$

$$u_j(l,r) \equiv \gamma \ln p_j(l,r) - \iota \ln T_j(l,r), \quad u(l) \equiv \frac{\alpha}{\upsilon-1}\ln \beta(l).$$

Equation (2) provides a direct way to examine the effect of the tariff ratio on the exports of a given product that is only traded under the RTA tariff scheme.

Equation (2) implies that the tariff ratio negatively affects total exports. Figure 3 demonstrates how a fall in the tariff ratio affects exports, considering both intensive and extensive margins in the homogeneous regime. Potential RTA profits increase for all firms when the tariff ratio falls and the RTA rates are reduced (i.e., the RTA profit line rotates counterclockwise). The "new" RTA profit locus is represented by the line $\pi_{ij}^{R\prime}(l,r,k)$. In this case, the existing RTA users increase their exports. This increase represents the effect through the intensive margin. As a result of the rotation of the RTA profit locus, the threshold productivity $\overline{\Phi}_{ij}^{R}(l,r)$ falls to $\overline{\Phi}_{ij}^{R\prime}(l,r)$, and some firms become new exporters, particularly RTA exporters. Such "new exporters" obviously contribute toward increasing total exports. This increase represents the effect through the extensive margin. In sum, both margins imply negative effects of the tariff ratio on exports. Thus, we predict a negative sign for the coefficient of the tariff ratio for products that belong to the homogeneous regime.

=== Figure 3 ===

3.2. Heterogeneous Regime

In the case of the heterogeneous regime, where a product is exported under both MFN and RTA schemes, total exports ($Q_{ij}^B(l)$) are obtained in the following manner:

$$Q_{ij}^B(l,r) = Q_{ij}^M(l,r) + Q_{ij}^R(l,r)$$

$$= \int_{\left[\bar{\Phi}_{ij}^{M}(l,r)\right]^{\frac{1}{\upsilon-1}}}^{\left[\bar{\Phi}_{ij}^{R>M}(l,r)\right]^{\frac{1}{\upsilon-1}}} p_{ij}^M(l,r,k)c_{ij}^M(l,r,k)G(\varphi)$$

$$+ \int_{\left[\bar{\Phi}_{ij}^{R>M}(l,r)\right]^{\frac{1}{\upsilon-1}}}^{\infty} p_{ij}^R(l,r,k)c_{ij}^R(l,r,k)G(\varphi),$$

or

$$Q_{ij}^B(l,r)$$

$$= \xi b_i^B w_i^{-\alpha}\left[P_j c_j\right]^{\frac{\alpha}{\upsilon-1}}[\beta(l)]^{\frac{\alpha}{\upsilon-1}}\left[\tau_{ij}(l,r)\right]^{-\iota}\left[p_j(l,r)\right]^{\gamma}\left[p_j(l)\right]^{\gamma}\left[T_j(l,r)\right]^{-\iota}F_i\left(\mu_{ij}(l,r)\right),$$

where

$$b_i^B \equiv \left[\frac{1}{f_i}\right]^{\frac{\alpha-\upsilon+1}{\upsilon-1}},$$

$$F_i\left(\mu_{ij}(l,r)\right) \equiv 1 + \left(\frac{f_i}{f_i^R}\left\{\left[\mu_{ij}(l,r)\right]^{-\upsilon} - 1\right\}\right)^{\frac{\alpha-\upsilon+1}{\upsilon-1}}\left\{\left[\mu_{ij}(l,r)\right]^{1-\upsilon} - 1\right\}.$$

Importantly, and unlike the case of the homogenous regime, the gravity equation includes both MFN and RTA rates. The introduction of applied tariff rates cannot simultaneously control for these two types of tariff rates. Therefore, the gravity estimates in previous studies may suffer from omitted-variable biases based on our examination of the products that are traded under both MFN and RTA schemes.

The log linearization of the above equation leads to

$$\ln Q_{ij}^B(l,r) = v_i + v_j + v_j(l) + v_j(l,r) + v(l) - \iota\ln\tau_{ij}(l,r) - \omega_i\ln\mu_{ij}(l,r), \qquad (3)$$

where

$$v_i \equiv \ln F_i(\mu) + \omega_i\ln\mu + \ln[\xi w_i^{-\alpha}b_i^B], \qquad v_j \equiv \frac{\alpha}{\upsilon-1}\ln P_j + \frac{\alpha}{\upsilon-1}\ln c_j,$$

$$v_j(l) \equiv \gamma\ln p_j(l), \quad v_j(l,r) \equiv \gamma\ln p_j(l,r) - \iota\ln T_j(l,r), \quad v(l) \equiv \frac{\alpha}{\upsilon-1}\ln\beta(l).$$

In this derivation, and to break down the highly nonlinear equation to a linear and estimable gravity framework, we use the following Taylor approximation:[7]

[7] See Anderson et al. (2016), Baier and Bergstrand (2009), and Behar and Nelson (2014) for the use of the Taylor approximation for the study of gravity equations.

$$\ln F_i\left(\mu_{ij}(l,r)\right) \cong \ln F_i(\mu) - \omega_i\left(\ln \mu_{ij}(l,r) - \ln \mu\right),$$

where

$$\omega_i \equiv -\left.\frac{d \ln F_i\left(\mu_{ij}(l,r)\right)}{d \ln \mu_{ij}(l,r)}\right|_{\mu_{ij}(l,r)=\mu} > 0,$$

and μ is the averaged value of $\mu_{ij}(l,r)$. Equation (3) provides a direct way to examine the effect of the tariff ratio on the export of a given product that is traded under both MFN and RTA tariff schemes.

Equation (3) implies that the tariff ratio negatively affects total exports. Figure 4 demonstrates how a fall in the tariff ratio affects total exports through the intensive and extensive margins in the heterogeneous regime. In terms of the intensive margin, the intuition is exactly the same as the case of the homogeneous regime; existing RTA users increase their exports when the tariff ratio falls. The RTA profit locus rotates counterclockwise (to the line $\pi_{ij}^{R\prime}(l,r,k)$) with a fall in the tariff ratio and the threshold productivity $\bar{\Phi}_{ij}^{R\geq M}(l,r)$ falls to $\bar{\Phi}_{ij}^{R\geq M\prime}(l,r)$. As a result, on the extensive margin, some of the MFN exporters switch to become RTA exporters when the tariff ratio falls in the case of the heterogeneous regime. These “switching” RTA users increase their exports because their tariff rates, which are now the RTA rates, are lower than before (i.e., MFN rates). Thus, total exports also increase through the extensive margin in the heterogeneous regime. Again, both margins imply negative effects of the tariff ratio on exports. Thus, the tariff ratio is expected to negatively affect exports for products that belong to the heterogeneous regime.

=== Figure 4 ===

3.3. Estimation Equation

In this subsection, we unify the two gravity equations above. As explained in the next section, our dataset does not allow us to estimate separate gravity equations for the homogenous and heterogeneous regimes. Such separate estimations are possible if we employ the trade data according to the tariff schemes that are used in, for example, Keck and Lendle (2012). In this case, however, we need to focus on trade by some specific countries because such data by tariff scheme are only available in a few countries, such as the United States. Since the purpose of this study is the extension of gravity equations that are usually estimated for worldwide trade, we estimate the unified gravity equation for worldwide trade rather than the gravity equations for trade in a specific country according to the regimes.

The gravity equation we estimate is as follows. Since our dataset includes trade over a period of years, we extend equations (2) and (3) to include a time dimension. Furthermore, we assume that the physical transport costs (i.e., τ_{ijt}) are specified as

$$\tau_{ijt}(l,r) = d_{ij}^{\varsigma(l,r)}\tilde{\epsilon}_{ij}(l,r,t).$$

d_{ij} is the geographical distance between countries i and j and is a time-invariant element. $\varsigma(l,r)$ and $\tilde{\epsilon}_{ij}(l,r,t)$ are a distance parameter and a disturbance term, respectively. As a result, appreciating the nature of our time-variant, country-pair product dataset, we can simplify our estimation equation as follows:

$$\ln Q_{ijrt} = \beta \ln \mu_{ijrt} + e_{it} + e_{jrt} + e_{ijr} + \epsilon_{ijrt}, \quad (4)$$

where Q_{ijrt} is the total exports of product r from countries i to j in year t. e_{it}, e_{jrt}, and e_{ijr} are exporter-year fixed effects, importer-product-year fixed effects, and exporter-importer-product fixed effects, respectively. Also, $\epsilon_{ijrt} = \ln \tilde{\epsilon}_{ij}(l,r,t)$. Namely, except for tariff ratio (i.e., μ_{ijrt})—which is the only time-variant, country-pair, and product-specific variable—all other elements can be captured by the fixed effects.

One noteworthy point is that, as demonstrated above, β should differ by regime, (i.e., homogeneous and heterogeneous regimes). β should be $-\iota$ in the case of the homogenous regime and $-\omega_i$ in the case of the heterogeneous regime. However, since our dataset does not enable us to differentiate trade regimes (i.e., tariff schemes), we cannot divide the sample into products traded under homogeneous and heterogeneous regimes; thus, we cannot estimate equation (4) for those regimes separately. What we can do is to estimate it for the whole sample, including both transactions under the homogeneous and heterogeneous regimes. One of our unique outcomes is that we prove that our estimate of β becomes a weighted average of coefficients under the two regimes (see Appendix B). In our case, the estimated coefficient becomes

$$o_A(-\iota) + o_B(-\omega_i).$$

o_A and o_B are the weights for the coefficients of the respective regimes and they range between 0 and 1. The predicted sign is negative.

From a theoretical point of view, the coefficient under the heterogeneous regime differs by exporting country. For example, its absolute value becomes lower when f_i^R/f_i is higher because a higher f_i^R/f_i leads to a lower share of RTA users for all exporters and thus, there is a smaller effect of the tariff ratio on total exports. In the baseline estimation, we do not differentiate this coefficient across exporting countries and thus, we estimate the world average. In the robustness check, we take this difference among exporters into account to some extent.

4. Empirical Issues

In this section, we explain our data sources and discuss some empirical issues. Since μ is generally defined at each import country's tariff line–level, we define product at an import country's tariff line–level and draw our tariff line–level import data from the database of WTA by GTIS. As in the regular trade databases such as UN Comtrade, this database does not enable us to identify the various tariff schemes in the transactions. However, it provides tariff line–level data on trade. GTIS was established in 1993. According to its website, the data are only obtained from the official sources for each reporting country (e.g., customs or national statistics agencies). This database has been used by corporations, governments, and associations in more than 50 countries. Although the WTA database is not often used in academic studies compared to, at least, the UN Comtrade database, it is reliable enough for academic trade analyses.

Our importing countries are selected based on data accessibility.[8] Furthermore, as explained below, we integrate the tariff data with the import data. Therefore, we also do not include import data for countries in which the tariff data are not available. In order to keep the version of the HS system consistent over the sample years used to construct a panel dataset, we restrict the sample years to the 2007–2011 period (i.e., HS2007). Therefore, we do not include importing countries in which the tariff/trade data are only available in versions other than HS2007. Furthermore, if a country switches the HS version during the above period, we only keep the importing country–year pairs under the HS2007 version. The number of sample years thus differs across importing countries. As a result, the number of importing and exporting countries becomes 43 and 181, respectively (see Appendix C).

We match the tariff data with the above import data at the tariff line–levels. The detailed tariff data are obtained from the database of the World Integrated Trade Solution (WITS). In the database, various kinds of tariff schemes, including not only MFN schemes and RTA schemes, but also GSP, are available. Since our main interest in this study lies in the effects of RTAs, we only use RTA rates in addition to MFN rates. We use *ad valorem* equivalent rates for non-*ad valorem* tariff rates. When multiple RTA rates are available, we choose the lowest rates for each product.[9] To combine the data on

[8] The Institute of Developing Economies has authority to access this database.

[9] For example, Japan has bilateral and multilateral RTAs with Thailand (i.e., Japan-Thailand Economic Partnership Agreement and ASEAN-Japan Comprehensive Economic Partnership).

trade and tariffs, we aggregate the number of digits in the tariff data when the number of digits in the most detailed level is finer in the tariff data than the trade data and pick the lowest tariff rates within the category of this aggregation. Using this tariff dataset, we compute the ratio of one plus RTA rates to one plus MFN rates (i.e., the tariff ratio). For example, when the RTA and MFN rates are 5% and 10%, respectively, the tariff ratio is calculated as (1+0.05)/(1+0.1) = 0.95. When the RTA rates are not available, we introduce the MFN rates to the RTA rates. Namely, in this case, the tariff ratio is equal to the value one. The basic statistics are presented in Table 1.

=== Table 1 ===

There are two noteworthy empirical issues. First, in the recent literature on gravity, zero-valued trade is a hot issue. Recent research addressing this issue uses the pseudo-poisson maximum likelihood technique (Silva and Tenreyro, 2006) or the extended technique of the Heckman two-step estimation (Helpman et al., 2008). We do not rigorously take this issue into account because, under these non-linear estimation methods, it is difficult to include our fixed effects. In our study, nearly 50% of the observations have zero-valued trade. Although this amount is not trivial and it is reasonable because of the nature of our dataset (i.e., exporter-importer-*tariff line*–year data), we simply drop these observations. This is because we believe that not controlling for such fixed effects yields more serious biases than not taking into account the zero-trade issue in a rigorous manner. Nevertheless, we will tackle the zero-valued trade issue in the later estimation. Second, we exclude products with zero MFN rates in the baseline estimation, since the entry of RTA does not change the tariff rates for such products. In the later estimation, we will also estimate the model by including such products.

5. Empirical Results

In this section, we estimate equation (4). We first report our basic estimation results. Then, several alternative estimations are conducted to employ our gravity equation.

5.1. Basic Estimation Results

Our baseline results are presented in column (I) in Table 2. The coefficient for the (log) tariff ratio (i.e., μ) is estimated to be significantly negative, as is consistent with our theoretical prediction. We also estimate the model for all observations, including those with zero MFN rates, and report the results in column (II). The number of observations greatly increases. The coefficient for the tariff ratio is again estimated to be significantly negative, although the absolute magnitude decreases somewhat. In addition, in order to further control for the variations across products, we include exporter-product-year fixed effects instead of exporter-year fixed effects, although our theoretical gravity model does not necessarily require us to include these effects.[10] The results are shown in columns (III) and (IV), and they are qualitatively unchanged, although the absolute magnitude greatly increases.[11]

=== Table 2 ===

5.2. Further Controls and RTA Eligibility

In the following subsections, we estimate various models to show the robustness of our above results. In column (I) of Table 3, we introduce importer-exporter-year fixed effects in order to further control for time-variant country-pair elements such as exchange rates. The coefficient is estimated to be negatively significant. As in the case of controlling for exporter-product-year fixed effects, the absolute magnitude rises. In column (II), we exclude observations in which RTA rates are not available. The tariff ratio becomes the value one for half of our observations (with positive MFN rates). This sample distribution may yield some biases to the coefficient. Indeed, the estimation result shows a significantly negative coefficient, and a great rise in the absolute magnitude.

=== Table 3 ===

5.3. Specific Products

We estimate our model for three specific sets of observations. First, we restrict the observations for our estimations to those in the manufacturing industries (i.e., excluding products in HS chapters 01–24). As mentioned above, *ad valorem* equivalent rates are used for non-*ad valorem* tariff rates. However, it is well known that these rates differ by

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[10] As is well known, the internationally common digit of HS codes is six. Therefore, exporter-product-year fixed effects are constructed based on HS six-digit codes, while we use tariff-line codes for the construction of importer-product-year and importer-exporter-product fixed effects.

[11] Some quantitative interpretation is provided in Section 6.

years of computation because of the changes in trade prices and thus, they may contain some errors. To avoid suffering from biases, we focus on trade in the manufacturing industries, in which tariff rates are likely to be in an *ad valorem* form. Second, the observations are restricted to trade in differentiated products simply because our theoretical model is based on such trade in differentiated products. The classification of differentiated products is based on the "liberal" classification of products by Rauch (1999). Third, sample products are only restricted to finished products. In the theoretical framework, we focus on trade in finished products. This focus is just for simplicity, but the choice of tariff schemes might be different between finished and intermediate products. For example, some countries allow duty-free imports of intermediate products that are used for exported products. In this case, firms do not need to pay the import duties without complying with the rules of origin. Therefore, we only estimate our model for trade in finished products, which are included in the 112, 112, 41, 51, 52, 62, and 63 categories within the Broad Economic Categories. These results are shown in Table 4 and are qualitatively unchanged from those in Table 2, although the absolute magnitude rises.

=== Table 4 ===

5.4. Heterogeneous Coefficients according to Exporters

Next, we take into consideration the difference in tariff ratio coefficients across export countries using two approaches under our assumption that their magnitudes are related to the level of economic development in the export countries. One is to estimate our gravity equation for the high- and low-income exporters separately.[12] The estimation results are reported in the "Exporters" column in Table 5. In both cases of the high- and low-income exporters, the coefficients are estimated to be significantly negative. The absolute effect is somewhat larger when exporting from the low-income countries. The other is to introduce the interaction term of the tariff ratio with GDP per capita in the export country. The results are shown in the "Interaction" column in Table 5 and they are qualitatively unchanged from the previous results in the "Exporters"

[12] Following World Bank classifications of income as of 2010, we divide our sample countries into high- and low-income countries. The following countries are classified as high-income countries: ABW, ADO, ANT, ARE, AUS, AUT, BEL, BHR, BHS, BMU, BRB, BRN, CAN, CHE, CHI, CYM, CYP, CZE, DEU, DNK, ESP, EST, FIN, FRA, FRO, GBR, GIB, GNQ, GRC, GRL, GUM, HKG, HRV, HUN, IMY, IRL, ISL, ISR, ITA, JPN, KOR, KWT, LIE, LUX, LVA, MAC, MCO, MLT, MNP, NCL, NLD, NOR, NZL, OMN, POL, PRI, PRT, PYF, QAT, SAU, SGP, SMR, SVK, SVN, SWE, TCA, TTO, USA, VIR.

column. Namely, exporters with higher income/GDP per capita have a smaller absolute effect on the tariff ratio. As mentioned in the previous section, the difference in f_i^R/f_i across exporting countries plays a key role in the difference in coefficients. Our results imply that f_i^R/f_i is higher in the high-income exporting countries.[13]

=== Table 5 ===

5.5. Controlling for the Non-Tariff Effects of RTAs

The next analysis is the estimation of a gravity equation with the regular RTA dummy variable, which takes the value one for country pairs with RTAs. This estimation controls for not only the effect of tariff reductions, but also some other effects of RTAs, such as the effect of eliminating NTBs. Although the latter effects are already controlled for when we introduce importer-exporter-year fixed effects (i.e., (I) in Table 3), we try to quantify these two types of RTA effects separately by explicitly introducing the RTA dummy variable. In column (I) in Table 6, we only introduce the RTA dummy, not the tariff ratio. As in the previous study on the trade-creation effects of RTAs, we obtain a significantly positive coefficient. The average effect of RTAs on trade is a 4.3% increase. We include both the RTA dummy and tariff ratio in column (II) and find that the tariff ratio coefficient is still significantly negative. While a tariff reduction through RTAs contributes to increasing trade by 3.8% (=−0.976 * −0.0387) on average, the other effects of RTAs increase trade by 1.2% (= exp(0.012) −1).

=== Table 6 ===

5.6. Tariff Ratio versus Preference Margin

We replace the tariff ratio (i.e., the ratio of RTA rates to MFN rates) with the preference margin (i.e., the difference between the MFN and RTA rates). So, far, based

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[13] In general, both fixed costs for exporting and RTA utilization will be lower in the high-income countries. Nevertheless, the difference in fixed costs for RTA utilization may be trivial because the absolute magnitude of these costs *per se* is not very large. On the other hand, the absolute magnitude of the fixed costs for exporting is much larger than that of the fixed costs for RTA utilization and thus, the difference between high- and low-income countries will be rather large. For example, while Das et al. (2007) structurally estimated the fixed costs of entry to the export markets and found that the sunk components are about US$400,000, Cherkashin et al. (2015) structurally estimated the documentation costs of compliance on the rules of origin in preferential trade and showed that these costs were US$4,240. As a result, the much lower fixed costs for exports from the high-income countries relative to the low-income countries lead to a higher f_i^R/f_i and thus, a smaller absolute magnitude of the coefficient for high-income exporters, which is consistent with our above result.

on our theoretical framework, we have used the log of the tariff ratio as a main independent variable. Its formulation is more tractable when theoretically examining the role of RTA rates relative to that of MFN rates.[14] However, many empirical studies on RTA utilization rates (i.e., the share of trade values under RTA in total trade values) have used the preference margin.[15] Therefore, as another robustness check, we estimate the model with the preference margin and report its estimation results in Table 7. We estimate this model for trade in products with positive MFN rates and for all products. Due to the change in variable formulation, the coefficient is estimated to be significantly positive. However, as is consistent with the previous results, it indicates that the lower the RTA rates relative to the MFN rates, the larger the bilateral trade values.

=== Table 7 ===

5.7. Zero-valued Trade at the Tariff Line–Level

In this last subsection, we examine the issue of zero-valued trade. First, we simply estimate the linear-probability model on whether or not to trade. Namely, the dependent variable is a binary variable that takes the value one for observations with positive trade values and the value zero for those with no trade values. The independent variables are the same as in equation (4). Due to our inclusion of a large number of dummy variables or fixed effects, we do not estimate the non-linear model (i.e., probit or logit models). The results are shown in column (I) in Table 8. The inclusion of zero-valued trade doubles the number of observations compared with the previous estimation. The results show a negatively significant coefficient for the tariff ratio, indicating that a trade relationship is likely to form in the products with low RTA rates relative to MFN rates. Figure 3 provides the rationale for this empirical finding. Suppose that products are traded using only RTA tariff rates (i.e., a homogeneous regime). The RTA profit locus rotates anticlockwise when the tariff ratio falls. As a result, some potential exporters will enter the market and begin to export using the RTA tariff rates. In a heterogeneous regime, the same holds true when such rotation of the RTA profit locus is great enough to change the regime to a homogenous regime. In sum, the number of exporters and thus exports are expected to increase when the tariff ratio falls.

[14] In addition, the reason for not separately introducing both the MFN and RTA rates is that these two rates are highly correlated (remember that RTA rates are equal to MFN rates when RTA rates are not available).

[15] See, for example, Bureau et al. (2007), Francois et al. (2006), Manchin (2006), and Hakobyan (2015).

=== Table 8 ===

Second, we aggregate our tariff line–level observations up to the HS six-digit level or the total level. Accordingly, the tariff ratio is also aggregated by taking a weighted-average of the tariff line–level tariff ratio. Import values are used as a weight. We drop the observations in which the average MFN rates are zero. Such aggregation obviously reduces the *share* of zero-valued observations in the total number of possible observations. The results are shown in columns (I) and (II) in Table 8. Both cases show significantly negative coefficients for the tariff ratio, as is consistent with our tariff line–level results. In sum, we conclude that the trade values are likely to be larger for the products with low RTA rates relative to MFN rates.

6. Simple Simulation

Using our estimates, we conduct a simple simulation on the effects of the subsequent reduction in RTA rates on trade in order to see the quantitative effects of our estimates. As is well known, tariff rates are not necessarily totally eliminated immediately after the RTAs take effect. The tariff reductions may start years after their introduction and/or the tariff rates may be proportionally reduced each year. As a result, due to such "staging" or "phase-in" structures of RTA tariff reductions, the ratio of RTA rates to MFN rates usually continues to decrease in some RTAs over time.

As an illustration, we employ the data on Japan's scheduled RTA rates for the Japan-Australia Economic Partnership Agreement (JAEPA), which are obtained from the Customs Agency in Japan. The simple reason for this EPA choice is that we have all of the scheduled EPA rates at the tariff line–level under the common HS version (i.e., HS2012). While JAEPA came into effect in January 2015, its tariff reduction/elimination was scheduled to be completed in 2032 (i.e., after 18 years). We consistently use the MFN rates in 2014 for our computation of the ratio of RTA rates to MFN rates, take the average of that ratio by year, and then multiply our estimates with the log-difference in the average between each year and 2014 (i.e., the value one). We exclude the products with non-ad valorem MFN rates, which accounts for only 0.2% of all products. Also, products with non-*ad valorem* RTA rates are also excluded (2%).

The transition of the effects is depicted in Figure 5. We use the estimates in the "Interaction" column in Table 5. Using GDP per-capita in Australia in 2014, we compute the marginal effect of the tariff ratio in the case of exports from Australia

(−1.52). Again, notice that these effects are only for the trade in products with positive MFN rates as of 2014, although 57% of all tariff-line products still have positive MFN rates in Japan. The vertical left axis shows the percentage increase in exports from Australia to Japan compared with exports in 2014 (i.e., just before JAEPA's effective date). It indicates the cumulative effects of the tariff reductions on trade. We also show the estimates in Magee (2008, Model 3 in Table 1), which indicate the world-average cumulative effects of the total RTA effects. Unlike our estimates, Magee's estimates are obtained from a country-level analysis, not a tariff line–level analysis, and include trade in products with zero MFN rates.

=== Figure 5 ===

As a result, there are three noteworthy points. First, our smaller effects than those for Magee look reasonable because we only include the effects of tariff reductions, while Magee includes the total effects (i.e., the effects of not only the tariff reductions but also the reduction/elimination of NTBs). Second, in the first year of JAEPA (i.e., 2015), exports from Australia to Japan were expected to increase by 6% compared with exports in 2014. Third, our effects show a smoother trend than those for Magee. This trend is natural because we based our calculations on the scheduled tariff reductions, in which the typical pattern is proportional over an annual period. Indeed, based on the corresponding patterns of tariff reduction in JAEPA, our cumulative effects relatively grow from 2015 to 2018, but do not change very much after 2024.

7. Concluding Remarks

This study contributes to the literature on gravity analysis by explicitly incorporating both MFN and RTA rates. Our gravity equation takes into consideration the fact that all exporters do not necessarily utilize RTA schemes when exporting products, even to their RTA partners, due to the existence of compliance costs under the rules of origin. We apply the tariff line–level data for worldwide trade to our gravity equation. As a result, we find a significantly negative coefficient for the ratio of RTA rates to MFN rates. This result is qualitatively unchanged, even when we restrict our sample to various sets. Also, the absolute magnitude is larger when exporting from lower-income countries. From the quantitative point of view we show that, in the first year of JAEPA (i.e., 2015), exports from Australia to Japan are expected to increase by 6% compared to exports in 2014. Furthermore, it is shown that, based on the subsequent reduction in RTA rates, the magnitude of the trade-creation effect through tariff reductions gradually rises over time.

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Table 1. Basic Statistics

	Obs	Mean	Std. Dev.	Min	Max
ln Q	13,269,686	10.3568	3.1011	-6.2146	24.5452
ln μ	13,269,686	-0.0387	0.0669	-4.6030	0
Preference margin	13,269,686	0.0423	0.1113	0	98.7868

Notes: μ is the ratio of one plus RTA rates to one plus MFN rates. Preference margin is the difference between MFN and RTA rates. The figures in this table are based on the observations in which MFN rates are positive.

Table 2. Estimation Results of OLS

	(I)	(II)	(III)	(IV)
ln μ	-1.000***	-0.989***	-1.354***	-1.301***
	[0.057]	[0.053]	[0.067]	[0.060]
Product coverage	Positive MFN	All	Positive MFN	All
Exporter dummy	Year	Year	Product-year	Product-year
R-squared	0.8763	0.8772	0.8907	0.8898
Number of observations	13,269,686	20,287,377	12,787,045	19,688,671

Notes: μ is a ratio of one plus RTA rates to one plus MFN rates. ***, **, and * represent significance at the 1%, 5%, and 10% statistical levels, respectively. The heteroscedasticity-consistent standard error is in parenthesis. Columns (I) and (II) include the exporter-year, importer-product-year, and exporter-importer-product fixed effects. Columns (III) and (IV) include the exporter-product-year fixed effects, instead of the exporter-year fixed effects. "Positive MFN" and "All" in product coverage indicate the inclusion of products with only positive MFN rates and that for all products, respectively.

Table 3. Further Controlling for Fixed Effects and Excluding RTA-ineligible Products

	(I)	(II)
ln μ	-1.327***	-2.483***
	[0.071]	[0.179]
Exporter-Importer-Year FE	YES	YES
Including one-valued μ	YES	NO
R-squared	0.8177	0.816
Number of observations	13,266,553	6,810,339

Notes: μ is a ratio of one plus RTA rates to one plus MFN rates. ***, **, and * represent significance at the 1%, 5%, and 10% statistical levels, respectively. The heteroscedasticity-consistent standard error is in parenthesis. The exporter-year, importer-product-year, and exporter-importer-product fixed effects are included. In addition to these fixed effects, we include the exporter-importer-year fixed effects in column (I). In column (II), we exclude observations in which the tariff ratio equals to one.

Table 4. Estimation Results under Sample Restrictions

	Manufacturing	Differentiated	Finished
ln μ	-1.279***	-1.173***	-1.212***
	[0.073]	[0.074]	[0.071]
R-squared	0.8746	0.8724	0.8772
Number of observations	11,468,778	8,823,670	6,317,120

Notes: μ is a ratio of one plus RTA rates to one plus MFN rates. ***, **, and * represent significance at the 1%, 5%, and 10% statistical levels, respectively. The heteroscedasticity-consistent standard error is in parenthesis. The exporter-year, importer-product-year, and exporter-importer-product fixed effects are included. In “Manufacturing,” we exclude the trade of products in HS chapters 01–24. In “Differentiated,” we restrict the sample products to differentiated products, in which the classification is based on the “liberal” classification of products by Rauch (1999). In “Finished,” we restrict the sample products to finished products, which are categorized into the 112, 112, 41, 51, 52, 62, and 63 categories within the Broad Economic Categories.

Table 5. Estimation Results: Low-income Exporters versus High-income Exporters

	Exporters		Interaction
	Low-income	High-income	
ln μ	-1.118***	-0.590***	-4.608***
	[0.089]	[0.092]	[0.509]
ln μ * ln Exporter GDP per capita			0.279***
			[0.039]
R-squared	0.8928	0.8798	0.8764
Number of observations	3,743,519	9,298,553	13,246,224

Notes: μ is a ratio of one plus RTA rates to one plus MFN rates. ***, **, and * represent significance at the 1%, 5%, and 10% statistical levels, respectively. The heteroscedasticity-consistent standard error is in parenthesis. The exporter-year, importer-product-year, and exporter-importer-product fixed effects are included. "High-income" and "Low-income" are based on the World Bank classifications of income as of 2010.

Table 6. RTA Dummy Variable

	(I)	(II)
RTA Dummy	0.042***	0.012*
	[0.007]	[0.007]
ln μ		-0.976***
		[0.059]
R-squared	0.8763	0.8763
Number of observations	13,269,686	13,269,686

Notes: RTA Dummy is a dummy variable taking the value one for country pairs with RTAs. μ is a ratio of one plus RTA rates to one plus MFN rates. ***, **, and * represent significance at the 1%, 5%, and 10% statistical levels, respectively. The heteroscedasticity-consistent standard error is in parenthesis. The exporter-year, importer-product-year, and exporter-importer-product fixed effects are included.

Table 7. Estimation Results: Preference Margin

	(I)	(II)
Preference margin	0.035***	0.040***
	[0.012]	[0.013]
Product coverage	Positive MFN	All
R-squared	0.8763	0.8772
Number of observations	13,269,686	20,287,377

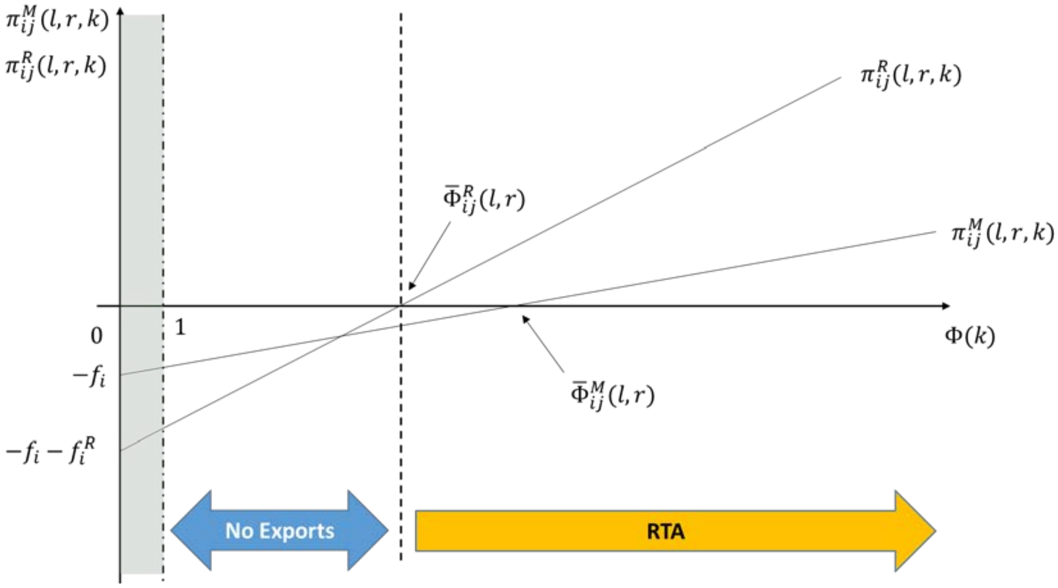
Notes: Preference margin is the difference between MFN and RTA rates. ***, **, and * represent significance at the 1%, 5%, and 10% statistical levels, respectively. The heteroscedasticity-consistent standard error is in parenthesis. The exporter-year, importer-product-year, and exporter-importer-product fixed effects are included. "Positive MFN" and "All" exclude and include the observations for products with zero MFN rates, respectively.

Table 8. Zero-valued Trade Issues

	(I)	(II)	(III)
ln μ	-0.479***	-0.177***	-0.245***
	[0.010]	[0.050]	[0.010]
Trade coverage	All	Positive	Positive
Aggregation	Tariff-line	HS6	Total
R-squared	0.5443	0.8849	0.9576
Number of observations	24,318,768	10,010,360	28,254

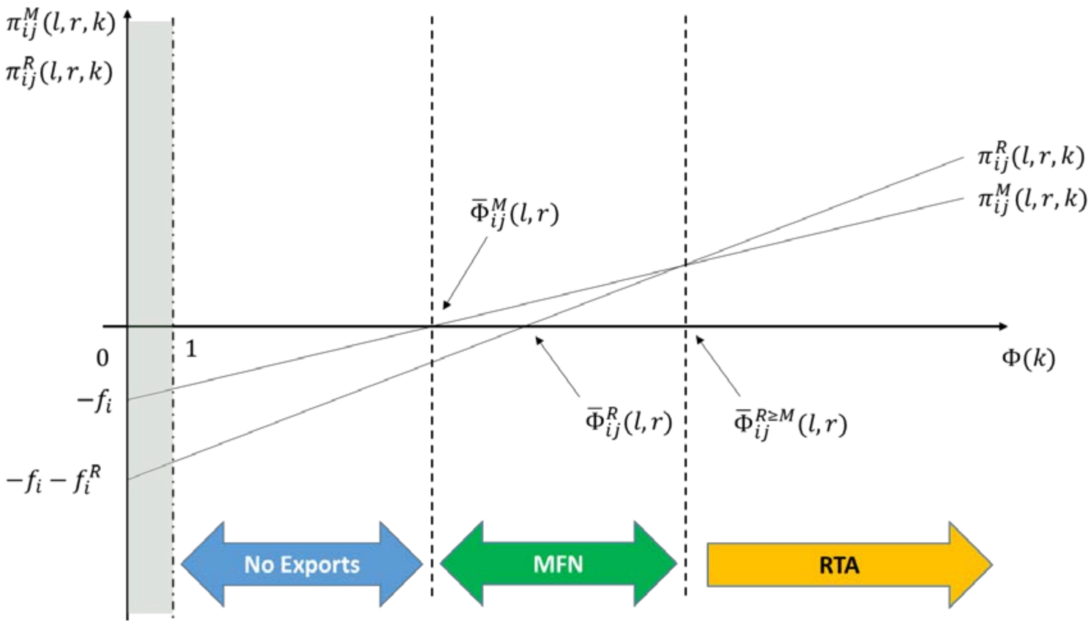
Notes: Column (I) reports the estimation results of our tariff line–level, linear-probability model, in which a dependent variable takes the value one for positive trade and the value zero for no trade. Columns (II) and (III) show the results for equation (4) at two aggregation levels. "HS6" is an HS six-digit level. In "Total," we aggregate up to the total bilateral trade values (i.e., exporter-importer-year observations). μ is a ratio of one plus RTA rates to one plus MFN rates. ***, **, and * represent significance at the 1%, 5%, and 10% statistical levels, respectively. The heteroscedasticity-consistent standard error is in parenthesis. The exporter-year, importer-product-year, and exporter-importer-product fixed effects are included.

Figure 1. Homogeneous Regime



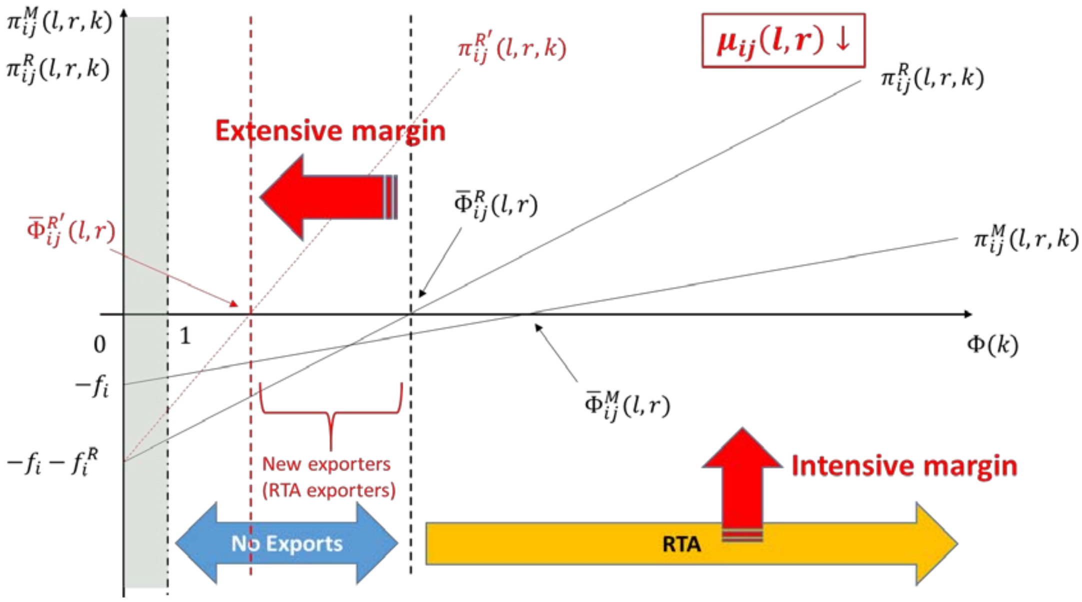
Source: Authors' compilations

Figure 2. Heterogeneous Regime



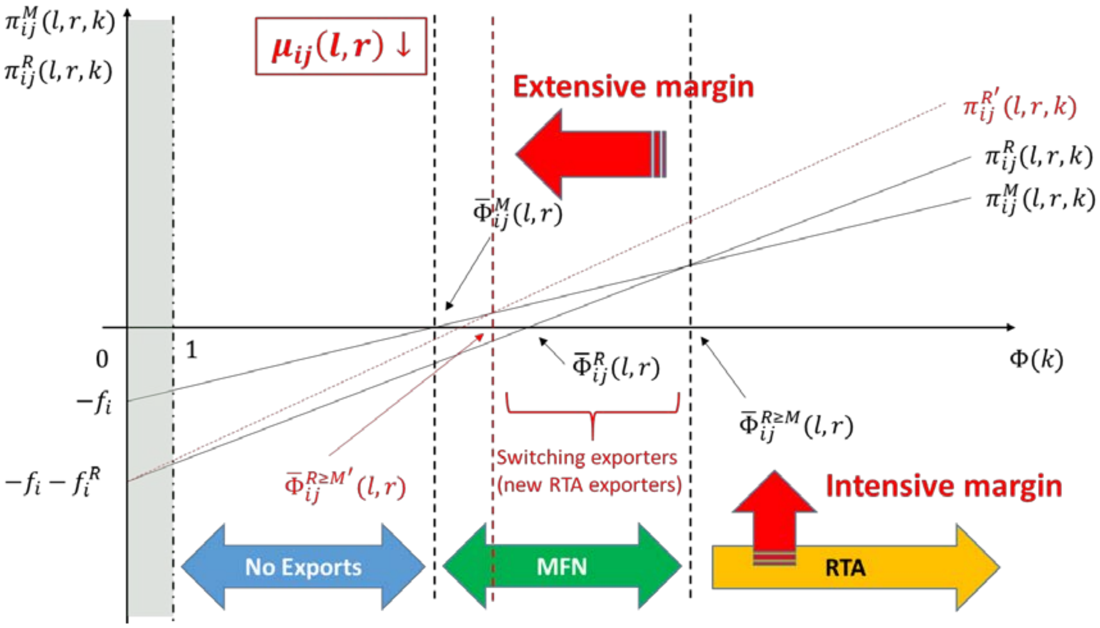
Source: Authors' compilations

Figure 3. Intensive and Extensive Margins in the Homogeneous Regime



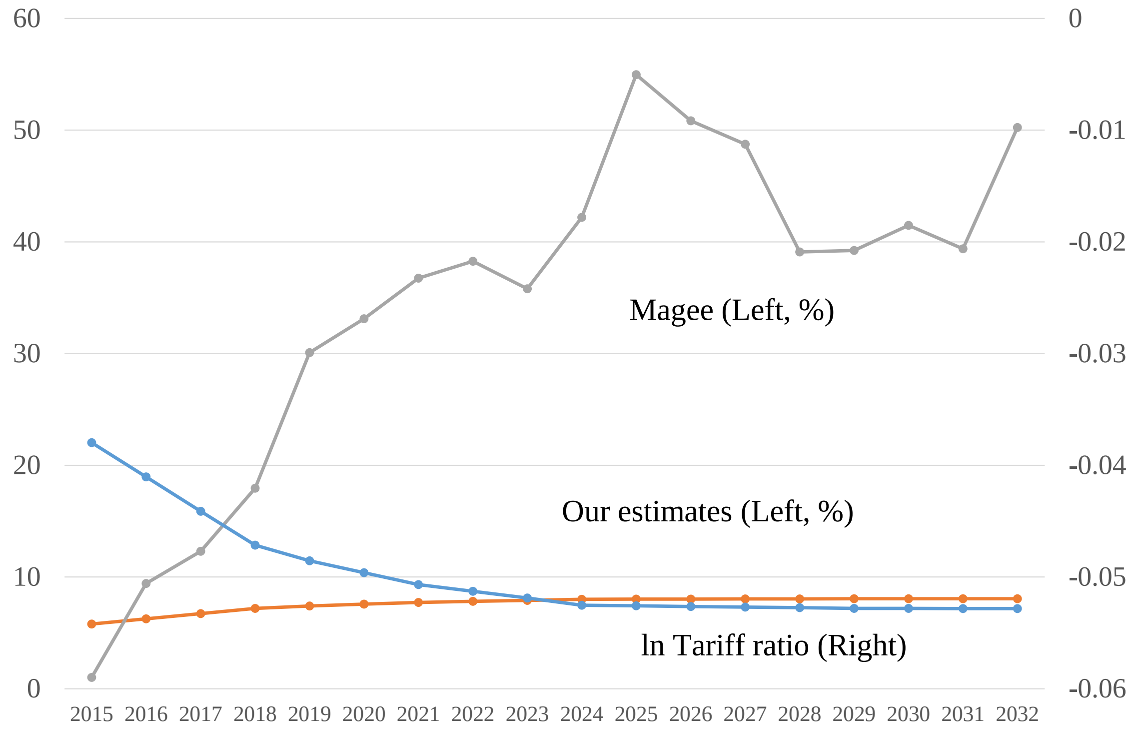
Source: Authors' compilations

Figure 4. Intensive and Extensive Margins in the Heterogeneous Regime



Source: Authors' compilations

Figure 5. Cumulative Effects of RTAs (%, log value)



Source: Authors' computations and Magee (2008)

Appendix A. A Case with Productivity Upper Bound

In this appendix, we demonstrate a case with an upper bound of the firms' productivity to replicate the case in which a product is only traded under the MFN tariff scheme, even between RTA member countries. To do this, we redefine the cumulative distribution function of productivity in the following manner:

$$G'(\varphi) = \frac{1 - \varphi^{-\alpha}}{1 - \left(\frac{1}{\varphi^H}\right)^{\alpha}},$$

where φ^H is the productivity upper bound and φ^H>1. Suppose that $(1 + f_i^R/f_i)^{1/\upsilon} > 1/\mu_{ij}(l,r)$. In this case, products are traded under both RTA and MFN schemes (i.e., heterogeneous regime) if there is not an upper bound for productivity.

An assumption that the productivity upper bound is so low that no exporters use the RTA tariff scheme for the transactions of the associated products enables us to show the case in which a product is only traded under the MFN tariff scheme. This condition is explicitly represented by

$$\left[\bar{\Phi}_{ij}^R(l,r)\right]^{\frac{1}{\upsilon-1}} > \varphi^H.$$

Total exports are given by

$$Q_{ij}^C(l,r) = Q_{ij}^M(l,r) = \int_{\left[\bar{\Phi}_{ij}^M(l,r)\right]^{\frac{1}{\upsilon-1}}}^{\varphi^H} p_{ij}^M(l,r,k) c_{ij}^M(l,r,k) G'(\varphi)$$

$$= \frac{1}{\alpha - \upsilon + 1}\left(\left\{\frac{\zeta_{ij}(l,r)}{f_{ij}\left[T_j(l,r)\right]^{\upsilon}}\right\}^{\frac{\alpha-\upsilon+1}{\upsilon-1}} - \left\{\frac{1}{\varphi^H}\right\}^{\alpha-\upsilon+1}\right)\Theta_{ij}(l,r),$$

where,

$$\Theta_{ij}(l,r) \equiv \left(\frac{\upsilon - 1}{\upsilon T_j(l,r)\tau_{ij}(l,r)w_j}\right)^{\upsilon-1} \frac{\alpha\beta(l)\left[p_j(l,r)\right]^{\upsilon-\kappa}\left[p_j(l)\right]^{\kappa-1} P_i c_i}{1 - \left(\frac{1}{\varphi^H}\right)^{\alpha}}.$$

This equation implies that total exports of these products are decreasing in MFN rates.

Appendix B. Coefficients from Two Regimes

Let $\mathbf{X}_A$ $(\mathbf{X}_B)$, and $\mathbf{Y}_A$ $(\mathbf{Y}_B)$ be vectors of the explanatory and dependent variables, respectively, for the sample in the homogeneous (heterogeneous) regime. Estimated coefficient vectors $\boldsymbol{\beta}_A$ and $\boldsymbol{\beta}_B$ are given by

$$\boldsymbol{\beta}_A = \left(\mathbf{X}_A^{\prime}\,\mathbf{X}_A\right)^{-1}\mathbf{X}_A^{\prime}\,\mathbf{Y}_A, \qquad \boldsymbol{\beta}_A = \left(\mathbf{X}_B^{\prime}\,\mathbf{X}_B\right)^{-1}\mathbf{X}_B^{\prime}\,\mathbf{Y}_B.$$

Define the whole sample as

$$\mathbf{X} = \begin{pmatrix}\mathbf{X}_A\\ \mathbf{X}_B\end{pmatrix}, \qquad \mathbf{Y} = \begin{pmatrix}\mathbf{Y}_A\\ \mathbf{Y}_B\end{pmatrix},$$

The regression of **X** on **Y** provides the following coefficient vector:

$$\boldsymbol{\beta} = \left(\mathbf{X}^{\prime}\,\mathbf{X}\right)^{-1}\mathbf{X}^{\prime}\,\mathbf{Y} = \left(\mathbf{X}_A^{\prime}\,\mathbf{X}_A + \mathbf{X}_B^{\prime}\,\mathbf{X}_B\right)^{-1}\left[\left(\mathbf{X}_A^{\prime}\,\mathbf{X}_A\right)\boldsymbol{\beta}_A + \left(\mathbf{X}_B^{\prime}\,\mathbf{X}_B\right)\boldsymbol{\beta}_B\right].$$

Namely, $\boldsymbol{\beta}$ is rewritten as the weighted average of $\boldsymbol{\beta}_A$ and $\boldsymbol{\beta}_B$. Note that o_A and o_B correspond to $\left(\mathbf{X}_A^{\prime}\,\mathbf{X}_A + \mathbf{X}_B^{\prime}\,\mathbf{X}_B\right)^{-1}\left(\mathbf{X}_A^{\prime}\,\mathbf{X}_A\right)$ and $\left(\mathbf{X}_A^{\prime}\,\mathbf{X}_A + \mathbf{X}_B^{\prime}\,\mathbf{X}_B\right)^{-1}\left(\mathbf{X}_A^{\prime}\,\mathbf{X}_A\right)$ respectively.

Appendix C. Sample Countries

C1. Importers (43)

	Tariff-line Digit	Sample Years	Tariff-line Number
Argentina	8	2007 - 2011	Approximately 11,000
Australia	8	2007 - 2011	Approximately 6,000
Austria	8	2007 - 2011	Approximately 10,000
Belgium	8	2007 - 2011	Approximately 10,000
Brazil	8	2007 - 2011	Approximately 10,000
Canada	8	2007 - 2010	Approximately 8,000
Chile	8	2007 - 2011	Approximately 9,000
China	8	2007 - 2011	Approximately 8,000
Colombia	10	2007 - 2011	Approximately 8,000
Costa Rica	10	2008 - 2010	Approximately 10,000
Czech Republic	8	2007 - 2011	Approximately 10,000
Denmark	8	2007 - 2011	Approximately 10,000
Finland	8	2007 - 2011	Approximately 10,000
France	8	2007 - 2011	Approximately 10,000
Germany	8	2007 - 2011	Approximately 10,000
Greece	8	2007 - 2011	Approximately 10,000
Hungary	8	2007 - 2011	Approximately 10,000
Indonesia	8	2007 - 2011	Approximately 8,000
Ireland	8	2007 - 2011	Approximately 10,000
Italy	8	2007 - 2011	Approximately 10,000
Japan	9	2007 - 2011	Approximately 9,000
Lithuania	8	2007 - 2011	Approximately 10,000
Luxembourg	8	2007 - 2011	Approximately 10,000
Mexico	8	2008 - 2010	Approximately 12,000
Netherlands	8	2007 - 2011	Approximately 10,000
New Zealand	8	2007 - 2010	Approximately 7,000
Norway	8	2007 - 2011	Approximately 7,000
Panama	8	2007 - 2008	Approximately 9,000
Peru	10	2007 - 2011	Approximately 8,000
Poland	8	2007 - 2011	Approximately 10,000
Portugal	8	2007 - 2011	Approximately 10,000
Romania	8	2007 - 2011	Approximately 10,000
Russian Federation	8	2007 - 2011	Approximately 10,000
Singapore	8	2007 - 2010	Approximately 12,000
Slovakia	8	2007 - 2011	Approximately 10,000
Slovenia	8	2007 - 2011	Approximately 10,000
South Africa	8	2007 - 2011	Approximately 7,000
Spain	8	2007 - 2011	Approximately 10,000
Sweden	8	2007 - 2011	Approximately 10,000
Thailand	8	2007 - 2011	Approximately 8,000
Turkey	8	2007 - 2011	Approximately 10,000
United Kingdom	8	2007 - 2011	Approximately 10,000
USA	8	2007 - 2011	Approximately 10,000

C2. Exporters (181)

ABW, AFG, AGO, ALB, AND, ARE, ARG, ARM, ATG, AUS, AUT, AZE, BDI, BEL, BEN, BFA, BGD, BGR, BHR, BHS, BIH, BLR, BLZ, BMU, BOL, BRA, BRB, BRN, BTN, BWA, CAF, CAN, CHE, CHL, CHN, CIV, CMR, COG, COL, COM, CRI, CUB, CYP, CZE, DEU, DJI, DMA, DNK, DOM, DZA, ECU, EGY, ERI, ESP, EST, ETH, EUN, FIN, FJI, FRA, GAB, GBR, GEO, GHA, GIN, GMB, GNB, GRC, GRL, GTM, GUY, HKG, HND, HRV, HTI, HUN, IDN, IND, IRL, IRN, IRQ, ISL, ISR, ITA, JAM, JOR, JPN, KAZ, KEN, KGZ, KHM, KIR, KOR, KWT, LAO, LBN, LBR, LBY, LKA, LSO, LTU, LUX, LVA, MAC, MAR, MDA, MDG, MDV, MEX, MKD, MLI, MLT, MMR, MNG, MNT, MOZ, MRT, MTQ, MUS, MWI, MYS, NAM, NER, NGA, NIC, NLD, NOR, NPL, NZL, OMN, PAK, PAN, PER, PHL, PNG, POL, PRT, PRY, QAT, ROM, RUS, RWA, SAU, SDN, SEN, SER, SGP, SLV, SOM, STP, SUR, SVK, SVN, SWE, SWZ, SYR, TCD, TGO, THA, TJK, TKM, TMP, TON, TTO, TUN, TUR, TUV, TWN, TZA, UGA, UKR, URY, USA, VEN, VNM, VUT, YEM, ZAF, ZAR, ZMB, ZWE.

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