Preferential Trade Agreements and Welfare: General Equilibrium Analysis*

Juyoung Cheong† Shino Takayama‡ Terence Yeo§

LaTeXed July 10, 2013

Abstract

This paper studies the welfare effects of a preferential trade agreement (PTA) within a general equilibrium framework following Eaton and Kortum (2002) and conducts a comparative statics analysis of the equilibrium. The paper provides a closed-form analysis with no assumption of balanced trade and analyzes how a PTA affects the price level, trade flows, and welfare of both member and nonmember countries. We show that a PTA decreases the price level of not only member but also nonmember countries. We also show that a positive coalition externality can arise in that a nonmember country can gain from the establishment of a PTA. Our analysis indicates that countries possessing a large nonmanufacturing sector relative to the economy or a high level of technology are more likely to gain from a coalition externality. Under no assumption of balanced trade, our analysis demonstrates that changes in tariff revenues and labor mobility between tradable and nontradable sectors are a key factor affecting welfare and, thus, countries' incentives to join a PTA. Finally, using a calibrated model for 38 countries, we estimate price and welfare changes under several scenarios of the Trans-Pacific Partnership (TPP) and numerically demonstrate our theoretical results.

Key Words: Trade, technology, geography, preferential trade agreements, welfare.
JEL Classification Numbers: F10, F14.

---

*We thank Prasada Rao and Robert Feenstra for their valuable advice on collecting the data for this project. We are also grateful to Andrew John and participants at the Australian Economic Theory Workshop in Sydney, 2012. This research is partly funded by an Australian Research Council grant (DP1093105). Takayama also gratefully acknowledges the hospitality of the Kyoto Institute of Economic Research and the University of British Columbia. All errors remaining are our own.

†E-mail: j.cheong@uq.edu.au.

‡*corresponding author*; School of Economics, University of Queensland, Level 6 - Colin Clark Building (39), QLD 4072, Australia; e-mail: s.takayama@economics.uq.edu.au; tel: +61-7-3346-7379; fax: +61-7-3365-7299.

§E-mail: cheng.yeo@uqconnect.edu.au.

1 Introduction

In this paper, we make a basic theoretical advance over the previous research in relation to a preferential trade agreement (hereafter PTA) and its welfare effect within the general equilibrium framework. In many areas of economics, we compare equilibrium allocations arising from independent decisions by agents with those achieved by coordination between agents. Then, one may ask a further question: would coordination harm or benefit each agent involved or agents not involved in coordination? This question is especially important in the area of international trade. We embed this question in a coherent general equilibrium framework and study the consequences of policy coordination between countries that are linked through fundamental economic variables such as prices of exports and imports.

Existing empirical studies typically use one of two distinct approaches to estimate PTA effects. The ex post approach uses a log-linear gravity equation and compares trade flows with and without PTAs following Tinbergen (1962)[1] (e.g., Baier and Bergstrand 2007; Helpman et al., 2008; Magee 2008). As it is difficult to measure the welfare effects of PTAs because of data limitations, this approach takes one step back and estimates the effects of PTAs on trade instead to obtain the welfare implications. The ex ante approach uses computable general equilibrium (CGE) models to evaluate potential PTAs (e.g., Brown et al., 1994; Kehoe and Kehoe 1994). Most of these studies follow the Armington (1969) model and assume increasing returns to scale. However, this approach has been criticized because of its poor fit to the data, its sensitivity to the model assumptions, and the complexity and difficulty in interpreting the results.

Recently, Eaton and Kortum (2002) (hereafter EK) developed a general equilibrium framework of the Ricardian model with a continuum of goods in many countries that incorporates geographic features and probabilistic formulation of technological heterogeneity. The model provides the structural equation for bilateral trade to estimate unobserved technologies (related to absolute and comparative advantages) and allows implementation of the model for counterfactual experiments in order to analyze the welfare effects of trade policies.

For the purpose of this paper, we explicitly introduce tariffs into the EK model, including them as economic distance. We conduct a comparative statics analysis in the equilibrium and provide a closed-form analysis of changes in equilibrium variables in the model. In many previous studies that extend the EK model, a trade balance is assumed to provide the equilibrium analysis (e.g., Alvarez and Lucas 2007, Costinot et al., 2012, Arkolakis et al., 2012). However, we do not assume balanced trade and are able to show who is likely to gain upon the establishment of a PTA by using the closed forms of the price changes and welfare changes of both member and nonmember countries under a PTA within the EK model.

Arkolakis et al., (2012) show that, in a Ricardian model, a price change is the only factor that can result in a welfare change due to labor market clearing and the budget constraint of the representative agent. Thus, independently of their micro-level data implications, the welfare prediction only depends

[1]The theoretical foundation of the gravity equation was first provided in Anderson (1979) and Bergstrand (1985). Following the Armington model, Anderson and van Wincoop (2003) derive the estimation equation of the gravity model and show that trade costs have nonlinear effects on bilateral trade flows through general equilibrium channels, which is mostly ignored in previous studies.

on two factors: the share of expenditure on domestic goods, and the elasticity of imports. Under no assumption of balanced trade, however, our analysis demonstrates that changes in tariff revenues and labor mobility between manufacturing and nonmanufacturing sectors are key factors affecting welfare and, thus, countries' incentives to join a PTA. Ultimately, our theoretical results indicate that countries with a large initial endowment or high level of technology have a higher possibility of being winners.

The theoretical analysis of the effect on welfare originated with Viner (1950), who indicates that a member country does not necessarily experience a welfare improvement because of both trade creation and trade diversion effects, whereas nonmember countries are harmed unambiguously by trade diversion. We demonstrate that there exists a positive coalition externality by which nonmembers can also gain from a PTA, even when the member countries' trade policies against them do not change, in contrast to a Vinerian world. A positive externality can arise because our model includes intermediate goods, which generate additional gains from trade through general equilibrium channels by changing the price indices of all countries.[2] In the literature, a coalition externality can be assumed exogenously (e.g., Aghion et al., 2007).

We show that the externality could arise as an equilibrium property within a general equilibrium framework. In our model, countries possessing a large nontradable sector relative to the economy or a high level of technology are more likely to gain from a coalition externality. When a PTA is formed, production costs tend to decrease for every country in the world. If a country has a large nonmanufacturing sector relative to its economy or a high level of technology, any loss in trade that occurs is small and does not greatly affect tariff revenues. At the same time, the country experiences a reduction in its production costs, and it is more likely than not that it will gain overall. The inclusion of intermediate goods in our analysis, on the other hand, also generates additional welfare gains for member countries that now import goods from the rest of the world, as well as from the partner country, at lower price indices.

The role of intermediate goods is also emphasized by Caliendo and Parro (2012), who extend the EK model by introducing sectoral linkages. As trade in intermediate goods has effects across industries, trade policies are evaluated in each sector, thus capturing the pattern of comparative advantage across sectors. The model is used to evaluate the North American Free Trade Agreement (NAFTA), and they show that gains are largest in Mexico. While the authors focus only on the member countries' welfare changes, our scope is extended to include the welfare effects on nonmember countries, which are also affected by the changes in the price indices of all their trading partners through the general equilibrium channel because of the existence of intermediate goods.

To conduct a counterfactual experiment, we consider the Trans-Pacific Partnership (TPP) using data on 38 countries, including both OECD and ASEAN countries, in the year 2005.[3] The TPP aims to further liberalize the economies of the Asia-Pacific region. These ongoing negotiations include an

[2]The importance of intermediate goods has been increasing in international trade. Feenstra and Hanson (1996) show that the share of imported intermediate inputs in the US increased from 5.3% to 11.6% between 1972 and 1990. Hummels et al., (2001) find that vertical specialization accounts for 21% of some OECD countries' and emerging markets, and it increased by around 30% between 1970 and 1990.

[3]We do not include Brunei, Cambodia, Lao PDR, and Myanmar because of a lack of data. Furthermore, Singapore is excluded as trade flows are not a good indicator of what is consumed within the country.

expanded version of agreements and encompass a larger number of countries.[4] The negotiations have drawn criticism and support from various public groups, yet the welfare consequences remain unclear and uncertain. To study the welfare consequences, we investigate several scenarios of the TPP where the sets of member countries are different.

The remainder of the paper is structured as follows. Section 2 summarizes the model on which our analysis is based. Section 3 presents our theoretical results, while Section 4 empirically explores our theoretical results. Section 5 concludes the paper.

2 The Model

We follow the EK model but include tariffs explicitly as economic distance in the model. There are N countries in the world, and the set of countries is denoted by $N := \{1, \cdots, N\}$. Within each country, there are two industry sectors: manufacturing and nonmanufacturing.

In each country, there is a single nonmanufactured good which serves as a numeraire, whereas there is a continuum of manufactured goods, and the set of manufactured goods is $\mathcal{I} := [0, 1]$.[5] Labor is the only input to the nonmanufactured good, but there are two inputs to manufactured goods: labor and manufactured goods, which are intermediate goods.

We make the usual Samuelson's iceberg assumption in the model. Under the iceberg assumption, delivering a unit of each good from country i to country n requires a certain amount of the good in country i. Assume that delivering a unit from country i to country n requires the production of $\bar{d}_{ni}$ units in country i.

We assume that the production technology for the nonmanufactured good is linear. To produce a unit of the manufactured good j for any $j \in \mathcal{I}$ requires a certain amount of labor and a bundle of manufactured goods. We regard this bundle of manufactured goods as one "composite" intermediate good. We suppose that the technology to produce manufactured goods from a bundle of inputs including labor and a composite intermediate good is the same across goods and countries, and that countries have differential access to the technology for producing each good. Thus, the production efficiency for each good varies across countries and also across commodities within each country. When one input bundle to produce good j includes I units of a composite good and L units of labor, we set $f_n^j(L, I) = Z_n(j) \cdot g(L, I)$ for some $Z_n(j) \in \mathbb{R}_+$. We can think of $Z_n(j)$ as the efficiency with which one input bundle is converted into good j. On the other hand, $g(L, I)$ is a deterministic production technology that is common across countries and goods.

To obtain a composite intermediate good, suppose that a nonnegative measurable function $v(k)$ for each $k \in \mathcal{I}$ specifies how many units of good k are needed to produce one unit of a composite good. We assume that the process of producing a composite intermediate good is of a Leontief type across

[4]The TPP was previously known as the Pacific Three Closer Economic Partnership. New Zealand, Chile, and Singapore (the "three"), joined by Brunei, were the initial members in 2005. In 2012, the US, Australia, Peru, Vietnam, Malaysia, Mexico, and Canada took part in the negotiations for the TPP. Potential new negotiators include Japan and the Republic of Korea.

[5]Unlike in the two-country model, in models with more than two countries with a continuum of goods (e.g., Jones (1961), Wilson (1980), Costinot et al., (2012)) the pattern of trade is not determined by the relative wages of the countries.

goods $k \in \mathcal{I}$ such that when the input of good k is s_k, $I = \min_{k\in\mathcal{I}} \left\{ \frac{s_k}{v(k)} \right\}$ units of a composite good are produced. We set $g(L, I) = (L)^\beta \cdot (I)^{1-\beta}$ for some $\beta \in (0, 1)$. β is the labor share in manufacturing production and is assumed to be common across all countries.

Suppose that country n's efficiency in producing good j, $Z_n(j)$, is the realization of a random variable $\tilde{\mathcal{Z}}_n^j$, which is drawn independently for each j from its country-specific probability distribution, $F_n(z) = \Pr[\mathcal{Z}_n \leq z]$. Each F_n for $n \in N$ is given by the Fréchet distribution, $F_n(z) = \exp(-T_n z^{-\theta})$ with $z \geq 0$, $T_n > 0$, and $\theta > 1$, where T_n is country n's state of technology.[6]

We assume that country $n \in N$ is endowed with a total labor supply of $\bar{L}_n$. We consider two cases of labor mobility between the manufacturing and nonmanufacturing sectors: mobile and immobile. If labor is mobile, workers are free to move within a country (but not between countries), even between the two sectors. If labor is immobile, the labor supply in each of the two sectors is fixed, although workers are still free to move within their sector.

It is assumed that the efficient input cost c_n of a bundle of labor and an intermediate good is chosen to satisfy a cost minimization problem for producers. Let w_n denote the manufacturing wage and let p_n denote the price of a composite intermediate good in country n. Assume that the total input cost $c_n = w_n L + p_n I$ is set by choosing L and I to minimize:

$$g(L, I) - w_n L - p_n I. \tag{1}$$

From the cost minimization problem, we obtain:

$$\beta c_n = w_n L \quad \text{and} \quad (1-\beta)c_n = p_n I. \tag{2}$$

Substituting (2) into $g(I, L)$, we obtain:

$$g(I, L) = \left(\frac{\beta c_n}{w_n}\right)^\beta \cdot \left(\frac{(1-\beta)c_n}{p_n}\right)^{1-\beta}. \tag{3}$$

Then, when $Z_n(j) \cdot \left(\frac{\beta \hat{c}_n}{w_n}\right)^\beta \cdot \left(\frac{(1-\beta)\hat{c}_n}{p_n}\right)^{1-\beta} = 1$, $\hat{c}_n = \frac{w_n^\beta p_n^{1-\beta}}{Z_n(j)\beta^\beta(1-\beta)^{1-\beta}}$. For simplicity of analysis, we normalize the cost of an input bundle by setting $c_n = w_n^\beta p_n^{1-\beta}$. The randomized efficiency $Z_n(j)$ determines how many units of good j can be produced from input cost c_n. When $Z_n(j) > Z_n(j')$, the cost of producing a unit of good j is smaller than that for good j'. In other words, the production of good j is more efficient than that of good j' in country n.

Now, we explain how tariffs are incorporated in our model under the iceberg assumption. We denote the economic distance (including tariffs) between country n and country i by d_{ni}. Let t_{ni} denote an ad valorem tariff rate imposed on imports from country i by country n. Then, $d_{ni} = (1 + t_{ni}) \cdot \bar{d}_{ni}$, where $d_{nn} = 1$ and $t_{nn} = 0$, $\forall\, n$.

We assume that the law of large numbers holds and, thus, the country-specific distribution $F_n(z)$ is also the fraction of goods for which country n's efficiency is below z.[7] Under perfect competition, the

[6] See footnote 14 of Eaton and Kortum (2002) for the reasons for this distribution.

[7] Following Eaton and Kortum (2002), we make this assumption even though technically this is a challenging issue. Al-Najjar (2004) considers sequences of finite but increasingly large economies that "discretize" the continuum. In the limit, he obtains a model that is continuum-like in important respects, yet has a countable set of agents with a finitely additive, "uniform" distribution. In this model, the law of large numbers is meaningful. The proof for the discretized good case is found in Remark 1 of Cheong et al., (2013).

price that consumers in country n actually pay for good j is the lowest across all source countries i:

$$p_n(j) = \min\{p_{ni}(j) : i \in N\}. \tag{4}$$

In country n, purchasing a unit of good j from country i costs the unit production cost multiplied by the geographic barrier d_{ni}, which is given by $\left(\frac{c_i}{\mathcal{Z}_i(j)}\right) \cdot d_{ni}$. As $\mathcal{Z}_i(j)$ is randomly drawn independently for each good j, the cost of country n purchasing any good from country i depends on the realization of the random variable $P_{ni} := \left(\frac{c_i}{\mathcal{Z}_i}\right) \cdot d_{ni}$. We fix good j arbitrarily and define the lowest price of good j among P_{ni}'s by $P_n := \min\{P_{ni} : i \in N\}$. Then, country n faces country i's price of good j with the following distribution:

$$G_{ni}(p) = 1 - \exp(-T_i(c_i d_{ni})^{-\theta} p^\theta). \tag{5}$$

Hence, the distribution of the price that country n actually pays for good j is given by:

$$G_n(p) = \Pr[P_n \leq p] = 1 - \Pi_{i=1}^N [1 - G_{ni}(p)]. \tag{6}$$

Let $\Phi_n := \sum_{i=1}^N T_i(c_i d_{ni})^{-\theta}$. Then, inserting (5) into (6) yields:

$$G_n(p) = 1 - \exp(-\Phi_n p^\theta). \tag{7}$$

Notice that, as the choice of good j is arbitrary, the distribution of the price of any good satisfies (7). Now, to obtain the price of a composite good in country n, denoted by p_n, consider the utility maximization problem for a representative consumer in country n. Let q denote a nonnegative-valued measurable function in $[0, 1]$. A representative consumer in country n purchases a bundle $\{q_n(j)\}_{j\in[0,1]}$ to maximize the utility:

$$U_n = \left[\int_0^1 q_n(j)^{\frac{\sigma-1}{\sigma}} \mathrm{d}j\right]^{\frac{\sigma}{\sigma-1}}, \tag{8}$$

subject to a budget constraint $\int_{j\in[0,1]} p_n(j) q_n(j) \leq X_n$.

This problem can be solved in a similar fashion to the cost minimization problem, as both problems involve a standard Cobb–Douglas objective function. Let U_n^* denote the indirect utility function and from the optimization problem, we obtain

$$U_n^* = \frac{X_n}{\left[\int_j p_n(j)^{1-\sigma} \mathrm{d}j\right]^{\frac{1}{1-\sigma}}}. \tag{9}$$

As the objective function is the CES utility function, consuming all the goods in $\mathcal{I}$ k-times yields a k-times higher utility. Then, setting $1 = \frac{p_n \cdot 1}{\left[\int_j p_n(j)^{1-\sigma} \mathrm{d}j\right]^{\frac{1}{1-\sigma}}}$, we obtain the price index as follows:

$$p_n = \left[\int_j p_n(j)^{1-\sigma} \mathrm{d}j\right]^{\frac{1}{1-\sigma}}. \tag{10}$$

As each $p_n(j)$ satisfies (7), we can calculate:[8]

$$p_n = \left[\Gamma\left(\frac{\theta + 1 - \sigma}{\theta}\right)\right]^{1/(1-\sigma)} \Phi_n^{-1/\theta}, \tag{11}$$

[8]A more detailed calculation is available in Remark 2 in Cheong et al., (2013).

where $\Gamma(z) := \int_0^\infty t^{z-1} \exp(-t)\mathrm{d}t$ is the Gamma function. It is assumed that this function only exists when $\sigma < 1+\theta$, in order to have a well-defined price index. For simplicity of notation, we denote $\left[\Gamma\left(\frac{\theta+1-\sigma}{\theta}\right)\right]^{1/(1-\sigma)}$ as γ.

Let π_{ni} denote the probability that country i's price turns out to be the lowest for country n. In other words, π_{ni} is the likelihood that country i supplies a particular good to country n. More formally:

$$\pi_{ni} = \Pr\left[P_{ni} \leq \min\{P_{ns} : s \neq i\}\right]. \tag{12}$$

By using the distributions (5) and (6), we can calculate the probability π_{ni}, which is given by:[9]

$$\pi_{ni} = \frac{T_i \left(c_i d_{ni}\right)^{-\theta}}{\Phi_n}. \tag{13}$$

As there is a continuum of goods, this probability is also the fraction of goods that country n buys from country i. Let X_{ni} denote country n's spending on imports of good j from country i and set $X_n := \sum_{i \in N} X_{ni}$. Then, we obtain:

$$\pi_{ni} = \frac{X_{ni}}{X_n}. \tag{14}$$

By (13) and (14), we obtain:

$$\frac{X_{ni}}{X_n} = \frac{T_i \left(c_i d_{ni}\right)^{-\theta}}{\Phi_n}. \tag{15}$$

Let I_n and L_n denote total inputs of intermediate goods and total manufacturing labor in country n, respectively, and let Y_n and α denote country n's GDP and the average demand for final manufactured goods as a fraction of GDP, respectively. Also, let $TR_{ni} := \frac{t_{ni} X_{ni}}{1+t_{ni}}$ denote country n's tariff revenues from country i, and let $Q_{ni} := \frac{X_{ni}}{1+t_{ni}}$ denote the total income earned by country i from country n. Let $TR_n = \sum_i TR_{ni}$ and $Q_n = \sum_i Q_{ni}$. For convenience, we define $Q_n^r = \sum_i Q_{in}$. Then, Q_n is total manufacturing expenditure excluding tariffs by country n, and Q_n^r is total manufacturing income excluding tariffs by country n. A similar argument to that of (2) gives us:

$$w_n L_n = \beta \sum_i Q_{in}. \tag{16}$$

As $(1-\beta) Q_n^r = p_n I_n$, by a similar argument to that of (2), total expenditure on intermediate goods is $\frac{1-\beta}{\beta} w_n L_n$. Thus, total manufacturing expenditures are:

$$X_n = \frac{1-\beta}{\beta} w_n L_n + \alpha Y_n. \tag{17}$$

To establish a link between trade flows and price differences between countries, we use π_{ni}. Notice that:

$$\frac{\pi_{ni}}{\pi_{ii}} = \frac{X_{ni}/X_n}{X_{ii}/X_i} = \frac{\Phi_i}{\Phi_n} d_{ni}^{-\theta} = \left(\frac{p_i}{p_n} d_{ni}\right)^{-\theta}. \tag{18}$$

To proceed, let us consider the world balance between demand from consumers and supply from producers in the economy. As a whole, there are three components of income: total income for consumers, total income for producers, and tariff revenues. As total income must be equal to total expenditure in the whole world, we have to make an assumption that tariff revenues are redistributed within

[9] A more detailed derivation is available upon request ("Stochastic Efficiency" in Cheong et al., (2013)).

each country. Otherwise, tariff revenues would have to be zero, which implies that there is no trade. In this way, the world balance is guaranteed. Then, total income consists of two parts: labor income and redistributed tariff revenues.

As the total labor supply and wages in country n are fixed, and because labor is the only income-earning factor of production, total income in country n is:

$$Y_n = w_n \bar{L}_n + TR_n. \tag{19}$$

Substituting (17) and (19) into (16) yields:

$$w_n L_n = \sum_{i=1}^{N} \frac{\pi_{in}}{1+t_{in}} \left((1-\beta) w_i L_i + \alpha\beta \cdot w_i \bar{L}_i + \alpha\beta TR_i \right). \tag{20}$$

Tariffs have to be paid whenever trade occurs, unless they are zero. Then, we would have a situation where consumers pay more than what producers receive in total. To avoid this situation, we redistribute tariff payments to consumers within their own country. We further explain how this assumption works in our computation. In Section 4, we conduct a comparative statics analysis where a set of member countries (denoted by A) establishes a PTA in one case but not in another case. We use the superscript 0 to denote a variable when a PTA is not formed and the superscript 1 to denote a variable when a PTA is formed. Note that TR_n are tariff revenues for country n, and at the same time they are tariff payments for a consumer in that country. In each case, a consumer in country n faces a trade-off between income Y_n and a tax payment TR_n, in total. In case 0, a consumer pays TR_n^0 for total tariffs and receives total income Y_n^0. Now, under the PTA, a consumer pays TR_n^1, and the difference $TR_n^0 - TR_n^1$ can be spent on consumption. To compare the two equilibria under the two different cases, we assume that:

$$Y_n^1 = Y_n^0 - TR_n^0 + TR_n^1. \tag{21}$$

Finally, we define an equilibrium in our economy. An *equilibrium* in this economy consists of the following:

1. *a vector of price indices across countries* $\mathbf{p} = (p_1, \cdots, p_n)$ such that (11) is satisfied for each n;
2. *an* $n \times n$ *matrix of manufacturing expenditures* $\mathbf{X} = (X_{ni})$ such that each X_{ni} satisfies (18) for each n and i; and
3. *a vector of labor supplies* $\mathbf{L} = (L_1, \cdots, L_n)$ such that (20) is satisfied for each n.

To conduct a welfare analysis, we use real GDP, $\frac{Y_n}{p_n^\alpha}$, as an approximate measure of each country's welfare. This measurement is performed by considering the following maximization problem for each country. Let C_n^M and C_n^O denote the consumption of a bundle of manufacturing goods and the consumption of a nonmanufacturing good in country n, respectively. We define total welfare for country n by $W_n = \frac{(C_n^M/p_n)^\alpha \cdot (C_n^O)^{1-\alpha}}{a}$ for some constant $a > 0$. Country n's budget constraint is given by $C_n^O + C_n^M \leq Y_n$. Then, by solving this standard Cobb–Douglas utility maximization problem, in equilibrium, we have:

$$C_n^{M*} = \alpha Y_n \quad \text{and} \quad C_n^{O*} = (1-\alpha) Y_n. \tag{22}$$

By setting $a = \alpha^\alpha (1-\alpha)^{1-\alpha}$, we obtain:

$$W_n = \frac{Y_n}{p_n^\alpha}. \tag{23}$$

3 Equilibrium Analysis

This section consists of three parts. We start with the simplest case, whereby one country unilaterally drops tariffs against another country, and obtain preliminary results to study the change in welfare for all countries. As we would like to study all the changes of variables for all the countries at once, we first set up matrix forms so that we can demonstrate how the equilibrium changes at once in the simplest case. Second, we consider the case where several countries form a PTA, and then define a coalition externality, in order to study the welfare effects on all the countries. Third, to show how the labor mobility makes a difference to the welfare consequences, we introduce another extreme case, where the labor is not mobile between the manufacturing and nonmanufacturing sectors. At the end of this section, we theoretically demonstrate the key factor determining the welfare consequences and who is likely to gain from a coalition externality.

3.1 Comparative Statics in the Mobile Labor Case

In this section, we study how an equilibrium changes in the simplest possible case, namely when country k drops its tariff on imports from country l, holding everything else constant. As we would like to start with the simplest case, we consider a unilateral tariff reduction by a country. In our model, the change in t_{kl} does not directly affect t_{ni} unless $(k,l) = (n,i)$. More specifically, we have:

$$\frac{\frac{\mathrm{d}d_{ni}}{\mathrm{d}t_{kl}}}{d_{ni}} = \begin{cases} \frac{1}{1+t_{kl}} & \text{for } (n,i) = (k,l) \\ 0 & \text{otherwise} \end{cases}. \tag{24}$$

Now, by (11) and (13), for all $n, i \in N$, we have:

$$\pi_{ni} = T_i \frac{\gamma^{-\theta} d_{ni}^{-\theta} w_i^{-\theta\beta} p_i^{-\theta(1-\beta)}}{p_n^{-\theta}} \quad \text{and} \quad p_n = \gamma \left(\sum_i T_i d_{ni}^{-\theta} w_i^{-\theta\beta} p_i^{-\theta(1-\beta)} \right)^{-1/\theta}. \tag{25}$$

Let $\boldsymbol{\iota}_k$ denote an N-dimensional column vector, the k-th element of which is 1, and the other elements of which are $zero$, and let $\mathbf{L}(x_n)$ denote an N-dimensional column vector, the n-th element of which is x_n. Let $\mathbf{\Pi}$ denote an $N \times N$ matrix, the (n,i)-th element of which is π_{ni}. We denote a change in variable x when t_{kl} drops by x'. Taking the logarithm of (25) and a derivative yields:

$$\begin{aligned} (\ln p_n)' &= \tfrac{-1}{\theta} \cdot \frac{\left(\gamma \sum_i T_i d_{ni}^{-\theta} w_i^{-\theta\beta} p_i^{-\theta(1-\beta)}\right)'}{\left(\gamma \sum_i T_i d_{ni}^{-\theta} w_i^{-\theta\beta} p_i^{-\theta(1-\beta)}\right)} \\ &= \tfrac{-1}{\theta} \cdot \textstyle\sum_i \pi_{ni} \left((\ln d_{ni}^{-\theta})' + (\ln p_i^{-\theta(1-\beta)})' \right). \end{aligned} \tag{26}$$

Together with (24), we obtain the following result:

Lemma 1. *The following holds:*

$$\mathbf{L}\left(\frac{p_n'}{p_n}\right) = \left(\mathbf{I} - (1-\beta)\mathbf{\Pi}\right)^{-1} \pi_{kl} \left(\frac{d_{kl}'}{d_{kl}}\right) \boldsymbol{\iota}_k. \tag{27}$$

We provide all the proofs in the Appendix. The next proposition is a simple consequence of Lemma 1.

Proposition 1. *If t_{kl} decreases, p_n decreases for every $n \in N$.*

Proposition 1 is intuitive. When t_{kl} falls, d_{kl} decreases. As the economic distance from country l to country k drops, the price of the intermediate goods each country imports from country k falls, which reduces the production costs for manufacturing goods in each country. As the price index represents a basket of production costs across all countries, the price index for every country decreases.

To see what determines the change in prices, we apply a Taylor expansion to (27), and obtain:

$$\mathbf{L}\left(\frac{p_n'}{p_n}\right) = \sum_{j=1}^{\infty} (1-\beta)^j \, \mathbf{\Pi}^j \cdot \pi_{kl}\left(\frac{d_{kl}'}{d_{kl}}\right) \boldsymbol{\iota}_k. \tag{28}$$

Consider the right-hand side (RHS) of (28). As the first and second terms are significant in the Taylor series, a large π_{nk}, π_{ni}, and π_{ik} will make the price change larger. This implies that a country n with a larger π_{nk}, and a trade relationship with country i characterized by large π_{ni} and π_{ik} values, has a greater effect on $\frac{p_n'}{p_n}$. In a sense, $\pi_{kl} \cdot \frac{d_{kl}'}{d_{kl}}$ is the direct effect of the tariff reduction. The Taylor expansion, $\sum_{j=1}^{\infty} (1-\beta)^j \, \mathbf{\Pi}^j$, describes how this direct effect spreads over all countries. When country k decreases t_{kl}, the first effect occurs in d_{kl}. Then, (28) shows how the change in d_{kl} prevails over the whole set of prices through the changes in production costs. Interestingly, but very naturally, it indicates that if country k's trade share is larger in country n, a greater percentage change in prices is produced by country n. Thus, we obtain the following result.

Proposition 2. *A country n with a relatively large π_{nk} has a greater effect on $\frac{p_n'}{p_n}$ when t_{kl} decreases.*

Moreover, by (25), it is easy to verify that:

$$\frac{\pi_{nn}'}{\pi_{nn}} = \theta\beta\left(\frac{p_n'}{p_n}\right). \tag{29}$$

By Proposition 1, the RHS of (29) is strictly positive. Therefore, as t_{kl} decreases, π_{nn}' also decreases. In addition, by Proposition 2, a country n with a relatively large π_{nk} has a greater effect on $\frac{\pi_{nn}'}{\pi_{nn}}$ when t_{kl} changes. Thus, we obtain the following result:

Proposition 3. *Country n's own share π_{nn} decreases when t_{kl} decreases. Also, a country n with a relatively large π_{nk} has a greater effect on $\frac{\pi_{nn}'}{\pi_{nn}}$.*

Proposition 3 states that a unilateral tariff reduction decreases the domestic shares of all the countries and results in trade creation everywhere. This may seem counterintuitive, as it states that when country n's prices decrease, its own trade share also decreases. By (25), the change in trade share π_{nn} is determined by two factors: changes in prices and production costs in country n. Relative to $\frac{p_n'}{p_n}$, the effect on $\frac{c_n'}{c_n}$ is reduced by $1-\beta$ by (2) because the wage does not change. This means that country n's production costs do not change as much as prices change. Therefore, country n's import share would increase, as its production costs relative to prices would indeed increase.

Then, we turn to the question of how tariff revenues change when a tariff rate imposed by one country on another country changes. We will explain how the change in the tariff affects the whole economy through a chain of production, imports, and exports. Let $\mathbf{M}\left(z_{ni}\right)$ denote an $N \times N$ matrix with z_{ni} being the element on the n^{th} row and i^{th} column and let $\mathbf{D}\left(z_n\right)$ denote an $N \times N$ diagonal matrix, with all off-diagonal elements being 0, and the n^{th} diagonal element being z_n. As $X_n = \sum_i X_{ni}$, and $\frac{\mathrm{d}X_n}{\mathrm{d}t_{kl}} = \sum_i \frac{\mathrm{d}X_{ni}}{\mathrm{d}t_{kl}}$, we can decompose the change in each X_{ni} into two parts: imports for country i and tariff revenues for country n. Then:

$$\mathbf{L}\left(\frac{\mathrm{d}X_n}{\mathrm{d}t_{kl}}\right) = \left(\mathbf{M}\left(\frac{1}{1+t_{ni}}\frac{\mathrm{d}X_{ni}}{\mathrm{d}t_{kl}}\right) + \mathbf{M}\left(\frac{t_{ni}}{1+t_{ni}}\frac{\mathrm{d}X_{ni}}{\mathrm{d}t_{kl}}\right)\right) \cdot \mathbf{1}_N, \tag{30}$$

where $\mathbf{1}_N$ denotes an N-column vector whose elements are all 1. As stated, from (30), we can see that the change in total expenditure $\frac{\mathrm{d}X_n}{\mathrm{d}t_{kl}}$ can be decomposed into two parts: the sum of changes in net expenditure on goods from all the countries and the sum of changes in tariff revenues. So, in (16), we need to study two factors: the change in manufacturing labor income, $\frac{\mathrm{d}w_n L_n}{\mathrm{d}t_{kl}}$, and the change in tariff revenues, $\frac{\mathrm{d}TR_n}{\mathrm{d}t_{kl}}$.

First, by (20), the following relationship holds between the changes in the labor income in country n and the total expenditure on goods from country n:

$$\frac{1}{\beta} \cdot \frac{\mathrm{d}w_n L_n}{\mathrm{d}t_{kl}} = \begin{cases} -\frac{X_{kl}}{(1+t_{kl})^2} + \sum_{i=1} \frac{\frac{\mathrm{d}X_{il}}{\mathrm{d}t_{kl}}}{1+t_{il}} & \text{for } n = l \\ \sum_{i=1} \frac{\frac{\mathrm{d}X_{in}}{\mathrm{d}t_{kl}}}{1+t_{in}} & \text{for } n \neq l \end{cases}. \tag{31}$$

In (31), $-\frac{X_{kl}}{(1+t_{kl})^2}$ is the direct effect of the tariff change. After the tariff change, consumers in country k do not need to pay tariffs on goods from country l, and producers in country l can receive more from country k. This effect is expressed as this term and it indicates that country l's manufacturing labor income increase further, as in (31).

Second, as $TR_n = \sum_{i=1} \frac{t_{ni}}{1+t_{ni}} X_{ni}$, the first derivative yields:

$$\frac{\mathrm{d}TR_n}{\mathrm{d}t_{kl}} = \begin{cases} \frac{X_{kl}}{(1+t_{kl})^2} + \sum_{i=1} \frac{t_{ni}}{1+t_{ni}}\frac{\mathrm{d}X_{ni}}{\mathrm{d}t_{kl}} & \text{for } n = k \\ \sum_{i=1} \frac{t_{ni}}{1+t_{ni}}\frac{\mathrm{d}X_{ni}}{\mathrm{d}t_{kl}} & \text{for } n \neq k \end{cases}. \tag{32}$$

Similarly, (32) shows the direct effect, $\frac{X_{kl}}{(1+t_{kl})^2}$. When country k reduces tariffs on country l's goods, it loses tariff revenue after the tariff change, which is expressed in this term. Then, from (31) and (32), we have:

$$\begin{aligned} \frac{1}{\beta}\mathbf{L}\left(\frac{\mathrm{d}w_n L_n}{\mathrm{d}t_{kl}}\right) &= \mathbf{M}\left(\frac{1}{1+t_{in}}\frac{\mathrm{d}X_{in}}{\mathrm{d}t_{kl}}\right)\mathbf{1}_N - \frac{X_{kl}}{(1+t_{kl})^2}\boldsymbol{\iota}_l; \\ \mathbf{L}\left(\frac{\mathrm{d}TR_n}{\mathrm{d}t_{kl}}\right) &= \mathbf{M}\left(\frac{t_{ni}}{1+t_{ni}}\frac{\mathrm{d}X_{ni}}{\mathrm{d}t_{kl}}\right)\mathbf{1}_N + \frac{X_{kl}}{(1+t_{kl})^2}\boldsymbol{\iota}_k. \end{aligned} \tag{33}$$

Equations (30) and (33) describe how the changes in parameters involved are related and offset by other changes. Further calculation gives us the following result. Let:

$$\psi_{ni} := \frac{Q_{ni}}{Q_i^r} = \frac{1/(1+t_{ni})X_{ni}}{\sum_{m=1}^{N} 1/(1+t_{mi})X_{mi}} \quad \text{and} \quad \lambda_{ni} := \frac{TR_{ni}}{TR_n} = \frac{t_{ni}/(1+t_{ni})X_{ni}}{\sum_{j=1}^{N} t_{nj}/(1+t_{nj})X_{nj}}.$$

Then, ψ_{ni} denotes the share of imports from country i in country n, excluding tariff revenues, and λ_{ni} is the share of tariff revenues from country i in country n. For notational simplicity, we define $\boldsymbol{\Psi} := \mathbf{M}\left(\psi_{ni}\right)$ and $\boldsymbol{\Lambda} := \mathbf{M}\left(\lambda_{ni}\right)$.

Proposition 4. *The following holds:*

$$\begin{aligned}\mathbf{L}\left(\frac{TR_n'}{TR_n}\right) &= \left[\mathbf{L}\left(\frac{X_n'}{X_n}\right) + \theta\left(\mathbf{I} - (1-\beta)\,\mathbf{\Lambda}\right)\mathbf{L}\left(\frac{p_n'}{p_n}\right)\right] + \frac{Q_{lk} - \theta TR_{kl}}{t_{kl}(1+t_{kl})} \cdot \boldsymbol{\iota}_k, \\ \mathbf{L}\left(\frac{Q_n^{r\prime}}{Q_n^r}\right) &= \mathbf{\Psi}\left[\mathbf{L}\left(\frac{X_n'}{X_n}\right) + \theta\left(\mathbf{I} - (1-\beta)\,\mathbf{\Psi}^{-1}\right)\mathbf{L}\left(\frac{p_n'}{p_n}\right)\right] - \frac{(1+\theta)Q_{lk}}{t_{kl}(1+t_{kl})} \cdot \boldsymbol{\iota}_l.\end{aligned}$$

Proposition 4 shows how we can solve for the equilibrium changes. As $X_n = \frac{1-\beta}{\beta} w_n L_n + \alpha Y_n$, and $Y_n = w_n \bar{L}_n + TR_n$, we can rewrite $X_n' = \frac{1-\beta}{\beta}(w_n L_n)' + \alpha TR_n'$. Also, $\beta Q_n^{r\prime} = w_n L_n'$ implies that $\mathbf{L}\left(\frac{Q_n^{r\prime}}{Q_n^r}\right) = \mathbf{L}\left(\frac{L_n'}{L_n}\right)$. So, the two equations in Proposition 4 include two unknowns, $\mathbf{L}\left(\frac{TR_n'}{TR_n}\right)$ and $\mathbf{L}\left(\frac{L_n'}{L_n}\right)$. The second term in $\mathbf{L}\left(\frac{TR_n'}{TR_n}\right)$ implies that country k faces a tariff reduction in addition to the first term that all the other countries face. The same is true for country l in $\mathbf{L}\left(\frac{Q_n^{r\prime}}{Q_n^r}\right)$. For example, consumers in country k do not need to pay tariffs on goods from country l if t_{kl} becomes $zero$, and the second term with $\boldsymbol{\iota}_l$ expresses this effect.

So, from Proposition 4, we can solve for the entire equilibrium changes because, by the assumption of labor mobility, meaning that wages in the manufacturing sector do not change, $\mathbf{L}\left(\frac{TR_n'}{TR_n}\right)$ and $\mathbf{L}\left(\frac{L_n'}{L_n}\right)$ are the only unknowns. In the supplementary appendix, we calculate how equilibrium variables, such as tariff revenues or manufacturing output, change with a tariff reduction in a general case where labor is not mobile between the manufacturing and nonmanufacturing sectors. As a simple consequence, we obtain Proposition 4 when labor is mobile. Now, we further compute the changes in equilibrium upon a reduction of t_{kl}. More calculations from Proposition 4 yield the closed form for these changes, and we state the result as follows. Let $\mathcal{T}$ denote the Taylor expansion.

Theorem 1. *Let* $\mathbf{K}_1 = \mathbf{\Psi}\mathbf{D}\left((1-\beta)\frac{Q_n^r}{X_n}\right)$ *and* $\mathbf{K}_2 = \mathbf{\Psi}\mathbf{D}\left(\alpha\frac{TR_n}{X_n}\right)$. *Then:*

$$\begin{aligned}\mathbf{L}\left(\frac{TR_n'}{TR_n}\right) = \mathcal{T}&\left(\mathbf{D}\left(\alpha\frac{TR_n}{X_n}\right) + \mathbf{D}\left((1-\beta)\frac{Q_n^r}{X_n}\right)\mathcal{T}\left(\mathbf{K}_1\right)\mathbf{K}_2\right) \times \\ &\times\left\{\mathbf{D}\left((1-\beta)\frac{Q_n^r}{X_n}\right) \times \mathcal{T}\left(\mathbf{K}_1\right)\left(\theta\left(\mathbf{\Psi} - (1-\beta)\,\mathbf{I}\right)\mathbf{L}\left(\frac{p_n'}{p_n}\right) - (1+\theta)\frac{\psi_{lk}}{1+t_{kl}}\boldsymbol{\iota}_l\right)\right. \\ &\qquad\left. + \theta\left(\mathbf{I} - (1-\beta)\,\mathbf{\Lambda}\right)\mathbf{L}\left(\frac{p_n'}{p_n}\right) + \frac{1-\theta t_{kl}}{t_{kl}(1+t_{kl})}\lambda_{kl}\boldsymbol{\iota}_k\right\}.\end{aligned}$$

The detailed calculation is found in the supplementary note. Theorem 1 states that there three factors determine the changes in equilibrium, which are $\frac{TR_n}{X_n}$'s, $\frac{Q_n^r}{X_n}$'s, and π_{ni}'s. The terms with $\boldsymbol{\iota}_k$ or $\boldsymbol{\iota}_l$ show the first, immediate effects of the reduced tariff t_{kl}. Then, these Taylor expansions show how these direct effects spread out to all the countries. If $\frac{TR_n}{X_n}$, $\frac{Q_n^r}{X_n}$, or π_{ni} is larger, the effects on L_n or TR_n' are also greater. In addition, as the first two terms are the two largest terms in the Taylor series, π_{nk} and π_{nl} are particularly important. Theorem 1 implies that, when t_{kl} changes, the magnitude of changes in L_n or TR_n tends to be greater if π_{nk} is larger; on the other hand, these effects tend to be greater in the opposite direction if π_{nl} is larger. This is intuitive because if the tariff revenues exceed the country's manufacturing expenditure, the effect of tariff changes would be greater; also, if the ratio of the country's manufacturing production to its manufacturing expenditure is larger, the effect on the manufacturing sector would be greater.

The interesting point about these formulas in Proposition 4 or Theorem 1 is that they present an effect similar to a "multiplier effect." As $Y_n' = TR_n'$ in this case, Theorem 1 relates to how GDP in country n changes. The first term is the Taylor expansion of the term which includes $\frac{TR_n}{X_n}$'s and $\frac{Q_n^r}{X_n}$'s. This indeed describes how the first, direct effects are recursively summed up through imports and exports.

Up to this point, we have assumed that $TR_n \neq 0$ for every n by assuming $t_{ni} > 0$ for all $i \neq n$. One may wonder how the equilibrium changes, and especially what the welfare consequences are, when $TR_n = 0$ for all n. Our method still works in this case. Here, we give a brief analysis of the case where $t_{ni} = 0$ for i. When $TR_n = 0$, namely $t_{ni} = 0$ for every $n, i \in N$, the analysis becomes simpler. The next proposition states that when $t_{ni} = 0$ for every $n, i \in N$, other countries lose when one country starts to impose a tariff on goods from another country. This demonstrates the way that a coalition externality may arise in equilibrium.

Proposition 5. *Suppose $t_{ni} = 0$ for every $n, i \in N$. If t_{kl} increases, W_n for all countries besides k decreases:*

$$\frac{\mathrm{d}\ln W_n}{\mathrm{d}t_{kl}} = \frac{\mathrm{d}\ln Y_n}{\mathrm{d}t_{kl}} - \alpha\frac{\mathrm{d}\ln p_n}{\mathrm{d}t_{kl}} < 0, \, \forall n \neq k,$$

and also $\frac{\mathrm{d}\ln W_k}{\mathrm{d}t_{kl}} > 0$.

This stems from the fact that $\mathbf{L}\left(\ln p_n'\right) = \left[\mathbf{I} - (1-\beta)\,\mathbf{\Pi}\right]^{-1}\pi_{kl}\boldsymbol{\iota}_k \gg \mathbf{L}(0)$, and $\frac{\mathrm{d}\ln Y_n}{\mathrm{d}t_{kl}} = 0$ for all $n \neq k$. That is, when country k increases tariff rates, manufacturing prices in every country increase, and the nominal national income in every country other than k remains unchanged, resulting in a net loss in "real" national income, which in turn decreases national aggregate welfare for all countries other than country k.

Another way of looking at Proposition 5 is that $t_{ni} = 0$ for every $n, i \in N$ is not supported as a Nash equilibrium as $\frac{\mathrm{d}\ln W_k}{\mathrm{d}t_{kl}} > 0$. One may wonder about the connection between Proposition 5 and global free trade. In reality, when a country deviates from a PTA, the country would be retaliated against or incur some penalty (at least, other member countries would start to charge tariffs against country k). Proposition 5 does not address this point; however, as long as it implies that there is a penalty greater than $\frac{\mathrm{d}\ln W_k}{\mathrm{d}t_{kl}}$, country k would still stay in the PTA. Although extending the analysis to a consideration of this aspect is beyond the scope of this paper, our analysis gives a reference framework for this extension.

In the next section, we will provide another theorem in the case of immobile labor that is equivalent to Theorem 1, and run several simulations to see how equilibrium variables are related after the tariff change. The two theorems concern each case; that is, the case of mobile labor and the case of immobile labor. These theorems extend the analysis in Proposition 4.

3.2 Coalition Externality

In this section, we start with a condition under which country n gains from the closed forms presented in the proofs of Theorem 1. This enables us to identify the most important determinant of the welfare consequences in each case and understand how labor mobility affects the relationship between the determinant factor and welfare gains. To draw a simple intuition, we make the following assumption.

Assumption 1. *Suppose that $t_{ni} = \bar{t} > 0$ for every $i \neq n$, and that $\bar{t}$ is sufficiently small.*

In the case of mobile labor, by Proposition 1, a decrease in t_{ni} reduces country n's prices. As a consequence, if tariff revenues are sufficiently small in country n compared with the size of its economy, then this country's tariff revenues would not be affected greatly, and it is likely to be better off with lowered prices. The next proposition conveys this intuition.

Proposition 6. *The change in tariff revenues, $\frac{TR_n'}{TR_n}$, is strictly positive, and it is decreasing in $\frac{Q_n}{X_n}$ or $\frac{Q_n^r}{X_n}$ under Assumption 1.*

By Proposition 1, when one country reduces tariffs on another country, the prices of all countries decrease. This implies that the greater the number of countries that reduce tariffs (or join a PTA), the more prices will decrease in all countries because we can apply the same argument in Proposition 1 recursively to each country in a PTA. Although tariff revenues may decrease, it is likely that, if more countries join a PTA, the positive welfare effects from the price changes will be greater, and more nonmember countries will start to gain.

Proposition 7. *As more countries join a PTA, $\frac{p_n'}{p_n}$ decreases more for every n.*

Last, from a nonmember country's point of view, this benefit can be thought of as an externality. To be more precise, we define a *coalition externality* in the following way: we say that a *coalition externality* from a PTA exists if there is a nonmember country n whose W_n increases upon the establishment of the PTA. We can summarize the welfare analysis by the following proposition. That is, we consider the change in welfare (23) after the establishment of the PTA. We can see that a nonmember country n with a relatively large Y_n and π_{nk} could gain from the PTA because, from Proposition 2, country n's price change is larger compared with the change in tariff revenues, regardless of whether or not tariff revenues for country n increase.

Proposition 8. *Under Assumption 1, when $\bar{t}$ decreases, country n gains if π_{nk} and Y_n are sufficiently large and $\frac{Q_n^r}{X_n}$ is sufficiently small.*

Proposition 8 states the characteristics of a country that is likely to be a winner from a coalition externality. Under Assumption 1, tariff revenues are sufficiently small. Then, if labor income in a tradable sector is small compared with a country's economy, the country would not be affected greatly through trade. On the other hand, if the country has a large π_{nk}, the country's price drops more than others'. So, this country is more likely to gain from the price change than are other countries.

3.3 Immobile Labor and Comparison

Up to this point, we have assumed that wages do not change. In reality, however, wages do change, and we would like to consider how this assumption of labor mobility changes our analytical results. As described after Proposition 4, in the case of mobile labor, we have to solve for $\mathbf{L}\left(\frac{TR_n'}{TR_n}\right)$ and $\mathbf{L}\left(\frac{L_n'}{L_n}\right)$ and then see how the equilibrium changes. In the case of immobile labor, a similar method works. To do this, we begin by describing a model related to the labor mobility model below.

Suppose that nonmanufacturing wages are fixed at a certain level and that productivity in the manufacturing and nonmanufacturing sectors determines manufacturing wages, w_n, for each n. As the labor supply in each sector is fixed by assumption, we assume that the nonmanufacturing labor income is fixed at Y_n^O. Then, total income in each country is:

$$Y_n = Y_n^O + w_n L_n + TR_n. \tag{34}$$

By substituting (17) and (34) into (16), we obtain:

$$w_n L_n = \sum_{i=1}^{N} \frac{\pi_{in}}{1+t_{in}} \left((1-\beta+\alpha\beta) w_i L_i + \alpha\beta \cdot Y_i^O + \alpha\beta \cdot TR_i\right). \tag{35}$$

Similarly, in the case of immobile labor, tariff redistribution (21) is also assumed, so that (34) is satisfied. In both cases, if there was no redistribution of tariffs, total income Y_n would be fixed, as seen by deleting TR_n in both (19) and (34). In this case, we replace the third condition for the definition of the equilibrium labor supply with the following. *A vector of equilibrium wages* $\mathbf{w} = (w_1, \cdots, w_n)$ is such that (35) is satisfied for each n.

In the case of immobile labor, by (23), we have:

$$\frac{W_n'}{W_n} = \frac{Y_n'}{Y_n} - \alpha \frac{p_n'}{p_n} = \frac{TR_n'}{Y_n} + \frac{w_n' L_n}{Y_n} - \alpha \frac{p_n'}{p_n}. \tag{36}$$

Similarly to Proposition 4 in the mobile labor case, as $X_n = \frac{1-\beta}{\beta} w_n L_n + \alpha Y_n$, and by (34), we can rewrite $X_n' = \frac{1-\beta+\alpha\beta}{\beta}(w_n L_n)' + \alpha TR_n'$. Also, $\beta Q_n^{r'} = w_n' L_n$ implies that $\mathbf{L}\left(\frac{Q_n^{r'}}{Q_n^r}\right) = \mathbf{L}\left(\frac{w_n'}{w_n}\right)$ in this case. So, we can solve for the equilibrium changes in this case as well, and we obtain the following result.

Theorem 2. *In the immobile labor case, for* $\chi := 1 - \beta + \alpha\beta$*, there are operations* $\mathcal{J}_1^I$*,* $\mathcal{J}_2^I$ *and* $\mathcal{J}_3^I$ *such that:*

$$\begin{aligned} \mathbf{L}\left(\tfrac{w_n'}{w_n}\right) = \mathcal{J}_1^I & \left(\alpha \mathbf{D}\left(\tfrac{TR_n}{X_n}\right), \chi \mathbf{D}\left(\tfrac{Q_n^r}{X_n}\right), \mathbf{\Psi}, \mathbf{\Lambda}, \mathbf{\Pi}\right) \times \\ & \times \mathcal{J}_2^I \left(\alpha \mathbf{D}\left(\tfrac{TR_n'}{X_n}\right), \mathbf{\Psi}, \mathbf{\Lambda}, \mathbf{\Pi}, \tfrac{1-\theta t_{kl}}{t_{kl}(1+t_{kl})}\lambda_{kl}, \tfrac{\pi_{kl}}{1+t_{kl}}\boldsymbol{\iota}_k, \tfrac{\psi_{lk}}{1+t_{kl}}\boldsymbol{\iota}_l\right), \end{aligned}$$

and

$$\begin{aligned} \mathbf{L}\left(\tfrac{TR_n'}{TR_n}\right) &= \mathcal{T}\left(\alpha \mathbf{D}\left(\tfrac{TR_n}{X_n}\right)\right)\left(\chi \mathbf{D}\left(\tfrac{Q_n^r}{X_n}\right) + \theta \mathcal{J}_3^I(\mathbf{\Pi}, \mathbf{\Lambda})\right) \mathbf{L}\left(\tfrac{w_n'}{w_n}\right) + \\ & + \mathcal{T}\left(\alpha \mathbf{D}\left(\tfrac{TR_n}{X_n}\right)\right)\left(\theta\left(\mathbf{I} - (1-\beta)\mathbf{\Lambda}\right)\mathcal{T}\left((1-\beta)\mathbf{\Pi}\right)\boldsymbol{\iota}_k + \tfrac{1-\theta t_{kl}}{t_{kl}(1+t_{kl})}\lambda_{kl}\boldsymbol{\iota}_k\right). \end{aligned}$$

Similarly to Theorem 1, a detailed calculation is found in the supplementary note. In the note, $\mathcal{J}_1^I$, $\mathcal{J}_2^I$ and $\mathcal{J}_3^I$ are defined explicitly. An intuition similar to that in Theorem 1 still holds. At first glance, the three terms $\frac{TR_n}{X_n}$'s, $\frac{Q_n^r}{X_n}$'s, and π_{ni}'s are important factors in this case, too. To compare what Theorem 1 and Theorem 2 imply for welfare and labor mobility, we further investigate the results. In the case of immobile labor, the effect is more complicated than in the case of mobile labor because wages also change, and so we have to solve the equilibrium at the same time, in contrast to the case of mobile labor, where the price changes can be obtained in a closed form in the first place. However, we have the following simple intuition for the change in tariff revenues.

Proposition 9. *Under Assumption 1, in the case of immobile labor,* $\frac{TR_n'}{TR_n}$ *is strictly positive and decreasing in* $\frac{Q_n}{X_n}$.

A straightforward implication of Proposition 9 is that when a uniform tariff rate is sufficiently small, then $TR_n \approx \bar{t}Q_n$ holds, and the percentage change in tariff revenues is decreasing in the size of imports to the economy, $\frac{Q_n}{X_n}$. In the case of immobile labor, wages also change. By Theorem 2, we can observe that $\frac{TR_n}{X_n}$ and $\frac{Q_n^r}{X_n}$ determine the magnitude of the effects. The important prediction from the model is that nonmember countries that have a smaller $\frac{Q_n}{X_n}$ in the case of immobile labor are more likely to gain. In a sense, $\frac{Q_n}{X_n}$ is a measure of trade surplus in manufacturing. The nonmember countries that do not have a large $\frac{Q_n}{X_n}$ would not face a significant decrease in TR_n or w_n. As a result, the price changes are large enough to make the welfare increase. A comparison between Proposition 6 and Theorem 2 tells us that a country n with a smaller $\frac{TR_n}{X_n} \approx \bar{t}\frac{Q_n}{X_n}$ and $\frac{Q_n^r}{X_n}$ tends to be less affected by changes in tariffs and, as a result, whenever a positive coalition externality arises, it tends to gain.

Now, we connect this observation with a fundamental variable in the model. In the case of mobile labor, as $1 = \frac{w_n(\bar{L}_n - L_n)}{Y_n} + \beta\frac{Q_n^r}{Y_n} + \frac{TR_n}{Y_n}$, if $\frac{w_n(\bar{L}_n - L_n)}{Y_n}$ is larger, $\beta\frac{Q_n^r}{Y_n} + \frac{TR_n}{Y_n}$ is smaller. In the case of immobile labor, as $1 = \frac{Y_n^O}{Y_n} + \beta\frac{Q_n^r}{Y_n} + \frac{TR_n}{Y_n}$, if $\frac{Y_n^O}{Y_n}$ is larger, $\beta\frac{Q_n^r}{Y_n} + \frac{TR_n}{Y_n}$ is smaller. In a sense, nonmanufacturing production is a "seed." Nonmanufacturing goods are used to produce a manufacturing good, and we can see that this is the important factor in both cases, although the fundamental component that makes a difference is slightly different between the two cases. In the case of mobile labor, a country with a higher $\frac{w_n(\bar{L}_n - L_n)}{Y_n}$ is likely to gain. We can see that, unlike the immobile labor case, a country's technological level is also important in the mobile labor case because the efficiency of production influences the division of labor between the manufacturing and nonmanufacturing sectors. A country with a higher technological level could produce more efficiently, and thus less labor is needed in manufacturing to produce the same amount of a good (holding other factors constant). Therefore, in the case of mobile labor, technological status is more important than in the case of immobile labor. Thus, the manufacturing sector is not affected greatly by the change in tariffs, and it tends to gain from price changes.

In summary, we would like to stress the following points. When a reasonably large number of countries form a PTA,

(P1) in the case of mobile labor, country n is more likely to gain when t_{ni} for every i is small;

(P2) in the case of mobile labor, a country n with a large $\frac{Y_n^O}{Y_n}$ and a high technological level is likely to gain; and

(P3) in the case of immobile labor, country n is likely to gain if $\frac{Y_n^O}{Y_n}$ is large.

The key point here is that, in any case, a country with a large nonmanufacturing sector relative to its economy, or a high level of technology, is more likely to experience a positive coalition externality than are countries without those characteristics. Simply speaking, when a PTA is formed, production costs tend to decrease for every country in the world. If a country possesses a large nonmanufacturing sector compared with its economy or a high level of technology, any loss in trade is small and does not greatly affect tariff revenues. At the same time, the country experiences a reduction of production costs and is more likely to gain than are countries without those characteristics.

4 Calibration Results

4.1 Calibrations of the Equilibrium in the Model

In this section, we calibrate the model to conduct the comparative statics analysis. Our main focus is the welfare consequences. Mainly, we seek to identify which countries gain upon the establishment of a PTA, and then we revisit our theoretical results, especially our theoretical conjectures (P1), (P2), and (P3). As in Section 3, we consider two cases: mobile and immobile labor across manufacturing and nonmanufacturing sectors. To solve for the variables in equilibrium in the case of mobile labor, (13), (11), and (14) are used to obtain the equilibrium price indices and trade shares, given exogenous wages, and then manufacturing employment is obtained from them with (20). In the case of immobile labor, we simultaneously solve (13), (11), (14), and (35) to obtain equilibrium price indices, trade shares, and wages.

For calibration, we consider the TPP, which aims to further liberalize the economies of the Asia-Pacific region. In this paper, we use the TPP as our example for a calibration because it is plausible and covers various countries in terms of economic fundamentals such as the technological level, GDP, and wages. Based on the progression of the TPP negotiations and for the purpose of analysis, we conduct the calibration for three scenarios of the TPP:

Scenario 1: Chile and NZ[10];

Scenario 2: countries in Scenario 1 plus Australia, Japan, Malaysia, the US, and Vietnam;

Scenario 3: countries in Scenario 2 plus Canada and Mexico.

To perform the counterfactual analyses in our model, we use the parameters estimated in Cheong and Takayama (2013). Cheong and Takayama (2013) estimate a trade equation using data on the bilateral trade of manufactured goods for a cross-section of 38 countries in 2005. The parameters correspond to: (i) each country's level of technology (T_i), (ii) the heterogeneity of technology across products (θ), and (iii) geographic barriers (d_{ni}). Table 1 summarizes the basic parameters in the model.[11]

Parameter	Value	Definition
θ	8.29	Comparative Advantage
α	0.12	Manufacturing Share
β	0.19	Labor Share in Costs

Table 1: Summary of Parameters

[10]We could not include Brunei because of a lack of data. Furthermore, we do not include Singapore, as a large amount of its trade flows involve reselling goods to other countries, and it is difficult to separate trade flows into what is consumed within the country and what is just transferred via the country.

[11]The details of our data set are found in the Appendix. The complete description of the estimation method and the estimation results are found in Cheong and Takayama (2013).

First, we compute the equilibrium variables in a baseline world in which countries form currently existing PTAs and impose the current average most-favored nation (MFN) duty rates on countries that do not have a PTA with them. Table 2 lists the groups of countries which were engaged in PTAs in 2005, and Table 3 and Table 4 show, respectively, the MFN tariffs of each country and the level of technology in each country, which is obtained from Cheong and Takayama (2013).

– Insert Table 2 here –
– Insert Table 3 here –
– Insert Table 4 here –

Calibration results, including welfare changes and those effects under the three scenarios in both cases, are presented in Tables 5, 6, and 7.[12] All numbers in these tables are presented as 10^{-2} times percentage changes. In each table, countries with one or two asterisks are the members of the TPP under the scenario concerned. Countries marked by one asterisk join the TPP under the scenario concerned and countries marked with two asterisks are already in the TPP under the previous scenario concerned.

4.2 Calibration Results

First, Tables 5, 6, and 7 show that Propositions 1, 2, and 3 hold in the case of mobile labor under all three scenarios. Price levels and the domestic import shares of all countries decrease, and these decreases are larger for countries whose import share from the member countries is relatively large. (The import shares from the member countries under each scenario are presented in Table 12.) For example, in Scenario 2, Korea, China, Thailand, the Philippines, and Indonesia, the five countries with the largest import shares from the member countries, experience greater decreases in both their domestic import share and price level compared with other nonmember countries, for which the import shares from the member countries are relatively small, such as the Netherlands, Belgium, France, and Switzerland. In addition, as predicted in Proposition 7, the price level for each country drops further as more countries join the TPP.

– Insert Table 5 here –
– Insert Table 6 here –
– Insert Table 7 here –
– Insert Table 12 here –

Next, we see how a country's welfare changes because of the TPP. Comparing the results in the case of mobile labor and the case of immobile labor, we see that labor mobility matters in terms of the welfare effects for both member and nonmember countries. For example, in Table 6, the welfare of Australia, a member country, falls under mobile labor, whereas it rises under immobile labor. Canada, a nonmember country, gains under mobile labor, whereas it loses under immobile labor. In particular, as shown in Lemma 2, in the case of mobile labor, nonmember countries that have a smaller TR_n/X_n

[12]For our calibration, we refer to the program that is available at: http://home.uchicago.edu/kortum/papers/tgt/tgtprogs.htm. We thank Samuel Kortum for clarification of their program.

tend to gain, whereas in the case of immobile labor, nonmembers that have a smaller Q_n^r/X_n tend to gain (the TR_n/X_n and Q_n^r/X_n of each country are presented in Table 13). For example, in the case of mobile labor in Table 6, welfare increases in Switzerland, Iceland, Germany, and Italy, for which the TR_n/X_n is relatively low, whereas welfare decreases in Thailand, China, India, the Russian Federation, and Vietnam, countries for which the TR_n/X_n is relatively high. In the case of immobile labor in Table 6, India, China, the USA, and Mexico, which have a relatively low Q_n^r/X_n, gain, whereas Austria, the Czech Republic, Belgium, and Vietnam, which have a relatively large Q_n^r/X_n, lose. These results also confirm the existence of the positive coalition externality, as indicated in Section 3.2 and 3.3.

– Insert Table 13 here –

Tables 8 and 9 show other observations about the welfare consequences of labor mobility. In Scenario 3, we compare two different scenarios: one is when Canada, which has a relatively high import share from member countries, joins the TPP; and the other is when Canada does not join the TPP. Table 8 presents the results for mobile labor and Table 9 presents the results for immobile labor. First, Canada's loss is larger in the case of immobile labor, regardless of whether it joins the TPP. More interestingly, in the case of mobile labor, as shown in Table 8, Canada is better off if it does not join: its welfare decreases if it joins the TPP, but increases if it does not join the TPP. However, this is reversed in the case of immobile labor: even though Canada's welfare decreases regardless of accession to the TPP, its welfare decreases less if it joins the TPP. Next, we see how the welfare of Vietnam, which has the largest TR_n/X_n, is affected by accession to the TPP under Scenario 3. The results are shown in Tables 10 and 11. Unlike Canada, as predicted in (P1), Vietnam loses in both cases, as its TR_n/X_n and Q_n^r/X_n are the largest. However, in the case of mobile labor, its loss is much smaller if it does not join the TPP, whereas in the case of immobile labor, the magnitude of the welfare loss is not greatly affected by accession to the TPP.

– Insert Table 8 here –

– Insert Table 9 here –

– Insert Table 10 here –

– Insert Table 11 here –

4.3 Labor Mobility and Welfare Consequences

Our calibration results clearly confirm the theoretical predictions in Section 3. From our calibration results, we see that labor mobility adds another channel to the welfare change. Furthermore, tariff rates, $TR_n/X_n, Q_n^r/X_n$, and π_{ni} are the important factors that determine the welfare change for not only nonmember countries but also member countries. Intuitively, both nonmembers and members that have high tariff rates, Q_n^r/X_n, or TR_n/X_n would face a large decrease in TR_n or w_nL_n upon the establishment of a PTA. As a result, the price changes would not be large enough to increase welfare, and these countries could lose.

A good example with which to convey the intuition in (P1) is Belgium or Austria. According to Table 4, these two countries are in the top group in terms of the level of technology, although they do not gain even under Scenario 3 in the mobile labor case, unlike Switzerland, which as a similar level of technology. First of all, Switzerland's MFN rate is almost half that of these two countries (see Table 3), and Switzerland has a larger Y_n^0/Y_n and a smaller TR_n/X_n.

We also see that the set of countries that gain in the mobile labor case differs slightly from the set in the immobile labor case. An example is India, which gains in the immobile labor case but does not in the mobile labor case. According to Table 4 and Table 13, India has a large Y_n^0/Y_n as well as a large TR_n/X_n, but a low technological level. This demonstrates the intuition in (P2) and (P3).

5 Concluding Remarks

Within the framework presented in Eaton and Kortum (2002), we have considered how forming a PTA affects both nonmember countries and member countries by explicitly incorporating tariffs into their model. We show that a PTA decreases the price level of not only member but also nonmember countries. We also show that a PTA may generate a positive coalition externality such that some nonmember countries may gain from the establishment of the PTA. Our calibration results confirm the theoretical predictions of this paper.

Several recent extensions and applications of the Eaton-Kortum model of international trade assume perfect substitutability of labor between different industrial sectors (for example, Caliendo and Parro 2012). As our results show, different assumptions of labor mobility results in some difference in predicted outcomes. Various extensions are possible from here. It might be interesting to extend our analysis to models with multiple manufacturing sectors between which labor mobility is not complete. Also, as this model excludes capital flows, one option would involve modeling the investment decision in an individual's maximization problem. Another extension would be to consider a PTA as a coalition and study the process of coalition formation. As we have presented how welfare changes, our analysis could be useful for modeling each country's welfare.

Appendix I: DATA DESCRIPTION

Gross Output in Manufacturing. We began with INDSTAT data on gross output in manufacturing from the United Nations Industrial Development Organization. As INDSTAT data were not available for Canada and Thailand, we used data from their National Accounts. Last, because we were not able to obtain data for China, we computed the value using total GDP and the ratio between total GDP and manufacturing sector output from the National Accounts data.

The Labor Share in Costs and the Manufacturing Share. Our handling of the labor share in costs is more involved. Although there are several data sources, no single source provides a complete data set. If necessary, we used data from government statistics offices. First, we started with National Accounts Official Country Data from the United Nations Statistics Division. We obtained compensation details, including wages, for employees in manufacturing for Australia, India, Japan, Korea, the Philippines, Thailand, the UK, and the US. The data for Canada are for 2004, and we used the inflation rate data from the IMF as a proxy of labor costs.

The workforce data are obtained from Labor STAT from the International Labor Organization (ILO), labeled "Total Employment." We obtained the data labeled "Total Paid Employment" for India because "Total Employment" was not available. The data for wages are obtained from the US Bureau of Labor Statistics (BLS). For the countries for which wage data were not available from the US BLS, the data were obtained from Labor STAT from the ILO, with the exception of Vietnam. The data for wages and employment for Vietnam are from the Vietnamese government's statistics office.

The data on average years of schooling are taken from data on the educational attainment of the total population from Barro and Lee (v.2.0, July 2010). We use data on regional trade agreements and PTAs from the World Trade Organization (WTO).[13]

[13]http://rtais.wto.org/UI/PublicMaintainRTAHome.aspx

Appendix II: PROOFS

Proof of Lemma 1. When $w_n = \bar{w}_n$, $\mathbf{L}\left(\frac{w'_n}{w_n}\right) = \mathbf{0}_N$. Thus, $\mathbf{L}\left(\frac{c'_n}{c_n}\right) = \beta\mathbf{L}\left(\frac{w'_n}{w_n}\right) + (1-\beta)\,\mathbf{L}\left(\frac{p'_n}{p_n}\right)$ becomes:

$$\mathbf{L}\left(\frac{c'_n}{c_n}\right) = (1-\beta)\,\mathbf{L}\left(\frac{p'_n}{p_n}\right).$$

□

Proof of Proposition 1. From the definition of expenditure shares, $\mathbf{\Pi}$ is a row stochastic matrix[14]. From the Perron–Frobenius theorem (see Chapter 8 of Meyer (2000)), $\mathbf{\Pi}^\infty := \lim_{j\to\infty}\Pi^j$ is a constant matrix, and there is a unique row vector p satisfying $p\mathbf{\Pi} = p$. Observing that for any i we have the limit $\lim_{r\to\infty}(\mathbf{\Pi}^r)_{i,j} = p_j$, where p_j is the j-th element of the row vector p, we conclude that $\mathbf{\Pi}^\infty$ has identical row vectors and that the sum of elements in each row is equal to 1. Therefore, it must be the case that $\lim_{j\to\infty}(1-\beta)^j\,\mathbf{\Pi}^j = 0_{N\times N}$, and the derivatives vector is bounded for all feasible combinations of parameters. By applying a Taylor expansion to (27) in Lemma 1, we obtain:

$$\mathbf{L}\left(\frac{p'_n}{p_n}\right) = \sum_{j=1}^{\infty}(1-\beta)^j\,\mathbf{\Pi}^j\cdot\pi_{kl}\left(\frac{d'_{kl}}{d_{kl}}\right)\boldsymbol{\iota}_k. \tag{28}$$

Consider the term $(1-\beta)\left(\pi_{nk} + (1-\beta)\sum_{i=1}^N\pi_{ni}\pi_{ik} + (1-\beta)^2\sum_{i=1}^N\sum_{j=1}^N\pi_{nj}\pi_{ji}\pi_{ik} + ...\right)$. It is the (n,k)-th element of the matrix $\sum_{j=1}^\infty(1-\beta)^j\,\mathbf{\Pi}^j$. Each element is strictly positive. Thus, we obtain the desired result. □

Proof of Proposition 2. In the proof of Proposition 1, we further consider the term

$$(1-\beta)\left(\pi_{nk} + (1-\beta)\sum_{i=1}^N\pi_{ni}\pi_{ik} + (1-\beta)^2\sum_{i=1}^N\sum_{j=1}^N\pi_{nj}\pi_{ji}\pi_{ik} + ...\right).$$

This is the n-th element of the RHS matrix of (28). From this, it is clear that as π_{nk} becomes larger, $\frac{p'_n}{p_n}$ also becomes larger. □

Proof of Proposition 3. Observe (29). Proposition 1 indicates the first statement, and Proposition 2 indicates the second statement. □

Proof of Proposition 4. The following relationships hold when labor is mobile:

$$\begin{aligned}
w_n^O &= w_n^M = \bar{w}_n \quad \text{for some constant } \bar{w}_n;\\
\bar{L}_n &= L_n^O + L_n^M;\\
Y_n^O &= \bar{w}L_n^O;\\
Y_n^M &= \bar{w}L_n^M;\\
\bar{Y}_n &= Y_n^O + Y_n^M = \bar{w}_n\bar{L}_n.
\end{aligned}$$

[14] A row stochastic matrix is a square matrix, each row of which consists of nonnegative real numbers that sum to unity.

Given that total expenditure on manufacturing in each country, n, is given as $X_n = (1-\beta) Q_n^r + \alpha \left(Y_n^M + TR_n + Y_n^O\right)$, and because $\beta Q_n^r = w_n^M L_n^M$, in the mobile labor scenario we have:

$$\begin{aligned} \mathbf{L}(X_n) &= (1-\beta)\mathbf{L}(Q_n^r) + \alpha\left(\mathbf{L}(TR_n) + \mathbf{L}\left(\bar{Y}_n\right)\right) \\ \beta\mathbf{L}(Q_n^r) &= \mathbf{D}(\bar{w}_n)\mathbf{L}\left(L_n^M\right). \end{aligned} \tag{37}$$

From the second result in Appendix II, we have $\mathbf{L}\left(\frac{p_n'}{p_n}\right) = \mathbf{\Pi}\mathbf{L}\left(\frac{c_n'}{c_n}\right) + \frac{\pi_{kl}}{1+t_{kl}}\boldsymbol{\iota}_k$, and as $\mathbf{L}\left(\frac{c_n'}{c_n}\right) = (1-\beta)\mathbf{L}\left(\frac{p_n'}{p_n}\right)$. Then, $\mathbf{L}\left(\frac{p_n'}{p_n}\right)\mathbf{L}\left(\frac{p_n'}{p_n}\right) = (1-\beta)\mathbf{\Pi}\mathbf{L}\left(\frac{p_n'}{p_n}\right) + \frac{\pi_{kl}}{1+t_{kl}}\boldsymbol{\iota}_k$ implies that:

$$\mathbf{L}\left(\frac{p_n'}{p_n}\right) = \left(\mathbf{I} - (1-\beta)\mathbf{\Pi}\right)^{-1}\frac{\pi_{kl}}{1+t_{kl}}\boldsymbol{\iota}_k.$$

Substituting $\mathbf{L}\left(\frac{c_n'}{c_n}\right) = (1-\beta)\mathbf{L}\left(\frac{p_n'}{p_n}\right)$ into $\mathbf{L}\left(\frac{p_n'}{p_n}\right) = \mathbf{\Pi}\mathbf{L}\left(\frac{c_n'}{c_n}\right) + \frac{\pi_{kl}}{1+t_{kl}}\boldsymbol{\iota}_k$ completes the proof. □

Proof of Theorem 1. From the theorem in the supplementary note, in the mobile labor case, let:

$$\begin{aligned} &\mathcal{J}_1^M\left(\mathbf{D}\left(\tfrac{TR_n}{X_n}\right), \mathbf{D}\left(\tfrac{Q_n'}{X_n}\right), \mathbf{\Psi}\right) := \\ &\quad = \mathcal{T}\left(\alpha\left((1-\beta)\mathbf{D}\left(\tfrac{Q_n^r}{X_n}\right)\mathcal{T}\left((1-\beta)\mathbf{\Psi}\mathbf{D}\left(\tfrac{Q_n^r}{X_n}\right)\right)\mathbf{\Psi} + \mathbf{I}\right)\cdot\mathbf{D}\left(\tfrac{TR_n}{X_n}\right)\right); \end{aligned}$$

and

$$\begin{aligned} &\mathcal{J}_2^M\left((1-\beta)\mathbf{D}\left(\tfrac{Q_n'}{X_n}\right), \mathbf{\Psi}, \mathbf{\Lambda}, \mathbf{\Pi}, \tfrac{1-\theta t_{kl}}{t_{kl}(1+t_{kl})}\lambda_{kl}, \tfrac{\pi_{kl}}{1+t_{kl}}\boldsymbol{\iota}_k, \tfrac{\psi_{lk}}{1+t_{kl}}\boldsymbol{\iota}_l\right) := \\ &= \left(\theta\left[(1-\beta)\mathbf{D}\left(\tfrac{Q_n^r}{X_n}\right)\mathcal{T}\left((1-\beta)\mathbf{\Psi}\mathbf{D}\left(\tfrac{Q_n^r}{X_n}\right)\right)\left(\mathbf{\Psi} - (1-\beta)\mathbf{I}\right) + \left(\mathbf{I} - (1-\beta)\mathbf{\Lambda}\right)\right] \times \mathcal{T}\left((1-\beta)\mathbf{\Pi}\right)\right. \\ &\quad \left. + \tfrac{1-\theta t_{kl}}{t_{kl}(1+t_{kl})}\lambda_{kl}\mathbf{I}\right)\cdot\tfrac{\pi_{kl}}{1+t_{kl}}\boldsymbol{\iota}_k - (1-\beta)(1+\theta)\mathbf{D}\left(\tfrac{Q_n^r}{X_n}\right)\mathcal{T}\left((1-\beta)\mathbf{\Psi}\mathbf{D}\left(\tfrac{Q_n^r}{X_n}\right)\right)\cdot\tfrac{\psi_{lk}}{1+t_{kl}}\boldsymbol{\iota}_l. \end{aligned}$$

□

Proof of Proposition 5. Let Y_n^L denote the labor income in country n. As $TR_n = \sum_i \pi_{ni}\frac{t_{ni}}{1+t_{ni}}X_n$ for all countries, and $t_{ni} = 0$ for (n,i), we must have the following:

$$\begin{aligned} \tfrac{\mathrm{d}TR_n}{\mathrm{d}t_{kl}} &= 0, \forall n \neq k \\ \tfrac{\mathrm{d}TR_k}{\mathrm{d}t_{kl}} &= \left(\textstyle\sum_i \tfrac{t_{ki}}{1+t_{ki}}\tfrac{\mathrm{d}\pi_{ki}X_k}{\mathrm{d}t_{kl}}\right) + \left(\textstyle\sum_i\left(\tfrac{\mathrm{d}}{\mathrm{d}t_{kl}}\tfrac{t_{ki}}{1+t_{ki}}\right)\pi_{ki}X_k\right) \\ &= \tfrac{1}{(1+t_{kl})^2}\pi_{kl}X_k \\ &= \pi_{kl}X_k. \end{aligned}$$

When country k incrementally increases the tariff rate t_{kl} on imports from country l from zero, while every other country maintains zero tariffs on imports, tariff revenues for every country other than k remain unchanged at zero. Marginal tariff revenues for k are $\pi_{kl}X_k$.

Then, it must also be the case that nominal national income Y_n for countries other than k would remain unchanged, such that $\frac{\mathrm{d}\ln Y_n}{\mathrm{d}t_{kl}} = 0$ for $n \neq k$, whereas:

$$\frac{\mathrm{d}\ln Y_k}{\mathrm{d}t_{kl}} = \frac{1}{Y_n^L}\left(\frac{\mathrm{d}Y_n^L}{\mathrm{d}t_{kl}} + \frac{\mathrm{d}TR_n}{\mathrm{d}t_{kl}}\right) = \pi_{kl}\frac{X_k}{Y_k^L}.$$

When $t_{ni}=0$ for all (n,i), the following holds:

$$\begin{array}{rcl}\ln W_k' & = & \frac{\mathrm{d}\ln Y_k}{\mathrm{d}t_{kl}}-\alpha\frac{\mathrm{d}\ln p_k}{\mathrm{d}t_{kl}}\\ \frac{\mathrm{d}\ln Y_k}{\mathrm{d}t_{kl}} & = & \pi_{kl}\frac{X_k}{Y_k^L}\\ \frac{\mathrm{d}\ln p_k}{\mathrm{d}t_{kl}} & = & \pi_{kl}\left(1+(1-\beta)\,\pi_{kk}+(1-\beta)^2\sum_{i_1}\pi_{ki_1}\pi_{i_1k}+\cdots\right).\end{array} \tag{38}$$

We want to show that $\frac{\mathrm{d}\ln U_k}{\mathrm{d}t_{kl}}>0$, for at least one country k, such that every country k has an incentive to unilaterally deviate from the world free trade outcome. In other words, we wish to prove:

$$\frac{\mathrm{d}\ln Y_k}{d\,t_{kl}}>\alpha\pi_{kl}\frac{X_k}{Y_k^L}.$$

As $X_k=(1-\beta)\,Q_k+\alpha Y_k^L$, we can write the log derivative of W_k as:

$$\begin{array}{rcl}\ln W_k' & = & \alpha\pi_{kl}\left[\frac{X_k}{X_k-(1-\beta)Q_k}-\left(1+(1-\beta)\,\pi_{kk}+(1-\beta)^2\sum_{i_1}\pi_{ki_1}\pi_{i_1k}+...\right)\right]\\ & = & \alpha\pi_{kl}\left[\frac{(1-\beta)Q_k}{X_k-(1-\beta)Q_k}-\left((1-\beta)\,\pi_{kk}+(1-\beta)^2\sum_{i_1}\pi_{ki_1}\pi_{i_1k}+...\right)\right]\\ & = & \alpha\,(1-\beta)\,\pi_{kl}\left[\frac{Q_k}{X_k-(1-\beta)Q_k}-\left(\pi_{kk}+(1-\beta)\sum_{i_1}\pi_{ki_1}\pi_{i_1k}+...\right)\right].\end{array}$$

Next, notice that because $\mathbf{L}\,(Q_n)=\mathbf{\Pi}^T\mathbf{L}\,(X_n)$ and $\mathbf{L}\,(X_n)=\alpha\left[\mathbf{I}-(1-\beta)\,\mathbf{\Pi}^T\right]^{-1}\mathbf{L}\left(Y_n^L\right)$, substituting the latter into the former expression implies:

$$\mathbf{L}\,(Q_n)=\alpha\left[\mathbf{I}-(1-\beta)\,\mathbf{\Pi}^T\right]^{-1}\mathbf{\Pi}^T\mathbf{L}\left(Y_n^L\right).$$

This in turn implies:

$$Q_k=\alpha\sum_j\left[Y_j^L\left(\pi_{jk}+(1-\beta)\sum_{i_1}\pi_{ji_1}\pi_{i_1k}+(1-\beta)^2\sum_{i_1}\sum_{i_2}\pi_{ji_1}\pi_{i_1i_2}\pi_{i_2k}+...\right)\right].$$

We then would have:

$$\begin{array}{rcl}\frac{Q_k}{X_k-(1-\beta)Q_k} & = & \frac{\alpha\sum_j\left[Y_j^L\left(\pi_{jk}+(1-\beta)\sum_{i_1}\pi_{ji_1}\pi_{i_1k}+...\right)\right]}{\alpha Y_k^L}\\ & = & \sum_j\left[\left(\frac{Y_j^L}{Y_k^L}\right)\left(\pi_{jk}+(1-\beta)\sum_{i_1}\pi_{ji_1}\pi_{i_1k}+...\right)\right].\end{array}$$

For notational clarity, we define $\pi_{jk,m}=\sum_{i_1}...\sum_{i_m}(\pi_{ji_1}...\pi_{j_mk})$, which could be interpreted as follows. Suppose X_j^m is the total expenditure on manufacturing goods that have been traded m times between the originating country and the final country j, and X_{jk}^m is country j's expenditure on goods originating from country k that were traded m times before finally arriving at country j. Then, $\pi_{jk,m}=\frac{X_{jk}^m}{X_j^m}$.

For convenience, let $\pi_{jk,0}:=\pi_{jk}$. We can restate $\ln W_k^{*'}$ as follows:

$$\begin{array}{rcl}\ln W_k' & = & \frac{\alpha(1-\beta)\pi_{kl}}{Y_k^L}\left[\sum_j\left(Y_j^L\sum_{m=0}^{\infty}(1-\beta)^m\pi_{jk,m}\right)-Y_k^L\sum_{m=0}^{\infty}(1-\beta)^m\pi_{kk,m}\right]\\ & = & \frac{\alpha(1-\beta)\pi_{kl}}{Y_k^L}\left[\sum_{m=0}^{\infty}(1-\beta)^m\left(\sum_j Y_j^L\pi_{jk,m}-Y_k^L\pi_{kk,m}\right)\right]\\ & = & \frac{\alpha(1-\beta)\pi_{kl}}{Y_k^L}\left[\sum_{m=0}^{\infty}(1-\beta)^m\left(\sum_{j\neq k}Y_j^L\pi_{jk,m}+Y_j^L\pi_{kk,m}-Y_k^L\pi_{kk,m}\right)\right]\\ & = & \frac{\alpha(1-\beta)\pi_{kl}}{Y_k^L}\left[\sum_{m=0}^{\infty}(1-\beta)^m\left(\sum_{j\neq k}Y_j^L\pi_{jk,m}\right)\right].\end{array}$$

As it is the case that $\pi_{ni,m}>0$ for all $(n,i)\in N^2$ and $m\in\mathbb{N}$, and $Y_k^L>0$, it must be the case that $\ln W_k^{*'}>0$. □

Proof of Theorem 2. In the immobile labor case, let:

$$\begin{aligned} F_1(\mathbf{\Pi}, \mathbf{\Psi}) &= \beta\left(\mathbf{\Psi} - (1-\beta)\,\mathbf{I}\right)\left(\mathbf{I} - (1-\beta)\,\mathbf{\Pi}\right)^{-1}; \\ F_2(\mathbf{\Pi}, \mathbf{\Lambda}) &= \beta\Big(\left(\mathbf{I} - (1-\beta)\mathbf{\Lambda}\right)\left(\mathbf{I} - (1-\beta)\,\mathbf{\Pi}\right)^{-1}\mathbf{\Pi} - \mathbf{\Lambda}\Big). \end{aligned}$$

Then, let:

$$\begin{aligned} &\mathcal{J}_1^I\left(\alpha\mathbf{D}\left(\tfrac{TR_n}{X_n}\right), \chi\mathbf{D}\left(\tfrac{Q_n^r}{X_n}\right), \mathbf{\Psi}, \mathbf{\Lambda}, \mathbf{\Pi}\right) := \\ &\mathcal{T}\left(\chi\mathbf{\Psi}\mathbf{D}\left(\tfrac{Q_n^r}{X_n}\right) + \theta\beta\left(F_1(\mathbf{\Pi},\mathbf{\Psi})\mathbf{\Pi} - \mathbf{I}\right) + \alpha\mathbf{\Psi}\mathbf{D}\left(\tfrac{TR_n}{X_n}\right)\cdot\mathcal{T}\left(\mathbf{D}\left(\alpha\tfrac{TR_n}{X_n}\right)\right)\left(\chi\mathbf{D}\left(\tfrac{Q_n^r}{X_n}\right) + \theta F_2(\mathbf{\Pi},\mathbf{\Lambda})\right)\right); \end{aligned}$$

and

$$\begin{aligned} &\mathcal{J}_2^I\left(\alpha\mathbf{D}\left(\tfrac{TR_n}{X_n}\right), \mathbf{\Psi}, \mathbf{\Lambda}, \mathbf{\Pi}\right) := \\ &\quad\Big\{\alpha\mathbf{\Psi}\mathbf{D}\left(\tfrac{TR_n}{X_n}\right)\cdot\mathcal{T}\left(\alpha\mathbf{D}\left(\tfrac{TR_n}{X_n}\right)\right)\left(\theta\left(\mathbf{I} - (1-\beta)\mathbf{\Lambda}\right)\left(\mathbf{I} - (1-\beta)\,\mathbf{\Pi}\right)^{-1} + \tfrac{1-\theta t_{kl}}{t_{kl}(1+t_{kl})}\lambda_{kl}\cdot\mathbf{I}\right)\boldsymbol{\iota}_k \\ &\quad + F_1(\mathbf{\Pi},\mathbf{\Psi})\tfrac{\theta\pi_{kl}}{1+t_{kl}}\boldsymbol{\iota}_k - (1+\theta)\,\tfrac{\psi_{lk}}{1+t_{kl}}\boldsymbol{\iota}_l\Big\}. \end{aligned}$$

By replacing F_2 with $\mathcal{J}_3^I$, we obtain the desired result. □

Lemma 2. *In the case of mobile labor, the following holds:*

$$\mathbf{L}\left(\frac{TR_n'}{TR_n}\right) \approx \left(\mathbf{D}\left(\alpha\frac{Q_n}{X_n}\right) + \mathbf{D}\left((1-\beta)\frac{Q_n^r}{X_n}\right)\mathcal{T}\left(\mathbf{K}_1\right)\mathbf{\Psi}\mathbf{D}\left(\alpha\frac{Q_n}{X_n}\right)\right)\frac{1-\theta\bar{t}}{(1+\bar{t})}\lambda_{kl}\boldsymbol{\iota}_k.$$

Proof of Lemma 2. For simplicity of notation, let

$$\mathbf{K}_1 = \mathbf{\Psi}\mathbf{D}\left((1-\beta)\frac{Q_n^r}{X_n}\right) \quad \text{and} \quad \mathbf{K}_2 = \mathbf{\Psi}\mathbf{D}\left(\alpha\frac{TR_n}{X_n}\right).$$

By Theorem 1 and Assumption 1:

$$\mathbf{L}\left(\frac{TR_n'}{TR_n}\right) = \bar{t}\mathcal{T}\left(\bar{t}^{-1}\mathbf{D}\left(\alpha\frac{TR_n}{X_n}\right) + \bar{t}^{-1}\mathbf{D}\left((1-\beta)\frac{Q_n^r}{X_n}\right)\mathcal{T}\left(\mathbf{K}_1\right)\mathbf{\Psi}\mathbf{D}\left(\alpha\frac{TR_n}{X_n}\right)\right)\frac{1-\theta\bar{t}}{\bar{t}\,(1+\bar{t})}\lambda_{kl}\boldsymbol{\iota}_k.$$

As $TR_n \approx \bar{t}Q_n$, the Taylor expansion is well defined even if $\bar{t}$ is sufficiently small, and we obtain the result by approximating the Taylor series by the first term. □

Proof of Proposition 6. As $\bar{t}$ is sufficiently small, we can assume that $1 - \theta\bar{t} > 0$. Then, Lemma 2 completes the proof. □

Proof of Proposition 7. The proof is done by recursively applying Proposition 1 to each member country in A. Suppose that the initial price is p_1. p_1 becomes $\bar{p}_1$ once country 1 in A drops its tariffs on country 2, and then $\bar{p}_1$ becomes p_2 once country 2 drops its tariffs on country 1. From Proposition 1, $p_1 > p_2$. Then, consider another country in A and country 1 in a similar way. Recursively applying the same argument to all the countries in A, we obtain the desired result. □

Lemma 3. *In the case of immobile labor, the following holds:*

$$\mathbf{L}\left(\frac{TR_n'}{TR_n}\right) \approx \mathcal{T}\left(\alpha\mathbf{D}\left(\frac{Q_n}{X_n}\right)\right)\frac{1-\theta\bar{t}}{1+\bar{t}}\lambda_{kl}\boldsymbol{\iota}_k.$$

Proof of Lemma 3. This is a direct consequence of $TR_n \approx \bar{t}Q_n$, Theorem 2, and Assumption 1. □

Proof of Proposition 8. Consider the equilibrium welfare (23). By taking the derivative, we obtain:

$$\frac{W_n'}{W_n} = \frac{Y_n'}{Y_n} - \alpha\frac{p_n'}{p_n}, \tag{39}$$

where $Y_n' = (w_n\bar{L}_n)' + TR_n'$, $Y_n' = TR_n'$. Notice that $\frac{Y_n'}{Y_n} = \frac{TR_n}{Y_n} \cdot \frac{TR_n'}{TR_n}$. Under Assumption 1, and because $\frac{Q_n^r}{X_n}$ is sufficiently small, $\frac{TR_n}{Y_n}$ is thus sufficiently small; also, $\frac{TR_n'}{TR_n}$ is finite and reasonably small from Lemma 2 and Proposition 6. Therefore, we conclude that $\frac{Y_n'}{Y_n}$ is sufficiently small. By Proposition 2, when $\bar{t}$ goes down, $-\alpha\frac{p_n'}{p_n}$ is positive, and a country n with a relatively large π_{nk} has a larger $-\alpha\frac{p_n'}{p_n}$. Thus, we obtain the desired result.

Now, suppose that a PTA A has been formed, and that there is a country n that has not joined the PTA and has a sufficiently large π_{nk} and Y_n. Then, we number all the countries in A. We consider the entire tariff reduction process by considering all the possible combinations in A; that is, country k drops tariffs against country $k+1$, and then country $k+1$ drops tariffs against country k. Recursively applying the first argument, we obtain the desired result. □

Proof of Proposition 9. This is a direct consequence of Lemma 3. □

Group 1	Australia & New Zealand
Group 2	Canada & Chile
Group 3	Canada & Israel
Group 4	Chile & Mexico
Group 5	[Austria, Belgium, Denmark, Finland, France, Czech Republic, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain, Sweden, UK] & each of [Chile, Iceland, Israel, Mexico, Norway, Switzerland, Turkey]
Group 6	[Chile, Israel, Mexico, Turkey] & each of [Iceland, Norway, Switzerland]
Group 7	Turkey & Israel
Group 8	US & Chile
Group 9	US & Israel
Group 10	US & Canada & Mexico
Group 11	US & Australia

Table 2: EXISTING PTAs

[a] "[A, B, C] & each of [D, E]" means that countries A, B, and C each have a PTA with Country D, and again, the three countries each also have a PTA with Country E.

	MFN Applied		MFN Applied
Australia	3.9	**Japan**	2.8
Austria	3.9	**Malaysia**	7.9
Belgium	3.9	**Mexico**	13.3
Canada	3.7	**Netherlands**	3.9
Chile	6	**New Zealand**	3.2
China	9	**Norway**	3.9
Czech Rep.	3.9	**Philippines**	5.8
Denmark	3.9	**Poland**	3.9
Finland	3.9	**Portugal**	3.9
France	3.9	**Korea, Rep.**	6.6
Germany	3.9	**Russian Fed.**	11.1
Greece	3.9	**Spain**	3.9
Hungary	3.9	**Sweden**	3.9
Iceland	2.4	**Switzerland**	2.1
India	10.1	**Thailand**	8.2
Indonesia	6.8	**Turkey**	4.7
Ireland	3.9	**United Kingdom**	3.9
Israel	4.9	**USA**	3.3
Italy	3.9	**Vietnam**	15.7

Table 3: TARIFF (MFN APPLIED, SIMPLE AVERAGE)

	Level of Technology		Level of Technology
Australia	0.76	**Japan**	0.87
Austria	1.18	**Malaysia**	0.11
Belgium	1.17	**Mexico**	0.08
Canada	0.77	**Netherlands**	1.1
Chile	0.04	**New Zealand**	0.33
China	0.02	**Norway**	1.03
Czech Rep.	0.13	**Philippines**	0.02
Denmark	1.2	**Poland**	0.15
Finland	1.04	**Portugal**	0.25
France	1.11	**Korea, Rep.**	0.43
Germany	1.28	**Russian Fed.**	0.03
Greece	0.32	**Spain**	0.62
Hungary	0.13	**Sweden**	0.98
Iceland	0.51	**Switzerland**	1.18
India	0.02	**Thailand**	0.04
Indonesia	0.02	**Turkey**	0.12
Ireland	0.92	**UK**	1.13
Israel	0.31	**US**	1
Italy	0.98	**Vietnam**	0.03

Table 4: LEVEL OF TECHNOLOGY

Cheong and Takayama (2013) consider S_i to be a "source country effect." By defining $S_i = (1/\beta)\ln T_i - \theta \ln w_i$, given the estimates of θ, S_i, and β in their results, the technological level T_i is estimated from wage data.

	Mobile Labor					Immobile Labor				
Country	Δp_n	ΔY_n	ΔL_n	$\Delta \pi_{nn}$	ΔW_n	Δp_n	ΔY_n	Δw_n	$\Delta \pi_{nn}$	ΔW_n
Australia	-0.05	-9.44	-917.86	-0.08	-9.44	-1030.26	-113.92	-1025.25	-8.25	6.73
Austria	-0.04	-9.76	-848.12	-0.06	-9.75	-1027.81	-283.56	-1013.65	-24.54	-165.98
Belgium	-0.04	-12.89	-839.91	-0.06	-12.89	-1027.65	-369.59	-1011.12	-28.74	-256.88
Canada	-0.04	-7.05	-780.30	-0.07	-7.04	-1024.74	-146.79	-994.35	-53.28	-25.34
Chile*	-3.81	-5.28	-808.26	-6.09	-4.82	-1032.12	-81.17	-991.14	-72.02	45.47
China	-0.04	-25.91	-1483.59	-0.07	-25.91	-1034.17	-65.79	-1226.22	353.18	43.62
Czech Rep.	-0.04	-11.69	-851.94	-0.06	-11.68	-1027.97	-325.68	-1014.19	-23.88	-210.81
Denmark	-0.04	-8.95	-846.84	-0.06	-8.95	-1027.83	-257.46	-1012.90	-25.91	-138.64
Finland	-0.04	-11.19	-864.12	-0.07	-11.19	-1028.59	-282.62	-1015.61	-22.44	-166.37
France	-0.04	-3.84	-812.70	-0.06	-3.83	-1026.70	-139.49	-1005.00	-37.90	-13.51
Germany	-0.04	-6.77	-831.75	-0.06	-6.77	-1027.27	-223.38	-1010.18	-29.72	-101.77
Greece	-0.04	-3.84	-843.19	-0.07	-3.84	-1028.15	-101.07	-1008.74	-33.86	25.74
Hungary	-0.04	-34.67	-1077.75	-0.07	-34.67	-1029.24	-238.47	-1093.21	115.83	-145.99
Iceland	-0.04	-5.93	-811.69	-0.07	-5.92	-1027.68	-207.23	-998.57	-51.03	-84.74
India	-0.04	-21.12	-1499.58	-0.07	-21.11	-1037.56	-49.90	-1216.67	328.92	64.33
Indonesia	-0.05	-38.54	-1333.95	-0.07	-38.54	-1037.22	-141.79	-1154.44	213.53	-45.77
Ireland	-0.04	-10.41	-851.61	-0.07	-10.40	-1027.78	-260.77	-1013.99	-23.87	-143.77
Israel	-0.04	-5.66	-814.36	-0.07	-5.65	-1027.98	-173.88	-998.19	-52.25	-49.56
Italy	-0.04	-4.53	-825.02	-0.06	-4.53	-1027.28	-146.85	-1006.65	-36.02	-21.64
Japan	-0.04	-6.39	-891.81	-0.07	-6.39	-1031.81	-113.42	-1011.05	-36.26	10.69
Malaysia	-0.05	-119.47	-1456.59	-0.07	-119.47	-1038.59	-347.83	-1196.12	288.49	-323.15
Mexico	-0.05	-7.13	-904.15	-0.07	-7.12	-1027.50	-79.37	-1031.43	7.68	45.19
Netherlands	-0.04	-8.25	-844.87	-0.06	-8.24	-1027.76	-237.10	-1012.27	-26.90	-117.21
New Zealand*	-1.10	-16.74	-957.91	-1.76	-16.61	-1031.68	-163.38	-1038.84	13.45	-51.49
Norway	-0.04	-5.10	-848.36	-0.06	-5.09	-1028.15	-138.03	-1011.33	-29.27	-13.13
Philippines	-0.05	-62.48	-1275.82	-0.07	-62.48	-1035.11	-252.45	-1141.34	193.21	-181.13
Poland	-0.04	-23.28	-1066.73	-0.06	-23.28	-1029.87	-170.16	-1085.92	101.45	-64.78
Portugal	-0.04	-6.17	-842.19	-0.07	-6.17	-1027.67	-170.02	-1011.14	-28.73	-46.95
Rep. of Korea	-0.04	-52.26	-1282.70	-0.07	-52.26	-1037.92	-231.24	-1131.78	170.54	-150.86
Russian Fed.	-0.04	-44.80	-1566.34	-0.06	-44.79	-1037.91	-102.47	-1241.83	375.80	-10.00
Spain	-0.04	-4.24	-825.14	-0.07	-4.24	-1027.30	-129.42	-1006.13	-36.98	-3.66
Sweden	-0.04	-8.26	-856.42	-0.06	-8.25	-1028.25	-218.11	-1014.23	-24.28	-97.83
Switzerland	-0.04	-4.29	-786.19	-0.06	-4.28	-1027.07	-265.33	-993.79	-58.39	-141.64
Thailand	-0.04	-95.47	-1467.91	-0.07	-95.46	-1037.64	-269.56	-1205.30	307.43	-223.20
Turkey	-0.04	-5.40	-878.93	-0.06	-5.39	-1028.67	-109.73	-1019.98	-14.83	15.42
United Kingdom	-0.04	-4.49	-828.33	-0.06	-4.49	-1027.15	-135.39	-1008.30	-32.87	-10.06
USA	-0.05	-3.13	-772.78	-0.07	-3.12	-1025.85	-65.06	-987.08	-68.07	62.43
Vietnam	-0.04	-464.13	-2014.42	-0.07	-464.12	-1043.38	-629.85	-1401.74	675.79	-858.51

Table 5: TPP UNDER SCENARIO 1

	Mobile Labor					Immobile Labor				
Country	Δp_n	ΔY_n	ΔL_n	$\Delta \pi_{nn}$	ΔW_n	Δp_n	ΔY_n	Δw_n	$\Delta \pi_{nn}$	ΔW_n
Australia*	-132.37	-32.20	-239.33	-210.93	-16.08	-1061.37	-89.63	-806.64	-438.94	12.44
Austria	-60.72	-9.84	-1128.85	-96.97	-2.46	-1022.24	-285.52	-1020.64	-2.15	-169.50
Belgium	-60.88	-13.12	-1118.86	-97.22	-5.72	-1022.00	-372.12	-1018.04	-6.36	-261.24
Canada	-74.21	-8.91	-948.11	-118.46	0.11	-1016.61	-150.36	-1018.57	4.17	-30.23
Chile**	-165.88	-33.75	79.27	-264.06	-13.52	-1096.47	-54.57	-666.40	-726.29	52.04
China	-77.33	-27.43	-1582.59	-123.43	-18.04	-1024.15	-67.30	-1254.30	425.05	40.10
Czech Rep.	-61.16	-11.85	-1128.23	-97.67	-4.42	-1022.31	-328.07	-1021.62	-0.54	-214.91
Denmark	-60.96	-8.97	-1124.71	-97.35	-1.56	-1022.17	-259.27	-1020.01	-3.16	-141.98
Finland	-62.64	-11.21	-1126.42	-100.03	-3.60	-1022.69	-285.05	-1024.34	3.63	-170.52
France	-58.45	-3.72	-1114.12	-93.34	3.39	-1021.63	-140.13	-1009.61	-20.67	-15.19
Germany	-59.33	-6.78	-1125.31	-94.76	0.43	-1021.90	-224.60	-1015.69	-10.36	-104.32
Greece	-62.51	-3.58	-1103.66	-99.82	4.02	-1022.26	-101.91	-1017.18	-8.36	23.71
Hungary	-62.53	-42.66	-1333.04	-99.85	-35.08	-1023.34	-240.40	-1102.06	142.63	-149.09
Iceland	-64.99	-5.93	-1052.57	-103.77	1.97	-1021.22	-209.81	-1010.97	-17.54	-88.73
India	-75.17	-22.81	-1643.11	-120.00	-13.67	-1030.54	-50.61	-1234.05	374.73	62.26
Indonesia	-86.57	-39.86	-1400.80	-138.14	-29.35	-1030.18	-145.49	-1184.55	282.35	-51.69
Ireland	-62.67	-10.41	-1112.14	-100.08	-2.79	-1021.77	-263.16	-1023.28	3.39	-147.86
Israel	-65.56	-5.10	-1050.69	-104.68	2.87	-1021.51	-176.09	-1010.89	-18.21	-53.25
Italy	-59.66	-4.42	-1114.80	-95.28	2.84	-1022.03	-147.69	-1012.40	-16.43	-23.60
Japan*	-124.11	-23.87	4.06	-197.82	-8.75	-1047.52	-84.24	-750.97	-507.34	24.35
Malaysia*	-359.07	-333.08	1809.42	-568.25	-290.12	-1258.35	-42.68	-146.76	-1742.30	-280.91
Mexico	-71.31	-5.83	-1086.65	-113.85	2.84	-1019.52	-80.87	-1050.94	56.93	41.65
Netherlands	-60.93	-8.24	-1122.17	-97.30	-0.83	-1022.09	-238.78	-1019.45	-4.02	-120.38
New Zealand**	-182.78	-72.81	824.84	-290.83	-50.57	-1102.18	-72.87	-463.34	-1049.39	-13.23
Norway	-61.73	-4.95	-1117.41	-98.59	2.56	-1022.37	-139.08	-1019.02	-5.28	-15.43
Philippines	-84.31	-65.48	-1342.86	-134.54	-55.28	-1026.53	-258.81	-1170.09	262.10	-190.32
Poland	-61.53	-28.75	-1330.79	-98.26	-21.28	-1024.17	-171.37	-1093.64	125.78	-67.02
Portugal	-61.77	-6.03	-1112.12	-98.64	1.48	-1021.91	-171.37	-1019.19	-4.15	-49.64
Rep. of Korea	-76.18	-55.66	-1403.43	-121.61	-46.44	-1028.85	-235.10	-1150.67	221.85	-157.44
Russian Fed.	-64.83	-50.28	-1784.54	-103.53	-42.43	-1031.70	-103.26	-1251.49	405.68	-12.17
Spain	-60.44	-4.10	-1106.13	-96.53	3.25	-1021.80	-130.26	-1012.66	-15.56	-5.66
Sweden	-62.27	-8.15	-1121.87	-99.44	-0.58	-1022.41	-219.91	-1022.62	1.07	-101.14
Switzerland	-59.37	-4.35	-1082.14	-94.81	2.87	-1021.84	-266.83	-999.41	-39.15	-144.22
Thailand	-86.32	-98.28	-1524.50	-137.75	-87.86	-1029.73	-276.15	-1234.76	377.56	-233.38
Turkey	-62.67	-5.15	-1137.89	-100.08	2.47	-1022.77	-110.63	-1028.35	10.65	13.24
United Kingdom	-60.52	-4.35	-1109.05	-96.66	3.01	-1021.57	-136.31	-1015.11	-10.80	-12.17
USA	-105.42	-13.29	-460.97	-168.13	-0.45	-1042.01	-56.47	-856.82	-321.39	63.77
Vietnam*	-743.56	-1117.69	5007.28	-1162.81	-1034.07	-1582.79	305.03	678.85	-3166.05	-914.70

Table 6: TPP UNDER SCENARIO 2

	Mobile Labor					Immobile Labor				
Country	Δp_n	ΔY_n	ΔL_n	$\Delta \pi_{nn}$	ΔW_n	Δp_n	ΔY_n	Δw_n	$\Delta \pi_{nn}$	ΔW_n
Australia**	-177.65	-38.78	146.49	-282.70	-17.11	-1073.70	-76.31	-686.81	-655.63	20.54
Austria	-83.69	-10.65	-1239.40	-133.56	-0.46	-1025.11	-287.67	-1028.34	6.46	-171.84
Belgium	-84.33	-14.19	-1226.69	-134.58	-3.93	-1024.89	-375.21	-1026.51	3.61	-264.74
Canada*	-139.80	-28.45	-472.98	-222.73	-11.41	-1046.77	-127.06	-860.72	-323.00	-21.91
Chile**	-194.06	-34.11	9.53	-308.66	-10.40	-1097.94	-55.90	-682.57	-702.96	50.90
China	-104.24	-28.18	-1629.53	-166.25	-15.50	-1024.45	-67.91	-1265.73	446.34	39.27
Czech Rep.	-84.30	-12.82	-1237.22	-134.53	-2.56	-1025.16	-330.60	-1029.49	8.45	-217.73
Denmark	-84.37	-9.72	-1233.08	-134.64	0.55	-1025.09	-261.40	-1028.39	6.60	-144.27
Finland	-86.27	-12.10	-1230.60	-137.67	-1.60	-1025.42	-287.38	-1032.74	13.77	-173.13
France	-81.04	-4.02	-1230.25	-129.33	5.85	-1024.80	-141.17	-1017.13	-12.94	-16.07
Germany	-82.11	-7.36	-1239.40	-131.04	2.64	-1024.93	-226.30	-1023.36	-2.09	-106.04
Greece	-86.11	-3.85	-1206.92	-137.41	6.64	-1025.00	-102.74	-1025.43	1.48	22.99
Hungary	-86.15	-45.83	-1434.11	-137.47	-35.38	-1026.08	-242.19	-1110.27	152.68	-150.84
Iceland	-89.79	-6.42	-1149.23	-143.27	4.52	-1023.94	-211.81	-1020.60	-5.23	-90.70
India	-101.43	-23.63	-1709.77	-161.78	-11.29	-1032.25	-51.00	-1243.41	389.31	61.93
Indonesia	-114.52	-41.20	-1453.71	-182.58	-27.28	-1031.36	-146.98	-1196.65	302.82	-53.49
Ireland	-86.67	-11.23	-1214.59	-138.31	-0.68	-1024.56	-265.46	-1032.24	14.40	-150.39
Israel	-90.16	-4.97	-1146.76	-143.85	6.02	-1024.11	-177.63	-1019.75	-7.05	-54.85
Italy	-82.34	-4.78	-1228.36	-131.41	5.25	-1025.07	-148.77	-1019.76	-8.74	-24.55
Japan**	-160.90	-27.31	326.85	-256.17	-7.67	-1051.05	-74.15	-661.03	-659.07	31.52
Malaysia**	-418.11	-358.81	2416.90	-660.50	-308.75	-1284.87	9.65	33.18	-2016.85	-255.07
Mexico*	-345.87	-64.96	967.76	-547.58	-22.47	-1216.82	-32.18	-418.15	-1299.21	58.90
Netherlands	-84.31	-8.92	-1230.39	-134.55	1.35	-1025.01	-240.75	-1027.86	5.79	-122.47
New Zealand**	-225.04	-80.91	1247.92	-357.61	-53.49	-1113.42	-52.51	-333.89	-1258.06	0.45
Norway	-85.43	-5.34	-1222.54	-136.34	5.06	-1025.24	-140.25	-1027.65	5.00	-16.55
Philippines	-112.08	-67.70	-1389.89	-178.72	-54.11	-1027.10	-261.46	-1182.06	283.36	-193.59
Poland	-84.78	-30.91	-1434.90	-135.29	-20.61	-1026.99	-172.59	-1101.40	134.85	-68.08
Portugal	-85.70	-6.53	-1217.35	-136.75	3.91	-1024.87	-172.89	-1028.21	6.67	-51.16
Rep. of Korea	-102.24	-57.43	-1459.40	-163.08	-45.04	-1029.27	-237.04	-1160.14	238.64	-159.96
Russian Fed.	-88.65	-52.54	-1873.01	-141.45	-41.79	-1034.11	-103.88	-1258.99	415.51	-12.77
Spain	-84.26	-4.45	-1214.26	-134.47	5.81	-1024.96	-131.43	-1021.76	-4.99	-6.70
Sweden	-86.11	-8.81	-1226.08	-137.41	1.67	-1025.24	-221.81	-1031.47	11.83	-103.17
Switzerland	-82.05	-4.72	-1197.02	-130.95	5.27	-1024.88	-268.81	-1006.83	-31.37	-146.08
Thailand	-113.93	-101.03	-1571.05	-181.66	-87.27	-1030.30	-278.75	-1246.37	398.57	-236.86
Turkey	-85.82	-5.21	-1241.83	-136.95	5.25	-1025.38	-111.41	-1035.60	18.96	12.56
United Kingdom	-83.70	-4.69	-1218.80	-133.57	5.50	-1024.53	-137.37	-1023.02	-1.98	-13.13
USA**	-135.82	-13.90	-518.57	-216.40	2.67	-1044.48	-57.54	-872.98	-298.22	63.03
Vietnam**	-821.80	-1173.72	6067.88	-1282.01	-1081.46	-1624.76	419.88	934.44	-3472.22	-861.76

Table 7: TPP UNDER SCENARIO 3

	Canada In					Canada Out				
Country	Δp_n	ΔY_n	ΔL_n	$\Delta \pi_{nn}$	ΔW_n	Δp_n	ΔY_n	ΔL_n	$\Delta \pi_{nn}$	ΔW_n
Australia**	-177.65	-38.78	146.49	-282.70	-17.11	-154.28	-33.38	-16.48	-245.69	-14.57
Austria	-83.69	-10.65	-1239.40	-133.56	-0.46	-75.14	-10.60	-1198.92	-119.94	-1.46
Belgium	-84.33	-14.19	-1226.69	-134.58	-3.93	-75.64	-14.16	-1187.60	-120.75	-4.96
Canada	-139.80	-28.45	-472.98	-222.73	-11.41	-91.66	-9.80	-1007.98	-146.24	1.36
Chile**	-194.06	-34.11	9.53	-308.66	-10.40	-183.52	-33.99	34.33	-291.98	-11.58
China	-104.24	-28.18	-1629.53	-166.25	-15.50	-93.67	-27.85	-1609.10	-149.45	-16.46
Czech Rep.	-84.30	-12.82	-1237.22	-134.53	-2.56	-75.68	-12.76	-1197.31	-120.81	-3.55
Denmark	-84.37	-9.72	-1233.08	-134.64	0.55	-75.77	-9.69	-1193.06	-120.94	-0.47
Finland	-86.27	-12.10	-1230.60	-137.67	-1.60	-77.46	-12.06	-1192.49	-123.63	-2.63
France	-81.04	-4.02	-1230.25	-129.33	5.85	-72.69	-4.04	-1188.39	-116.04	4.81
Germany	-82.11	-7.36	-1239.40	-131.04	2.64	-73.73	-7.34	-1197.38	-117.69	1.64
Greece	-86.11	-3.85	-1206.92	-137.41	6.64	-77.31	-3.87	-1169.10	-123.40	5.54
Hungary	-86.15	-45.83	-1434.11	-137.47	-35.38	-77.35	-44.67	-1397.02	-123.46	-35.29
Iceland	-89.79	-6.42	-1149.23	-143.27	4.52	-80.46	-6.43	-1115.96	-128.42	3.37
India	-101.43	-23.63	-1709.77	-161.78	-11.29	-91.14	-23.34	-1686.24	-145.42	-12.26
Indonesia	-114.52	-41.20	-1453.71	-182.58	-27.28	-103.34	-40.73	-1435.05	-164.81	-28.18
Ireland	-86.67	-11.23	-1214.59	-138.31	-0.68	-77.77	-11.22	-1177.57	-124.13	-1.76
Israel	-90.16	-4.97	-1146.76	-143.85	6.02	-80.75	-4.92	-1114.23	-128.88	4.91
Italy	-82.34	-4.78	-1228.36	-131.41	5.25	-73.92	-4.78	-1187.07	-118.00	4.22
Japan**	-160.90	-27.31	326.85	-256.17	-7.67	-144.43	-24.63	244.15	-230.07	-7.01
Malaysia**	-418.11	-358.81	2416.90	-660.50	-308.75	-386.48	-336.33	2145.07	-611.11	-290.03
Mexico*	-345.87	-64.96	967.76	-547.58	-22.47	-334.68	-64.78	988.40	-530.05	-23.69
Netherlands	-84.31	-8.92	-1230.39	-134.55	1.35	-75.71	-8.89	-1190.49	-120.86	0.32
New Zealand**	-225.04	-80.91	1247.92	-357.61	-53.49	-203.83	-74.07	1075.54	-324.11	-49.25
Norway	-85.43	-5.34	-1222.54	-136.34	5.06	-76.73	-5.35	-1183.69	-122.47	3.99
Philippines	-112.08	-67.70	-1389.89	-178.72	-54.11	-100.93	-66.88	-1372.55	-160.98	-54.66
Poland	-84.78	-30.91	-1434.90	-135.29	-20.61	-76.12	-30.12	-1396.68	-121.50	-20.87
Portugal	-85.70	-6.53	-1217.35	-136.75	3.91	-76.95	-6.53	-1178.82	-122.82	2.83
Rep. of Korea	-102.24	-57.43	-1459.40	-163.08	-45.04	-91.95	-56.65	-1435.18	-146.70	-45.50
Russian Fed.	-88.65	-52.54	-1873.01	-141.45	-41.79	-79.54	-51.73	-1841.01	-126.94	-42.09
Spain	-84.26	-4.45	-1214.26	-134.47	5.81	-75.70	-4.46	-1174.25	-120.84	4.75
Sweden	-86.11	-8.81	-1226.08	-137.41	1.67	-77.34	-8.79	-1187.56	-123.45	0.62
Switzerland	-82.05	-4.72	-1197.02	-130.95	5.27	-73.58	-4.72	-1155.85	-117.46	4.24
Thailand	-113.93	-101.03	-1571.05	-181.66	-87.27	-102.80	-99.96	-1552.95	-163.96	-87.55
Turkey	-85.82	-5.21	-1241.83	-136.95	5.25	-77.00	-5.22	-1204.25	-122.90	4.15
United Kingdom	-83.70	-4.69	-1218.80	-133.57	5.50	-75.10	-4.71	-1179.09	-119.87	4.43
USA**	-135.82	-13.90	-518.57	-216.40	2.67	-124.03	-13.70	-509.53	-197.69	1.43
Vietnam**	-821.80	-1173.72	6067.88	-1282.01	-1081.46	-777.38	-1122.99	5538.29	-1214.42	-1035.45

Table 8: SCENARIO 3 IN THE MOBILE LABOR CASE, WHEN CANADA JOINS AND WHEN IT DOES NOT JOIN

	Canada In					Canada Out				
Country	Δp_n	ΔY_n	Δw_n	$\Delta \pi_{nn}$	ΔW_n	Δp_n	ΔY_n	Δw_n	$\Delta \pi_{nn}$	ΔW_n
Australia**	-1073.70	-76.31	-686.81	-655.63	20.54	-1065.00	-82.18	-739.66	-555.46	18.97
Austria	-1025.11	-287.67	-1028.34	6.46	-171.84	-1025.56	-287.39	-1027.33	3.87	-171.40
Belgium	-1024.89	-375.21	-1026.51	3.61	-264.74	-1025.37	-374.78	-1025.33	0.63	-264.10
Canada	-1046.77	-127.06	-860.72	-323.00	-21.91	-1020.65	-151.72	-1027.77	13.40	-31.41
Chile**	-1097.94	-55.90	-682.57	-702.96	50.90	-1098.73	-55.62	-679.20	-709.67	51.27
China	-1024.45	-67.91	-1265.73	446.34	39.27	-1025.26	-67.75	-1262.62	438.89	39.62
Czech Rep.	-1025.16	-330.60	-1029.49	8.45	-217.73	-1025.61	-330.26	-1028.44	5.74	-217.22
Denmark	-1025.09	-261.40	-1028.39	6.60	-144.27	-1025.55	-261.14	-1027.36	3.94	-143.86
Finland	-1025.42	-287.38	-1032.74	13.77	-173.13	-1025.91	-287.05	-1031.53	10.74	-172.62
France	-1024.80	-141.17	-1017.13	-12.94	-16.07	-1025.22	-141.05	-1016.26	-15.24	-15.84
Germany	-1024.93	-226.30	-1023.36	-2.09	-106.04	-1025.36	-226.11	-1022.52	-4.34	-105.72
Greece	-1025.00	-102.74	-1025.43	1.48	22.99	-1025.48	-102.62	-1024.25	-1.48	23.22
Hungary	-1026.08	-242.19	-1110.27	152.68	-150.84	-1026.56	-241.93	-1109.05	149.57	-150.45
Iceland	-1023.94	-211.81	-1020.60	-5.23	-90.70	-1024.53	-211.45	-1018.88	-9.35	-90.19
India	-1032.25	-51.00	-1243.41	389.31	61.93	-1032.88	-50.91	-1241.30	384.15	62.15
Indonesia	-1031.36	-146.98	-1196.65	302.82	-53.49	-1031.97	-146.60	-1193.57	295.93	-52.90
Ireland	-1024.56	-265.46	-1032.24	14.40	-150.39	-1025.07	-265.12	-1030.91	11.12	-149.87
Israel	-1024.11	-177.63	-1019.75	-7.05	-54.85	-1024.70	-177.33	-1017.99	-11.26	-54.42
Italy	-1025.07	-148.77	-1019.76	-8.74	-24.55	-1025.49	-148.64	-1018.89	-11.04	-24.31
Japan**	-1051.05	-74.15	-661.03	-659.07	31.52	-1047.85	-77.25	-688.64	-609.34	30.51
Malaysia**	-1284.87	9.65	33.18	-2016.85	-255.07	-1267.70	-14.73	-50.66	-1883.44	-258.61
Mexico*	-1216.82	-32.18	-418.15	-1299.21	58.90	-1217.79	-31.89	-414.45	-1306.11	59.30
Netherlands	-1025.01	-240.75	-1027.86	5.79	-122.47	-1025.46	-240.51	-1026.82	3.12	-122.08
New Zealand**	-1113.42	-52.51	-333.89	-1258.06	0.45	-1105.97	-61.19	-389.08	-1165.78	-2.66
Norway	-1025.24	-140.25	-1027.65	5.00	-16.55	-1025.71	-140.10	-1026.55	2.20	-16.28
Philippines	-1027.10	-261.46	-1182.06	283.36	-193.59	-1027.86	-260.74	-1178.82	275.92	-192.58
Poland	-1026.99	-172.59	-1101.40	134.85	-68.08	-1027.45	-172.42	-1100.31	132.03	-67.82
Portugal	-1024.87	-172.89	-1028.21	6.67	-51.16	-1025.35	-172.70	-1027.06	3.76	-50.83
Rep. of Korea	-1029.27	-237.04	-1160.14	238.64	-159.96	-1029.97	-236.56	-1157.79	233.00	-159.21
Russian Fed.	-1034.11	-103.88	-1258.99	415.51	-12.77	-1034.63	-103.77	-1257.66	412.02	-12.52
Spain	-1024.96	-131.43	-1021.76	-4.99	-6.70	-1025.40	-131.30	-1020.79	-7.51	-6.46
Sweden	-1025.24	-221.81	-1031.47	11.83	-103.17	-1025.72	-221.56	-1030.30	8.89	-102.77
Switzerland	-1024.88	-268.81	-1006.83	-31.37	-146.08	-1025.32	-268.54	-1005.83	-33.95	-145.70
Thailand	-1030.30	-278.75	-1246.37	398.57	-236.86	-1030.97	-278.05	-1243.26	391.41	-235.80
Turkey	-1025.38	-111.41	-1035.60	18.96	12.56	-1025.86	-111.29	-1034.42	15.99	12.81
United Kingdom	-1024.53	-137.37	-1023.02	-1.98	-13.13	-1024.99	-137.23	-1022.00	-4.63	-12.87
USA**	-1044.48	-57.54	-872.98	-298.22	63.03	-1045.59	-57.22	-868.12	-308.41	63.48
Vietnam**	-1624.76	419.88	934.44	-3472.22	-861.76	-1596.14	359.43	799.90	-3305.20	-873.87

Table 9: SCENARIO 3 IN THE IMMOBILE LABOR CASE, WHEN CANADA JOINS AND WHEN IT DOES NOT JOIN

	Vietnam In					Vietnam Out				
Country	Δp_n	ΔY_n	ΔL_n	$\Delta \pi_{nn}$	ΔW_n	Δp_n	ΔY_n	ΔL_n	$\Delta \pi_{nn}$	ΔW_n
Australia**	-177.65	-38.78	146.49	-282.70	-17.11	-148.44	-37.32	69.11	-236.43	-19.23
Austria	-83.69	-10.65	-1239.40	-133.56	-0.46	-62.39	-10.62	-1147.12	-99.63	-3.04
Belgium	-84.33	-14.19	-1226.69	-134.58	-3.93	-62.91	-14.14	-1135.61	-100.45	-6.50
Canada*	-139.80	-28.45	-472.98	-222.73	-11.41	-114.59	-27.23	-483.67	-182.70	-13.28
Chile**	-194.06	-34.11	9.53	-308.66	-10.40	-163.80	-32.76	-60.75	-260.77	-12.78
China	-104.24	-28.18	-1629.53	-166.25	-15.50	-78.53	-27.51	-1587.35	-125.34	-17.97
Czech Rep.	-84.30	-12.82	-1237.22	-134.53	-2.56	-62.85	-12.77	-1146.42	-100.36	-5.14
Denmark	-84.37	-9.72	-1233.08	-134.64	0.55	-62.92	-9.73	-1142.17	-100.48	-2.08
Finland	-86.27	-12.10	-1230.60	-137.67	-1.60	-64.31	-12.10	-1144.48	-102.70	-4.28
France	-81.04	-4.02	-1230.25	-129.33	5.85	-60.38	-4.08	-1132.39	-96.43	3.26
Germany	-82.11	-7.36	-1239.40	-131.04	2.64	-61.22	-7.37	-1143.21	-97.77	0.07
Greece	-86.11	-3.85	-1206.92	-137.41	6.64	-64.20	-3.94	-1121.35	-102.51	3.87
Hungary	-86.15	-45.83	-1434.11	-137.47	-35.38	-64.23	-43.21	-1350.30	-102.56	-35.43
Iceland	-89.79	-6.42	-1149.23	-143.27	4.52	-67.41	-6.37	-1070.03	-107.64	1.83
India	-101.43	-23.63	-1709.77	-161.78	-11.29	-73.95	-23.19	-1669.89	-118.05	-14.20
Indonesia	-114.52	-41.20	-1453.71	-182.58	-27.28	-82.69	-41.10	-1442.52	-131.97	-31.06
Ireland	-86.67	-11.23	-1214.59	-138.31	-0.68	-64.84	-11.20	-1128.93	-103.53	-3.32
Israel	-90.16	-4.97	-1146.76	-143.85	6.02	-67.71	-5.45	-1068.46	-108.11	2.79
Italy	-82.34	-4.78	-1228.36	-131.41	5.25	-61.26	-4.84	-1134.30	-97.83	2.61
Japan**	-160.90	-27.31	326.85	-256.17	-7.67	-131.15	-26.20	222.60	-208.99	-10.22
Malaysia**	-418.11	-358.81	2416.90	-660.50	-308.75	-368.08	-349.76	1953.05	-582.35	-305.77
Mexico*	-345.87	-64.96	967.76	-547.58	-22.47	-310.08	-62.83	865.71	-491.46	-24.80
Netherlands	-84.31	-8.92	-1230.39	-134.55	1.35	-62.87	-8.94	-1139.71	-100.40	-1.30
New Zealand**	-225.04	-80.91	1247.92	-357.61	-53.49	-197.47	-79.21	1182.27	-314.05	-55.19
Norway	-85.43	-5.34	-1222.54	-136.34	5.06	-63.72	-5.41	-1134.58	-101.75	2.35
Philippines	-112.08	-67.70	-1389.89	-178.72	-54.11	-79.57	-67.64	-1386.49	-126.99	-58.01
Poland	-84.78	-30.91	-1434.90	-135.29	-20.61	-63.21	-29.12	-1348.11	-100.93	-21.45
Portugal	-85.70	-6.53	-1217.35	-136.75	3.91	-64.17	-6.55	-1128.40	-102.47	1.25
Rep. of Korea	-102.24	-57.43	-1459.40	-163.08	-45.04	-75.33	-56.23	-1416.89	-120.25	-47.11
Russian Fed.	-88.65	-52.54	-1873.01	-141.45	-41.79	-65.95	-50.75	-1801.25	-105.31	-42.76
Spain	-84.26	-4.45	-1214.26	-134.47	5.81	-63.17	-4.49	-1121.73	-100.87	3.20
Sweden	-86.11	-8.81	-1226.08	-137.41	1.67	-64.27	-8.85	-1139.00	-102.62	-1.04
Switzerland	-82.05	-4.72	-1197.02	-130.95	5.27	-61.10	-4.73	-1100.97	-97.57	2.70
Thailand	-113.93	-101.03	-1571.05	-181.66	-87.27	-80.49	-101.37	-1571.16	-128.46	-91.67
Turkey	-85.82	-5.21	-1241.83	-136.95	5.25	-63.86	-5.30	-1156.63	-101.97	2.47
United Kingdom	-83.70	-4.69	-1218.80	-133.57	5.50	-62.58	-4.73	-1126.39	-99.94	2.89
USA**	-135.82	-13.90	-518.57	-216.40	2.67	-109.98	-13.20	-537.72	-175.38	0.20
Vietnam	-821.80	-1173.72	6067.88	-1282.01	-1081.46	-77.56	-488.32	-2132.42	-123.80	-479.34

Table 10: SCENARIO 3 IN THE MOBILE LABOR CASE, WHEN VIETNAM JOINS AND WHEN IT DOES NOT JOIN

	Vietnam In					Vietnam Out				
Country	Δp_n	ΔY_n	Δw_n	$\Delta\pi_{nn}$	ΔW_n	Δp_n	ΔY_n	Δw_n	$\Delta\pi_{nn}$	ΔW_n
Australia**	-1073.70	-76.31	-686.81	-655.63	20.54	-1070.48	-78.97	-710.69	-611.77	18.52
Austria	-1025.11	-287.67	-1028.34	6.46	-171.84	-1022.94	-286.44	-1023.94	2.48	-170.71
Belgium	-1024.89	-375.21	-1026.51	3.61	-264.74	-1022.73	-373.59	-1022.07	-0.48	-263.15
Canada*	-1046.77	-127.06	-860.72	-323.00	-21.91	-1044.92	-128.91	-873.22	-298.60	-23.31
Chile**	-1097.94	-55.90	-682.57	-702.96	50.90	-1092.98	-58.11	-709.61	-651.33	49.32
China	-1024.45	-67.91	-1265.73	446.34	39.27	-1022.95	-67.31	-1254.38	427.43	39.93
Czech Rep.	-1025.16	-330.60	-1029.49	8.45	-217.73	-1023.00	-329.16	-1025.02	4.29	-216.36
Denmark	-1025.09	-261.40	-1028.39	6.60	-144.27	-1022.93	-260.27	-1023.92	2.46	-143.25
Finland	-1025.42	-287.38	-1032.74	13.77	-173.13	-1023.31	-286.07	-1028.02	9.10	-171.89
France	-1024.80	-141.17	-1017.13	-12.94	-16.07	-1022.54	-140.61	-1013.08	-16.14	-15.73
Germany	-1024.93	-226.30	-1023.36	-2.09	-106.04	-1022.72	-225.38	-1019.20	-5.58	-105.27
Greece	-1025.00	-102.74	-1025.43	1.48	22.99	-1022.88	-102.27	-1020.78	-3.05	23.25
Hungary	-1026.08	-242.19	-1110.27	152.68	-150.84	-1023.96	-241.16	-1105.56	147.88	-149.91
Iceland	-1023.94	-211.81	-1020.60	-5.23	-90.70	-1022.06	-210.77	-1015.61	-10.78	-89.78
India	-1032.25	-51.00	-1243.41	389.31	61.93	-1030.11	-50.71	-1236.26	379.72	62.07
Indonesia	-1031.36	-146.98	-1196.65	302.82	-53.49	-1029.03	-145.69	-1186.14	287.42	-52.11
Ireland	-1024.56	-265.46	-1032.24	14.40	-150.39	-1022.52	-264.26	-1027.56	9.69	-149.25
Israel	-1024.11	-177.63	-1019.75	-7.05	-54.85	-1022.25	-176.79	-1014.90	-12.38	-54.23
Italy	-1025.07	-148.77	-1019.76	-8.74	-24.55	-1022.83	-148.15	-1015.51	-12.33	-24.14
Japan**	-1051.05	-74.15	-661.03	-659.07	31.52	-1048.69	-77.04	-686.80	-613.74	29.18
Malaysia**	-1284.87	9.65	33.18	-2016.85	-255.07	-1270.79	-17.80	-61.21	-1874.26	-271.14
Mexico*	-1216.82	-32.18	-418.15	-1299.21	58.90	-1208.48	-34.70	-450.86	-1238.18	57.24
Netherlands	-1025.01	-240.75	-1027.86	5.79	-122.47	-1022.85	-239.70	-1023.38	1.63	-121.55
New Zealand**	-1113.42	-52.51	-333.89	-1258.06	0.45	-1110.68	-55.99	-356.03	-1221.63	-2.33
Norway	-1025.24	-140.25	-1027.65	5.00	-16.55	-1023.10	-139.63	-1023.07	0.64	-16.11
Philippines	-1027.10	-261.46	-1182.06	283.36	-193.59	-1024.88	-259.00	-1170.95	266.70	-190.79
Poland	-1026.99	-172.59	-1101.40	134.85	-68.08	-1024.84	-171.88	-1096.90	130.53	-67.54
Portugal	-1024.87	-172.89	-1028.21	6.67	-51.16	-1022.78	-172.14	-1023.74	2.41	-50.56
Rep. of Korea	-1029.27	-237.04	-1160.14	238.64	-159.96	-1027.38	-235.61	-1153.16	229.14	-158.35
Russian Fed.	-1034.11	-103.88	-1258.99	415.51	-12.77	-1032.04	-103.49	-1254.23	410.28	-12.47
Spain	-1024.96	-131.43	-1021.76	-4.99	-6.70	-1022.82	-130.89	-1017.55	-8.68	-6.35
Sweden	-1025.24	-221.81	-1031.47	11.83	-103.17	-1023.11	-220.81	-1026.79	7.26	-102.29
Switzerland	-1024.88	-268.81	-1006.83	-31.37	-146.08	-1022.65	-267.68	-1002.59	-34.95	-145.15
Thailand	-1030.30	-278.75	-1246.37	398.57	-236.86	-1027.84	-276.15	-1234.76	381.06	-233.65
Turkey	-1025.38	-111.41	-1035.60	18.96	12.56	-1023.25	-110.92	-1030.99	14.50	12.87
United Kingdom	-1024.53	-137.37	-1023.02	-1.98	-13.13	-1022.41	-136.80	-1018.80	-5.73	-12.75
USA**	-1044.48	-57.54	-872.98	-298.22	63.03	-1042.36	-58.47	-887.19	-270.34	62.22
Vietnam	-1624.76	419.88	934.44	-3472.22	-861.76	-1034.15	-641.26	-1427.13	744.17	-879.07

Table 11: SCENARIO 3 IN THE IMMOBILE LABOR CASE, WHEN VIETNAM JOINS AND WHEN IT DOES NOT JOIN

	$\hat{\pi}_{n1}$		$\hat{\pi}_{n2}$		$\hat{\pi}_{n3}$
Australia	0.018277	**Rep. of Korea**	0.261921	**Canada**	0.593929
USA	0.010329	**China**	0.242336	**Mexico**	0.463296
Japan	0.008833	**Thailand**	0.236344	**Rep. of Korea**	0.43549
Indonesia	0.008538	**Philippines**	0.223439	**New Zealand**	0.431113
Philippines	0.008323	**Indonesia**	0.212498	**Australia**	0.430268
Malaysia	0.007953	**Vietnam**	0.202111	**Philippines**	0.425047
Thailand	0.007931	**New Zealand**	0.201164	**China**	0.41792
India	0.007655	**USA**	0.166612	**Indonesia**	0.411291
Rep. of Korea	0.007482	**India**	0.159818	**Thailand**	0.406151
Mexico	0.007045	**Malaysia**	0.155417	**Chile**	0.388145
China	0.006866	**Australia**	0.152034	**Vietnam**	0.369746
Vietnam	0.006555	**Mexico**	0.129129	**India**	0.364531
Canada	0.006148	**Chile**	0.128124	**Malaysia**	0.340575
Spain	0.005552	**Russian Fed.**	0.118548	**USA**	0.336217
Russian Fed.	0.005534	**Israel**	0.100732	**Israel**	0.3018
Israel	0.005143	**Turkey**	0.100161	**Iceland**	0.289671
United Kingdom	0.005134	**Greece**	0.097114	**Russian Fed.**	0.279875
Chile	0.005121	**Finland**	0.096892	**Japan**	0.268555
Portugal	0.005098	**Sweden**	0.095128	**United Kingdom**	0.23896
Italy	0.005063	**Canada**	0.094963	**Turkey**	0.236465
Ireland	0.005029	**Iceland**	0.094654	**Ireland**	0.232917
Greece	0.004996	**Germany**	0.093819	**Spain**	0.232623
Finland	0.004944	**Hungary**	0.092591	**Greece**	0.230791
Iceland	0.0049	**United Kingdom**	0.091865	**Finland**	0.230392
Sweden	0.004894	**Norway**	0.091862	**Portugal**	0.228356
Germany	0.004838	**Poland**	0.090846	**Sweden**	0.227581
Norway	0.004773	**Spain**	0.090688	**Germany**	0.225971
Hungary	0.004742	**Ireland**	0.089638	**Italy**	0.225019
Turkey	0.004675	**Portugal**	0.089113	**Norway**	0.22105
Poland	0.004674	**Italy**	0.088747	**Hungary**	0.220237
Denmark	0.004488	**Austria**	0.086706	**Poland**	0.215897
Austria	0.004441	**Denmark**	0.086381	**Denmark**	0.20786
Czech Rep.	0.004375	**Czech Rep.**	0.085423	**Austria**	0.206238
France	0.004361	**Netherlands**	0.084107	**Czech Rep.**	0.203188
Netherlands	0.004354	**Belgium**	0.081592	**Netherlands**	0.202553
Belgium	0.004208	**France**	0.076744	**Belgium**	0.199571
Switzerland	0.004056	**Switzerland**	0.071338	**France**	0.199032
New Zealand	0.003014	**Japan**	0.058896	**Switzerland**	0.182781

Table 12: IMPORT SHARE OF EACH COUNTRY FROM PTA MEMBER COUNTRIES UNDER EACH SCENARIO

[a] $\hat{\pi}_{ns}$ denotes the import share of country i from member countries in Scenario s of the TPP.

[b] Countries are sorted from highest $\hat{\pi}_n$ to lowest.

	Y_n^O/Y_n		Q_n^r/X_n		TR_n/X_n
India	0.958984774	**India**	0.725906698	**Switzerland**	0.004878
China	0.946343705	**China**	0.804391108	**France**	0.008119
USA	0.934092868	**USA**	0.860502269	**Iceland**	0.008403
Mexico	0.92304644	**Mexico**	0.899971515	**Germany**	0.008792
Chile	0.918107545	**Chile**	0.91507439	**Italy**	0.008994
Russian Fed.	0.917488737	**Russian Fed.**	0.916872356	**Israel**	0.009527
Greece	0.899808236	**Greece**	0.960966803	**Spain**	0.009543
Turkey	0.89241618	**Turkey**	0.976017955	**United Kingdom**	0.009636
Australia	0.888888907	**Australia**	0.982640186	**Austria**	0.009816
Japan	0.887823186	**Japan**	0.984575911	**Denmark**	0.00993
Indonesia	0.877175402	**Indonesia**	1.002423877	**Netherlands**	0.009951
Spain	0.871370298	**Spain**	1.011138786	**Belgium**	0.010025
United Kingdom	0.86571999	**United Kingdom**	1.019026168	**Czech Rep.**	0.010199
Norway	0.863519782	**Norway**	1.021951773	**Portugal**	0.010404
France	0.861207635	**France**	1.024943541	**Norway**	0.010506
Italy	0.854115586	**Italy**	1.03362671	**Sweden**	0.010704
Canada	0.852377842	**Canada**	1.035647952	**Greece**	0.010851
Poland	0.84330089	**Poland**	1.045590855	**Finland**	0.011108
New Zealand	0.842729984	**New Zealand**	1.046183834	**Ireland**	0.011339
Portugal	0.83185362	**Portugal**	1.056824739	**Turkey**	0.013624
Israel	0.82580739	**Israel**	1.062247411	**Chile**	0.014141
Rep. of Korea	0.795682001	**Rep. of Korea**	1.085077095	**Canada**	0.014595
Iceland	0.792468659	**Iceland**	1.087168998	**USA**	0.014639
Sweden	0.784955471	**Sweden**	1.091845139	**Japan**	0.015242
Hungary	0.781862045	**Hungary**	1.093687827	**Australia**	0.022067
Germany	0.778867224	**Germany**	1.095428355	**Mexico**	0.024405
Philippines	0.778812925	**Philippines**	1.095459528	**New Zealand**	0.025298
Thailand	0.776351434	**Thailand**	1.09685859	**Poland**	0.033158
Netherlands	0.765773194	**Netherlands**	1.102573192	**Hungary**	0.0351
Denmark	0.745814123	**Denmark**	1.112192795	**Rep. of Korea**	0.047393
Ireland	0.742827076	**Ireland**	1.113517013	**Philippines**	0.052587
Switzerland	0.733015191	**Switzerland**	1.117678723	**Indonesia**	0.05585
Finland	0.721725375	**Finland**	1.122138441	**Malaysia**	0.066877
Austria	0.720257423	**Austria**	1.122694352	**Thailand**	0.068931
Malaysia	0.709203909	**Malaysia**	1.126716395	**China**	0.077092
Czech Rep.	0.678874917	**Czech Rep.**	1.136447824	**India**	0.081274
Belgium	0.634475248	**Belgium**	1.14799553	**Russian Fed.**	0.082032
Vietnam	0.550661991	**Vietnam**	1.163951199	**Vietnam**	0.120785

Table 13: Y_n^O/Y_n, Q_n^r/X_n and TR_n/X_n

[a] Countries are sorted from highest Y_n^O/Y_n to lowest, and from lowest to highest for the other two variables.

References

Aghion, P., P. Antràs, and E. Helpman, 'Negotiating Free Trade,' *Journal of International Economics* **73** (2007), 1–30.

Al-Najjar, N. I., 'Aggregation and the Law of Large Numbers in Large Economies,' *Games and Economic Behavior* **47** (2004), 1–35.

Alvarez, F., and R. Lucas, 'General Equilibrium Analysis of the Eaton–Kortum Model of International Trade,' *Journal of Monetary Economics* **54** (2007), 1726–1768.

Anderson, J. E., 'A Theoretical Foundation for the Gravity Equation,' *American Economic Review* **69** (1979), 106–116.

Anderson, J. E., and E. van Wincoop, 'Gravity with Gravitas: A Solution to the Border Puzzle,' *American Economic Review* **83** (2003), 170–192.

Arkolakis, C., A. Costinot, and A. Rodríguez-Clare, 'New Trade Models, Same Old Gains?,' *American Economic Review* **102** (2012), 94–130.

Armington, P., 'A Theory of Demand for Products Distinguished by Place of Products Distinguished by Place of Production,' *IMF Staff Papers* **16** (1969), 159–176.

Baier, S. L., and J. H. Bergstrand, 'Do Free Trade Agreements Actually Increase Members' International Trade?' *Journal of International Economics* **71** (2007), 72–95.

Bergstrand, J. H., 'The Gravity Equation in International Trade: Some Microeconomic Foundations and Empirical Evidence,' *Review of Economics and Statistics* **67** (1985), 474–481.

Bils, M., and P. Klenow, 'Does Schooling Cause Growth?' *American Economic Review* **39** (2000), 1160–1183.

Brown, D. K., A. E. Deardorff, and R. M. Stern, 'North American Integration,' *Economic Journal* **102** (1992), 1507–1518.

Burbidge, J. B., J. DePater, G. Meyers, and A. Sengupta, 'A Coalition-Formation Approach to Equilibrium Federations and Trading Blocs,' *American Economic Review* **87** (1997), 940–956.

Caliendo, L., and F. Parro, 'Estimates of the Trade and Welfare Effects of NAFTA,' *NBER Working Paper No. 18508* (2012).

Cheong, J., and S. Takayama, 'Who Gains the Most in Preferential Trade Agreements?' *School of Economics Discussion Paper No. 475* (2013).

Cheong, J., S. Takayama, and T. Yeo, 'Preferential Trade Agreements and Welfare: Technical Note,' *mimeo* (2013).

Costinot, A., D. Donaldson., and I. Komunjer, ‘What Goods Do Countries Trade? A Quantitative Exploration of Ricardo’s Ideas,’ *Review of Economic Studies* **79** (2012), 581–608.

Eaton, J., and S. Kortum, ‘Technology, Geography and Trade,’ *Econometrica* **70** (2002), 1741–1779.

Feenstra, R. C., and G. Hanson, ‘Globalization, Outsourcing and Wage Inequality,’ *American Economic Review* **86** (1996), 240–245.

Fabinger, M., ‘Trade and Interdependence in a Spatially Complex World,’ *mimeo* (2012).

Helpman, E., M. Melitz, and Y. Rubinstein, ‘Estimating Trade Flows: Trading Partners and Trading Volumes,’ *The Quarterly Journal of Economics* **123** (2008), 441–487.

Hummels, D., J. Ishii, and K.-M. Yi, ‘The Nature and Growth of Vertical Specialization in World Trade,’ *Journal of International Economics* **54** (2001), 75–96.

Jones, R. W., ‘Comparative Advantage and the Theory of Tariffs: A Multi-Country, Multi-Commodity Model,’ *Review of Economic Studies* **28** (1961), 161–175.

Kehoe, P., and T. J. Kehoe, ‘Capturing NAFTA’s Impact with Applied General Equilibrium Models,’ *Federal Reserve Bank of Minneapolis Quarterly Review* **18** (1994) 17–34.

Magee, C. S., ‘New Measures of Trade Creation and Trade Diversion,’ *Journal of International Economics* **75** (2008), 349–362.

Meyer, C., *Matrix Analysis and Applied Linear Algebra*, Philadelphia: Society for Industrial and Applied Mathematics (2000).

Tinbergen, J., *Shaping the World Economy*, New York: The Twentieth Century Fund (1962).

Viner, J., *The Customs Union Issue*, New York: Carnegie Endowment for International Peace (1950).

Wilson, C. A., ‘On the General Structure of Ricardian Models with a Continuum of Goods: Applications to Growth Tariff Theory, and Technical Change,’ *Econometrica* **48** (1980) 1675–1702.