The Welfare Effect of Foreign Productivity and Quality Growth: A Quantitative Analysis*

Taiji Furusawa† Yoichi Sugita‡

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Abstract

Is the growth of emerging economies a benefit or a threat for the rest of the world? Ikema (1969, *Oxford Economic Papers*) theoretically demonstrated that a country's productivity growth normally benefits other countries. Ohyama (1998, *Mita Journal of Economics*; 2010, *Keio Economic Studies*) demonstrated that a country's quality growth may hurt other countries if consumer preference exbihits home bias for quality. Using a multi-country, multi-industry Ricardian model of global value chains allowing quality home bias, this paper estimates the productivity growth and the quality growth of emerging economies during 1995–2007 and quantifies their welfare effects on Japan and other countries.

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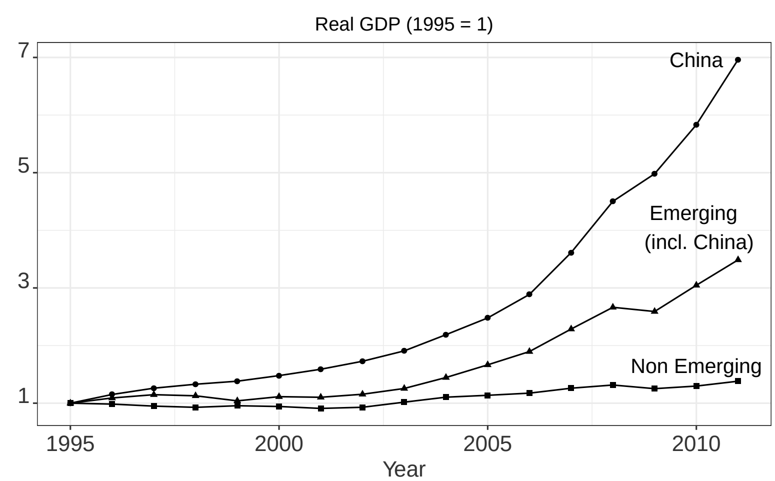
†Graduate School of Economics, University of Tokyo, Japan, (furusawa@e.u-tokyo.ac.jp)

‡Graduate School of Economics, Hitotsubashi University, Japan, (yoichi.sugita@r.hit-u.ac.jp)

1 Introduction

Since the late 1980s, the world economy has experienced the third wave of globalization. A notable feature that distinguishes it from the first wave before WWI and the second wave during 1950s–80s, is the participation and growth of developing economies through the global value chains. As shown in Figure 1, several those countries have quickly grown, gained export shares, and become to be called "emerging economies". Whether the growth of emerging economies benefit or hurt the rest of the world has been a central question in the debates of pro- and anti-globalization policies.

Figure 1: Real GDP Growth of China and emerging economies



Data source: WIOD. Note: emerging economies are Brazil, China, Czech Republic, Hungary, India, Mexico, Poland, Russia, Taiwan and Turkey.

The literature of international trade theory has a long history of analyzing this question. Hicks (1953) suggested in his famous inaugural lecture at Oxford that a country's uniform productivity growth across industries benefits other countries. One country's productivity growth that reduces costs improves foreign country's terms of trade and benefits foreign consumers. Ikema (1969) provided a formal proof for Hicks's claim using a simple diagram for neoclassical economies with homothetic preferences.[1] This Hicks-Ikema Theorem has been scrutinized and generalized under various settings (e.g., Kemp and Shimomura, 1988; Kemp, Ng and Shimomura, 1993).[2]

[1] Kemp (1955) provide a formal proof for Keynesian economies with unemployment.

[2] For instance, Samuelson (2004) emphasized that productivity growth may hurt other countries if it occurs in

The drivers of economic growth include not only cost reducing innovation but also quality improving innovation. Ohyama (1998; 2010) theoretically demonstrated that "[t]he effects of cost-reducing and quality-improving innovation on the terms of trade and economics welfare are revealed almost dramatically opposite."(Ohyama, 2010, abstract). Namely, one country's economic growth may hurt other countries' welfare in contrast to the Hicks-Ikema Theorem. The result holds when consumer preference exhibits home bias for quality: quality improvement of a product is less appreciated by foreign consumers than by domestic consumers, possibly because of the difference in culture and lifestyle. We discuss some examples in section 2. As an extreme case, suppose that only domestic consumers appreciate quality improvement, but foreign consumers do not at all. Then, increased domestic demands raise the world price, which unambiguously hurt foreign consumers who do not appreciate the quality improvement.

The theoretical literature suggests that the welfare effect of emerging countries' growth on the rest of the world depends on the distribution of productivity growth across industries and the quality home bias. This paper is the first to quantify the welfare impact of the productivity and quality growth of emerging economies on the rest of the world, incorporating quality home bias in the spirit of Ohyama (1998; 2010). Our model is based on a multi-country, multi-industry Ricardian model of global value chains that we developed in Sugita, Furusawa, Jakobbson and Yamamoto (2019) where we introduced quality differentiation and distinction of final goods and intermediate goods in a quantifiable Ricardian model of Eaton and Kortum (2002) and Caliendo and Parro (2015). The current model further extends Sugita et al. (2019) by introducing quality home bias.

Based on the model, we develop a novel method of estimating quality home bias from a time-differenced gravity equation. We also estimate quality growth and productivity growth for each country, industry and year, following the method we developped in Sugita et al. (2019).[3] Using the estimated model and *the exact hat algebra* (Dekle, Eaton and Kortum, 2008; Caliendo and Parro,

import-substituting industries.

[3]Sugita et al. (2019) generalized industry productivity estimation by Levchenko and Zhang (2016) and Shikher (2012) by allowing quality shocks.

2015; Costinot and Rodríguez-Clare, 2014), we conduct counterfactual simulations of the world without emerging economies' productivity growth and quality growth to quantify their impacts on the welfare of other countries.

Our study provides several new findings. First, most emerging economies exhibit higher growth in technology than the rest of the world, but the relative contribution of productivity and quality growth is heterogeneous among emerging economies. For instance, China mainly grew in productivity while Russia and India in quality. Second, quality home bias are prevalent, confirming Ohyama(1998; 2010)'s hypothesis. Roughly speaking, quality improvement is 20% discounted in foreign markets than in home markets. Quality home bias also exists in all industries. Third, the productivity and quality growth of tradable industries in emerging economies have only modest impacts on the welfare of other countries. The growth of emerging economies are not large enough to have sizable impacts on other countries' terms of trade.

The rest of the paper proceeds as follows. Section 2 demonstrates the key mechanisms of Ikema (1969) and Ohyama(1998; 2010) in a simple two-country, two-good model. Section 3 sets up the quantitative model. Section 4 estimates parameters of the model including quality home bias, productivity growth and quality growth. Section 5 presents counterfactual exercises to quantify the welfare impact of emerging countries' growth. Section 6 concludes the paper.

2 Mechanism

Before presenting a quantitative model, we revisit the implication of one country's productivity growth and quality growth on other country's welfare in a simple two-good, two-country Ricardian model. The following is a version of Ohyama (1998; 2010) with the CES utility functions.

There are two countries, Home and Foreign, and two goods X and Y. Home specializes in good X and produces $\bar{X}$ of good X, while Foreign specializes in good Y and produce $\bar{Y}^*$. Foreign's variable is denoted by "$*$". The utility functions of Home's and Foreign's consumers, are given by:

$$u = \left[(\kappa_X X)^{\frac{\sigma-1}{\sigma}} + (a\kappa_Y^{\rho} Y)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \text{ and } u^* = \left[\left(a\kappa_X^{\rho} X^*\right)^{\frac{\sigma-1}{\sigma}} + (\kappa_Y Y^*)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \tag{1}$$

respectively, where X and Y are Home's consumption of X and Y, respectively; X^* and Y^* are Foreign's consumption of X and Y, respectively; and $\sigma > 1$ is the elasticity of substitution. Parameter κ_X and κ_Y represent the quality of X and Y, respectively. Quality is defined as a positive demand shifter.

The utility functions (1) take into account consumers' home bias both for *quantity* and for *quality*. If both goods have the same quality, $\kappa_X = \kappa_Y = \kappa$, then the utility function becomes a usual CES utility function:

$$u = \kappa \left[(X)^{\frac{\sigma-1}{\sigma}} + (aY)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \text{ and } u^* = \kappa \left[(aX^*)^{\frac{\sigma-1}{\sigma}} + (Y^*)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}.$$

Parameter $a \leq 1$ represents consumers' home bias. The marginal rate of substitutions are

$$MRS \equiv - \left.\frac{dY}{dX}\right|_{du=0} = \frac{1}{a^{\frac{\sigma-1}{\sigma}}} \left(\frac{Y}{X}\right)^{1/\sigma} \text{ and } MRS^* \equiv - \left.\frac{dY^*}{dX^*}\right|_{du^*=0} = a^{\frac{\sigma-1}{\sigma}} \left(\frac{Y^*}{X^*}\right)^{1/\sigma}.$$

When the two goods are sold at the same price, Home consumer consumes more good X than good Y and Foreign consumer consumes more good Y than good X if and only if $a < 1$. Since parameter $a \leq 1$ represents the extent of consumer's home bias and hence affects quantities demanded even when there is no quality difference between X and Y, we may consider parameter a to represent the *quantity home bias.*

The utility function (1) allows quality to grow at different speed between the two goods, and introduces home bias for quality. The marginal rates of substitutions for Home and Foreign are:

$$MRS = \left(\frac{\kappa_X}{a\kappa_Y^{\rho}}\right)^{\frac{\sigma-1}{\sigma}} \left(\frac{Y}{X}\right)^{1/\sigma} \text{ and } MRS^* = \left(\frac{a\kappa_X^{\rho}}{\kappa_Y}\right)^{\frac{\sigma-1}{\sigma}} \left(\frac{Y^*}{X^*}\right)^{1/\sigma},$$

respectively. For a given consumption bundle, an increase in κ_X increases the marginal rate substitution of X to Y in both countries but asymmetrically:

$$\frac{\partial \ln MRS}{\partial \ln \kappa_x} = \frac{\sigma - 1}{\sigma} \geq \left(\frac{\sigma - 1}{\sigma}\right)\rho = \frac{\partial \ln MRS^*}{\partial \ln \kappa_x},$$

where an improvement in the quality of Home products is less appreciated in Foreign than in Home if only if $\rho < 1$. Parameter ρ represents *quality home bias.*

It is not difficult to find examples of quality home bias. Here we mention three. First, take a US carmaker's choice to increase the size of SUVs. US consumers mostly appreciate the size increase as quality improvement, because it enhances driver's safety and driving stability. However, Japanese consumers may appreciate it less, because the car has become too big for typical roads in Japan. Second, take Japanese laptop PCs that equip with many devices (Blue ray disks, touch screen, etc.) and many slots (USB, SD card, LAN, etc.). Japanese consumers may appreciate it, preferring to carry all of them just in case. US consumers may appreciate it less, considering the laptops have lost elegance in their appearances. Third, Japanese rice cookers make progress in making cooked short grain rice more sticky, but this improvement is likely to be little appreciated in other Asian countries where the rice cooker is used to cook long-grain rice with little stickiness.

Ohyama (1998; 2010) demonstrated the quality home bias could drastically change the welfare effect of economic growth. In the following, we revisit Ohyama (1998; 2010)'s result. Let Y be the numeraire and normalize $\kappa_Y = 1$. Let $\kappa = \kappa_X$ and p be the price of X. Demands for good X in Home and Foreign, respectively, are derived as

$$X = \left[\frac{(p/\kappa)^{-\sigma}\kappa^{-1}}{(p/\kappa)^{1-\sigma} + (1/a)^{1-\sigma}}\right] p\bar{X} \text{ and } X^* = \left[\frac{(p/a\kappa^{\rho})^{-\sigma}(a\kappa^{\rho})^{-1}}{(p/a\kappa^{\rho})^{1-\sigma} + 1}\right] \bar{Y}^*.$$

Changing variables as $\tau \equiv 1/a > 1$, $\tilde{p} \equiv p/\kappa$ and $\tilde{p}^* \equiv p/\kappa^{\rho}$, these expressions become

$$X = \left[\frac{\tilde{p}^{-\sigma}}{\tilde{p}^{1-\sigma} + \tau^{1-\sigma}}\right] \tilde{p}\bar{X} \text{ and } X^* = \left[\frac{(\tilde{p}^*\tau)^{-\sigma}}{(\tilde{p}^*\tau)^{1-\sigma} + 1}\right] \frac{\tau}{\kappa^{\rho}} \bar{Y}^*$$

which is similar to the corresponding equations without quality differentiation. As is well known in the literature, quantity home bias τ plays a similar role as trade costs. Prices $\tilde{p}$ and $\tilde{p}^*$ can be interpreted as quality-adjusted prices in Home and Foreign, respectively.

We make some observations about quality-adjusted prices. First, Foreign quality-adjusted price $\tilde{p}^*$ is a sufficient statistic for Foreign's utility, which is given by

$$u^* = \bar{Y}^* \left((\tilde{p}^* \tau)^{1-\sigma} + 1 \right)^{\frac{1}{\sigma - 1}}.$$

Second, under perfect competition, p is the marginal cost of production. The elasticity of quality-adjusted prices with respect to marginal costs is:

$$\frac{\partial \ln \tilde{p}}{\partial \ln p} = \frac{\partial \ln \tilde{p}^*}{\partial \ln p} = 1.$$

Thus, one percent decrease in marginal costs leads to one percent decrease in quality-adjusted prices equally in both countries. Third, the elasticity of quality adjusted prices with respect to quality is

$$\frac{\partial \ln \tilde{p}}{\partial \ln \kappa} = -1 < -\rho = \frac{\partial \ln \tilde{p}^*}{\partial \ln \kappa}$$

Thus, one percent increase in quality leads to one percent decrease in quality-adjusted prices in Home but ρ percent decrease in Foreign.

The impact of Home's productivity growth $d\bar{X} > 0$ on Foreign quality-adjusted price is assessed by

$$\frac{d \ln \tilde{p}^*}{d \ln \bar{X}} = \frac{d \ln p}{d \ln \bar{X}}.$$

In normal cases, we expect that the price falls thanks to the productivity growth, $d \ln p / d \ln \bar{X} < 0$. This improves the Foreign welfare.

The impact of Home's quality growth $d\kappa > 0$ on Foreign quality-adjust price $\tilde{p}^* = p/\kappa^\rho$ is

$$\frac{d \ln \tilde{p}^*}{d \ln \kappa} = \frac{d \ln p}{d \ln \kappa} - \rho.$$

Home's quality growth will increase p through a rise in Home's demands, i.e. $d\ln p/d\ln\kappa > 0$. If $\rho = 0$, then Foreign quality adjust price $\tilde{p}^*$ increases, and hence the Foreign welfare deteriorates. When $\rho > 0$, Foreign consumers also appreciate the quality improvement, which offsets the price increase. When $\rho = 1$, quality enters in the utility function in a multiplicative way, so that an increase in κ is equivalent with an increase in $\bar{X}$, as shown in the Appendix. Therefore, Foreign welfare improves. The following lemma shows that there exists a threshold $\tilde{\rho} \in (0,1)$ such that $du^*/d\kappa > 0$ if and only if $\rho > \tilde{\rho}$.

Lemma 1. *(1) An increase in Home's productivity unambiguously enhances Foreign's welfare. (2) A quality improvement of Home's product enhances Foreign's welfare if Foreign's consumers sufficiently evaluate the improvement of Home's product, but it deteriorates Foreign's welfare otherwise.*

Proof. In the Appendix. □

Lemma 1 implies that the welfare impact of foreign economic growth crucially depends on the extent of productivity growth, quality growth and quality home bias. In the following of the paper, we develop an empirical framework to estimate them and to quantify the aggregate welfare consequences.

3 Quantitative Model

The model is a static Ricardian model of global value chains that extends Eaton and Kortum (2002), Caliendo and Parro (2015), and Sugita et al. (2019) by incorporating for quality differentiation, the distinction of final goods and intermediate goods, and quality home bias. There are N countries indexed by $i,n \in \{1,...,N\}$, S industries indexed by $s,k \in \{1,...,S\}$ and one homogenous factor, labor. All goods and labor are traded in perfectly competitive markets. There is no saving or investment. Each industry produces two types of goods with different usages, final goods and intermediate goods. Final goods, denoted by f, are used only for final consumption, while intermediate goods, denoted by m, are used only for inputs for production. There is a continuum of varieties $\omega^{su} \in [0,1]$ for each usage $u \in \{f, m\}$ in industry s.

Country n's representative consumer's utility function is given by

$$U_n = \prod_{s=1}^{S} \left(Q_{nt}^{sf}\right)^{\alpha^s}, \; Q_{nt}^{sf} \equiv \left[\int_0^1 q_{nt}^{sf*}\left(\omega^{sf}\right)^{\frac{\sigma^{sf}-1}{\sigma^{sf}}} d\omega^{sf}\right]^{\frac{\sigma^{sf}}{\sigma^{sf}-1}},$$

where $\sigma^{sf} > 1$ is the elasticity of substitution. $q_{nt}^{sf*}\left(\omega^{sf}\right)$ is country n's quality-adjusted consumption of variety ω^{sf} at time t, and given by

$$q_{nt}^{sf*}\left(\omega^{sf}\right) \equiv \sum_{i=1}^{n} \lambda_{nit}^{s} q_{nit}^{sf}\left(\omega^{sf}\right),$$

where $q_{nit}^{sf}\left(\omega^{sf}\right)$ is country n's consumption of variety ω^{sf} produced in country i at time t and λ_{nit}^{s} is the quality of country i's industry s perceived by country n at time t. Parameter λ_{nit}^{s} is shared by all varieties in industry s in country i and given by

$$\lambda_{nit}^{s} = \begin{cases} \kappa_{it}^{s} & \text{if } i = n \\ a_n^s \left(\kappa_{it}^{s}\right)^{\rho_s} & \text{if } i \neq n, \end{cases} \tag{2}$$

where κ_{it}^{s} is the intrinsic quality of country i's product, parameter a_n^s represents quantity home bias, and parameter ρ_s represents quality home bias in line with the model in Section 2.

A firm in industry s in country n produces $y_{nt}\left(\omega^{su}\right)$ units of variety ω^{su} of usage u by the constant returns to scale production function:

$$y_{nt}^{s}\left(\omega^{su}\right) = A_{nt}^{s} z_n\left(\omega^{su}\right) l_{nt}\left(\omega^{su}\right)^{\beta_n^s} \prod_{k=1}^{S} m_{nt}^{sk}\left(\omega^{su}\right)^{\beta^{sk}}, \; \beta^s + \sum_{k=1}^{S} \beta^{sk} = 1,$$

where $l_{nt}\left(\omega^{su}\right)$ is labor input; $A_{nt}^{s} z_n\left(\omega^{su}\right)$ is total factor productivity (TFP); A_{nt}^{s} is the country-industry specific component of TFP; and $z_n\left(\omega^{su}\right)$ is the idiosyncratic component drawn from a Fréchet distribution $F^s(z) = \exp\left(-z^{-\theta^s}\right)$. $m_{nt}^{sk}\left(\omega^{su}\right)$ is the composite intermediate input for good

k given by

$$m_{nt}^{sk}\left(\omega^{su}\right) \equiv \left[\int_0^1 \tilde{m}_{nt}^{*sk}\left(\omega^{km};\omega^{su}\right)^{\frac{\sigma^{km}-1}{\sigma^{km}}} d\omega^{km}\right]^{\frac{\sigma^{km}}{\sigma^{km}-1}},$$

where $\sigma^{km} > 1$ is the elasticity of substitution and $\tilde{m}_{it}^{*sk}\left(\omega^{km};\omega^{su}\right)$ is the quality-adjusted input of variety ω^{km} for production of variety ω^{su} in country i, which is given by

$$\tilde{m}_{nt}^{*sk}\left(\omega^{km};\omega^{su}\right) \equiv \sum_{i=1}^{N} \lambda_{nit}^{k} \tilde{m}_{nit}^{sk}\left(\omega^{km};\omega^{su}\right),$$

where $\tilde{m}_{nit}^{sk}\left(\omega^{km};\omega^{su}\right)$ is the amount of ω^{km} produced in country i and used as input for production of ω^{su} in country n. Quality parameter λ_{nit}^{k} is the same across the usages. Note that within an industry, intermediate goods and final goods share the same quality parameter, productivity parameter, and Fréchet parameter. The only meaningful distinction between final usage and intermediate usage is trade costs.

Country n purchases variety ω^{sf} with the lowest quality adjusted price with

$$p_{nt}^{*}\left(\omega^{su}\right) \equiv \min_{i=\{1,\cdots,N\}} \frac{p_{nit}\left(\omega^{sf}\right)}{\lambda_{nit}^{s}},$$

where $p_{nit}(\omega^{su})$ is the unit cost of supplying from country i to country n. The quality-adjusted price index for usage u of industry s in country n is given by $P_{nt}^{su*} = \left[\int_0^1 p_{nt}^{*}\left(\omega^{su}\right)^{1-\sigma^{su}} d\omega^{su}\right]^{\frac{1}{1-\sigma^{su}}}$. Trade costs d_{nit}^{su} satisfies $p_{nit}(\omega^{su}) = d_{nit}^{su} p_{iit}(\omega^{su})$ for those varieties that country n imports from country i. Those trade costs consist of tariffs τ_{nit}^{s} and non-tariff barriers D_{nit}^{su} of iceberg type such that

$$\ln d_{nit}^{su} = \ln(1+\tau_{nit}^{s}) + \ln D_{nit}^{su}$$

where the triangle inequality $d_{njt}^{su} d_{jit}^{su} \geq d_{nit}^{su}$ is satisfied and each component of domestic trade costs is normalized to one: $d_{iit}^{su} = 1+\tau_{iit}^{s} = D_{iit}^{su} = 1$.

Following Dornbusch, Fischer and Samuelson (1977), Dekle et al. (2008) and Caliendo and Parro (2015), we assume trade deficit TD_{nt} is exogenously given and tariff revenue R_{nt} is transferred to the representative consumer. Therefore, the income of country n is given by $I_{nt} \equiv w_{nt}L_{nt} + R_{nt} + TD_{nt}$.

3.1 Equilibrium Properties

The model shares several properties with the Eaton and Kortum (2002) model. The unit cost of producing variety ω^{su} in country i is $p_{iit}(\omega^{su}) = \frac{c_{it}^s}{A_{it}^s z_i(\omega^{su})}$ where c_{it}^s is the unit cost index given by

$$c_{it}^s = \xi^s w_{it}^{\beta^s} \prod_{k=1}^{S} \left(P_{it}^{km*}\right)^{\beta^{sk}}, \tag{3}$$

where ξ^s is a constant and w_{it} is wage in country i. The quality-adjusted price index for usage u of industry s in country i is given by

$$\left(\frac{P_{nt}^{su*}}{\gamma^{su}}\right)^{-\theta^s} = \sum_{i=1}^{N} \left(\frac{A_{it}^s \lambda_{nit}^{su}}{c_{it}^s d_{nit}^{su}}\right)^{\theta^s} \equiv \Phi_{nt}^{su}, \tag{4}$$

where $\gamma^{su} \equiv \left[\Gamma\left((\theta^s + 1 - \sigma^{su})/\theta^s\right)\right]^{1/(1-\sigma^{su})}$ and Γ is the gamma function. The trade share of country i's products with usage u in industry s in market n is given by

$$\pi_{nit}^{su} = \frac{1}{\Phi_{nt}^{su}} \left(\frac{A_{it}^s \lambda_{nit}^{su}}{c_{it}^s d_{nit}^{su}}\right)^{\theta^s}. \tag{5}$$

Let X_{nt}^{su} be country n's tariff-inclusive expenditure on usage u in industry s. The Cobb-Douglass production and utility functions imply

$$X_{nt}^{sm} = \sum_{k=1}^{S} \beta^{ks} Y_{nt}^k \text{ and } X_{nt}^{sf} = \alpha^s \left[w_{nt}L_{nt} + R_{nt} + TD_{nt}\right], \tag{6}$$

where the tariff-exclusive gross revenue of industry k, Y_{nt}^k, country n's tariff revenue, R_{nt}, and country n's trade deficit, TD_{nt}, are given by

$$
\begin{aligned}
Y_{nt}^{k} &= \sum_{i=1}^{N} \sum_{u\in\{f,m\}} \frac{\pi_{int}^{ku}}{1+\tau_{int}^{k}} X_{it}^{ku}, \\
R_{nt} &= \sum_{s=1}^{S} \sum_{i=1}^{N} \sum_{u\in\{f,m\}} \frac{\tau_{nit}^{s} \pi_{nit}^{su}}{1+\tau_{nit}^{s}} X_{nt}^{su}, \\
TD_{nt} &= \sum_{s=1}^{S} \sum_{i=1}^{N} \sum_{u\in\{f,m\}} \left(\frac{\pi_{nit}^{su} X_{nt}^{su}}{1+\tau_{nit}^{s}} - \frac{\pi_{int}^{su} X_{it}^{su}}{1+\tau_{int}^{s}} \right).
\end{aligned} \tag{7}
$$

Conditions (3), (4), (5), (6) and (7) determine an equilibrium.

Following Dekle et al. (2008) and Caliendo and Parro (2015), we consider a system of equilibrium conditions for changes in variables. Let x_t be the value of variable x in an initial equilibrium at time t, x_t' be its value in a counterfactual equilibrium at time t and $\hat{x}_t \equiv x_t'/x_t$ be a counterfactual change of variable x. As an exogenous constraint on changes in trade deficit, we assume trade deficit relative to the world GDP remains the same between the two equilibria. Then, we obtain equilibrium conditions for changes in variables as follows.

Definition 1. A collection of changes in endogenous variables $\left\{\hat{w}_{it}, \hat{c}_{it}^{s}, \hat{P}_{it}^{su*}, \hat{\pi}_{int}^{su}, \hat{X}_{nt}^{su}\right\}$ is called changes in equilibrium when they satisfy the following conditions:

$$\hat{c}_{it}^{s} = \hat{w}_{it}^{\beta^s} \prod_{k=1}^{S} \left(\hat{P}_{it}^{km*}\right)^{\beta^{sk}}, \tag{8}$$

$$\left(\hat{P}_{it}^{su*}\right)^{-\theta^s} = \sum_{h=1}^{N} \pi_{nh0}^{su} \left(\frac{\hat{A}_{it}^{s}\hat{\lambda}_{nit}^{su}}{\hat{c}_{it}^{s}\hat{d}_{nit}^{su}}\right)^{\theta^s}, \tag{9}$$

$$\hat{\pi}_{nit}^{su} = \left(\hat{P}_{it}^{su*}\right)^{\theta^s} \left(\frac{\hat{A}_{it}^{s}\hat{\lambda}_{nit}^{su}}{\hat{c}_{it}^{s}\hat{d}_{nit}^{su}}\right)^{\theta^s},$$

$$\hat{\lambda}_{nit}^{s} = \hat{\kappa}_{it}^{s} + I_{n\neq i}\left(a_n^s\left(\hat{\kappa}_{it}^{s}\right)^{\rho_s} - \hat{\kappa}_{it}^{s}\right),$$

$$X_{nt}^{sf\prime} = \alpha^s \left[\hat{w}_{nt}L_{n0}w_{n0} + \sum_{s=1}^{S}\sum_{i=1}^{N}\sum_{u\in\{f,m\}} \frac{\tau_{nit}^{s\prime}\pi_{nit}^{su\prime}}{1+\tau_{nit}^{s\prime}} X_{nt}^{su\prime} + TD_{nt}^{\prime}\right],$$

$$X_{nt}^{sm\prime} = \sum_{k=1}^{S} \beta^{ks} \left(\sum_{i=1}^{N}\sum_{u\in\{f,m\}} \frac{\pi_{int}^{ku\prime}}{1+\tau_{int}^{k\prime}} X_{it}^{ku\prime}\right),$$

$$TD_{nt}^{\prime} = \sum_{s=1}^{S}\sum_{i=1}^{N}\sum_{u\in\{f,m\}} \left(\frac{\pi_{nit}^{su\prime}X_{nt}^{su\prime}}{1+\tau_{nit}^{s\prime}} - \frac{\pi_{int}^{su\prime}X_{it}^{su\prime}}{1+\tau_{int}^{s\prime}}\right),$$

$$\frac{TD_{nt}^{\prime}}{\sum_i \hat{w}_{it}\hat{L}_{it}w_{i0}L_{i0}} = \frac{TD_{n0}}{\sum_i w_{i0}L_{i0}}, \tag{10}$$

where $I_{n\neq i}$ is an indicator of international trade.

Computation of counterfactuals follows the algorithm developed by Caliendo and Parro (2015) that numerically solves the above system for wage changes. Since $\sum_{n=1}^{N} TD_{nt} = 0$ from the Warlas's law, there are only $N-1$ independent equations of (10). Therefore, we normalize $\hat{w}_N = 1$.

3.2 Counterfactual Exercise

To quantify the impact of emerging economies' growth on the world economy, we simulate a counterfactual world economy in 2007 without the high growth of emerging economies. Denote emerging economies by $\{1,...,M\}$ and non-emerging economies by $\{M+1,...,N\}$. Let $x_{it}^{s} \in \{A_{it}^{s}, \kappa_{it}^{s}, \Lambda_{it}^{s}\}$ be technology parameters, of which we conduct counterfactual exercises. Emerging economy m's counterfactual change in x_{mt}^{su} is given by

$$\hat{x}^s_{m2007} \equiv \min\left\{\exp\left[-\sum_{t=1996}^{2007}\left(d\ln x^s_{m,t} - d\ln \bar{x}^s_{NMt}\right)\right], 1\right\} \tag{11}$$

where $d\ln x^s_{m,t} = \ln x^s_{m,t} - \ln x^s_{m,t-1}$, while $d\ln \bar{x}_{NMt} \equiv \frac{1}{N-M}\sum_{i=M+1}^{N} d\ln x_{i,t}$ is the average growth rate of non-emerging economies. Emerging economies' productivity and/or quality are reduced to those levels that would be if the growth rate of emerging economies during 1995–2007 is the same as the average growth rates of non-emerging economies. No change is made for non-tradable service industries and for those tradable industries where emerging country's growth rate is lower than the average rate of non-emerging economies. We choose the year 2007 to avoid potential influences of the Lehman crisis and the great trade collapse in 2008.

In section 4, we present our novel method of estimating $\hat{x}^s_{m2007}$ from trade data. With $\hat{x}^s_{m2007}$, we calculate counterfactual changes in variables by solving a system of equilibrium conditions in Definition 1. We measure each country's welfare change by a change in real value-added per worker, which is real wage in the model:[4]

$$\hat{W}_{it} = \frac{\hat{w}_{it}}{\prod_{s=1}^{S}\left(\hat{P}^{*sf}_{it}\right)^{\alpha_s}}.$$

4 Quantification

4.1 Data

The main dataset is the World Input Output Database (WIOD) of 2013 release. WIOD contains multi-country input-output tables and associated data about price index and factor usages for 40 countries and 35 sectors for each year from 1995 to 2011. Because of missing values, we merge industries 4 and 5 to industry 4, industries 19 and 20 to industry 19, and industries 31, 34, and 35 to industry 31 and include five countries (Cyprus, Indonesia, Luxembourg, Latvia, and Malta) in

[4] A potential concern of using real wage as a welfare measure is that it does not take into account tariff revenue. However, this omission of tariff revenue is unlikely to case a problem. In our dataset, the share of tariff revenue in the world income is only 0.52% in 1995 and 0.43% in 2007.

the rest of the world (RoW). Usage is assigned based on whether the demand is from production or others. All service industries are treated as non-tradable goods. The final dataset contains 31 industries and 35 countries including RoW for 1995–2009.

Table 1 is the list of countries in our sample. Emerging economies are classified according to FTSE Russel Annual Country Clarification 2009 (FSTE2009). WIOD includes many European countries but do not include some important countries in Southeast Asia (e.g., Thailand), South America (e.g., Argentina), and most countries in Africa. Nevertheless, those countries in the sample except RoW account for 88% of the world GDP in 2000.

Table 1: List of Countries in Sample

emerging economies	Non emerging economies			
Brazil	Australia	France	Portugal	Turkey
China	Austria	Germany	Romania	USA
Czech Rep	Belgium	Greece	Slovakia	UK
Hungary	Bulgaria	Ireland	Slovenia	RoW
India	Canada	Italy	South Korea	
Mexico	Denmark	Japan	Spain	
Poland	Estonia	Lithuania	Sweden	
Russia	Finland	Netherlands	Taiwan	

Note: the classification of emerging economies follow FTSE Russel Annual Country Clarification 2009.

The data source for tariffs is UNCTAD TRAINS downloaded from the World Trade Integrated System. In Sugita et al. (2019), we newly aggregated tariffs reported at the Harmonized System 6 digit level to the WIOD industry level, using import volume in 1995 as time-invariant weights. Missing values are imputed up to +/- 3 years. Since bilateral tariffs are available only for a subset of countries, we construct *quasi bilateral tariffs* as a proxy measure, which assumes zero tariff rate for trade under preferential trade agreements and MFN tariff rates for the others. That is, the quasi bilateral tariff is calculated as $\tilde{\tau}^{s}_{nit} \equiv (1 - PTA_{nit})\,\tau^{MFN,s}_{nt}$ where $\tau^{MFN,s}_{nt}$ is MFN tariffs by country n in year t and PTA_{nit} is an indicator on whether countries i and n had a free trade agreement or formed a customs union in year t. The data source of employment L_{nt} is the Penn World Table. See Sugita et al. (2019) for further details on the construction of the data.

4.2 Basic Parameters

4.2.1 Trade Shares, Wages, and Cobb-Douglass Parameters

WIOD reports trade values in final good s imported by country n from country i, M_{nit}^{sf}, and trade values in intermediate good s imported by industry r in country n purchased from country i, M_{nit}^{rs}, both in producer prices excluding tariffs. Let tariff-inclusive expenditures be $X_{nt}^{sf} \equiv \sum_{i=1}^{N} M_{nit}^{sf}(1+\tilde{\tau}_{nit}^{s})$ and $X_{nt}^{sm} = \sum_{i=1}^{N}\sum_{r=1}^{S} M_{nit}^{rs}(1+\tilde{\tau}_{nit}^{s})$. For country n, the gross sales of industry s in producer prices are $Y_{nt}^{s} = \sum_{i=1}^{N}\left(M_{int}^{sf} + \sum_{r=1}^{S} M_{int}^{rs}\right)$, the value added of industry s is $V_{nt}^{s} = Y_{nt}^{s} - \sum_{r=1}^{S} M_{nit}^{rs}(1+\tilde{\tau}_{nit}^{s})$ and the total value-added (GDP) of country n is $V_{nt} \equiv \sum_{s=1}^{S} V_{nt}^{s}$. The labor endowment is the total number of workers, $L_{nt} \equiv \sum_{s=1}^{S} L_{nt}^{s}$, while the wage is GDP per worker $w_{nt} = V_{nt}/L_{nt}$. We estimate the Cobb-Douglass parameters as:

$$\alpha^{s} = \frac{\sum_t \sum_n X_{nt}^{sf}}{\sum_t \sum_n \sum_{s=1}^{S} X_{nt}^{sf}},\ \beta^{s} = \frac{\sum_t \sum_n V_{nt}^{s}}{\sum_t \sum_n Y_{nt}^{s}},\ \text{and}\ \beta^{sk} = \frac{\sum_t \sum_n \sum_i M_{nit}^{sk}(1+\tilde{\tau}_{nit}^{k})}{\sum_t \sum_n Y_{nt}^{s}}.$$

4.2.2 Fréchet Parameter θ^{s}

We use Fréchet parameters θ^{s} that Sugita et al. (2019) estimated from a gravity equation and bilateral tariff data. We show that their method is valid in the current model with quality home bias. From (2) and (5), the log of trade share for $n \neq i$ becomes

$$\ln \pi_{nit}^{su} = \theta^{s} \ln \frac{A_{it}^{s}\left(\kappa_{it}^{s}\right)^{\rho_s}}{c_{it}^{s}} + \theta^{s} \ln \frac{a_n}{\Phi_{nt}^{su}} - \theta^{s} \ln d_{nit}^{su}. \tag{12}$$

Trade costs d_{nit}^{su} are modeled as:

$$\ln d_{nit}^{su} = \ln\left(1+\tau_{nit}^{s}\right) + \zeta_{nt}^{su} + \sum_{k} TC_{ni,k}\delta_{kt}^{su} + \tilde{\varepsilon}_{nit}^{su} \tag{13}$$

where τ_{nit}^{su} is bilateral tariff rates; ζ_{nt}^{su} is importer-usage fixed components of non-tariff barriers that aim to capture domestic regulation and standards; $TC_{ni,k}$ is k-th variable representing country-pair characteristics, which may have different impacts across time and across usages; and $\tilde{\varepsilon}_{nit}^{su}$ is an idiosyncratic component. The determinant of non-tariff barriers $TC_{ni,k}$ includes log of distance, contiguity dummy, common language dummy, and ever-colonial relationship dummy, which are from CEPII datasets.

Substituting (13) into (12), the log trade share becomes

$$\ln \pi_{nit}^{su} = -\theta^s \ln\left(1+\tau_{nit}^s\right) - \sum_k TC_{ni,k}\delta_{kt}^{su}\theta^s + \theta^s \ln \frac{A_{it}^s\left(\kappa_{it}^s\right)^{\rho_s}}{c_{it}^s} + \theta^s\left(\ln\frac{a_n}{\Phi_{nt}^{su}} - \zeta_{nt}^{su}\right) - \theta^s\tilde{\varepsilon}_{nit}^{su}.$$

Then, we estimate the following gravity model with fixed effects separately for each tradable industry and each year by the OLS:

$$\ln \pi_{nit}^{su} = \gamma_\tau^s \ln\left(1+\tau_{nit}^s\right) + \sum_k TC_{ni,k}\left(\gamma_{kt}^{sf} + I_{u=m}\gamma_{kt}^{sm}\right) + \sum_i ex_{it}^s\gamma_{it}^s + \sum_n\sum_u im_{nt}^{su}\gamma_{nt}^{su} + \varepsilon_{nit}^{su} \qquad (14)$$

where $I_{u=m}$ is an indicator of trade in intermediate goods; ex_{it}^s is time-exporter fixed effects, which captures $\theta^s \ln \frac{A_{it}^s\left(\kappa_{it}^s\right)^{\rho_s}}{c_{it}^s}$; im_{it}^{su} is usage-time-importer fixed effects, which captures $\theta^s\left(\ln\frac{a_n}{\Phi_{nt}^{su}} - \zeta_{nt}^{su}\right)$; and $\varepsilon_{nit}^{su} \equiv -\theta^s\tilde{\varepsilon}_{nit}^{su}$. Equation (14) is estimated for observations of international trade ($n \neq i$) where bilateral tariffs are available.

Sugita et al. (2019) estimate Fréchet parameters as $\tilde{\theta}^s = -\tilde{\gamma}_\tau^{su}$, as shown in Table 2 with robust standard errors. Parameters θ^s are precisely estimated with small standard errors. These estimates of $\tilde{\theta}^s$ are reasonable sizes given that it satisfies $\tilde{\theta}^s > \max\{\sigma^{sf}+1, \sigma^{sm}+1\}$ for most of the elasticities of substitution reported in the literature.

Table 2: Trade Elasticities (Fréchet Parameters θ^s)

Industry Description	Theta	Robust SE	n.obs
Agriculture, Hunting, Forestry and Fishing	6.28	(0.54)	36,980
Mining and Quarrying	9.31	(1.58)	33,657
Food, Beverages and Tobacco	7.32	(0.39)	37,101
Textile Products, Leather Products and Footwear	6.27	(0.32)	37,467
Wood and Products of Wood and Cork	9.18	(0.60)	37,133
Pulp, Paper, Paper , Printing and Publishing	11.48	(0.71)	37,394
Coke, Refined Petroleum and Nuclear Fuel	6.12	(0.95)	36,633
Chemicals and Chemical Products	6.55	(0.54)	37,470
Rubber and Plastics	6.30	(0.41)	37,433
Other Non-Metallic Mineral	4.83	(0.47)	37,391
Basic Metals and Fabricated Metal	7.81	(0.55)	37,446
Machinery, Nec	7.31	(0.46)	37,480
Electrical and Optical Equipment	9.75	(0.77)	37,166
Transport Equipment	6.89	(0.40)	36,946
Manufacturing, Nec; Recycling	8.05	(0.52)	37,439

Note: Table shows the estimates of Frichet parameters in column "Theta" with robust standard errors.

4.3 Estimation of Quality Home Bias, Quality Changes and Productivity Changes

4.3.1 Identification Logic

Quality Home Bias

We develop a new method of identifying quality home bias from the time differenced gravity model of bilateral exports. Before presenting the details, we explain the logic behind the identification.

The structual gravity model in general explains a change in a country's export share in a given market by changes in four factors: (1) bilateral trade costs; (2) exporter's product quality; (3) exporter's production costs; and (4) the competitiveness of the market. Following the practice of the gravity model estimation, we control for changes in (1) trade costs by observable variables and changes in (4) the market competitiveness by importer fixed effects. In a usual gravity model, exporter fixed effects control for (2) product quality and (3) production costs all together. Instead of doing that, we follow Sugita et al. (2019) to use the country-industry level output price index in WIOD to proxy for changes in (3) production costs under the assumption of constant markups. After the effect of (3) production costs is removed, the exporter fixed effects estimate only the effect of (2) quality change.

Quality home bias creates the difference between the effect of quality change on domestic sales and that on export sales. Estimating quality changes for domestic sales and export sales separately, we identify the quality bias parameter ρ from their differences. The identification does not impose any restriction on the size of ρ. Whether ρ is smaller than one depends on the nature of data.

Productivity Changes

The identification of country-industry level productivity changes follows the method developed by Sugita et al. (2019). We first estimate the change in the combined shock of productivity and quality at the country-industry-year level. The change in the combined shock is identified as the residual of export competitiveness change that cannot be explained by changes in factor prices, which can be obtained from data, and gains from imports of intermediates. The export competitiveness is estimated from quality changes and production costs changes obtained during the estimation of quality home bias. Gains from imports of intermediates are estimated from the change in domestic market shares, following a similar logic in Eaton and Kortum (2002) and Arkolakis, Costinot and Rodríguez-Clare (2012). The productivity change is estimated as the difference between the change in the combined shock and that in the quality, which is already estimated for the estimation of quality home bias.

4.3.2 Quality Home Bias

Taking the log difference of (5), we obtain

$$d\ln\pi_{nit}^{su} = \theta^{s}\left(d\ln A_{it}^{s} - d\ln c_{it}^{s}\right) + \theta^{s} d\ln P_{nt}^{*su} - \theta^{s} d\ln\left(1+\tau_{nit}^{s}\right) - \theta^{s} d\zeta_{nt}^{su} - \theta^{s}\sum_{k} TC_{ni,k} d\delta_{kt}^{su} + \theta^{s} d\ln\lambda_{nit}^{su}.$$

To capture changes in marginal costs, we use the following assumption.

Assumption 1. *The price deflator of gross outputs reflects changes in unit production costs as*

$$d\ln\tilde{P}_{it}^{s}=d\ln c_{it}^{s}-d\ln A_{it}^{s}.$$

Assumption 1 is satisfied if the statistical office creates price deflators by sampling only goods domestically produced at time t and $t-1$, following the best practice recommended by international organizations (e.g., IMF, 2004). Using Assumption 1 and substituting quasi-tariffs and (2), we obtain

$$\begin{aligned}d\ln\pi_{nit}^{su}+\theta^{s}d\ln\left(1+\tau_{nit}^{s}\right)+\theta^{s}d\ln\tilde{P}_{it}^{s}=&\left[\theta^{s}d\ln P_{nt}^{*su}-\theta^{s}d\zeta_{nt}^{su}\right]+\theta^{s}\sum_{k}TC_{ni,k}d\delta_{kt}^{su}\\&+\theta^{s}d\ln\kappa_{it}^{s}+\theta^{s}\left(\rho_{i}^{s}-1\right)I_{n\neq i}d\ln\kappa_{it}^{s}\end{aligned}$$

where $I_{n\neq i}$ is an indicator of international trade. Using estimates $\tilde{\theta}^{s}$ from Table 2 and quasi bilateral tariffs $\tilde{\tau}_{nit}^{s}$, we estimate

$$\begin{aligned}d\ln\pi_{nit}^{su}+\tilde{\theta}^{s}d\ln\left(1+\tilde{\tau}_{nit}^{s}\right)+\tilde{\theta}^{s}d\ln\tilde{P}_{it}^{s}=&\sum_{n}\sum_{u}im_{nt}^{su}\gamma_{nt}^{su}+\sum_{k}TC_{ni,k}\gamma_{kt}^{su}\\&+\sum_{i}ex_{it}^{s}\left(\gamma_{it}^{s}+I_{n\neq i}\gamma_{ixt}^{s}\right)+I_{n\neq i}\gamma_{xt}^{s}+\varepsilon_{nit},\end{aligned}$$

for each year and industry separately, where im_{nt}^{su} is importer-time-usage dummies; ex_{it}^{s} is exporter-time dummies; and $I_{n\neq i}\gamma_{xt}^{s}$ is included to allow exporter fixed effects to differ between domestic trade and international trade due to the quality home bias. The exporter fixed effects reflect

$$\gamma_{it}^{s}=\theta^{s}\left(d\ln\kappa_{it}^{s}-d\ln\kappa_{bt}^{s}\right)\text{ and }\gamma_{ixt}^{s}=\left(\rho_{s}-1\right)\theta^{s}\left(d\ln\kappa_{it}^{s}-d\ln\kappa_{bt}^{s}\right),\tag{15}$$

where b represents a benchmark country for which an exporter dummy is dropped.[5] Intuitively,

[5] We must exclude a constant term and one dummy from the pool of exporter dummies and importer dummies because the sum of all exporter dummies equals to the sum of all importer dummies.

equation (15) identifies the quality shocks as residuals of changes in country i's export market shares that cannot be explained by changes in trade costs, importer's market conditions and prices of exported goods. Using (15), we estimate quality home bias elasticities ρ_s by regressing estimated $(\tilde{\gamma}^s_{ixt} + \tilde{\gamma}^s_{it})$ on estimated $\tilde{\gamma}^s_{it}$.

Table 3 reports estimated $\tilde{\rho}_s$ for each industry as well as an estimate for overall tradable industries from a pooled sample. These elasticities are estimated with very small standard errors, though the standard errors must be carefully interpreted since $\tilde{\gamma}^s_{ixt}$ and $\tilde{\gamma}^s_{it}$ themselves are estimates. Consistently with the hypothesis by Ohyama(1998; 2010), point estimates of elasticities are smaller than one in all industries. The differences of the estimates from one are all greater than two times estimated standard errors. Therefore, all estimates are also statistically different from one if we believe the estimated standard errors in Table 3. The bottom row reports the estimate from the pooled sample of all industries. The point estimate 0.80 means that on average, quality growth is discounted by 20% in foreign markets than in domestic markets, which seems of plausible size.

Table 3: Quality Home Bias Elasticities

Industry	Elasticity (ρ_s)	Std.err	R^2	n. obs.
Agriculture, Hunting, Forestry and Fishing	0.71	(0.064)	0.234	504
Mining and Quarrying	0.84	(0.031)	0.094	469
Food, Beverages and Tobacco	0.76	(0.064)	0.187	504
Textile Products, Leather Products and Footwear	0.64	(0.049)	0.312	504
Wood and Products of Wood and Cork	0.95	(0.022)	0.022	504
Pulp, Paper, Paper, Printing and Publishing	0.95	(0.022)	0.023	504
Coke, Refined Petroleum and Nuclear Fuel	0.90	(0.028)	0.041	500
Chemicals and Chemical Products	0.77	(0.036)	0.185	504
Rubber and Plastics	0.83	(0.040)	0.091	504
Other Non-Metallic Mineral	0.80	(0.041)	0.108	504
Basic Metals and Fabricated Metal	0.88	(0.030)	0.079	504
Machinery, Nec	0.76	(0.036)	0.193	504
Electrical and Optical Equipment	0.87	(0.029)	0.093	498
Transport Equipment	0.62	(0.054)	0.250	493
Manufacturing, Nec; Recycling	0.67	(0.083)	0.231	502
Overall Tradable Industries	0.80	(0.013)	0.126	7502

4.3.3 Quality Changes

From (15), we obtain country i's quality shocks relative to the world average:

$$d\ln\kappa_{it}^{s} - d\ln\bar{\kappa}_{t}^{s} = \left(\tilde{\gamma}_{it}^{s} - \frac{1}{N}\sum_{n=1}^{N}\tilde{\gamma}_{nt}^{s}\right)/\tilde{\theta}^{s}.$$

For non-tradable service industries, we cannot estimate them from trade data. Thus, we assume the relative quality across countries remains stable: $d\ln\kappa_{it}^{s} = d\ln\bar{\kappa}_{t}^{s}$.

4.3.4 Productivity Changes

From (8), the log cost change is

$$d\ln c_{it}^{s} = \beta_{i}^{s} d\ln w_{it} + \sum_{k=1}^{S}\beta^{sk} d\ln P_{it}^{sm*}.$$

Let $\Lambda_{it}^{s} \equiv (\kappa_{it}^{s} A_{it}^{s})^{\theta^{s}}$ be the combined shock of quality and productivity and let $S_{it}^{s} \equiv \Lambda_{it}^{s}(c_{it}^{s})^{-\theta^{s}}$ be the export competitiveness index of country i in industry s. By definition, the log change in the combined shock is the sum of competitiveness and unit costs changes:

$$d\ln\Lambda_{it} = d\ln S_{it} + d\ln W_{it}^{\beta\theta} + Bd\ln P_{it}^{m*\theta}$$

where $d\ln S_{it} \equiv (d\ln S_{it}^{1}, \ldots, d\ln S_{it}^{S})^{T}$, $d\ln\Lambda_{it} \equiv (d\ln\Lambda_{it}^{1}, \ldots, d\ln\Lambda_{it}^{S})^{T}$, $d\ln W_{it}^{\beta\theta} \equiv (\theta^{1}\beta_{i}^{1} d\ln w_{it}, \ldots, \theta^{s}\beta_{i}^{S} d\ln w_{it})^{T}$ and $d\ln P_{it}^{m*\theta} \equiv (\theta^{1} d\ln P_{it}^{1m*}, \ldots, \theta^{S} d\ln P_{it}^{Sm*})^{T}$ are $S \times 1$ vectors, and B is a $S \times S$ input-output matrix with β^{sk} as its sk element. From (5) and (9), the change in a price index is obtained as

$$d\ln P_{it}^{m*\theta} = d\ln\pi_{iit}^{m} - d\ln S_{it},$$

where $d\ln\pi_{iit}^{m} \equiv (d\ln\pi_{iit}^{1m}, \ldots, d\ln\pi_{iit}^{Sm})^{T}$. Then, the change in the combined shocks becomes

$$d\ln\Lambda_{it} = (I-B)d\ln S_{it} + d\ln W_{it}^{\beta\theta} + Bd\ln\pi_{iit}^{m}. \tag{16}$$

Equation (16) implies that the combined shock can be identified as the residual of export competitiveness change ($d\ln S_{it}$) that cannot be explained by either factor price ($d\ln W_{it}^{\beta\theta}$) or gains from imports of intermediates ($d\ln \pi_{iit}^{m}$).

On the other hand, the definitions of $S_{it}^{s} \equiv \Lambda_{it}^{s}\left(c_{it}^{s}\right)^{-\theta^{s}}$ and $\Lambda_{it}^{s} \equiv \left(\kappa_{it}^{s} A_{it}^{s}\right)^{\theta^{s}}$, and Assumption 1 imply that changes in export competitiveness can be decomposed into changes in quality and price:

$$d\ln S_{it} = d\ln \kappa_{it}^{\theta} - d\ln \tilde{P}_{it}^{\theta}, \tag{17}$$

Let $d\ln\Omega_{it} \equiv d\ln\kappa_{it}^{\theta} - d\ln\bar{\kappa}_{t}^{\theta} - d\ln\tilde{P}_{it}^{\theta}$. Since $d\ln\kappa_{it}^{\theta} - d\ln\bar{\kappa}_{t}^{\theta}$ is already identified above, $d\ln\Omega_{it} = d\ln S_{it} - d\ln\bar{\kappa}_{t}^{\theta}$ is also identified. Substituting $d\ln S_{it} = d\ln\Omega_{it} + d\ln\bar{\kappa}_{t}^{\theta}$ into (16), we obtain combined shocks

$$d\ln\Lambda_{it} = (I-B)d\ln\Omega_{it} + d\ln W_{it}^{\beta\theta} + Bd\ln\pi_{iit}^{m} + (I-B)d\ln\bar{\kappa}_{t}^{\theta},$$

and demean it to obtain

$$\begin{aligned} d\ln\Lambda_{it} - d\ln\bar{\Lambda}_{t} = {} & (I-B)d\ln\Omega_{it} + d\ln W_{it}^{\beta\theta} + Bd\ln\pi_{iit}^{m} \\ & - \frac{1}{N}\sum_{n=1}^{N}\left((I-B)d\ln\Omega_{nt} + d\ln W_{it}^{\beta\theta} + Bd\ln\pi_{iit}^{m}\right). \end{aligned}$$

Since an unobservable term $d\ln\bar{\kappa}_{NMt}^{\theta}$ is removed, all variables on the right-hand side are identified. Then, $d\ln A_{it}^{\theta} - d\ln\bar{A}_{t}^{\theta}$ is identified as follows:

$$d\ln A_{it}^{\theta} - d\ln\bar{A}_{t}^{\theta} = d\ln\Lambda_{it} - d\ln\bar{\Lambda}_{t} - \left(d\ln\kappa_{it}^{\theta} - d\ln\bar{\kappa}_{t}^{\theta}\right).$$

Once we obtain the changes in technology of interest $x_{it}^{s} \in \{A_{it}^{s}, \kappa_{it}^{s}, \Lambda_{it}^{s}\}$ relative to the world average, $d\ln x_{it}^{s} - d\ln\bar{x}_{NMt}^{s}$, that will be used for counterfactual analysis, (11) can be calculated as follows:

$$d\ln x_{it}^{s} - d\ln\bar{x}_{NMt}^{s} = d\ln x_{it}^{s} - d\ln\bar{x}_{t}^{s} - \frac{1}{N-M}\sum_{i=M+1}^{N}\left(d\ln x_{it}^{s} - d\ln\bar{x}_{t}^{s}\right).$$

4.3.5 Summary of Quality and Productivity Changes

Table 4 shows summary statistics of the cumulative growth of TFP and quality relative to the world average in tradable industries, i.e., $d\ln A_{it}^{s} - d\ln \bar{A}_{t}^{s}$ and $d\ln \kappa_{it}^{s} - d\ln \bar{\kappa}_{t}^{s}$. It reports mean and standard deviation (SD) across tradable industries for each country.

Table 4: Relative Growth Rate of TFP and Quality in 1995–2007

Country	TFP		Quality		Combined Shock	
	mean	sd	mean	sd	mean	sd
Australia	-21.49%	(14.10)	21.76%	(13.53)	-0.30%	(5.40)
Austria	-0.61%	(10.21)	-22.45%	(14.19)	-23.63%	(6.87)
Belgium	-6.45%	(12.86)	-12.91%	(21.05)	-19.93%	(10.37)
Bulgaria	-41.09%	(66.54)	52.40%	(66.92)	10.74%	(14.27)
Brazil*	-25.20%	(13.58)	7.98%	(13.11)	-17.79%	(6.10)
Canada	-4.93%	(10.66)	6.11%	(14.42)	0.61%	(5.44)
China*	34.10%	(17.21)	-1.40%	(30.99)	32.13%	(21.18)
Czech Rep*	-2.63%	(7.15)	21.78%	(8.56)	18.59%	(8.36)
Germany	-1.46%	(11.14)	-26.41%	(19.07)	-28.44%	(8.72)
Denmark	-16.20%	(22.95)	2.82%	(26.60)	-13.95%	(6.25)
Spain	-6.20%	(16.56)	-7.05%	(16.32)	-13.82%	(7.18)
Estonia	20.28%	(29.52)	13.71%	(28.62)	33.42%	(17.18)
Finland	-4.91%	(19.70)	-10.53%	(24.87)	-16.00%	(11.06)
France	19.23%	(22.22)	-36.71%	(19.32)	-18.05%	(9.33)
UK	-7.88%	(12.14)	7.72%	(13.53)	-0.73%	(4.09)
Greece	-6.22%	(19.35)	-1.78%	(21.17)	-8.57%	(8.26)
Hungary*	-3.09%	(43.37)	20.13%	(48.00)	16.48%	(9.58)
India*	-1.47%	(19.66)	15.62%	(26.19)	13.58%	(12.42)
Ireland	21.97%	(21.33)	-11.09%	(22.29)	10.32%	(11.43)
Italy	-16.88%	(15.40)	8.55%	(19.69)	-8.89%	(5.59)
Japan	9.34%	(18.00)	-51.11%	(16.81)	-42.34%	(8.17)
South Korea	14.94%	(25.18)	-20.64%	(29.88)	-6.27%	(18.99)
Lithuania	0.78%	(28.19)	44.93%	(35.80)	45.14%	(13.34)
Mexico*	-7.03%	(13.42)	14.07%	(17.14)	6.47%	(11.51)
Netherlands	-13.73%	(12.56)	2.79%	(13.17)	-11.51%	(9.08)
Poland*	29.35%	(24.47)	-15.50%	(25.57)	13.29%	(10.80)
Portugal	-10.80%	(32.70)	8.67%	(58.64)	-2.70%	(33.47)
Romania	1.66%	(34.93)	44.57%	(27.52)	45.65%	(13.11)
RoW	-31.60%	(28.97)	20.61%	(33.00)	-11.55%	(10.62)
Russia*	-20.92%	(23.00)	49.24%	(31.46)	27.75%	(11.77)
Slovakia	32.23%	(27.78)	-9.41%	(28.66)	22.26%	(16.51)
Slovenia	4.99%	(22.56)	-8.26%	(26.06)	-3.84%	(26.36)
Sweden	-4.27%	(16.30)	-6.77%	(19.09)	-11.60%	(8.38)
Turkey	51.46%	(35.95)	-48.88%	(42.50)	2.00%	(14.30)
Taiwan	22.38%	(44.15)	-50.72%	(51.81)	-28.90%	(19.83)
USA	-7.69%	(20.82)	-1.34%	(22.39)	-9.60%	(5.16)

Note: emerging economies are labeled by *.

Table 4 shows several notable patterns. First, only few countries achieved positive growth both in TFP and quality. There are negative correlations between quality growth and productivity growth. An OLS regression of TFP changes on quality changes with industry fixed effects and country fixed effects shows that 1% increase in quality growth is associated with 0.7% decrease in productivity (with a standard error of 0.017). This negative correlation may represent a tradeoff between quality and productivity, i.e., costs to produce high-quality products are often high.

Second, most emerging economies achieved positive mean growth in combined shocks. In the table, countries classified as "emerging market economies" by FTSE Russel Annual Country Clarification 2009 (FSTE2009) are labeled by "*". All emerging economies except Brazil achieved positive growth in mean combined shocks. This means two things. First, emerging countries indeed achieved export growth. Second, their export growth are associated with technology growth in a sense that they cannot solely be explained by trade costs and importer's market conditions. Third, the main driver of export growth is heterogeneous among emerging countries. China and Poland grew mainly in productivity, while Czech, Hungary, India, Mexico and Russia in quality. Finally, large standard deviations show that the growth pattern is also heterogenous across industries within a country.

5 Results

We are ready to conduct the counterfactual analysis. Table 5 reports real wage changes in 2007 under the counterfactual growth in TFP, quality and combined shocks of China and emerging economies (FSTE 2009). emerging economies are labeled by "*" and their values are underlined. Countries with *negative* changes imply their *positive* welfare gains from emerging economies's growth. Three patterns can be seen from the table. First, the removal of technological growth in emerging economies causes significant welfare loss in those emerging economies, but their impacts on other countries are modest and often less than 1% changes. Second, different types of technology shocks such as productivity, quality and combined shocks appear to have similar welfare effects on many countries, though the difference exists for some countries. Third, Japan received positive welfare gains from emerging economies's growth.

Table 5: Real Wage Changes under Counterfactual Growth of China and Emerging Countries in 2007

Country	China			Emerging Economies		
	TFP	Quality	Combined	TFP	Quality	Combined
Australia	-0.66%	-0.58%	-0.71%	-0.81%	-0.41%	-0.72%
Austria	-0.94%	-1.06%	-1.03%	-0.84%	-1.15%	-1.09%
Belgium	-0.29%	-0.17%	-0.25%	-0.29%	-0.14%	-0.26%
Bulgaria	2.92%	2.97%	2.89%	2.69%	3.02%	2.85%
Brazil*	0.02%	0.05%	0.02%	-0.38%	-7.12%	2.33%
Canada	-0.06%	-0.05%	-0.11%	-0.17%	0.12%	-0.09%
China*	-17.31%	-5.33%	-20.11%	-17.94%	-5.75%	-21.21%
Czech Rep*	1.73%	1.57%	1.63%	0.98%	-9.92%	-9.05%
Germany	-0.40%	-0.49%	-0.47%	-0.38%	-0.57%	-0.57%
Denmark	-0.89%	-0.91%	-0.95%	-0.98%	-0.87%	-0.95%
Spain	-0.15%	-0.12%	-0.16%	-0.15%	-0.24%	-0.27%
Estonia	0.57%	0.59%	0.52%	0.58%	0.45%	0.36%
Finland	0.37%	0.26%	0.30%	0.44%	0.23%	0.28%
France	-0.79%	-0.75%	-0.78%	-0.80%	-0.82%	-0.86%
UK	-1.76%	-1.75%	-1.79%	-1.83%	-1.70%	-1.83%
Greece	-2.11%	-2.03%	-2.11%	-2.20%	-2.11%	-2.19%
Hungary*	1.39%	1.38%	1.40%	-4.95%	-4.38%	-4.76%
India*	0.33%	0.33%	0.31%	-3.88%	-7.16%	-7.36%
Ireland	0.50%	0.58%	0.57%	0.69%	0.55%	0.63%
Italy	0.02%	0.01%	0.04%	0.08%	-0.09%	0.03%
Japan	-0.63%	-0.75%	-0.75%	-0.60%	-0.76%	-0.78%
South Korea	0.36%	0.17%	0.17%	0.46%	0.18%	0.14%
Lithuania	0.41%	0.63%	0.53%	0.50%	-0.02%	0.19%
Mexico*	0.24%	0.24%	0.23%	-1.93%	-7.43%	-5.70%
Netherlands	-0.68%	-0.64%	-0.70%	-0.73%	-0.60%	-0.70%
Poland*	0.44%	0.47%	0.42%	-12.26%	-1.97%	-8.42%
Portugal	-0.21%	-0.16%	-0.17%	-0.13%	-0.31%	-0.18%
Romania	0.41%	0.46%	0.42%	0.20%	0.37%	0.38%
Russia*	-0.10%	-0.14%	-0.19%	-1.49%	-22.06%	-14.30%
RoW	1.20%	1.21%	1.10%	1.05%	1.33%	1.14%
Slovakia	1.16%	1.11%	1.15%	1.15%	0.71%	0.88%
Slovenia	1.02%	1.01%	1.03%	1.11%	0.78%	0.87%
Sweden	-0.48%	-0.60%	-0.55%	-0.46%	-0.64%	-0.61%
Turkey*	0.23%	0.32%	0.29%	-14.70%	-3.40%	-6.34%
Taiwan*	0.19%	0.29%	0.06%	-8.37%	0.13%	0.03%
USA	-0.91%	-0.90%	-0.94%	-0.96%	-0.85%	-0.97%

Note: emerging economies are labeled by *.

There are several potential reasons for the small effects obsereved in Table 5. First, home quality bias elasticity, measured by the inverse of ρ_s, may be too small to create sizable differences between productivity and quality effects; if $\rho_s = 1$, then productivity and quality growth have the same impacts on equilibrium allocation, as mentioned in Section 2 and shown in the Appendix. Second, the growth in tradable industries may not have a large impact since tradable industries have smaller final expenditure shares than non-tradable service industries. Table 6 reports simple means of cumulative technological changes in columns "mean", and their weighted means using Cobb-Douglass consumption-share parameter α_s as weight in columns "α mean"; α_s weighted means aim to capture the heterogeneity of industries in their size and welfare impacts. For most emerging economies, "α mean" growth rates are much smaller than mean growth rates. Third, their economic sizes may not be large enough to have sizable impacts on other countries. The relative GDP shares of emerging economies is 10.8% in 1995 and 18.0% in 2007.

The small effect may also explain the small difference between productivity effects and quality effects in Table 5. Note that counterfactual changes in Table 5 are obtained under the assumption that equilibrium conditions are exactly satisfied in the initial equilibrium. In data, equilibrium conditions are likely to hold as an approximation. Therefore, if true quality and productivity effects are small, those noises due to approximation errors may mask the small differences between productivity effects and quality effects.

Table 6: Relative Growth Rate of TFP and Quality in 1995–2007

Country	TFP		Quality		Combined Shock	
	mean	α mean	mean	α mean	mean	α mean
Australia	-21.49%	-5.01%	21.76%	4.85%	-0.30%	-0.23%
Austria	-0.61%	-0.50%	-22.45%	-5.48%	-23.63%	-6.05%
Belgium	-6.45%	-1.37%	-12.91%	-3.62%	-19.93%	-5.06%
Bulgaria	-41.09%	-9.61%	52.40%	11.52%	10.74%	1.84%
Brazil*	-25.20%	-6.19%	7.98%	2.60%	-17.79%	-3.66%
Canada	-4.93%	-1.44%	6.11%	1.38%	0.61%	-0.14%
China*	34.10%	7.65%	-1.40%	2.57%	32.13%	10.15%
Czech Rep*	-2.63%	-0.94%	21.78%	6.35%	18.59%	5.34%
Germany	-1.46%	-1.06%	-26.41%	-5.75%	-28.44%	-6.88%
Denmark	-16.20%	-2.84%	2.82%	-1.04%	-13.95%	-3.96%
Spain	-6.20%	-2.16%	-7.05%	-0.89%	-13.82%	-3.12%
Estonia	20.28%	4.01%	13.71%	3.22%	33.42%	7.15%
Finland	-4.91%	0.04%	-10.53%	-4.28%	-16.00%	-4.31%
France	19.23%	4.18%	-36.71%	-8.60%	-18.05%	-4.50%
UK	-7.88%	-1.47%	7.72%	1.16%	-0.73%	-0.38%
Greece	-6.22%	-1.37%	-1.78%	-1.13%	-8.57%	-2.57%
Hungary*	-3.09%	-2.37%	20.13%	7.05%	16.48%	4.60%
India*	-1.47%	0.24%	15.62%	2.56%	13.58%	2.72%
Ireland	21.97%	4.40%	-11.09%	-2.09%	10.32%	2.24%
Italy	-16.88%	-4.80%	8.55%	2.59%	-8.89%	-2.28%
Japan	9.34%	3.26%	-51.11%	-13.10%	-42.34%	-9.92%
South Korea	14.94%	4.44%	-20.64%	-7.10%	-6.27%	-2.74%
Lithuania	0.78%	0.78%	44.93%	9.76%	45.14%	10.47%
Mexico*	-7.03%	-1.44%	14.07%	3.12%	6.47%	1.61%
Netherlands	-13.73%	-2.98%	2.79%	0.12%	-11.51%	-2.94%
Poland*	29.35%	6.82%	-15.50%	-4.30%	13.29%	2.45%
Portugal	-10.80%	-0.59%	8.67%	-0.19%	-2.70%	-0.86%
Romania	1.66%	-0.50%	44.57%	12.40%	45.65%	11.83%
RoW	-31.60%	-7.93%	20.61%	5.69%	-11.55%	-2.31%
Russia*	-20.92%	-4.35%	49.24%	11.22%	27.75%	6.79%
Slovakia	32.23%	7.89%	-9.41%	-2.16%	22.26%	5.65%
Slovenia	4.99%	0.46%	-8.26%	-0.76%	-3.84%	-0.37%
Sweden	-4.27%	0.86%	-6.77%	-4.09%	-11.60%	-3.30%
Turkey	51.46%	10.50%	-48.88%	-8.81%	2.00%	1.61%
Taiwan	22.38%	4.14%	-50.72%	-10.47%	-28.90%	-6.41%
USA	-7.69%	-0.71%	-1.34%	-1.68%	-9.60%	-2.47%

Note: emerging economies are labeled by *.

To further investigate these hypotheses for small effects, we conduct two additional counterfactual exercises. The first one is with extremely large quality home bias. The first four columns in Table 7 report the impacts of quality growth and combined shock growth, respectively, with $\rho^s = 0.1$ and with the estimates $\tilde{\rho}_s$ in Table 3; the results with $\tilde{\rho}^s$ are the copies from Table 5. Lowering ρ^s from $\tilde{\rho}^s$ to $\rho^s = 0.1$ reduces the welfare gains in many non-emerging countries in line with Ohyama(1998; 2010) and Lemma 1 in Section 2. As the quality home bias becomes stronger, the quality growth of emerging economies do more harm than good for other countries. In addition, Table 7 shows that welfare gains are significantly reduced for the emerging economies themselves. As other countries heavily discount the quality growth, demands for the goods produced in the emerging economies do not increase as much. Also as a supplementary exercise, we regress those numbers of welfare impacts in Table 7 on the dummy variable for $\rho^s = 0.1$. Table 8 shows the results that reducing ρ^s from $\tilde{\rho}^s$ to $\rho^s = 0.1$ indeed increases the quality effect by 0.04 percentage point and the combined shock effect by 0.3 percentage point with statistical significance. However, the magnitude of the changes is small. Therefore, the size of quality home bias does not seem the main reason for the small effects in Table 5.

Table 7: Real Wage Changes under Counterfactual Growth of Emerging Countries in 2007 with Alternative Quality Home Bias Elasticities

Country	Emerging economies			
	Quality		Combined	
	$\hat{\rho}_s$	$\rho = 0.1$	$\hat{\rho}_s$	$\rho = 0.1$
Australia	-0.41%	-0.56%	-0.72%	-0.72%
Austria	-1.15%	-1.03%	-1.09%	-0.72%
Belgium	-0.14%	-0.20%	-0.26%	-0.30%
Bulgaria	3.02%	2.95%	2.85%	3.36%
Brazil*	-7.12%	-0.96%	2.33%	9.88%
Canada	0.12%	-0.02%	-0.09%	-0.09%
China*	-5.75%	-0.45%	-21.21%	-15.71%
Czech Rep*	-9.92%	-0.06%	-9.05%	1.74%
Germany	-0.57%	-0.47%	-0.57%	-0.35%
Denmark	-0.87%	-0.89%	-0.95%	-0.67%
Spain	-0.24%	-0.14%	-0.27%	-0.09%
Estonia	0.45%	0.52%	0.36%	1.57%
Finland	0.23%	0.29%	0.28%	0.74%
France	-0.82%	-0.76%	-0.86%	-0.74%
UK	-1.70%	-1.74%	-1.83%	-1.74%
Greece	-2.11%	-2.02%	-2.19%	-2.05%
Hungary*	-4.38%	-0.33%	-4.76%	30.81%
India*	-7.16%	-0.95%	-7.36%	1.85%
Ireland	0.55%	0.56%	0.63%	0.67%
Italy	-0.09%	-0.02%	0.03%	0.17%
Japan	-0.76%	-0.70%	-0.78%	-0.69%
South Korea	0.18%	0.15%	0.14%	0.31%
Lithuania	-0.02%	0.45%	0.19%	1.49%
Mexico*	-7.43%	-1.00%	-5.70%	3.08%
Netherlands	-0.60%	-0.64%	-0.70%	-0.66%
Poland*	-1.97%	0.11%	-8.42%	-5.23%
Portugal	-0.31%	-0.23%	-0.18%	0.01%
Romania	0.37%	0.43%	0.38%	0.87%
Russia*	-22.06%	-3.47%	-14.30%	13.56%
RoW	1.33%	1.18%	1.14%	1.48%
Slovakia	0.71%	1.06%	0.88%	1.71%
Slovenia	0.78%	0.97%	0.87%	1.57%
Sweden	-0.64%	-0.56%	-0.61%	-0.48%
Turkey*	-3.40%	-0.37%	-6.34%	-1.92%
Taiwan*	0.13%	0.23%	0.03%	0.24%
USA	-0.85%	-0.88%	-0.97%	-0.93%

Note: emerging economies are labeled by *. High growth level countries are labeled by (L).

Table 8: The Effects of Quality Home Bias on Quality Effects and Combined Effects

	Quality Effect	Combined effects
$I\{\rho^s = 0.1\}$	0.047*	0.309***
(s.e.)	(0.027)	(0.069)
Country FE	X	X
Obs.	72	72

Note: *p<0.1; **p<0.05; ***p<0.01.

The second exercise examines the impact of growth in nine countries that have experienced the largest growth *levels* in value-added of tradable sections instead of the emerging economies that have experienced large growth *rates*. Those nine countries are labeled by (L). Table 9 reports the results for high growth rate countries with those for emerging economies copied from Table 5. Though the difference between the productivity effect and the quality effect becomes evident for some countries (e.g., Ireland, South Korea), the overall effects are still modest. These two exercises suggest that the growth of tradable sectors in emerging economies are not large enough to have sizable impacts on other countries' terms of trade in the vieiw of the estimated Ricardian model.

Table 9: Real Wage Changes under Counterfactual Growth of High Growth Level Countries and Emerging Countries in 2007

Country	High Growth Level Countries			Emerging Economies		
	TFP	Quality	Combined	TFP	Quality	Combined
Australia (L)	-1.21%	-12.50%	0.60%	-0.81%	-0.41%	-0.72%
Austria	-0.91%	-1.49%	-1.00%	-0.84%	-1.15%	-1.09%
Belgium	-0.36%	-0.18%	0.01%	-0.29%	-0.14%	-0.26%
Bulgaria	2.76%	3.72%	2.80%	2.69%	3.02%	2.85%
Brazil (L)*	-0.07%	-7.74%	2.68%	-0.38%	-7.12%	2.33%
Canada (L)	-1.34%	-5.85%	-0.52%	-0.17%	0.12%	-0.09%
China (L)*	-15.31%	-7.16%	-20.20%	-17.94%	-5.75%	-21.21%
Czech Rep*	1.95%	1.02%	1.71%	0.98%	-9.92%	-9.05%
Germany	-0.24%	-1.17%	-0.18%	-0.38%	-0.57%	-0.57%
Denmark	-0.80%	-0.31%	-0.69%	-0.98%	-0.87%	-0.95%
Spain	-0.13%	-0.76%	-0.33%	-0.15%	-0.24%	-0.27%
Estonia	0.59%	0.54%	0.41%	0.58%	0.45%	0.36%
Finland	0.62%	-0.47%	0.47%	0.44%	0.23%	0.28%
France	-0.75%	-1.28%	-0.85%	-0.80%	-0.82%	-0.86%
UK	-1.81%	-0.62%	-1.43%	-1.83%	-1.70%	-1.83%
Greece	-2.26%	-2.14%	-2.27%	-2.20%	-2.11%	-2.19%
Hungary*	1.89%	0.53%	1.22%	-4.95%	-4.38%	-4.76%
India (L)*	-2.52%	-8.37%	-6.64%	-3.88%	-7.16%	-7.36%
Ireland	0.93%	-0.03%	0.60%	0.69%	0.55%	0.63%
Italy	0.07%	-0.85%	-0.30%	0.08%	-0.09%	0.03%
Japan	-0.34%	-1.67%	-0.80%	-0.60%	-0.76%	-0.78%
South Korea	0.86%	-1.48%	-0.11%	0.46%	0.18%	0.14%
Lithuania	0.33%	-0.00%	-0.26%	0.50%	-0.02%	0.19%
Mexico (L)*	-1.96%	-9.09%	-4.52%	-1.93%	-7.43%	-5.70%
Netherlands	-0.77%	0.12%	-0.42%	-0.73%	-0.60%	-0.70%
Poland*	0.39%	0.58%	0.43%	-12.26%	-1.97%	-8.42%
Portugal	-0.09%	-0.76%	-0.63%	-0.13%	-0.31%	-0.18%
Romania	0.34%	0.25%	0.19%	0.20%	0.37%	0.38%
Russia (L)*	-0.96%	-21.89%	-12.40%	-1.49%	-22.06%	-14.30%
RoW (L)	0.39%	-12.40%	5.75%	1.05%	1.33%	1.14%
Slovakia	1.35%	0.65%	1.21%	1.15%	0.71%	0.88%
Slovenia	1.07%	0.29%	1.00%	1.11%	0.78%	0.87%
Sweden	-0.39%	-1.01%	-0.26%	-0.46%	-0.64%	-0.61%
Turkey*	0.16%	0.12%	-0.36%	-14.70%	-3.40%	-6.34%
Taiwan*	0.95%	-1.09%	-0.00%	-8.37%	0.13%	0.03%
USA (L)	-2.81%	-6.41%	0.13%	-0.96%	-0.85%	-0.97%

Note: high growth level countries are labeled by (L). Emerging economies are labeled by *.

6 Conclusion

Whether fast-growing emerging economies benefit or hurt other countries has been an important question in the study of international trade. The theoretical literature developed by Hicks (1953), Ikema (1969), Ohyama(1998; 2010), and others have established that the answer depends on the bias of productivity growth across sectors and the home bias of quality preferences. This paper has developed an empirical framework to quantify the welfare effect of a country's productivity and quality growth on other countries by using a multi-country Ricardian model with multi-region input-output tables. Quality home bias are found in all industries, supporting Ohyama(1998; 2010). We find, however, the growth of emerging economies during 1995–2007 had only modest impacts on other countries' welfare.

The WIOD dataset we used has some limitation. First, it includes information only after 1995, when the GVC was already being established. Second, it does not cover some major South Asian countries. One way to overcome these limitations is to supplementarily use the Asian Input-Output Tables created by IDE-JETRO, which includes IO tables from 1980s and covers more Asian countries.[6] We leave this exercise as a future extension of our analysis.

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A Proof of Lemma 1

Proof. Noting $\tilde{p} = \tilde{p}^* \kappa^{\rho-1}$, we write the market clearing condition for X as

$$\frac{\tilde{p}^{*-\sigma}\kappa^{\sigma(1-\rho)}}{\tilde{p}^{*1-\sigma}\kappa^{(\sigma-1)(1-\rho)}+\tau^{1-\sigma}}\tilde{p}^*\kappa^{\rho-1}\bar{X}+\frac{\tilde{p}^{*-\sigma}\tau^{1-\sigma}}{\tilde{p}^{*1-\sigma}\tau^{1-\sigma}+1}\frac{\bar{Y}^*}{\kappa^{\rho}}=\bar{X}$$

which is simplified as

$$\frac{\tilde{p}^*\bar{X}}{\tilde{p}^{*1-\sigma}\kappa^{(\sigma-1)(1-\rho)}+\tau^{1-\sigma}}=\frac{1}{\tilde{p}^{*\sigma-1}+\tau^{1-\sigma}}\frac{\bar{Y}^*}{\kappa^{\rho}}.$$

It is evident that defining

$$f(\tilde{p}^*,\kappa,\bar{X}) \equiv \ln\tilde{p}^* + \ln(\tilde{p}^{*\sigma-1}+\tau^{1-\sigma}) - \ln[\tilde{p}^{*1-\sigma}\kappa^{(\sigma-1)(1-\rho)}+\tau^{1-\sigma}] + \ln\bar{X} - \ln\bar{Y}^* + \rho\ln\kappa.$$

then the market clearing condition is equivalent to $f(\tilde{p}^*,\kappa,\bar{X}) = 0$.

To find how a change in $\bar{X}$ or κ affects $\tilde{p}^*$ and hence u^*, we differentiate f with respect to the logarithm of each argument. With a slight abuse of notation, we obtain

$$\begin{aligned}
\frac{\partial f}{\partial \ln \tilde{p}^*} &= 1+\frac{(\sigma-1)\tilde{p}^{*\sigma-1}}{\tilde{p}^{*\sigma-1}+\tau^{1-\sigma}}+\frac{(\sigma-1)p^{*1-\sigma}\kappa^{(\sigma-1)(1-\rho)}}{p^{*1-\sigma}\kappa^{(\sigma-1)(1-\rho)}+\tau^{1-\sigma}}>0,\\
\frac{\partial f}{\partial \ln \bar{X}} &= 1>0,\\
\frac{\partial f}{\partial \ln \kappa} &= \rho-\frac{(\sigma-1)(1-\rho)\tilde{p}^{*1-\sigma}\kappa^{(\sigma-1)(1-\rho)}}{p^{*1-\sigma}\kappa^{(\sigma-1)(1-\rho)}+\tau^{1-\sigma}}\\
&= \frac{[1-\sigma(1-\rho)]p^{*1-\sigma}\kappa^{(\sigma-1)(1-\rho)}+\rho\tau^{1-\sigma}}{p^{*1-\sigma}\kappa^{(\sigma-1)(1-\rho)}+\tau^{1-\sigma}}
\end{aligned}$$

To find the sign of $\partial f/\partial \ln \kappa$, we first note that the last expression for $\partial f/\partial \ln \kappa$ is negative when $\rho=0$, while it is positive when $\rho=(\sigma-1)/\sigma$, in which case $1-\sigma(1-\rho)=0$, and when $\rho=1$. The derivative of $[1-\sigma(1-\rho)]p^{*1-\sigma}\kappa^{(\sigma-1)(1-\rho)}+\rho\tau^{1-\sigma}$, the numerator of the expression, with respect to ρ is given by

$$\tilde{p}^{*1-\sigma}\kappa^{(\sigma-1)(1-\rho)}\{\sigma-[1-\sigma(1-\rho)](\sigma-1)\ln\kappa\}+\tau^{1-\sigma}.$$

It is easy to see that this takes a positive value for $0\le\rho\le(\sigma-1)/\sigma$, so that $\partial f/\partial \ln \kappa$ increases with ρ in this range. As ρ increases further, it monotonically declines and may become negative. But because of the monotonicity, it follows from $\partial f/\partial \ln \kappa>0$ for $\rho=(\sigma-1)/\sigma$ and $\rho=1$ that there exists $\tilde{\rho}\in(0,1)$ such that

$$\frac{\partial f}{\partial \ln \kappa}\left\{\begin{array}{c}<\\=\\>\end{array}\right\}0\Leftrightarrow\rho\left\{\begin{array}{c}<\\=\\>\end{array}\right\}\tilde{\rho}.$$

Now, using the implicit function theorem, we find that $d\ln\tilde{p}^*/d\ln\bar{X}<0$ and that $d\ln\tilde{p}^*/d\ln\kappa>0$ if and only if $\rho<\tilde{\rho}$

To conclude the proof, we show that when the quality parameter κ enters the Foreign utility function linearly, i.e., $\rho=1$, an increase in κ is equivalent to an increase in $\bar{X}$, the endowment of the Home good, in terms of equilibrium resource allocation.

On the one hand, the equilibrium (p, X, X^*, Y, Y^*) of our two-country model is given by solving the two countries' individual utility maximization problems:

$$\begin{aligned} \max \quad & u = \left[(\kappa X)^{\frac{\sigma-1}{\sigma}} + (aY)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \\ \text{s.t.} \quad & pX + Y = p\bar{X}, \end{aligned}$$

for Home and

$$\begin{aligned} \max \quad & u = \left[(a\kappa X^*)^{\frac{\sigma-1}{\sigma}} + Y^{*\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \\ \text{s.t.} \quad & pX^* + Y^* = p\bar{Y}, \end{aligned}$$

for Foreign. On the other hand, the equilibrium $(\check{p}, \check{X}, \check{X}^*, \check{Y}, \check{Y}^*)$ of the alternative model in which Home's endowment of good X is $\kappa\bar{X}$ is given by solving the following maximization problems:

$$\begin{aligned} \max \quad & u = \left[\check{X}^{\frac{\sigma-1}{\sigma}} + (a\check{Y})^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \\ \text{s.t.} \quad & \check{p}\check{X} + \check{Y} = \check{p}\kappa\bar{X}, \end{aligned}$$

for Home and

$$\begin{aligned} \max \quad & u = \left[(a\check{X}^*)^{\frac{\sigma-1}{\sigma}} + \check{Y}^{*\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \\ \text{s.t.} \quad & \check{p}\check{X}^* + \check{Y}^* = p\bar{Y}, \end{aligned}$$

for Foreign. It is straightforward to see that these two solutions are the same, given $\check{p} = p/\kappa$, $\check{X} = \kappa X$, $\check{X}^* = \kappa X^*$, $\check{Y} = Y$, and $\check{Y}^* = Y^*$. □