# Comparative Advantage and Multi-Stage Production

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**Abstract**

The theory of comparative advantage touts the benefits of specializing production in relatively efficient sectors. In this paper, I explore whether this principle holds for stages of production as well. I derive a simple one sector model with tradable intermediate (stage 1) and final (stage 2) goods, showing that the gains from trade are, in theory, potentially higher when the cross-stage margin of specialization is exploited. I then extend this model to many countries and many sectors to match data from the World Input Output Database and calculate the gains from specialization in intermediate or final goods production. I find that, on average, the gains are modest at less than 1% of GDP. However, for a set of emerging economies the gains are significantly higher than this. Contrary to some theories, these results suggest that emerging economies benefit relatively more from international trade in intermediate goods than more developed economies.

JEL classification codes: F11, F14, F60

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# 1 Introduction

Ricardo's theory of comparative advantage is perhaps the most famous adage in international trade. It states that any country, regardless of overall productive capability, can benefit from trade by specializing production in relatively efficient sectors.

To illustrate this concept, Ricardo (1817) used a two good example: cloth and wine. Interestingly, these two goods are quite different in terms of their use. Wine is, for the most part, a final good that is directly consumed. In contrast, cloth is largely used as an intermediate good to produce other goods in, for example, the textiles industry. These details were not emphasized by Ricardo, perhaps because he was focused on illustrating the point that both England and Portugal (which had comparative advantage in cloth and wine respectively) could benefit from trade.

In more recent years, however, trade economists have also become interested in quantifying the global gains from trade and the distribution of these gains across countries based on micro-founded trade models.[1] In light of this, the distinction between intermediate and final goods is worth exploring in greater detail. Do countries that specialize in producing intermediate goods benefit as much as those that specialize in producing final goods? If not, which producer benefits more, and how does this correspond to the existing world where many countries trade both intermediate and final goods?

In this paper, I examine the relationship between comparative advantage and cross-stage specialization. Cross-stage specialization (CSS), as I define it, is the process whereby each country in a bilateral trade relationship specializes in either intermediate or final goods production due to comparative advantage. I use a simple two country, two good theoretical model to illustrate how comparative advantage can explain patterns of CSS. I provide a simple equation for calculating the gains from this type of trade, showing that there are gains from specialization across stages of production. I also illustrate that the distribution of these gains is potentially uneven and depends crucially on both where a country's comparative advantage lies (intermediate versus final goods) and how important, in terms of value-added share, intermediate goods are in the economy.

This model is derived from the workhorse heterogeneous firms Ricardian model of Eaton and Kortum (2002) (EK). As in many recent extensions of the EK model, my model provides a basis for including many sectors, as well as intermediate goods. In addition, I allow for differences in technology for intermediate and final goods production for a given country and sector. As a result, the model provides a basis for CSS which is absent from other versions of the EK model. I find that, by abstracting from this channel of specialization, the standard EK framework will either overestimate or underestimate

[1] See, for example, Arkolakis et al (2012).

the gains from trade, depending on several factors.

To assess the implications of this mechanism quantitatively, I use sectoral data on international trade and input-output production tables from the World Input Output Database (WIOD) for 2005. The WIOD includes production and bilateral trade data for 34 countries, 16 sectors and two stages of production. I calculate the gains from trade according to an extended version of my model and isolate the gains from CSS. I find that the gains from trade are, on average, higher under my model than under the standard EK (2002) model. Average gains are, however, quite modest at less than 1% of GDP.

Despite these modest average gains, there is considerable heterogeneity across countries. I illustrate that the gains due to CSS are highest among several emerging economies, including China, Brazil, India, Indonesia and Mexico.

This paper contributes to the literature in several ways. First, it relates to a recent literature that attempts to identify the role of comparative advantage across sectors in empirical trade flows. For examples, see Chor (2010), Costinot and Donaldson (2012), Costinot, Donaldson and Kumunjer (2012) and French (2015). My paper reveals that comparative advantage across stages of production is generally not as significant as comparative advantage across sectors. However, under certain settings and for several emerging countries, it is more important, leading to higher welfare gains than the gains from traditional comparative advantage trade.

My results also provide interesting insights into the theoretical and quantitative importance of placement along the value chain across countries. As far back as Hamilton (1790), some economists have argued in favor of protectionism based on the premise that poorer economies possess comparative advantage in more basic goods. My model provides theoretical support for the assertion that countries which specialize in basic goods production benefit relatively less from trade, where intermediate goods are considered "more basic", under certain conditions. This intuition is also supported by other recent papers by Melitz and Redding (2014) and Fally and Hilberry (2015). Both paper underscore that the benefits of being placed downstream on the value chain are over and above those of being placed further upstream.[2] I find, however, that these insights are quantitatively not that important. At the country level, intermediate and final goods are quite evenly traded for most countries, regardless of industrialization stage. In fact, less-developed economies tend to specialize *relatively more* in final goods production, leading to significant positive gains due to CSS. This is exactly the opposite of what a Hamiltonian argument might assume. In calculating the gains from intermediate goods trade across countries, I find that, on average, these gains are roughly on par with the gains

[2]Fally and Hilberry (2015) also derive this result from a Ricardian setting. However, their model is more complex and the mechanisms that drive their results are somewhat different than those in the present paper.

from trade in final goods. For emerging countries, however, the gains from intermediate goods trade are significantly larger than the gains from final goods trade. Whereas in the past it might have been true that less developed economies exported upstream and imported downstream goods, the emergence of global value chains has permitted these economies to add-value at an intermediate step and, as a result, receive the economic benefits of producing downstream.

My work also relates to a recent discussion in the literature pertaining to the gains from trade according to micro-founded trade models. In a seminal paper, Arkolakis et al (2012) argued that, across a broad set of micro-founded trade models, the gains from international trade can be calculated from two variables: the overall share of imports in consumption and the elasticity of international trade with respect to trade costs. A crucial limitation for this calculation is the assumption that economic activity is symmetric across sectors. As is pointed out by Levchenko and Zhang (2014), this assumption undermines the importance of comparative advantage, or differences in productivity across sectors, as a basis for gains from trade. They reveal that by extending the basic Arkolakis et al (2012) framework to 20 sectors, the gains from trade are on average 30% higher than the basic model suggests. This is consistent with other papers, including Caliendo and Parro (2015), Ossa (2015) and French (2015), which reveal of importance of sectoral differences in quantifying the gains from trade. In this paper, I explore a third margin, specialization across stages of production, as a source of gains from trade.

The remainder of the paper is organized as follows. In Section 2, I illustrate a simple model with comparative advantage across stages of production. The model reveals that there are gains from trade due to specialization across these stages. In Section 3, I extend the model to many sectors and countries. In Section 4, I discuss and summarize the data. In Section 5, I discuss the results. In Section 6, I conclude. An appendix follows.

# 2 Basic Model

## 2.1 Environment

Consider the following two-country ($n = a, b$) one-sector EK (2002) model. There are two stages of production: an intermediate (1) stage and a final (2) stage. Consumers in $n$ have labor endowment $L_n$ and receive labor income at wage $w_n$. They derive utility from consuming a composite final good $C_{2,n}$:

$$U_n = C_{2,n} \tag{1}$$

The budget constraint for consumers in $n$ is given by:

$$P_{2,n}C_{2,n} = w_n L_n \tag{2}$$

where $P_{2,n}$ denotes the aggregate price index for the final good.

The final composite good in $n$ is produced using a continuum of final good varieties indexed by $\omega \in [0, 1]$ according to the following CES production technology:

$$Q_{2,n} = \left( \int q_{2,n}(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}} \tag{3}$$

where $\sigma > 1$ denotes the elasticity of substitution across varieties and $q_{2,n}(\omega)$ denotes the quantity of a given final good variety. I denote the final goods price index as:

$$P_{2,n} = \left[ \int_0^1 p_{2,n}(\omega)^{1-\sigma} d\omega \right]^{\frac{1}{1-\sigma}} \tag{4}$$

where $p_{2,n}(\omega)$ denotes the price of a given final good variety.

Final good varieties are produced with productivity drawn from a country-specific Fréchet distribution of the following form:

$$F_{2,n}(z) = Pr\left(z_{2,n} < z\right) = exp\left\{-T_{2,n}z^{-\theta}\right\} \tag{5}$$

where $T_{2,n}$ depicts a parameter of country-level average productivity in final goods while $\theta$ provides dispersion across productivity draws. The dispersion parameter provides a basis for gains from trade in final goods.

Final good varieties are produced using labor and a composite intermediate good input $M_n$. Letting $1 - \beta$ denote the Cobb-Douglas share of labor used in production, the final goods production technology for $\omega$ is:

$$q_{2,n}(\omega) = z_{2,n}(\omega) \left(l_{2,n}(\omega)\right)^{1-\beta} \left(M_{2,n}(\omega)\right)^{\beta} \tag{6}$$

The intermediate composite good is produced according to a similar technology as the final composite good:

$$Q_{1,n} = \left( \int q_{1,n}(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}} \tag{7}$$

where $q_{1,n}(\omega)$ denotes the quantity of a given intermediate good variety. I denote the intermediate goods price index as:

$$P_{1,n} = \left[ \int_0^1 p_{1,n}(\omega)^{1-\sigma} d\omega \right]^{\frac{1}{1-\sigma}} \tag{8}$$

where $p_{1,n}(\omega)$ denotes the price of a given intermediate good variety.

Intermediate good varieties are also produced with productivity drawn from a country-specific Fréchet distribution:

$$F_{1,n}(z) = Pr\left(z_{1,n} < z\right) = exp\left\{-T_{1,n} z^{-\theta}\right\} \tag{9}$$

Note that the only manner in which (9) is distinct from (5) comes from the average productivity terms $T_{2,n}$ and $T_{1,n}$.

Like final goods, intermediate good varieties are produced using labor and the composite intermediate good input $M_n$. The intermediate goods production technology for $\omega$ is:

$$q_{1,n}(\omega) = z_{1,n}(\omega) \left(l_{1,n}(\omega)\right)^{1-\beta} \left(M_{1,n}(\omega)\right)^{\beta} \tag{10}$$

Product and factor markets are perfectly competitive. All goods sold by producers in country $b$ to demanders in country $a$ are subject to a stage specific ad-valorum bilateral iceberg transportation cost $\kappa_{s,ab}$ where $\kappa_{s,ab} > \kappa_{s,bb} = 1$ for $s = 1, 2$. Accordingly, producers of stage $s$ goods in country $b$ sell their products in country $a$ at a price equal to marginal cost:

$$p_{s,ab}(\omega) = \frac{c_b \kappa_{s,ab}}{z_{s,b}(\omega)} \tag{11}$$

where

$$c_b = \Psi_b \left(w_b\right)^{1-\beta} \left(P_{1,b}\right)^{\beta} \tag{12}$$

denotes the unit cost of production in country $b$ and $\Psi_b$ is a constant [3].

[3]Specifically, $\Psi_b = (\beta)^{-\beta}(1-\beta)^{\beta-1}$

## 2.2 Equilibrium

The competitive equilibrium consists of a set of prices and allocation rules such that, taking prices as given, (i) intermediate and final goods firms satisfy first order conditions in each country (ii) consumers satisfy their first order conditions in each country (iii) the labor market clears in each country (iv) the goods markets clears for both stages in each country and (v) trade is balanced for each country.

I will provide the solution from the perspective of country $a$, although the following identities also apply to country $b$.

### 2.2.1 Demand and Prices

The solution to the consumers' and producers' problems yields the following demand expenditure function for stage-specific good variety $\omega$ in country $a$:

$$x_{s,ab}(\omega) = \left[\frac{p_{s,ab}(\omega)}{P_{s,a}}\right]^{1-\sigma} X_{s,a} \tag{13}$$

where $X_{s,a} = P_{s,a}Y_{s,a}$ denotes total spending in $a$ on stage $s$ goods.

The upper level Cobb-Douglas production function yields the following expression for total intermediate goods expenditure in $a$:

$$X_{1,a} = \beta\left(Y_{1,a} + Y_{2,a}\right) \tag{14}$$

where $Y_{s,a}$ denotes the total value of output of stage $s$ goods. Labor input shares can be expressed as the following:

$$L_{s,a} = (1-\beta)Y_{s,a} \tag{15}$$

for $s = 1, 2$.

The utility function yields the following expression for total final goods expenditure:

$$X_{2,a} = w_a L_a \tag{16}$$

We can simplify the expressions for $P_{s,a}$ in (4) and (8) by making use of some convenient properties of the Fréchet distribution. Let $G_{s,ab}\left(p\right)$ denote the probability that the price at which country $b$ can supply a stage $s$ variety to country $a$ is lower than or equal to $p$. From (11), it is clear that $p = c_b\kappa_{s,ab}/z$. When we substitute this into $G_{s,ab}\left(p\right)$ and make use of distributions in (5) and (9), we find that:

$$G_{s,ab}\left(p\right) = Pr\left(\frac{c_b\kappa_{s,ab}}{z_{s,b}} < \frac{c_b\kappa_{s,ab}}{z}\right) = Pr\left(z_{s,b} > \frac{c_b\kappa_{s,ab}}{p}\right) = 1 - F_{s,b}\left(c_b\kappa_{s,ab}/p\right) \tag{17}$$

Let $p_{s,a}(\omega) \equiv min\{p_{s,a1}(\omega), p_{s,a2}(\omega), ..., p_{s,aN}(\omega)\}$ denote the lowest price of variety $\omega$ offered to country $a$ for a particular stage. Then $p_{s,a}(\omega)$ is distributed according to the following function:

$$G_{s,a}(p) = 1 - exp\left\{-\phi_{s,a}p^{\theta}\right\} \tag{18}$$

where

$$\phi_{s,a} = T_{s,a}\left[c_a\kappa_{s,aa}\right]^{-\theta} + T_{s,b}\left[c_b\kappa_{s,ab}\right]^{-\theta} \tag{19}$$

This is a standard result from the EK (2002) set-up.

Let $\pi_{s,ab}$ denote the probability that country $b$ provides the lowest price in country $a$ of a given stage $s$ variety $\omega$. This probability is equivalent to the contribution share that country $b$ provides to $\phi_{s,a}$.[4] That is,

$$\pi_{s,ab} = \frac{T_{s,b}\left[c_b\kappa_{s,ab}\right]^{-\theta}}{\phi_{s,a}} \tag{20}$$

The share of total spending in $a$ on goods from $b$ for a given stage $s$ can also be represented as $\pi_{s,ab}$.

Using these results, we can simplify (4) and (8) to the following general closed-form solution:

$$P_{s,a} = \gamma[\phi_{s,a}]^{\frac{1}{-\theta}} \tag{21}$$

where $\gamma = \Gamma\left(\frac{\theta+1-\sigma}{\theta}\right)^{\frac{1}{1-\sigma}}$ is a constant. Again, these results all essentially apply to the original EK (2002) model (except for the $s$ subscripts).

Separating into stages, the expression $P_{1,a}$ represents the intermediate price index for producers in $a$. The expression $P_{2,a}$ represents the final goods price index for consumers in $a$.

### 2.2.2 The Trade Share Equations

I denote $X_{s,ab}$ as total expenditure in $a$ on stage $s$ goods imported from $b$. Under the Fréchet distribution, the share of total spending by country $a$ on goods from $b$ for a given stage is equal to the probability that country $b$ offers the lowest price in country $a$, $\pi_{s,ab}$. That is,

$$\pi_{s,ab} = \frac{X_{s,ab}}{X_{s,a}} = \frac{T_{s,b}\left[c_b\kappa_{s,ab}\right]^{-\theta}}{\phi_{s,a}} \tag{22}$$

[4]The distribution $G_{s,a}(p)$ also represents the distribution prices for goods purchased by $a$ conditional on source country. That is, the unconditional distribution of prices of goods purchased is equal to the conditional distribution of prices of goods purchased. This result indicates that firms do not adjust prices at the intensive margin; rather, all of the adjustment due to a change in input costs, productivity or trade costs occurs at the extensive margin.

This expression applies for all $s$ for both $a$ and $b$. For a given stage $s$, the share of total spending by $a$ on goods from $b$ is positively related to the overall stage productivity parameter in $b$, $T_{s,b}$, and negatively related to unit cost of production $c_b$ in that country and the stage specific trade cost $\kappa_{s,ab}$. The denominator denotes a multilateral resistance term for exporters to $a$ in stage $s$ goods: it is equal to the sum of $T_{s,i}\left[c_i \kappa_{s,ai}\right]$ across $i = a, b$.

### 2.2.3 Market Clearing

The stage-specific goods market clearing conditions for intermediate and final goods can be depicted as:

$$Y_{s,a} = X_{s,aa} + X_{s,ba} = \pi_{s,aa} X_{s,a} + \pi_{s,ba} X_{s,b} \tag{23}$$

To derive an expression for balanced trade, I define total exports of stage $s$ goods for $a$ and $b$ respectively as $EX_{s,a} = X_{s,ba}$, $EX_{s,b} = X_{s,ab}$. For imports, the corresponding identities are $IM_{s,a} = X_{s,ab}$, $IM_{s,b} = X_{s,ba}$. The balanced trade condition for $i = a, b$ is thus:

$$\sum_{s=1}^{2} \left(EX_{s,i} - IM_{s,i}\right) = 0 \tag{24}$$

The factor market clearing condition for $a$ must satisfy:

$$L_a = L_{1,a} + L_{2,a} \tag{25}$$

Since trade is balanced, total expenditure by consumers in country $a$ is equal to total income in that country:

$$X_{2,a} = w_a L_a \tag{26}$$

Substituting the goods market clearing and balanced trade conditions into the demand equation for intermediates yields the following expenditure equation:

$$X_{1,a} = \beta \left[ \sum_{i=a,b} \pi_{1,ia} X_{1,i} + \sum_{i=a,b} \pi_{2,ia} X_{2,i} \right] \tag{27}$$

## 2.3 Welfare

Welfare per capita in country $a$ can be represented as the following:

$$W_a = \frac{w_a}{P_{2,a}} \tag{28}$$

We can substitute (21) into (22) to find the following expression for domestic expenditure share on final goods $\pi_{2,aa}$:

$$\pi_{2,aa} = \frac{X_{aa}}{X_a} = \frac{T_{2,a}\left[c_a\right]^{-\theta}}{\left[P_{2,a}\right]^{-\theta}} \tag{29}$$

Substituting in the unit cost expression in (12) yields:

$$\pi_{2,aa} = \frac{X_{aa}}{X_a} = \frac{T_{2,a}\left[\Psi_a\left(w_a\right)^{1-\beta}\left(P_{1,a}\right)^{\beta}\right]^{-\theta}}{\left[P_{2,a}\right]^{-\theta}} \tag{30}$$

The analogous expression to (30) for domestic expenditure share on intermediate goods is:

$$\pi_{1,aa} = \frac{T_{1,a}\left[\Psi_a\left(w_a\right)^{1-\beta}\left(P_{1,a}\right)^{\beta}\right]^{-\theta}}{\left[P_{1,a}\right]^{-\theta}} = T_{1,a}\left[\Psi_a\left(w_a\right)^{1-\beta}\left(P_{1,a}\right)^{-(1-\beta)}\right]^{-\theta} \tag{31}$$

Rearranging this expression in terms of $P_{1,a}$ yields:

$$P_{1,a} = \left(\frac{T_{1,a}}{\pi_{1,aa}}\right)^{\frac{-1}{\theta(1-\beta)}}\left(\Psi_a\right)^{\frac{1}{(1-\beta)}} w_a \tag{32}$$

When we substitute (32) into (30) and rearrange in terms of $P_{2,a}$, we find the following:

$$P_{2,a} = \left(\frac{T_{2,a}}{\pi_{2,aa}}\right)^{\frac{-1}{\theta}}\left(\frac{T_{1,a}}{\pi_{1,aa}}\right)^{\frac{-\beta}{\theta(1-\beta)}} w_a \tag{33}$$

Finally, substituting (33) into the welfare equation in (28) yields the following expression for welfare:

$$W_a^S = \left(\frac{T_{2,a}}{\pi_{2,aa}}\right)^{\frac{1}{\theta}}\left(\frac{T_{1,a}}{\pi_{1,aa}}\right)^{\frac{\beta}{\theta(1-\beta)}} \tag{34}$$

Remarkably, welfare in $a$ can be represented as a simple function: increasing in average productivity for the final and intermediate goods stages in that country ($T_{2,a}$ and $T_{1,a}$) and decreasing in the share of domestic expenditure for final goods and domestic expenditure for intermediate goods ($\pi_{2,aa}$ and $\pi_{1,aa}$). Moreover, the relative impact of each stage on overall welfare depends on the value-added share $(1-\beta)$. As $\beta$ rises, the intermediate goods stage has a bigger relative impact on welfare.

In the case where $\pi_{aa}$ is equal for both intermediate and final goods, expression (34) reduces to the same welfare expression as in the basic EK (2002) model with intermediate inputs (derived in Arkolakis *et al.* (2012)):

$$W_a^{EK} = \left(\frac{T_a}{\pi_{aa}}\right)^{\frac{1}{\theta(1-\beta)}} \tag{35}$$

To find the gains from trade, I take take the logarithm of (34) and consider the comparative static of going from autarky, where $\widetilde{\pi}_{s,aa} = 1$, to the current state where $\pi_{s,aa} \leq 1$. This reduces to the following expression for the gains from trade:

$$GFT_a^S = d\ln(W_a^S) = -\frac{1}{\theta}d\ln(\pi_{2,aa}) - \frac{\beta}{\theta(1-\beta)}d\ln(\pi_{1,aa}) \tag{36}$$

To calculate the gains from trade according to (36), all that one needs is data on domestic consumption shares for consumption and production respectively, the share of intermediates used in production, and a measure of the sectoral dispersion parameter.

The gains from trade formula in the traditional EK (2002) model can be depicted as:

$$GFT_a^{EK} = d\ln(W_a^{EK}) = -\frac{1}{\theta(1-\beta)}d\ln(\pi_{aa}) \tag{37}$$

For this case, one only needs data for overall domestic consumption share, which is assumed to be equal for intermediate and final goods, and the dispersion parameter.

EK (2002) essentially abstracts from differences in $\pi_{s,aa}$ across stages of production and assumes that they are equivalent. To illustrate the impact of this assumption, I consider the case where $\beta = 0.5$ and trade is free, so that $\kappa_{s,ab} = 1$ for $s = 1, 2$. In addition, I let average stage productivities exhibit the "mirror image assumption" where $T_{1,a} = T_{2,b}$ and $T_{2,a} = T_{1,b}$.[5] This provides a basis for comparative advantage trade across stages of production.

Since $\beta = 0.5$, intermediate goods are as important in production as labor. Given the mirror image assumption and free trade, these countries will have identical wages in equilibrium, which I set to one. I can depict the share of intermediate imports for country $a$ as:

$$\pi_{1,ab} = \frac{T_{1,b}\left[(P_{1,b})^{\beta}\right]^{-\theta}}{T_{1,b}\left[(P_{1,b})^{\beta}\right]^{-\theta} + T_{1,a}\left[(P_{1,a})^{\beta}\right]^{-\theta}} \tag{38}$$

[5] See Levchenko and Zhang (2014) for a similar exposition.

The equivalent expression for the final goods imports is:

$$\pi_{2,ab} = \frac{T_{2,b}\left[(P_{1,b})^{\beta}\right]^{-\theta}}{T_{2,b}\left[(P_{1,b})^{\beta}\right]^{-\theta} + T_{2,a}\left[(P_{1,a})^{\beta}\right]^{-\theta}} \tag{39}$$

Note that $P_{1,a} = P_{1,b}$ due to free trade. This, coupled with the mirror image assumption, leads to equivalence in $\pi_{2,ab}$ and $\pi_{1,ab}$. As a result:

$$\pi_{2,ab} + \pi_{1,ab} = 1 \tag{40}$$

Given that $\pi_{2,ab} + \pi_{2,aa} = 1$ and $\pi_{1,ab} + \pi_{1,aa} = 1$ by definition, it is clear that $\pi_{1,ab} = \pi_{2,aa}$ and $\pi_{2,ab} = \pi_{1,aa}$. Overall, I can show that the relative size of $\pi_{2,aa}$ over $\pi_{1,ab}$ in this equilibrium, as well as the relative size of $\pi_{2,aa}$ over $\pi_{2,ab}$, depend solely the relative average stage productivities or, to put in Ricardian terms, *comparative advantage* across stage of production:

$$R_1 = \frac{\pi_{1,aa}}{\pi_{1,ab}} = \frac{T_{1,a}}{T_{1,b}}, \qquad R_2 = \frac{\pi_{2,aa}}{\pi_{2,ab}} = \frac{T_{2,a}}{T_{2,b}} = \frac{1}{R_1} \tag{41}$$

When $R_1 > R_2$, country $a$ can be thought to have a comparative advantage in the intermediate stage. If, on the other hand, $R_1 < R_2$ then comparative advantage is in final goods. The EK (2002) case abstracts from this by assuming that $R_1 = R_2$, in which case there is no comparative advantage across stages.

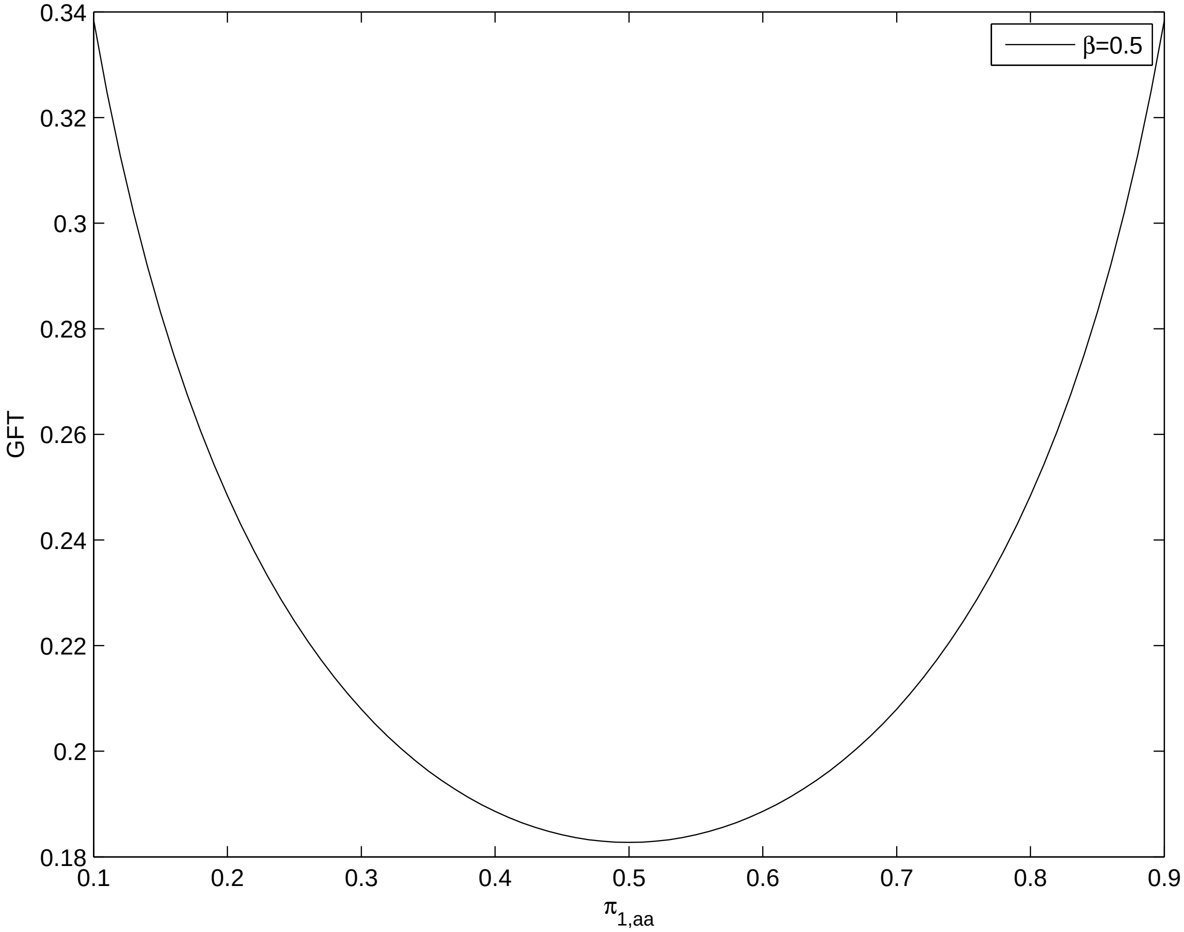
Figure 3.1 presents the relationship between the gains from trade in $a$ and $\pi_{1,aa}$[6]. When $\pi_{1,aa}$ is very low, $\pi_{2,aa}$ is very high and country $a$ has a comparative advantage in the final goods stage. Since there is free trade, country $a$ specializes heavily in final goods production and the gains from trade are relatively high. As we move right along the x-axis, the force of comparative advantage across stages weakens until the point where $\pi_{1,aa} = \pi_{2,aa}$; there is no comparative advantage across stages and the gains from trade are minimized. This is equivalent to the EK (2002) case with intermediate goods where it is assumed that import shares and average productivity are equal across stages of production. As we move further right from this point, the figure depicts cases where $a$ has a comparative advantage in the intermediate goods stage. Again, as the force of comparative advantage strengthens and $\pi_{1,aa}$ rises towards one, the gains from trade increase.

In sum, in this special case where $\beta = 0.5$, the EK (2002) assumption corresponds to the minimum point of the gains from trade, and any deviation from this assumption

[6]Figures 3.1 and 3.2 depict gains from trade where $\theta = 8.26$ as in the Eaton and Kortum (2002).

where $\pi_{1,aa} \neq \pi_{2,aa}$ will yield positive welfare gains.

Figure 1: Gains From Trade: $\beta = 0.5$

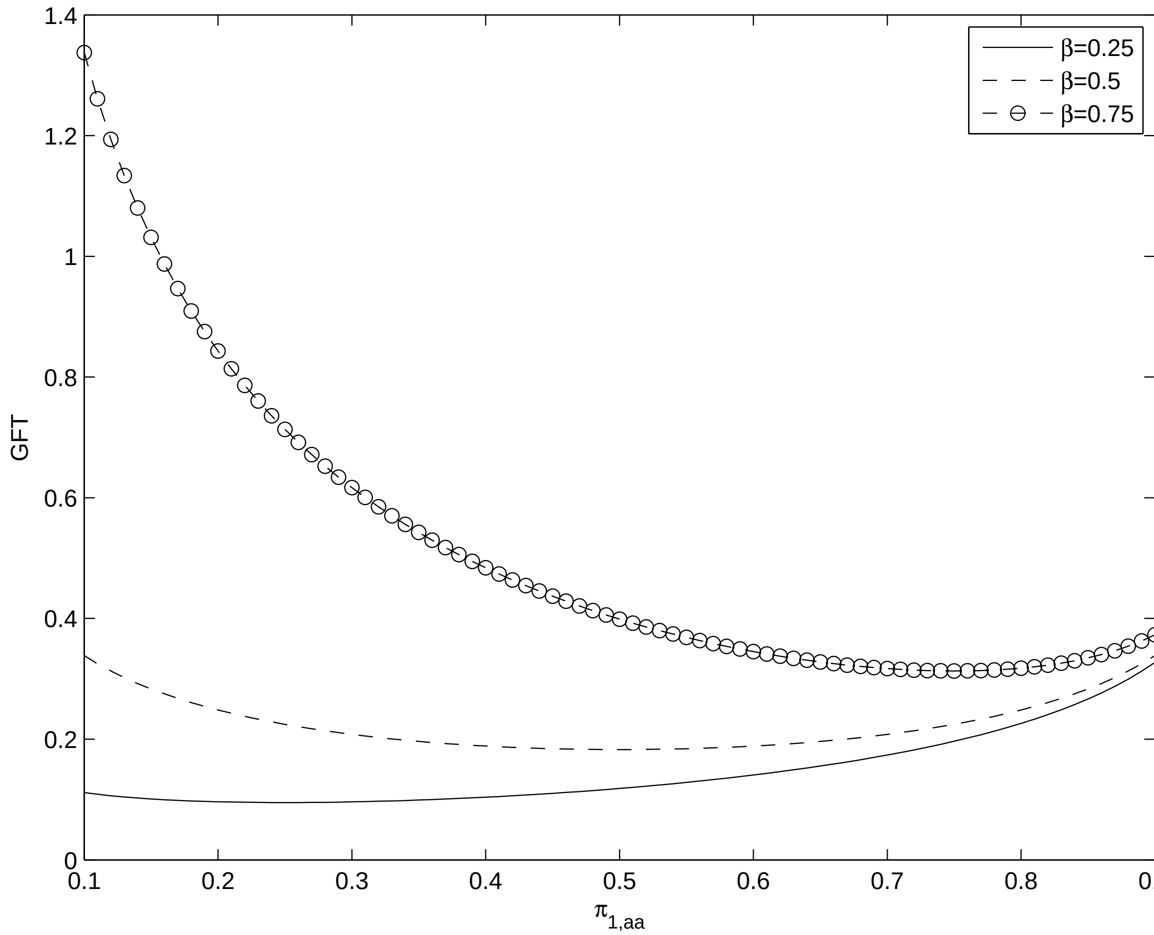



How does this relationship change when $\beta \neq 0.5$? Considering (36), it is fairly clear that as the share of value added $(1-\beta)$ falls, the gains are higher for trade in intermediate goods as compared to final goods.

Figure 3.2 considers the cases when $\beta = 0.75$ and $\beta = 0.25$ and compares with the baseline case where $\beta = 0.5$. This again depicts rising share of $\pi_{1,aa}$ moving left to right and assumes that $\pi_{1,aa} + \pi_{2,aa} = 1$.[7] As we see, when $\beta = 0.75$ and the value added share in production is relatively low, the gains from trade in $a$ are generally much higher for relatively high shares of trade in intermediate goods (low shares of domestic expenditure for intermediate goods). In contrast, when $\beta = 0.25$ and the share of value added in production is higher, there is generally a larger payoff, in terms of welfare, to importing a relatively high share in final goods and producing a high share of intermediate goods.

[7] When $\beta \neq 0.5$, it is no longer the case that wages are equal across countries. As a result, we cannot derive a simple closed-form solution relating comparative advantage to trade shares as in (41). However, equation (36) for the gains from trade still holds.

Figure 2: Gains From Trade: $\beta = 0.25, 0.5, 0.75$




Note that, due to the symmetry of this set-up, the $\beta = 0.75$ curve for country $a$ is equivalent to the same curve for country $b$, only beginning from the right side of the graph. While for country $a$ the gains from trade are remarkably high when $\pi_{1,aa}$ is closest to zero, the gains from trade for country $b$, which imports a relatively high share of final goods at this point, are relatively low. When $\beta = 0.25$, the opposite is true. While for country $a$ the gains from trade are relatively low when $\pi_{1,aa}$ is close to zero, the gains from trade for country $b$, which imports a relatively high share of final goods at this point, are relatively high.

When $\beta > 0.5$, the minimum point for the gains from trade for $a$ is to the right of $\pi_{1,aa} = 0.5$, where $\pi_{1,aa} > \pi_{2,aa}$. The EK formula *overestimates (underestimates)* the gains from trade for $a$ if $\pi_{1,aa} > \pi_{2,aa}$ ($\pi_{1,aa} < \pi_{2,aa}$). When $\beta < 0.5$, the minimum point for the gains from trade for $a$ is to the left of $\pi_{1,aa} = 0.5$ and the EK formula *underestimates (overestimates)* the gains from from trade if $\pi_{1,aa} > \pi_{2,aa}$ ($\pi_{1,aa} < \pi_{2,aa}$).[8]

[8]Note as well that the curve for $\beta = 0.75$ is above that for $\beta = 0.25$ for all values of $\pi_{1,aa}$. This is due to the fact that global gains from trade are higher when the intermediate goods share is higher.

Overall, the differences between estimates from the EK formula versus (36) depends both on the share of value added in production and the difference between $\pi_{1,aa}$ and $\pi_{2,aa}$ for a given country $a$.

Empirically, $\beta$ differs both across countries and across sectors in a given country. To quantify the impact of making the EK assumption, it is useful to establish a quantitative model with many countries and many sectors. This is done in the next section.

# 3 Extended Model

## 3.1 Environment

The following is a two-stage multi-sector EK model of international trade. As a framework, I use a similar model as in Caliendo and Parro (2015).

Consider a similar world as in the previous section, however with $N$ countries and $J$ sectors. Country $n$ has a labor endowment $L_n$. Income $I_n$ is derived from labor supplied at wage $w_n$. Consumers in each countries have preferences that reflect love of variety over final good varieties $\omega^j$ in each sector $j$. They purchase final composite goods $Y_{2,n}^j$ from each sector for consumption, maximizing utility subject to their budget constraint in accordance with the following utility function:

$$U = \prod_{j=1}^{J} \left(C_{2,n}^j\right)^{\alpha_n^j} \tag{42}$$

where $\sum_{j=1}^{J} \alpha_n^j = 1$ for all $n$ and $j$. The budget constraint for consumers in $n$ is given by:

$$\sum_{j=1}^{J} P_{2,n}^j C_{2,n}^j = w_n L_n \tag{43}$$

where $P_{2,n}^j$ denotes the price index for the final good in sector $j$. As in the previous section, the final composite good in each sector consists of a continuum of final good varieties $q_{2,n}^j(\omega)$ over [0,1], denoted as the following:

$$Q_{2,n}^j = \left( \int q_{2,n}^j(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}} \tag{44}$$

The final goods price index for sector $j$ is denoted as:

$$P_{2,n}^j = \left[ \int_0^1 p_{2,n}^j(\omega)^{1-\sigma} d\omega \right]^{\frac{1}{1-\sigma}} \tag{45}$$

Final good varieties are produced with productivity drawn from a country-sector specific Fréchet distribution of the following form:

$$F_{2,n}^j(z) = Pr\left(z_{2,n}^j < z\right) = exp\left\{-T_{2,n}^j z^{-\theta^j}\right\} \tag{46}$$

where $T_{2,n}^j$ depicts a parameter of country-sector average productivity in final goods while $\theta^j$ provides dispersion across productivity draws in the sector. In this environment, dispersion parameters provides a basis for intra-industry gains from trade in final goods. The $T_{2,n}^{j}$ parameters, since they differ across sectors, provide a basis for gains from trade due to comparative advantage across sectors.

Final good varieties are produced using labor and a product of sectoral composite intermediate goods $M_{2,n}^{k}$ from each of the $k$ sectors in the economy. Letting $1-\beta_{n}^{j}$ denote the Cobb-Douglas share of labor used in production for sector $j$, the final goods production technology for $\omega$ is:

$$q_{2,n}^{j}(\omega) = z_{2,n}^{j}(\omega) \left(l_{2,n}^{j}(\omega)\right)^{1-\beta_{n}^{j}} \prod_{k=1}^{J} \left(M_{2,n}^{k}(\omega)\right)^{\beta_{n}^{k,j}} \tag{47}$$

where $\sum_{k=1}^{J} \beta_{n}^{k,j} = \beta_{n}^{j}$. The intermediate composite good in a given sector $j$ is produced according to a similar technology as the final composite good in that sector:

$$Q_{1,n}^{j} = \left(\int q_{1,n}^{j}(\omega)^{\frac{\sigma-1}{\sigma}} d\omega\right)^{\frac{\sigma}{\sigma-1}} \tag{48}$$

where $q_{1,n}^{j}(\omega)$ denotes a given intermediate good variety in that sector. I denote the sectoral intermediate goods price index as:

$$P_{1,n}^{j} = \left[\int_{0}^{1} p_{1,n}^{j}(\omega)^{1-\sigma} d\omega\right]^{\frac{1}{1-\sigma}} \tag{49}$$

where $p_{1,n}^{j}(\omega)$ denotes the price of a given intermediate good variety.

Intermediate good varieties are also produced with productivity drawn from a country-sector specific Fréchet distribution:

$$F_{1,n}^{j}(z) = Pr\left(z_{1,n}^{j} < z\right) = exp\left\{-T_{1,n}^{j} z^{-\theta^{j}}\right\} \tag{50}$$

As in the previous section, the only manner in which (50) is distinct from (46) comes from the average productivity terms $T_{2,n}^{j}$ and $T_{1,n}^{j}$. The degree to which these differ will dictate, in equilibrium, the degree to which there is comparative advantage across stages of production. In the standard EK model, these are assumed to be equivalent for a given $n$ and $j$ pair.

Like final goods, intermediate good varieties in sector $j$ are produced using labor and a product of composite intermediate goods $M_{1,n}^{k}$ from each of the $k$ sectors. Letting $1-\beta_{n}^{j}$ denote the Cobb-Douglas share of labor used in production, the intermediate goods production technology for $\omega$ is:

$$q_{2,n}^{j}(\omega) = z_{1,n}^{j}(\omega)\left(l_{1,n}^{j}(\omega)\right)^{1-\beta_n^j}\prod_{k=1}^{J}\left(M_{1,n}^{k}(\omega)\right)^{\beta_n^{k,j}} \tag{51}$$

Product and factor markets are perfectly competitive. All goods sold by producers in country $i$ to demanders in country $n$ are subject to a stage specific ad-valorum bilateral iceberg transportation cost $\kappa_{s,ni}^{j}$ where $\kappa_{s,ni}^{j} > \kappa_{s,ii}^{j} = 1$ for all $n$,$i$,$j$ and $s$ where $s = 1, 2$. Accordingly, producers of stage $s$ goods from sector $j$ in country $i$ sell their products in country $n$ at a price equal to marginal cost:

$$p_{s,ni}^{j}(\omega) = \frac{c_i^j \kappa_{s,ni}^{j}}{z_{s,i}^{j}(\omega)} \tag{52}$$

where

$$c_i^j = \Psi_i^j\left(w_i\right)^{1-\beta_i^j}\prod_{k=1}^{J}\left(P_{1,i}^{k}\right)^{\beta_i^{k,j}} \tag{53}$$

denotes the unit cost of production in country $i$ and $\Psi_i^j$ is a constant [9].

## 3.2 Equilibrium

The competitive equilibrium consists of a set of prices and allocation rules such that, taking prices as given, (i) intermediate and final goods firms satisfy first order conditions in each country and sector (ii) consumers satisfy their first order conditions in each country (iii) the labor market clears in each country (iv) the goods markets clear for all goods in each sector and stages of production and (v) trade is balanced for each country.

### 3.2.1 Demand and Prices

The solution to the consumer's and producers' problems yield the following demand expenditure function for country-stage specific good variety $\omega$:

$$x_{s,n}^{j}(\omega) = \left[\frac{p_{s,n}^{j}(\omega)}{P_{s,n}^{j}}\right]^{1-\sigma} X_{s,n}^{j} \tag{54}$$

where $X_{s,n}^{j} = P_{s,n}^{j} Y_{s,n}^{j}$ denotes total spending in $n$ on stage $s$ sector $j$ goods and

$$P_{s,n}^{j} = \left[\int_0^1 p_{s,n}^{j}(\omega)^{1-\sigma} d\omega\right]^{\frac{1}{1-\sigma}} \tag{55}$$

[9]Specifically, $\Psi_i = (1-\beta_i^j)^{\beta_i^j - 1}\prod_{k=1}^{J}(\beta_i^{k,j})^{-\beta_i^{k,j}}$

denotes the price index for stage $s$ goods in sector $j$ of country $n$. The upper level Cobb-Douglas production function yields the following expression for total intermediate goods sectoral expenditure in $n$:

$$X_{1,n}^{j}=\sum_{k=1}^{J}\beta_{n}^{j,k}\left(Y_{1,n}^{k}+Y_{2,i}^{k}\right) \tag{56}$$

where $Y_{s,i}^{k}$ denotes the total value of output of sector $k$ stage $s$ goods. Labor input shares can be expressed as the following:

$$L_{s,n}^{j}=\left(1-\beta_{n}^{j}\right)Y_{s,n}^{j} \tag{57}$$

for $s=1,2$.

The utility function yields the following expression for total final goods expenditure:

$$X_{2,n}^{j}=\alpha_{n}^{j}w_{n}L_{n} \tag{58}$$

We can simplify the expressions for $P_{s,n}^{j}$ in (45) and (49) as in the previous section to find the following general closed-form solution:

$$P_{s,n}^{j}=\gamma^{j}[\phi_{s,n}^{j}]^{\frac{1}{-\theta}} \tag{59}$$

where $\gamma^{j}=\Gamma\left(\frac{\theta^{j}+1-\sigma}{\theta^{j}}\right)^{\frac{1}{1-\sigma}}$ is a constant and

$$\phi_{s,n}^{j}=\sum_{i=1}^{N}T_{s,i}^{j}\left[c_{i}^{j}\kappa_{s,ni}^{j}\right]^{-\theta^{j}} \tag{60}$$

Separating into stages, the expression $P_{1,n}^{j}$ represents the intermediate price index for producers in sector $j$ of $n$. The expression $P_{2,n}^{j}$ represents the price index for consumers in sector $j$ of $n$.

### 3.2.2 The Trade Share Equations

I denote $X_{s,ni}^{j}$ as total expenditure in $n$ on sector $j$ stage $s$ goods imported from $i$. The share of total spending by country $n$ on goods from $i$ for a given sector and stage is equal to the probability that country $i$ offers the lowest price in country $n$, $\pi_{s,ni}^{j}$. That is,

$$\pi_{s,ni}^{j}=\frac{X_{s,ni}^{j}}{X_{s,n}^{j}}=\frac{T_{s,i}^{j}\left[c_{i}^{j}\kappa_{s,ni}^{j}\right]^{-\theta^{j}}}{\phi_{s,n}^{j}} \tag{61}$$

This expression applies for all $n$, $i$, $j$ and $s$. For a given stage $s$, the share of total sectoral spending by $n$ on goods from $i$ is positively related to the overall sector-stage productivity parameter in $i$, $T^j_{s,i}$, and negatively related to unit cost of production $c^j_i$ in that sector and country and the sector-stage specific trade cost $\kappa^j_{s,ni}$. The denominator denotes a multilateral resistance term for exporters to $n$ in stage $s$ of sector $j$ goods: it is equal to the sum of $T^j_{s,k}\left[c^j_k \kappa^j_{s,nk}\right]$ across all countries $k$.

### 3.2.3 Market Clearing

The stage-sector specific goods market clearing conditions for intermediate and final goods can be depicted as:

$$Y^j_{s,n} = \sum_{i=1}^{N} X^j_{s,in} \tag{62}$$

To showcase an expression for balanced trade, I define total exports and imports for a given country, sector and stage as $EX^j_{s,n} = \sum_{i=1}^{N} X^j_{s,in} - X^j_{s,nn}$ and $IM^j_{s,n} = \sum_{i=1}^{N} X^j_{s,ni} - X^j_{s,nn}$. The balanced trade condition for each country is thus:

$$\sum_{s=1}^{2}\sum_{j=1}^{J}\left(EX^j_{s,n} - IM^j_{s,n}\right) = 0 \tag{63}$$

Factor market clearing conditions must satisfy:

$$L_n = \sum_{j=1}^{J}\left(L^j_{1,n} + L^j_{2,n}\right) \tag{64}$$

for each $n$.

Since trade is balanced, total expenditure by consumers in country $n$ is equal to total income in that country:

$$X^j_{2,n} = \alpha^j_n w_n L_n \tag{65}$$

Substituting the goods market clearing and balanced trade conditions into the demand equation for intermediates yields the following expenditure equation:

$$X^j_{1,n} = \sum_{k=1}^{J} \beta^{j,k}_n \left[\sum_{i=1}^{N} \pi^k_{1,in} X^k_{1,i} + \sum_{i=1}^{N} \pi^k_{2,in} X^k_{2,i}\right] \tag{66}$$

### 3.3 Welfare

We can represent overall welfare per capita in country $n$ as the following:

$$W_n = \frac{w_n}{P_{2,n}^C} = \prod_{j=1}^{J} \left( \frac{w_n}{P_{2,n}^j} \right)^{\alpha_n^j} \tag{67}$$

To find an expression for $w_n/P_{2,n}^j$ by sector $j$, I go through similar steps as in the previous section. Taking expressions (59) and (61), it is clear that:

$$\pi_{2,nn}^j = \frac{T_{2,n}^j \left[c_n^j\right]^{-\theta^j}}{\left[P_{2,n}^j\right]^{-\theta^j}} = \frac{T_{2,n}^j \left[ \Psi_n^j \left(w_n\right)^{1-\beta_n^j} \prod_{k=1}^J \left(P_{1,n}^k\right)^{\beta_n^{k,j}} \right]^{-\theta^j}}{\left[P_{2,n}^j\right]^{-\theta^j}} \tag{68}$$

Similarly, for intermediate goods we have the following expression:

$$\pi_{1,nn}^j = \frac{T_{1,n}^j \left[ \Psi_n^j \left(w_n\right)^{1-\beta_n^j} \prod_{k=1}^J \left(P_{1,n}^k\right)^{\beta_n^{k,j}} \right]^{-\theta^j}}{\left[P_{1,n}^j\right]^{-\theta^j}} \tag{69}$$

Equation (69) can be rearranged in terms of $w_n/P_{1,n}^j$ as follows:

$$\frac{w_n}{P_{1,n}^j} = \left(\Psi_n^j\right)^{\frac{-1}{1-\beta_n^j}} \underbrace{\left( \frac{\pi_{1,nn}^j}{T_{1,n}^j} \right)^{\frac{-1}{\left(1-\beta_n^j\right)\theta^j}}}_{(1)} \underbrace{\prod_{k=1}^{J} \left( \frac{P_{1,n}^k}{P_{1,n}^j} \right)^{\frac{-\beta_n^{k,j}}{\left(1-\beta_n^j\right)\theta^j}}}_{(2)} \tag{70}$$

Expression (70) provides two main terms that relate to intermediate goods trade. Part (1) captures the impact of openness in the intermediate goods sector $j$. Intuitively, as the share of domestic expenditure falls, the real wage rises due to imports of more productive goods into country $n$. Moreover, the $1 - \beta_n^j$ term in the exponent of the domestic expenditure share reflects the impact of the input-output loop. Since a portion $\beta_n^j$ of goods are used as intermediates to produce other goods, the impact of trade is amplified as the overall share of intermediate goods in production rises.

Part (2) captures the influence that sectoral linkages have on the real wage. When there are no sectoral linkages, this expression reduces to 1. However, when sectoral linkages exist, openness in one sector impacts other sectors through the intermediate goods channel.

To account for these sectoral linkages, expression (69) can be re-expressed as the following:

$$\pi^j_{1,nn} = T^j_{1,n}\left[\Psi^j_n \prod_{k=1}^{J}\left(\frac{w_n}{P^k_{1,n}}\right)^{I-\beta^{k,j}_n}\right]^{-\theta^j} \tag{71}$$

where $I$ denotes an indicator function which equals 1 when $k = j$ and equals 0 when $k \neq j$. This expression can be rearranged as the following:

$$\prod_{k=1}^{J}\frac{w_n}{P^k_{1,n}} = \left(\Psi^j_n\right)^{-\gamma^{k,j}_n}\left(\frac{\pi^j_{1,nn}}{T^j_{1,n}}\right)^{\frac{-\gamma^{k,j}_n}{\theta^j}} \tag{72}$$

where $\gamma^{k,j}_n$ represents the elasticity of the price index in sector $k$ with respect to changes in the price index for sector $j$. This elasticity is equivalent to the $kj$th entry of the Leontief inverse of the input-output matrix for country $n$; that is, the matrix $(\mathbf{I}-\mathbf{A}_n)^{-1}$ where the $kj$th entry of $\mathbf{A}_n$ is equal to $\beta^{k,j}_n$. Finally, taking the product of (72) across all the sectoral dimensions $j$ and $k$ yields the following:

$$\prod_{k,j=1}^{J}\frac{w_n}{P^k_{1,n}} = \prod_{k=1}^{J}\frac{w_n}{P^k_{1,n}} = \prod_{k,j=1}^{J}\left(\Psi^j_n\right)^{-\gamma^{k,j}_n}\left(\frac{\pi^j_{1,nn}}{T^j_{1,n}}\right)^{\frac{-\gamma^{k,j}_n}{\theta^j}} \tag{73}$$

Next, we can rearrange expression (68) to find the following:

$$\pi^j_{2,nn} = T^j_{2,n}\left[\Psi^j_n\left(\frac{w_n}{P^j_{2,n}}\right)\prod_{k=1}^{J}\left(\frac{w_n}{P^k_{1,n}}\right)^{-\beta^{k,j}_n}\right]^{-\theta^j} \tag{74}$$

Substituting in (73) into this expression and rearranging in terms of $w_n/P^j_{2,n}$ yields the following:

$$\frac{w_n}{P^j_{2,n}} = \left(\left(\Psi^j_n\right)^{-1}\frac{\pi^j_{2,nn}}{T^j_{2,n}}\right)^{\frac{-1}{\theta^j}}\prod_{k,l=1}^{J}\left(\left(\Psi^l_n\right)^{-\gamma^{k,l}_n}\left(\frac{\pi^l_{1,nn}}{T^l_{1,n}}\right)^{\frac{-\gamma^{k,l}_n}{\theta^l}}\right)^{\beta^{k,j}_n} \tag{75}$$

Finally, overall welfare per capita can be found by substituting (75) into (67):

$$W^{S,L}_n = \prod_{j=1}^{J}\left(\left(\left(\Psi^j_n\right)^{-1}\frac{\pi^j_{2,nn}}{T^j_{2,n}}\right)^{\frac{-1}{\theta^j}}\prod_{k,l=1}^{J}\left(\left(\Psi^l_n\right)^{-\gamma^{k,l}_n}\left(\frac{\pi^l_{1,nn}}{T^l_{1,n}}\right)^{\frac{-\gamma^{k,l}_n}{\theta^l}}\right)^{\beta^{k,j}_n}\right)^{\alpha^j_n} \tag{76}$$

If we ignore sectoral linkages and assume that $\beta^{j,k}_n$ equals one for $k = j$ and equals zero for all $k \neq j$, then this expression simplifies to the following multi-sector analogue to welfare equation derived in Section 3.2:

$$W_n^S = \prod_{j=1}^J \left( \left( \left(\Psi_n^j\right)^{-1} \frac{\pi_{2,nn}^j}{T_{2,n}^j} \right)^{\frac{-1}{\theta^j}} \left(\Psi_n^j\right)^{\frac{-\beta_n^j}{\left(1-\beta_n^j\right)}} \left( \frac{\pi_{1,nn}^j}{T_{1,n}^j} \right)^{\frac{-\beta_n^j}{\left(1-\beta_n^j\right)\theta^j}} \right)^{\alpha_n^j} \tag{77}$$

Again, I note that changes in trade costs will have no effect on constant terms in either of these equations. The gains from trade when sectoral linkages are included can be depicted by taking the logarithm of (76) and considering the comparative static of moving from autarky where $\widetilde{\pi}_{s,nn}^j = 1$ to the status quo where $\pi_{s,nn}^j < 1 \; \forall \; j, s$. Accordingly, the gains from trade are the following:

$$GFT_n^{S,L} = d\ln(W_n^{S,L}) = \sum_{j=1}^J \left( \frac{-\alpha_n^j}{\theta^j} d\ln(\pi_{2,nn}^j) + \sum_{k,l=1}^J \left( \frac{-\alpha_n^j \gamma_n^{k,l} \beta_n^{k,j}}{\theta^l} d\ln(\pi_{1,nn}^l) \right) \right) \tag{78}$$

In the context where sectoral linkages are absent, this comparative static reduces to the following:

$$GFT_n^S = d\ln(W_n^S) = \sum_{j=1}^J \left( \frac{-\alpha_n^j}{\theta^j} d\ln(\pi_{2,nn}^j) + \frac{-\alpha_n^j \beta_n^j}{\left(1-\beta_n^j\right)\theta^j} d\ln(\pi_{1,nn}^j) \right) \tag{79}$$

Note that both of these equations are different in the classic EK framework where $\pi_{s,nn}^j$ is equivalent for intermediate and final goods. In that setting, expressions (76) and (77) reduce to the following two equations:

$$W_n^{EK,L} = \prod_{j,k=1}^J \left( \left(\Psi_n^j\right)^{-\gamma_n^{j,k}} \left( \frac{\pi_{nn}^k}{T_n^k} \right)^{\frac{-\gamma_n^{j,k}}{\theta^k}} \right)^{\alpha_n^j} \tag{80}$$

$$W_n^{EK} = \prod_{j=1}^J \left( \left(\Psi_n^j\right)^{\frac{-1}{\left(1-\beta_n^j\right)}} \left( \frac{\pi_{nn}^j}{T_n^j} \right)^{\frac{-1}{\left(1-\beta_n^j\right)\theta^j}} \right)^{\alpha_n^j} \tag{81}$$

The gains from trade in these scenarios can be represented as the following:

$$GFT_n^{EK,L} = d\ln(W_n^{EK,L}) = \sum_{j,k=1}^J \left( \frac{-\alpha_n^j \gamma_n^{j,k}}{\theta^k} d\ln(\pi_{nn}^k) \right) \tag{82}$$

$$GFT_n^{EK} = d\ln(W_n^{EK}) = \sum_{j=1}^{J} \left( \frac{-\alpha_n^j}{\left(1-\beta_n^j\right)\theta^j} d\ln(\pi_{nn}^j) \right) \tag{83}$$

Similarly as in the model from Section 3.2, the difference between (79) and (83) indicates the added gains after accounting for CSS when sectoral linkages are absent. Since this is the framework under which the insights from Section 3.2 are derived, I will focus on this setting when considering the pattern of CSS across countries. For sectors where $\beta_n^j > 0.5$, expression (79) will generally produce a greater value when the import share of intermediate goods is larger than the import share of final goods. For sectors where $\beta_n^j < 0.5$, the opposite is true.

In reality, however, sectoral linkages also matter for the added gains. In sectors that use intermediate inputs which originate from sectors that are highly traded, the gains from trade are comparatively large.[10]

Overall, the added gains after accounting for CSS depend both on the overall share of intermediates used by a sector and the degree to which those intermediate goods come from heavily traded sectors. To capture this, I will compare (78) and (82), both of which include sectoral linkages, to provide a more accurate depiction of the gains from trade.

[10]To take an example, consider the Coke, Petroleum and Nuclear sector. This sector uses a high share of intermediate inputs, and a considerable share of those intermediates come from the Mining and Quarrying sector. Since most countries import a high share in the Mining and Quarrying sector, the gains from this trade are also passed on to the Coke, Petroleum and Nuclear sector through the intermediate channel.

# 4 Data

The main data source for this exercise is the World Input Output Database (WIOD). The WIOD provides an integrated global input-output (IO) matrix comprised of 40 countries (in addition to one "rest-of-world" country) and 35 sectors from 1995 to 2011. A list of the countries and sectors included in the database is provided in the Appendix.[11] For each country, the global IO matrix includes one domestic and 40 bilateral IO matrices, one for each of the other trade partners in the database.

The bilateral IO matrices are built from combining product-level bilateral international trade data with product-by-sector national supply and use tables (SUT) for each country. The trade data is initially collected at the HS6 product level from UN Comtrade. From there, each product is assigned to a specific "use" category (intermediate, final or capital) based on the UN Broad Economic Category (BEC) classification.[12] Then, these traded products are grouped into separate intermediate, final and capital groups and aggregated up to CPA product groups (a total of 59) to correspond with the national SUTs. In the end, for each country bilateral shares of intermediate, final and capital goods imports are constructed for each CPA product group. From here, these shares are combined with national SUTs to produce international SUTs, from which the global input-output table is constructed.

This procedure is crucially different from the standard approach taken to construct imported IO matrices, based on the import proportionality assumption. Typically, uses for domestically-produced and imported goods are assumed to be equal and, therefore, correspond to shares taken from the national use tables. As a result, the shares of imported intermediate and final goods for a given product group are assumed to be equal.[13] The import proportionality assumption, while convenient and sometimes necessary, is clearly violated empirically for many product groups.[14] Moreover, this assumption makes it impossible to identify separate patterns of specialization for intermediate and final goods at the sector level, which is the basis for identification according to the model in Section 2. For these reasons, it is important to choose data that is constructed without assuming import proportionality across intermediate and final uses for this exercise.

[11] Sectors in the WIOD correspond to the two digit ISIC Revision 2 classification.

[12] The HS6 classification includes over 6000 products, many of which correspond to a unique use category. In some cases, however, a given product is assigned to more than one group. In these cases, use shares are assigned.

[13] Examples of projects that assume import proportionality include OECD, GTAP, and Johnson and Noguera (2012a).The WIOD does make a proportionality assumption within intermediate, final and capital goods so that, for example, the share of total metal ore intermediate products that are used by the Machinery Nec. sector is the assumed to be the same for domestic- and foreign-produced basic metals.

[14] See Dietzenbacher et al (2013) for examples.

Rather than using the global IO table provided by the WIOD, I derive import shares based on a separate global IO table constructed from the international SUTs. This alternative approach is necessary in order to capture the share of imported *products* according to the spirit of the model.

To explain with an example, total supply of intermediate products from the Construction sector in Australia can be calculated from the WIOD global IO table by taking the sum of this corresponding row across all intermediate sector columns in the table. Furthermore, total imports of intermediate products from that sector can be calculated by taking this same sum net of products produced by the Australian Construction sector. This, apparently, provides a measure of import share for Construction sector intermediate goods in Australia. However, this does not necessarily correspond to a consistent share of *products* since the product mix for a given industry differs across countries. For example, the product mix of the Australian Construction sector (which is reported in the national SUT) is different from that of the same sector in Canada. As a result, a different set of products might be exported from the Canadian Construction sector than those produced by the Australian sector and, hence, the import share of a given product group cannot be derived from the WIOD global IO tables directly.

Instead, I construct an alternative global IO table from the international SUTs which reports bilateral imports according to the product-mix produced by the domestic industry for each country. From this, bilateral shares of intermediate and final goods can be calculated at the sector-level based on a common set of products across countries, and domestic expenditure shares according to equations (**??**), (**??**), (**??**) and (**??**) can be constructed.

In this analysis, I include 31 of these sectors, where 16 are goods and 15 are services.[15] The list of these sectors is reported in Table 3. I also narrow the group of countries to 34, consistent with Costinot and Rodriguez-Clare (2014), which is listed in Table 4. This includes “rest-of-world”, which is comprised of total imports for each country that either comes from or ends up in a place outside of the 33 other countries.

## 4.1 Model Parameters

The WIOD data provides five out of the six parameters that I need to compute country-level welfare according to equations (79) and (83). For measures of sectoral consumption shares $\alpha_n^j$ at the country-sector level, I use the sectoral sum of spending on final goods, divided by this sum for all sectors in $n$. For shares of intermediate inputs

[15] I use only 31 of the 35 sectors to follow Costinot and Rodriguez (2013) who use the same database. The authors do not explicitly state why they do not use all 35 sectors. However, from observation is it clear that the “deleted” sectors often have missing data.

used in production $\beta_n^j$, I use the sum of intermediate inputs used by a given sector across all source sectors reported in the WIOD tables. For the domestic expenditure shares of total goods $\pi_{nn}^j$, final goods $\pi_{2,nn}^j$ and intermediate goods $\pi_{1,nn}^j$, I take the the sum of total spending minus imports for a given sector-country pair for total goods, final goods and intermediate goods respectively. Although the data spans 1995-2011, the analysis is done for 2005. I chose 2005 because I want to capture the secular components of international trade patterns and avoid any changes that might be related to the global financial crisis of 2008. Since some of the symptoms of this crisis began before 2008, I chose 2005 as a conservative base year to provide a relatively recent analysis of the gains from international trade before the onset of the crisis. In Table B.2 provided in Appendix B, I report changes in the gains from trade from 1995 to 2011 across all of the models considered in this chapter. As I discuss in Section 3.5, there are not significant changes in the added gains after accounting for CSS over this period.[16]

To compute welfare according to equations (78) and (82), I also need data on $\gamma_n^{k,j}$ across countries, source and destination sectors. For this, I use the Leontief inverse computed using the sector-level input-output tables for each country provided by the WIOD.

For values of the sectoral dispersion parameters $\theta^j$, I use the values calculated by Caliendo and Parro (2015), reported in Table B.1 in Appendix B. Caliendo and Parro estimate these parameters according to an EK model using tariff data from 1989-1995 across 15 countries. Their model is similar to the model described in Section 3.3. The only significant difference is that my model has differences in $T_{s,n}^j$ across stages $s$ for a given $nj$ country-sector pair. To concentrate on the importance of CSS, I assume common values of $\theta^j = 5$ for all $j$ as in Costinot and Rodriguez-Clare (2013) for the baseline analysis.

Table 1: Summary Statistics for 2005

| **Variable** | **Mean** | **Std. Dev.** | **Min.** | **Max.** | **N** |
|---|---|---|---|---|---|
| $n$ | | | 1 | 34 | 1054 |
| $j$ | | | 1 | 31 | 1054 |
| $\alpha_n^j$ | 0.032 | 0.036 | 0 | 0.247 | 1054 |
| $\pi_{nn}^j$ | 0.746 | 0.271 | 0.002 | 1 | 1054 |
| $\pi_{1,nn}^j$ | 0.73 | 0.267 | 0.001 | 1 | 1054 |
| $\pi_{2,nn}^j$ | 0.774 | 0.275 | 0.004 | 1 | 1054 |
| $\theta^j$ | 7.018 | 8.559 | 0.37 | 51.08 | 1054 |
| $\beta_n^j$ | 0.534 | 0.163 | 0.055 | 0.956 | 1054 |

[16]For Greece, Hungary, Korea and Slovakia, the WIOD for 1995 has missing values which made computation based on some of the gains from trade formulas impossible. As a result, I chose to exclude these countries for Table B.2.

Table 3.1 provides summary statistics for these variables (except for $\gamma_n^{k,j}$) for 2005. This table includes data from all 31 sectors and 34 countries. As the table indicates, the overall share of intermediates is approximately 0.53 on average across countries and sectors. According to the insights from the basic model in Section 3.2, this suggests that the added gains after accounting for CSS are potentially positive and fairly evenly distributed across intermediate and final goods producers.

To what degree do countries specialize across stages of production? As the table indicates, the average share of domestic expenditure (*i.e.* 1−average import expenditure share) is approximately 0.73 and 0.77 for intermediate and final goods respectively. That is, the average country imports a higher share of intermediate goods than final goods. A model which abstracts from this channel, as does EK (2002), would suggest that this share is 0.75 across both intermediate and final goods.

Table 2: Summary Statistics for 2005: Tradables Only

| Variable | Mean | Std. Dev. | Min. | Max. | N |
|---|---|---|---|---|---|
| $n$ | | | 1 | 34 | 510 |
| $j$ | | | 1 | 15 | 510 |
| $\alpha_n^j$ | 0.018 | 0.019 | 0 | 0.134 | 510 |
| $\pi_{nn}^j$ | 0.586 | 0.264 | 0.002 | 0.986 | 510 |
| $\pi_{1,nn}^j$ | 0.597 | 0.266 | 0.001 | 0.983 | 510 |
| $\pi_{2,nn}^j$ | 0.616 | 0.279 | 0.004 | 0.993 | 510 |
| $\theta^j$ | 9.170 | 11.939 | 0.37 | 51.08 | 510 |
| $\beta_n^j$ | 0.634 | 0.112 | 0.119 | 0.956 | 510 |
| $\pi_{2,nn}/\pi_{1,nn}$ | 1.258 | 1.932 | 0.049 | 39.072 | 510 |
| $count_j$ | 18.07 | 7.95 | 6 | 34 | 510 |
| $count_n$ | 8.441 | 3.23 | 2 | 16 | 34 |

These patterns are slightly different when I consider tradable sectors only, as indicated in Table 3.2. As we see, the average share of total intermediate inputs used by tradable sectors is higher at approximately 0.63. The share of domestic expenditure for intermediate and final goods are, on average, approximately 0.60 and 0.62 respectively. Under the standard EK (2002) model, the share of domestic expenditure would be 0.59 for both intermediate and final goods.[17] Given these figures, the insights from the model in Section 3.2 suggest that countries that specialize in final goods production and import a higher share of intermediate goods stand to enjoy higher gains from trade than the EK (2002) model would suggest. In contrast, countries that specialize in intermediate goods production might have lower gains from trade compared to the EK (2002) model.

[17]The fact that the average for $\pi_{nn}^j$ falls below $\pi_{1,nn}^j$ and $\pi_{2,nn}^j$ rather than between them is an artifact of country weighting in the cross-country average. In fact, on a specific country-sector level $\pi_{nn}^j$ always falls between $\pi_{1,nn}^j$ and $\pi_{2,nn}^j$ in the data.

From both tables it is clear that, on average, the shares of domestic expenditure for intermediate and final goods are quite similar. For tradable goods, this difference is only about 0.02 on average, which represents only about 8% of a standard deviation in domestic expenditure share across countries and sectors.

This similarity, however, masks more significant variation at the sector and country level. In Table 3.3, I provide summary statistics at the sector level for tradable goods. I also include an indicator for the ratio of intermediate goods domestic expenditure share to final goods domestic expenditure share. On average, this ratio is approximately 1.26, indicating that the average sector-country pair is roughly 25% more specialized in final goods production than intermediate goods production. In addition, the standard deviation for this ratio is almost 2, indicating that there are many sectors or countries where the ratio is below 1 and many where the ratio is well above the average. In other words, while on average the intermediate and final goods domestic expenditure shares are quite similar, this is not due to a lack of CSS but rather to the fact that patterns of CSS tend to balance at the global level. This is intuitive, since we might expect any patterns of comparative advantage to be largely masked when looking at cross-country averages like those in Tables 3.1 and 3.2.

Looking at the *count* variables in Table 3.2 gives a better sense of these patterns at the country and sector level. The first variable, $count_j$, provides a sector-level count of the number of countries for which the share of domestic expenditure for final goods is higher than that share for intermediate goods. In other words, this provides a sense of CSS for each sector. We see that, on average, 18 out of the 34 countries specialize relatively more in final goods than intermediate goods production.

If we look at individual sectors in Table 3.3, however, we see that for some sectors the pattern of CSS is highly uneven across countries. For example, in Mining & Quarrying, 33 out of 34 countries specialize relatively more in final goods production.[18] Moreover, the average domestic expenditure share for final goods is approximately twice the share of domestic expenditure share for intermediate goods in that sector, indicating that intermediate goods trade largely dominates final goods trade. At the other extreme, in Food, Beverages & Tobacco the average share of domestic expenditure for final goods is roughly 0.15 lower than the share for intermediate goods and only 6 countries import a higher share of intermediate than final goods.

The $count_n$ variable in Table 3.2 provides a country-level count of the number of tradable sectors for which the final share of domestic expenditure is greater than the intermediate share. The average count is approximately 8, indicating that out of the 15

[18]Judging by the $count_j$ variable, it is also clear that service sectors tend to import a larger proportion intermediate goods in almost all countries. Since trade shares in these sectors tend to be very low (except for Transport services), we restrict most of the analysis to tradables.

Table 3: Sectoral Level: Averages across Countries

| **Sector** | $\alpha_n^j$ | $\pi_{nn}$ | $\pi_{1,nn}$ | $\pi_{2,nn}$ | $\beta_n$ | $\pi_{2,nn}/\pi_{1,nn}$ | $count_j$ |
|---|---|---|---|---|---|---|---|
| Agriculture & Hunting | 0.031 | 0.840 | 0.849 | 0.818 | 0.469 | 0.962 | 16 |
| Mining & Quarrying | 0.003 | 0.425 | 0.404 | 0.811 | 0.424 | 4.038 | 33 |
| Food, Bev. & Tobacco | 0.061 | 0.788 | 0.870 | 0.734 | 0.700 | 0.839 | 6 |
| Textiles & Leath. | 0.019 | 0.404 | 0.471 | 0.369 | 0.635 | 0.758 | 11 |
| Wood & Prod. | 0.001 | 0.753 | 0.731 | 0.836 | 0.645 | 1.247 | 24 |
| Pulp & Publishing | 0.009 | 0.761 | 0.741 | 0.807 | 0.619 | 1.115 | 25 |
| Coke, Petro & Nuclear | 0.014 | 0.644 | 0.609 | 0.686 | 0.775 | 1.518 | 25 |
| Chemicals | 0.018 | 0.427 | 0.419 | 0.425 | 0.665 | 1.216 | 22 |
| Rubber & Plastics | 0.004 | 0.596 | 0.587 | 0.598 | 0.656 | 1.229 | 19 |
| Other Non-Metallics | 0.002 | 0.793 | 0.785 | 0.819 | 0.598 | 1.060 | 18 |
| Basic Metals | 0.009 | 0.611 | 0.595 | 0.715 | 0.680 | 1.277 | 28 |
| Machinery, Nec | 0.028 | 0.425 | 0.483 | 0.377 | 0.646 | 0.792 | 10 |
| Electrical & Optical | 0.029 | 0.342 | 0.362 | 0.325 | 0.663 | 0.951 | 13 |
| Transport | 0.038 | 0.424 | 0.428 | 0.422 | 0.705 | 1.023 | 13 |
| Manufacturing, Nec | 0.011 | 0.558 | 0.621 | 0.501 | 0.632 | 0.840 | 8 |
| Electricity, Gas & Water | 0.018 | 0.947 | 0.934 | 0.966 | 0.551 | 1.084 | 29 |
| Construction | 0.120 | 0.989 | 0.965 | 0.995 | 0.590 | 1.033 | 34 |
| Motor Sales | 0.056 | 0.937 | 0.911 | 0.973 | 0.405 | 1.088 | 33 |
| Retail Trade | 0.040 | 0.981 | 0.979 | 0.983 | 0.370 | 1.005 | 23 |
| Hotels & Restaurants | 0.037 | 0.908 | 0.778 | 0.946 | 0.481 | 1.435 | 32 |
| Inland Transport | 0.022 | 0.883 | 0.844 | 0.948 | 0.474 | 1.141 | 32 |
| Water Transport | 0.002 | 0.592 | 0.564 | 0.649 | 0.597 | 1.526 | 29 |
| Air Transport | 0.004 | 0.589 | 0.549 | 0.609 | 0.628 | 1.206 | 23 |
| Travel | 0.010 | 0.862 | 0.822 | 0.919 | 0.507 | 1.177 | 28 |
| Post & Telecom | 0.017 | 0.928 | 0.904 | 0.967 | 0.430 | 1.073 | 34 |
| Financial Intermediation | 0.034 | 0.920 | 0.893 | 0.957 | 0.380 | 1.077 | 32 |
| Real Estate | 0.080 | 0.985 | 0.974 | 0.973 | 0.258 | 0.996 | 33 |
| Renting | 0.028 | 0.857 | 0.821 | 0.897 | 0.426 | 1.293 | 31 |
| Education | 0.051 | 0.991 | 0.884 | 0.997 | 0.221 | 1.194 | 34 |
| Health and Social Work | 0.073 | 0.996 | 0.957 | 0.997 | 0.366 | 1.047 | 34 |
| Other Services | 0.131 | 0.971 | 0.891 | 0.989 | 0.369 | 1.119 | 34 |
| **Average** | 0.037 | 0.797 | 0.772 | 0.825 | 0.503 | 1.188 | 24.400 |

tradable sectors, the average country imports relatively more intermediate goods for 8 sectors and relatively more final goods for 7 sectors. If we look at individual countries in Table 3.4, we see that some countries specialize in particular stages much more than others. For example, Mexico specializes relatively more in final goods production for all 15 tradable sectors. The average domestic expenditure share for intermediate goods in that country is approximately 0.15 lower than the share for final goods. At the other extreme, Korea specializes relatively more in intermediate goods production for every tradable sector except one (Agriculture & Hunting). In that country, the average domestic expenditure share for intermediate goods is almost 0.15 higher than the share for final goods.

Although the pattern is mixed, there appears to be a negative relationship between level of economic development and $count_n$ in Table 3.4. The countries with the highest values of $count_n$ include Mexico, Indonesia and Romania. Those with the lowest values include Korea, Russia, Japan and the United States. Remarkably, this pattern is in strong contrast to the notion that less developed economies tend to specialize in more basic goods (*i.e.* intermediate goods) production.

Overall, these tables indicate several general patterns. First, most countries import more intermediate than final goods and this difference is, on average, fairly modest. However, there appears to be noticeable heterogeneity across countries and sectors in the relative share of intermediate to final goods imports. Since the gains from trade are determined at the country level, this latter point is important. Based on observing the $count_n$ variable across countries, there appears to be a negative relationship between level of economic development and stage of specialization. That is, emerging economies like Mexico and Indonesia are more specialized in final goods production and import a relatively large share of intermediate goods. Since the intermediate input share is above 0.5 in most sectors, this pattern suggests relatively higher added gains after accounting for CSS for these emerging economies. The degree to which this is true, based on the model described in Section 3.3, is determined in the next section.

Table 4: Country Level: Averages across Tradable Sectors

| **Country** | $\pi_{nn}$ | $\pi_{1,nn}$ | $\pi_{2,nn}$ | $\beta_n$ | $\pi_{2,nn}/\pi_{1,nn}$ | $count_n$ |
|---|---|---|---|---|---|---|
| AUS | 0.675 | 0.722 | 0.662 | 0.629 | 0.901 | 5 |
| AUT | 0.418 | 0.432 | 0.487 | 0.600 | 1.253 | 8 |
| BEL | 0.262 | 0.283 | 0.319 | 0.665 | 4.007 | 8 |
| BRA | 0.885 | 0.867 | 0.912 | 0.622 | 1.061 | 11 |
| CAN | 0.550 | 0.593 | 0.541 | 0.609 | 0.859 | 5 |
| CHN | 0.851 | 0.853 | 0.844 | 0.712 | 0.993 | 5 |
| CZE | 0.509 | 0.542 | 0.514 | 0.687 | 0.995 | 6 |
| DEU | 0.553 | 0.563 | 0.575 | 0.624 | 1.029 | 8 |
| DNK | 0.386 | 0.400 | 0.422 | 0.589 | 1.476 | 10 |
| ESP | 0.633 | 0.691 | 0.601 | 0.654 | 1.063 | 6 |
| FIN | 0.595 | 0.615 | 0.583 | 0.632 | 1.040 | 6 |
| FRA | 0.589 | 0.629 | 0.609 | 0.665 | 1.214 | 7 |
| GBR | 0.561 | 0.586 | 0.583 | 0.569 | 0.990 | 7 |
| GRC | 0.560 | 0.547 | 0.629 | 0.586 | 1.201 | 10 |
| HUN | 0.466 | 0.462 | 0.551 | 0.671 | 1.381 | 9 |
| IDN | 0.668 | 0.637 | 0.710 | 0.557 | 1.198 | 13 |
| IND | 0.789 | 0.766 | 0.833 | 0.656 | 1.182 | 11 |
| IRL | 0.408 | 0.445 | 0.448 | 0.632 | 1.012 | 8 |
| ITA | 0.707 | 0.726 | 0.760 | 0.658 | 1.221 | 8 |
| JPN | 0.805 | 0.854 | 0.768 | 0.637 | 1.039 | 4 |
| KOR | 0.764 | 0.792 | 0.658 | 0.676 | 0.813 | 1 |
| MEX | 0.663 | 0.606 | 0.753 | 0.591 | 1.328 | 15 |
| NLD | 0.340 | 0.344 | 0.436 | 0.613 | 1.452 | 9 |
| POL | 0.578 | 0.581 | 0.629 | 0.654 | 1.117 | 10 |
| PRT | 0.538 | 0.564 | 0.587 | 0.657 | 1.309 | 4 |
| ROM | 0.553 | 0.495 | 0.629 | 0.591 | 1.340 | 12 |
| RUS | 0.766 | 0.798 | 0.717 | 0.600 | 0.888 | 2 |
| SVK | 0.399 | 0.392 | 0.522 | 0.655 | 2.109 | 10 |
| SVN | 0.404 | 0.415 | 0.478 | 0.633 | 1.613 | 10 |
| SWE | 0.493 | 0.525 | 0.522 | 0.623 | 1.102 | 6 |
| TUR | 0.697 | 0.679 | 0.784 | 0.643 | 1.209 | 11 |
| TWN | 0.528 | 0.548 | 0.530 | 0.692 | 1.215 | 9 |
| USA | 0.747 | 0.788 | 0.727 | 0.633 | 0.938 | 4 |
| RoW | 0.587 | 0.556 | 0.627 | 0.647 | 1.208 | 13 |
| **Average** | 0.586 | 0.597 | 0.616 | 0.634 | 1.258 | 8.441 |

# 5 Results

In the following section, I report results from two different settings. In the first, I consider the added gains after accounting for CSS trade when sectoral intermediate input linkages are absent. This setting is useful for illustrative purposes since it is most closely aligned with the basic, one-sector model described in Section 3.2. I also assume that values of are equal across sectors in order to isolate patterns of CSS and gains from trade more clearly. In the second setting, I allow for sectoral linkages while maintaining equality of $\theta^j$ across sectors.[19] In light of these findings, I also include an analysis of the overall gains from trade in intermediate goods and compare this with the gains from trade in final goods.

## 5.1 Classic Assumption: No Linkages, Common $\theta$

The first and perhaps most natural extension of the the basic EK model is to include many sectors, maintain the original model's abstraction from sectoral linkages and differences in $\theta^j$ across sectors, but allow for differentiation across stages of production, which is absent from other versions of the EK model. This exercise illustrates the impact of extending the basic model to include specialization across stages of production (and many sectors). I assume here that $\theta^j = \theta = 5$.[20]

To contextualize the significance of added gains after accounting for CSS, I also consider gains from trade in models without CSS that (i) move from a setting with one sector to many sectors and (ii) move from a setting that ignores intermediate goods to a setting that includes them. Columns 1 and 2 in Table 3.5 report the gains from trade for each country using the one-sector model with no intermediate goods and the model with 31 sectors and no intermediate goods respectively. If we ignore sectors and intermediate goods, then the gains from trade equation for country $n$ becomes the following:

$$GFT_n = \left( \frac{-1}{\theta} d\ln(\pi_{nn}) \right) \tag{84}$$

where $\pi_{nn}$ denotes country-wide domestic expenditure share. The difference between Columns 1 and 2 reflects the differences between calculations from (84) and a version of (83) where $\beta_n^j = 0$ for all $j$.

Notice that the change in gains from trade after adding the sectoral dimension is not positive in all cases. This is clear from Column 1 in Table 3.6, where some of the values

[19] In Appendix II include calculations of the gains from trade with different values of $\theta^j$ across sectors.

[20] Setting $\theta^j = 5$ is very close to the aggregate value of $\theta^j$ from the pooled regression analysis performed by Caliendo and Parro (2015). This magnitude is also fairly close to values found in Simonovska and Waugh (2014).

Table 5: Gains From Trade (% of GDP), Common $\theta$

| | **One** $J$ | **Many** $J$ | **Inc.** $M$ | **Two** $S$ | **Inc.** $M, L$ | **Two** $S, L$ |
|---|---|---|---|---|---|---|
| **Country** | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** |
| AUS | 2.5% | 3.1% | 8.5% | 8.2% | 6.7% | 6.9% |
| AUT | 6.1% | 7.9% | 20.1% | 20.4% | 16.8% | 17.0% |
| BEL | 7.5% | 10.0% | 28.4% | 27.9% | 24.8% | 25.8% |
| BRA | 1.5% | 1.2% | 3.4% | 3.9% | 2.9% | 2.9% |
| CAN | 4.3% | 5.4% | 14.6% | 14.6% | 11.3% | 11.5% |
| CHN | 2.5% | 1.7% | 6.9% | 8.5% | 7.3% | 7.3% |
| CZE | 6.7% | 6.7% | 21.6% | 21.1% | 19.8% | 20.2% |
| DEU | 4.4% | 4.8% | 12.2% | 12.0% | 9.8% | 9.9% |
| DNK | 5.6% | 7.0% | 23.5% | 29.4% | 14.7% | 15.2% |
| ESP | 3.4% | 3.2% | 9.9% | 9.0% | 9.2% | 9.4% |
| FIN | 4.5% | 3.8% | 9.4% | 9.5% | 10.6% | 10.6% |
| FRA | 3.2% | 3.1% | 9.8% | 9.5% | 7.7% | 7.9% |
| GBR | 3.2% | 4.1% | 9.9% | 11.6% | 8.4% | 8.6% |
| GRC | 4.1% | 4.5% | 10.3% | 10.1% | 9.7% | 10.0% |
| HUN | 7.8% | 7.7% | 23.7% | 23.2% | 21.9% | 22.1% |
| IDN | 3.5% | 3.0% | 7.6% | 9.2% | 8.6% | 8.9% |
| IND | 2.5% | 2.4% | 8.2% | 9.8% | 6.9% | 7.1% |
| IRL | 8.8% | 8.0% | 18.6% | 18.7% | 21.1% | 21.7% |
| ITA | 2.9% | 2.5% | 8.1% | 7.5% | 7.0% | 7.1% |
| JPN | 1.4% | 0.9% | 2.3% | 2.2% | 3.7% | 3.8% |
| KOR | 3.6% | 1.9% | 5.6% | 5.9% | 9.9% | 10.0% |
| MEX | 3.7% | 3.5% | 11.4% | 12.8% | 8.8% | 9.1% |
| NLD | 6.1% | 6.8% | 18.1% | 17.7% | 14.9% | 15.2% |
| POL | 4.4% | 4.6% | 13.9% | 13.8% | 11.6% | 11.8% |
| PRT | 4.4% | 4.9% | 14.7% | 14.1% | 13.0% | 13.1% |
| ROM | 5.1% | 5.8% | 13.0% | 14.9% | 15.1% | 15.5% |
| RUS | 2.7% | 3.5% | 9.6% | 10.1% | 6.9% | 6.9% |
| SVK | 8.5% | 10.2% | 29.7% | 29.4% | 26.2% | 26.7% |
| SVN | 7.4% | 11.3% | 31.8% | 31.8% | 24.7% | 25.3% |
| SWE | 5.1% | 5.0% | 13.9% | 13.4% | 11.9% | 12.1% |
| TUR | 2.9% | 2.9% | 8.3% | 8.1% | 7.6% | 7.8% |
| TWN | 6.6% | 5.3% | 17.6% | 17.6% | 17.0% | 17.6% |
| USA | 1.8% | 1.6% | 4.3% | 3.9% | 4.0% | 4.0% |
| RoW | 5.1% | 5.0% | 14.3% | 15.3% | 14.0% | 14.6% |
| **Average** | 4.5% | 4.8% | 13.6% | 14.0% | 12.2% | 12.5% |
| **Average (Adv)** | 5.1% | 5.6% | 15.7% | 15.8% | 13.8% | 14.1% |
| **Average (Emer)** | 3.5% | 3.4% | 9.9% | 10.7% | 9.2% | 9.5% |

are negative.

This result can be explained by the fact that most consumption occurs in service sectors which have relatively lower import shares. The average consumption share for service and non-service sectors across these countries is 1.8% and 4.5% respectively; in contrast, the average import shares are 41% and 10% respectively. As a result, the assumption that import shares are even across sectors, which is implied by the calculations in Column 1 of Table 3.5, leads to higher than actual gains from trade in the one sector model in some cases. Working in the opposite direction, the assumption that import shares are equal across sectors misses the gains due to traditional comparative advantage trade (*i.e.* trade due to productivity differences across sectors). The difference between Columns 1 and 2 in Table 3.5 combine these opposing factors, resulting in values for Column 1 in Table 3.6 that can be positive or negative depending on the country.

On average, the increase in measured gains from trade from including multiple sectors is 2.4%. In cases where higher shares of imports are in sectors with a higher consumption share, this difference tends to be higher. For example, in Australia, where the percentage change in going from the one sector model to the 31 sector model is 24.3%, the correlation in consumption share and import share across non-service sectors is 0.24; on the other hand, for Finland where the percentage change is -15.7 this correlation is lower at 0.09.

In sum, although the impact of comparative advantage across sectors generally leads to positive gains from trade when going from a model with one sector to one with many sectors, the overall gains are also affected by variation in consumption shares across sectors and countries.[21]

Column 3 in Table 3.5 includes the gains from trade when many sectors and also intermediates are included in the model as in (83). As we see, the increase in gains from trade from including intermediates is positive in all cases, as indicated by Column 2 in Table 3.6. This is predictable since, unlike in the case of including sectors, the minimizing value for gains from trade is always where the intermediate share, $\beta_n^j$, is zero across all sectors. Recall that the share of intermediate inputs is, on average, 0.53 across all sectors and countries. Moreover, this share is relatively high for tradable sectors at 0.63 on average. Since intermediate inputs generally make up a higher share of output than value-added, and especially more in manufacturing and commodities sectors where import shares are relatively high, the impact of including intermediate goods provides, on average, a substantial 187% increase in the percentage gains from trade.

Column 4 in Table 3.5 indicates the gains from trade in the model where CSS is included as in (82). The percentage changes in the gains from trade after accounting for

[21] If we were to assume common consumption shares across sectors, then the percentage change in the gains from including sectors would be, on average, larger than the gains from adding either intermediates or stage specialization.

Table 6: % Change in Gains From Trade, Common $\theta$

| | **Gains** $J$ | **Gains** $M$ | **Gains** $S$ | **Gains** $M, L$ | **Gains** $S, L$ |
|---|---|---|---|---|---|
| **Country** | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** |
| AUS | 24.3% | 171.8% | -3.4% | 116.1% | 2.0% |
| AUT | 29.5% | 153.6% | 1.6% | 111.8% | 1.4% |
| BEL | 34.0% | 183.4% | -1.8% | 147.8% | 3.9% |
| BRA | -15.5% | 171.0% | 16.5% | 132.5% | 0.5% |
| CAN | 23.7% | 172.8% | -0.4% | 110.2% | 1.9% |
| CHN | -30.0% | 301.0% | 22.8% | 323.2% | -0.2% |
| CZE | -0.2% | 222.1% | -2.1% | 195.6% | 2.1% |
| DEU | 9.4% | 156.8% | -1.7% | 106.1% | 1.1% |
| DNK | 24.1% | 238.5% | 25.1% | 110.8% | 3.7% |
| ESP | -6.9% | 209.7% | -8.4% | 188.2% | 2.9% |
| FIN | -15.7% | 146.6% | 1.1% | 177.2% | 0.5% |
| FRA | -3.3% | 218.1% | -3.2% | 151.4% | 2.5% |
| GBR | 25.2% | 144.5% | 16.7% | 106.7% | 2.6% |
| GRC | 10.8% | 128.6% | -1.2% | 116.5% | 3.1% |
| HUN | -1.6% | 207.7% | -1.9% | 184.7% | 0.7% |
| IDN | -16.5% | 154.9% | 22.0% | 191.7% | 2.8% |
| IND | -3.2% | 245.8% | 18.8% | 189.6% | 2.6% |
| IRL | -9.4% | 133.1% | 0.5% | 164.3% | 2.8% |
| ITA | -13.6% | 222.5% | -7.9% | 179.3% | 1.2% |
| JPN | -39.4% | 162.1% | -5.5% | 328.2% | 2.9% |
| KOR | -48.6% | 199.5% | 6.5% | 431.4% | 1.9% |
| MEX | -4.2% | 221.4% | 12.8% | 149.1% | 3.3% |
| NLD | 11.2% | 165.6% | -2.0% | 118.6% | 2.2% |
| POL | 4.7% | 200.8% | -0.7% | 149.4% | 2.0% |
| PRT | 11.5% | 198.0% | -4.2% | 163.8% | 0.6% |
| ROM | 13.9% | 123.4% | 14.8% | 159.5% | 2.6% |
| RUS | 31.9% | 174.9% | 5.5% | 97.0% | 0.5% |
| SVK | 18.8% | 192.7% | -1.1% | 157.4% | 1.9% |
| SVN | 51.3% | 182.6% | 0.1% | 119.0% | 2.8% |
| SWE | -0.9% | 176.7% | -3.5% | 137.9% | 1.2% |
| TUR | -1.4% | 188.8% | -1.5% | 165.2% | 2.6% |
| TWN | -18.8% | 229.5% | 0.1% | 218.2% | 3.6% |
| USA | -10.0% | 164.7% | -8.7% | 146.9% | 1.4% |
| RoW | -2.1% | 185.2% | 6.5% | 178.1% | 4.2% |
| **Average** | 2.4% | 186.7% | 3.3% | 168.3% | 2.1% |
| **Average (Adv)** | 6.1% | 181.2% | 0.1% | 164.7% | 2.1% |
| **Average (Emer)** | -4.3% | 196.8% | 9.1% | 175.0% | 2.2% |

CSS are indicated in Column 3 from Table 3.6. As described in my model, the added gains are not necessarily positive; they largely depend on the shares of intermediate inputs used in production, $\beta_n^j$. When the intermediate shares are all 0.5, the gains monotonically increase with the degree of CSS. However, when these shares are uneven, the gains from trade depend on whether a country specializes in intermediate or final goods production.

From Column 3 in Table 3.6 we see that the percentage changes in measured gains after accounting for CSS are, on average, positive at 3.3%. This is largely due to the fact that, in general, $\beta_n^j$ is greater than 0.5 and intermediate goods import shares are higher than final goods import shares for most countries and sectors. Notice also that, for several countries, the percentage changes in the measured gains are higher than those from traditional comparative advantage trade indicated in Column 1. In other words, the impact of specialization across sectors is not as significant as the impact from specialization across stages of production for these countries. This gap, and the magnitude of the added gains after accounting for CSS, is particularly high for several emerging economies including China, Indonesia, India, Brazil and Mexico.[22]

For China, a significant share of these gains come from the Construction sector. In that sector, the share of intermediate goods imports is roughly 10%, compared with the final goods imports share of less than 1%. Since this sector uses a very high share of intermediate inputs, at 0.76, and the consumption share is remarkably high at 0.2, the added gains after accounting for CSS are substantial.

In contrast, for Brazil, India, Indonesia and Mexico, the added gains mainly come from manufacturing sectors. For Brazil and India, the added gains are highest in the Transport sector and Textiles and Manufacturing Nec. sectors respectively. The added gains are fairly evenly spread across manufacturing for Indonesia. For Mexico, in the Chemicals, Transport, Machinery Nec., and Electrical sectors, the share of intermediate goods imports is significantly higher than the share of final goods imports. Moreover, these sectors have a relatively high consumption share and use a share of intermediate inputs significantly above 0.5.

Notice that among all the countries in the sample only one, the United States, experiences a significantly negative percentage change in added gains after accounting for CSS at -8.7%. This is because the United States, as Mexico's main trade partner, has a relatively higher final goods imports share than intermediate goods imports share in these same sectors. In accordance with the basic model derived in Section 3.2, countries that import a higher share of final goods in sectors where $\beta_n^j > 0.5$ have lower gains from

[22]Romania, Great Britain and Denmark also have relatively high added gains after accounting for CSS. However, except for Britain, these fall once $\theta^j$ is permitted to differ across sectors so, I will abstain from going into detail about these cases. For Britain, added gains from CSS come mainly from the Chemicals, Transport, and Hotels & Restaurants sectors.

trade when CSS is accounted for. The United States also imports a relatively high share of final goods in the textiles industry, due to trade with Asian countries.

Overall, while the sources of the added gains after accounting for CSS vary across these countries, a similar pattern can be seen across all cases where the gains are rooted in relatively higher intermediate goods import shares in sectors with high intermediate and high consumption shares.

Moreover, a pattern exists whereby emerging economies experience relatively larger average added gains from trade due to CSS, at 9.1%, than developed economies, at 0.1%. This pattern underlines the importance of global value chains in the modern global economy. In this context, developed economies export intermediate goods for processing to emerging economies which, in turn, add value and export final goods.

Despite this pattern, the welfare gains due to this type of trade are, generally speaking, quite modest. On average, gains from accounting for CSS amount to roughly 0.4% of GDP. Even in the relatively extreme cases mentioned above, the added welfare gains are consistently below 1.5% of GDP.

## 5.2 Refined Assumption: Including Sectoral Linkages, Common $\theta^j$

Column 5 in Table 3.5 reports the gains from trade when 31 sectors, intermediate goods and sectoral linkages are included as in (82). As we see, when comparing Column 5 with Column 3, the gains from trade are generally lower than the gains for the case with no sectoral linkages. This is consistent with previous findings from Levchenko and Zhang (2014) and it reflects the fact that traded goods use and are used by non-tradable goods, which lowers the gains from trade.[23]

Column 6 reports the gains from trade when sectors, intermediates goods, sectoral linkages and CSS are included as in (78). Again, the gains are, on average, slightly lower than in Column 4, where there are no sectoral linkages. Comparing Columns 5 and 3 in Table 3.6, we observe that including sectoral linkages typically lowers the variance in the added gains after accounting for CSS or, put differently, leads to mean reversion across countries. For the cases where the percentage change in the added gains are high in Column 3 (China, Brazil, India, Indonesia and Mexico), the values are significantly lower in Column 5 once we include sectoral linkages. In contrast, while there are several negative values in Column 3, there is only country, China, where the added gains after accounting for CSS are negative when we include sectoral linkages.

[23]There are, however, several exceptions to this trend, including China, Indonesia, Ireland, Japan, Korea and Romania where the gains are higher once sectoral linkages are included.

Overall, including sectoral linkages reinforces the finding that the impact of CSS is quite modest, both in terms of the average added gains after accounting for CSS and the variation in gains across countries.

## 5.3 Analysis

Overall, the results relating to the added gains from trade after accounting for CSS provide some interesting insights.

First, both in theory and practice, added gains rely on specialization across countries, sectors and stages of production. The sectoral composition of this pattern is examined in Table 3.9. This table provides values for the added gains after accounting for CSS according the model without sectoral linkages, using common $\theta^j$ (Columns 1 and 2) and different $\theta^j$ (Columns 3 and 4) across sectors. As we can see in Columns 1 and 2, a few sectors are associated with very large added gains due to accounting for CSS; these include Food, Beverages & Tobacco, Textiles, Coke & Petroleum and Machinery Nec.. In addition, while the average is not very high for the Transport sector, the standard deviation is remarkably high for this sector as it is for these other four sectors. For all of these sectors, the average share of intermediate inputs across countries is above 0.6 indicating that the added gains after accounting for CSS are positive for those that import intermediate goods and negative for those that import final goods.

For the Food, Beverages & Tobacco, Textiles, Machinery Nec. and Transport sectors, there is a clear pattern whereby emerging economies, like China, Brazil, India, Indonesia and Mexico, specialize relatively more in final goods production and import more intermediate goods. This leads to additional potential welfare gains for these countries (relative to the standard multi-sector EK model) and losses for their trading partners, which tend to be more developed economies like the United States.

For Coke & Petroleum, the picture is more mixed and dominated by a few European countries including Denmark, Netherlands, Romania and Slovenia.

In Columns 3 and 4 of Table 3.9, which allow for differences in $\theta^j$, we see that the importance of the Coke & Petroleum sector significantly declines, whereas that of the Machinery Nec. and Transport sectors significantly rises. This change is due to the impact of $\theta^j$ which, relative to the mean, is large for the former sector and small for the latter sectors.

In analyzing these results, it appears that added gains after accounting for CSS tend to be significantly higher for countries that specialize in the final stage of manufacturing production, particularly in sectors with a high share of intermediate inputs that are also relatively competitive in terms of market power. According to this analysis, the sectors where the benefits tend to be the highest are the Machinery Nec. and Transport sectors.

Table 7: % Change in Gains From Trade, Sectors

| **Sector** | **Average** | **St. Dev.** | **Average** | **St. Dev.** | **Difference** |
|---|---|---|---|---|---|
| Agriculture & Hunting | 0.076 | 0.350 | 0.042 | 0.192 | -0.034 |
| Mining & Quarrying | -0.270 | 0.265 | -0.077 | 0.075 | 0.194 |
| Food, Bev. & Tobac. | -1.445 | 3.092 | -2.496 | 5.345 | -1.051 |
| Textiles & Leath. | -0.567 | 1.174 | -0.455 | 0.943 | 0.112 |
| Wood & Products | -0.029 | 0.041 | -0.012 | 0.017 | 0.017 |
| Pulp & Paper | -0.026 | 0.079 | -0.013 | 0.039 | 0.013 |
| Coke & Petroleum | 2.976 | 11.328 | 0.283 | 1.106 | -2.693 |
| Chemicals | 0.307 | 0.535 | 0.288 | 0.501 | -0.019 |
| Rubber & Plastics | 0.012 | 0.100 | 0.032 | 0.268 | 0.020 |
| Other Minerals | -0.027 | 0.056 | -0.043 | 0.090 | -0.016 |
| Basic Metals | -0.234 | 0.298 | -0.131 | 0.166 | 0.103 |
| Machinery, Nec. | -0.743 | 2.020 | -2.039 | 5.534 | -1.296 |
| Electrical & Optical | 0.124 | 0.802 | 0.055 | 0.347 | -0.070 |
| Transport | -0.020 | 2.939 | 0.472 | 23.664 | 0.492 |
| Manufacturing, Nec. | -0.015 | 0.987 | -0.013 | 0.882 | 0.002 |

However, as we also observe in this section, once sectoral linkages are factored in to the model most of these sector or country specific patterns tend to dissipate. Why does this happen? In short, while certain countries might specialize in one stage of production for a particular sector, this pattern often follows the opposite pattern for other sectors. This point is indicated by the $count_n$ column in Table 3.4, where it is clear that countries specialize in intermediate goods production in some sectors and final goods production in other sectors. While we might expect that this pattern would lead to mutual increases in gains across countries, even for the model without sectoral linkages, the impact of asymmetries in $\alpha_n^j$ and $\beta_n^j$ across sectors leads to asymmetries across countries in the added gains after accounting for CSS. However, due to linkages through intermediate inputs, these asymmetries are largely offset in the end. Even for countries with strong specialization across nearly all tradable sectors, like Mexico or the United States, the impact of sectoral linkages with non-tradable service sectors weakens the impact of CSS.

Remarkably, these patterns of CSS also appear to be very stable over time. In Table B.2 in Appendix B, I provide figures for how the gains from trade have grown, in terms of percentage change, from 1995 to 2011 across all of these models.[24] As indicated in Column 1, the gains from trade in the one sector model grew, on average, by 37.7% over the period. The percentage growth in the multi-sector model (Column 2) and the model including intermediate goods (Column 3) were, on average, even higher at 48.3% and 67.3% respectively. These growth percentages can be interpreted as the growth in welfare

[24]Table B.2 provides results from the model where $\theta$ is assumed to be equal to 5 for all sectors.

due to increases in aggregate imports, imports inclusive of comparative advantage trade, and imports inclusive of comparative advantage trade and intermediate goods trade over the 1995-2011 period.

In contrast, the percentage growth according to the model with CSS (reported in Column 4) was, on average, slightly lower at than the previous column at 66.2%. In other words, the added growth in the gains from trade after accounting for CSS from 1995-2011 was, on average, negligible. When the model with sectoral linkages is considered as in Columns 5 and 6, a similar story unfolds. The growth in the model which ignores CSS is, on average, 63.1%. After accounting for CSS, the average growth changes very little to 63.6%, suggesting that gains from trade after accounting for CSS were stable going from 1995 to 2011.

## 5.4 The Welfare Gains from Intermediate Goods Trade

Up to this point, I have explored the role that intermediate goods play in establishing gains from trade through three channels: the classical input-output channel, the channel of sectoral linkages, and the channel of specialization across stages of production. Given the inclusion of all three channels, we might wonder "What are the welfare gains due to intermediate goods trade as compared with final goods trade?".

To answer this question, I perform two counter-factual exercises. In the first, I set intermediate goods trade to zero so that there is only trade in final goods and compare welfare in this scenario with the measured welfare when both intermediate and final goods are traded. I refer to the difference between these calculations as the welfare gains from intermediate goods trade. In the second counter-factual, I do the same exercise for final goods and refer to this difference as the gains from final goods trade.

Columns 1 and 2 in Table 3.10 report both of these findings for the case when $\theta^j$ are equal across sectors and Column 3 reports the percentage of overall gains from trade that can be attributed to intermediate goods trade. As we see, the welfare gains from intermediate goods trade are, for all countries, higher than the gains from final goods trade. Put differently, the cost - in terms of welfare - of entirely inhibiting intermediate goods trade is higher than the cost of inhibiting final goods trade. Moreover, this pattern appears to be particularly strong for emerging economies: the countries with the highest share of welfare gains due to intermediate goods trade include Brazil, China, India, Indonesia, Korea and Mexico.

Columns 4 and 5 report these findings for the case when $\theta^j$ differs across sectors. Compared to the previous case, we see that the share of gains from intermediate goods trade, indicated by Column 6, is generally lower. On average, this represents approximately half of the gains from trade. Again, the shares are highest amongst the same set of emerging economies as in the previous case.[25]

In sum, the impact of inhibiting intermediate goods trade is generally higher for emerging economies than for more developed economies. Moreover, this pattern is not surprising given the importance of processing trade for emerging economies during the 2000s.

[25]Notice that the relative gains from intermediate to final goods trade are significantly lower when $\theta^j$ differs across sectors. This is largely due to the diminished impact of a few sectors, most importantly Coke & Petroleum, in the latter case. Since over three quarters of the output in this sector is in intermediate inputs, the gains from intermediate goods trade are much more diminished than the gains from final goods trade.

Table 8: Gains From Trade, Intermediate versus Final Goods

| | **Gains Int** | **Gains Fin** | **% Int** | **Gains Int** | **Gains Fin** | **% Int** |
|---|---|---|---|---|---|---|
| **Country** | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** |
| AUS | 3.6% | 3.2% | 52.8% | 4.8% | 10.4% | 31.9% |
| AUT | 9.7% | 6.8% | 58.9% | 18.6% | 19.3% | 49.2% |
| BEL | 15.9% | 8.4% | 65.4% | 20.4% | 22.6% | 47.5% |
| BRA | 2.1% | 0.8% | 71.5% | 3.3% | 1.5% | 69.4% |
| CAN | 5.8% | 5.4% | 51.6% | 13.0% | 18.6% | 41.1% |
| CHN | 5.8% | 1.5% | 79.7% | 5.7% | 3.0% | 65.2% |
| CZE | 13.0% | 6.5% | 66.7% | 16.4% | 15.4% | 51.7% |
| DEU | 5.3% | 4.5% | 54.0% | 7.2% | 11.5% | 38.4% |
| DNK | 8.1% | 6.6% | 55.2% | 10.4% | 21.8% | 32.3% |
| ESP | 5.5% | 3.8% | 59.3% | 8.5% | 14.2% | 37.5% |
| FIN | 7.0% | 3.4% | 67.2% | 9.8% | 10.4% | 48.5% |
| FRA | 4.7% | 3.2% | 59.7% | 6.9% | 9.0% | 43.2% |
| GBR | 4.6% | 3.9% | 53.7% | 8.6% | 9.9% | 46.7% |
| GRC | 5.7% | 4.1% | 58.2% | 5.7% | 18.1% | 23.8% |
| HUN | 15.3% | 5.9% | 72.1% | 20.7% | 17.7% | 53.8% |
| IDN | 6.6% | 2.2% | 74.8% | 9.9% | 4.6% | 68.1% |
| IND | 5.3% | 1.8% | 74.8% | 4.6% | 2.6% | 63.8% |
| IRL | 13.9% | 6.9% | 66.7% | 12.6% | 23.7% | 34.8% |
| ITA | 4.6% | 2.5% | 64.4% | 5.9% | 9.1% | 39.3% |
| JPN | 2.6% | 1.2% | 68.7% | 1.7% | 1.8% | 47.8% |
| KOR | 7.9% | 2.1% | 79.0% | 5.1% | 4.0% | 55.9% |
| MEX | 6.6% | 2.5% | 72.5% | 12.0% | 6.5% | 65.1% |
| NLD | 8.9% | 5.8% | 60.6% | 12.4% | 19.2% | 39.3% |
| POL | 7.4% | 4.2% | 64.0% | 11.4% | 12.0% | 48.6% |
| PRT | 8.1% | 4.7% | 63.3% | 11.0% | 16.6% | 39.7% |
| ROM | 10.4% | 4.8% | 68.6% | 9.9% | 13.3% | 42.7% |
| RUS | 3.2% | 3.7% | 45.8% | 12.2% | 11.9% | 50.6% |
| SVK | 17.6% | 7.6% | 69.9% | 27.9% | 13.7% | 67.0% |
| SVN | 14.6% | 9.3% | 61.2% | 16.0% | 26.2% | 37.8% |
| SWE | 7.0% | 4.8% | 59.4% | 10.5% | 10.8% | 49.2% |
| TUR | 5.3% | 2.5% | 68.3% | 7.1% | 10.9% | 39.4% |
| TWN | 11.5% | 5.5% | 67.7% | 9.8% | 9.6% | 50.5% |
| USA | 2.3% | 1.7% | 57.0% | 3.3% | 5.0% | 39.3% |
| RoW | 11.0% | 3.4% | 76.6% | 21.4% | 8.0% | 72.8% |
| **Average** | 7.0% | 3.8% | 64.7% | 10.7% | 12.1% | 48.0% |
| **Average (Adv)** | 7.7% | 4.5% | 62.4% | 11.5% | 14.7% | 43.5% |
| **Average (Emer)** | 5.8% | 2.5% | 68.8% | 9.2% | 7.4% | 56.3% |

# 6 Conclusion

This paper has sought to explore the relationship, qualitatively and quantitatively, between comparative advantage and cross stage specialization (CSS). I derived a simple version of the Eaton-Kortum (2002) model of trade that illustrates the gains from specialization across stages of production. This model yields a simple solution relating the gains from trade to the share of home consumption in both intermediate and final goods and the share of intermediate inputs used in production.

The results relating to the added gains due to CSS provide some interesting insights. First, both in theory and practice, the added gains rely on specialization at across countries, sectors and stages of production. In looking broadly across countries, it is clear that for most sectors the share of intermediate goods used in production is above 0.5. This suggest that, for these sectors, there are positive gains from importing a relatively higher share on intermediate goods and negative gains from importing a higher share of final goods, relative to the baseline assumption that these shares are equivalent (as in EK (2002)).

To examine this relationship empirically, I extended the model the many countries and sectors, and then calculated the gains from trade using data from 2005 for 34 countries and 31 sectors based on the the World Input Output Database (WIOD).

I find that the gains from trade are fairly similar under the CSS framework as in the the standard EK model that abstracts from CSS. Surprisingly, most countries import a similar share of intermediate goods and final goods for a given sector. For some countries, however, the added gains due to CSS are significantly higher than for other countries. The countries that gain the most tend to be emerging economies that import intermediate goods and add value to produce final goods for exports.

This latter point, that emerging economies gain the most from CSS, might be surprising to some international trade critics who point to the unequal balance of gains from trade across more and less developed economies. My model offers some theoretical support for this criticism, revealing that countries which specialize in intermediate goods production benefit less, in terms of welfare, due to CSS. However, empirically it is more developed economies, not emerging ones, that tend to specialize in intermediate goods production. Emerging countries tend to specialize in the latter stage of production and, as a result, experience higher added gains due to CSS.

This finding illustrates how the emergence of global value chains has altered the relationship between stage of development, comparative advantage and placement on the value chain. Whereas in the past it might have been true that developing countries had a comparative advantage in producing basic upstream goods, in modern times emerging economies generally import a higher share of intermediate goods and specialize more in final goods production than developed economies.

While these results suggest that the added gains due to CSS are fairly modest across all countries, it should also be noted that the magnitude of these gains could be on account of the level of aggregation in the data. While I have only identified 2 stages of production, for some sectors there might be many more stages and there could be multi-stage production within sectors that cannot be captured at the 2-digit level of classification. With these points in mind, I consider my findings as a lower bound for the gains from trade due to specialization across stages.

# 7 Appendix I: Additional Tables and Proofs

## 7.1 Tables

Table 9: Dispersion Parameters for ISIC Rev. 2 Groups

| Isic Rev. 2 group | $\theta_{EK}$ | Se. | Obs |
|---|---|---|---|
| Agriculture | 8.11 | (1.86) | 496 |
| Mining | 15.72 | (2.76) | 296 |
| Food, Beverages and Tobacco | 2.55 | (0.61) | 495 |
| Textiles, Leather and Footwear | 5.56 | (1.14) | 437 |
| Wood and Wood Products | 10.83 | (2.53) | 315 |
| Paper, Paper prod. and Printing | 9.07 | (1.69) | 507 |
| Coke, Petroleum, Nuclear | 51.08 | (18.05) | 91 |
| Chemical and Chemical Products | 4.75 | (1.77) | 430 |
| Rubber and Plastics | 1.66 | (1.41) | 376 |
| Non-metallic Mineral Products | 2.76 | (1.43) | 342 |
| Basic and Fabricated Metals | 7.99 | (2.53) | 388 |
| Metal products | 4.30 | (2.15) | 404 |
| Machinery, Nec. | 1.52 | (1.81) | 397 |
| Electrical and Optical Equipment | 10.60 | (1.38) | 343 |
| Transport | 0.37 | (1.08) | 245 |
| Machinery, Nec. Recycling | 5.00 | (0.92) | 412 |
| Average | 4.55 | (0.35) | 7212 |

Table 10: **% Growth in Gains From Trade, 1995-2011, Common $\theta$**

| **Country** | **Gains** $N$ | **Gains** $J$ | **Gains** $M$ | **Gains** $S$ | **Gains** $M, L$ | **Gains** $S, L$ |
|---|---|---|---|---|---|---|
| AUS | 17.5% | 46.7% | 68.1% | 63.0% | 27.4% | 30.9% |
| AUT | 40.6% | 61.1% | 95.9% | 83.8% | 78.9% | 79.6% |
| BEL | 14.9% | 15.0% | 29.8% | 32.3% | 36.9% | 38.5% |
| BRA | 53.3% | 64.0% | 60.4% | 77.5% | 61.8% | 63.5% |
| CAN | -12.5% | -21.8% | -12.2% | -16.1% | -12.0% | -11.6% |
| CHN | 8.0% | -25.1% | -6.3% | 16.8% | 23.4% | 23.7% |
| CZE | 54.2% | 65.4% | 82.1% | 95.1% | 67.7% | 68.3% |
| DEU | 75.3% | 104.6% | 124.4% | 121.8% | 113.4% | 115.6% |
| DNK | 32.9% | 21.2% | 93.7% | 78.8% | 38.4% | 41.7% |
| ESP | 38.0% | 55.0% | 75.2% | 82.7% | 68.9% | 67.7% |
| FIN | 32.6% | 30.9% | 53.0% | 46.1% | 55.1% | 55.7% |
| FRA | 34.2% | 60.9% | 99.3% | 127.8% | 61.9% | 69.1% |
| GBR | 19.6% | 47.5% | 54.8% | 59.1% | 46.1% | 45.8% |
| IDN | 6.3% | 0.8% | 8.4% | 11.1% | 14.1% | 14.8% |
| IND | 79.2% | 125.4% | 178.0% | 127.3% | 158.3% | 166.7% |
| IRL | 37.8% | 9.7% | 1.6% | 3.7% | 24.2% | 24.8% |
| ITA | 33.8% | 27.8% | 48.7% | 53.1% | 67.9% | 68.0% |
| JPN | 113.0% | 76.3% | 97.1% | 107.1% | 230.5% | 233.7% |
| MEX | 39.4% | 52.0% | 67.0% | 53.9% | 50.8% | 49.9% |
| NLD | 20.4% | 6.8% | 29.1% | 29.6% | 20.5% | 19.2% |
| POL | 119.3% | 175.9% | 244.7% | 248.3% | 181.0% | 175.9% |
| PRT | 7.9% | 14.1% | 3.4% | -1.1% | 17.3% | 17.5% |
| ROM | 47.4% | 85.8% | 64.8% | 93.0% | 74.3% | 76.1% |
| RUS | 8.9% | 50.0% | 56.5% | 46.7% | 43.9% | 44.1% |
| SVN | 18.2% | 74.7% | 57.3% | 57.0% | 66.0% | 65.2% |
| SWE | 27.8% | 33.8% | 72.9% | 66.5% | 41.1% | 41.1% |
| TUR | 75.1% | 98.8% | 181.0% | 131.9% | 127.2% | 113.1% |
| TWN | 51.1% | 31.4% | 51.8% | 45.1% | 54.4% | 56.2% |
| USA | 43.4% | 69.0% | 45.4% | 54.3% | 55.0% | 57.3% |
| RoW | -6.6% | -7.0% | -8.1% | -10.8% | -2.3% | -5.0% |
| **Average** | 37.7% | 48.3% | 67.3% | 66.2% | 63.1% | 63.6% |

## 7.2 Proofs

*Proof of equation (18)*:

From (9), it is clear that $G^j_{s,ni}(p) = 1 - exp\left\{-T^j_{s,i}\left(c^j_i \kappa^j_{s,ni}\right)^{-\theta^j} p^{\theta^j}\right\}$. It follows that the probability of receiving a price in $n$ below $p$ for a given variety from *any* country is equal to $G^j_{s,n}(p) = \prod_{i=1}^N G^j_{s,ni}(p)$. Solving for this expression yields:

$$G^j_{s,n}(p) = 1 - \prod_{i=1}^{N} exp\left\{-T^j_{s,i}\left(c^j_i \kappa^j_{s,ni}\right)^{-\theta^j} p^{\theta^j}\right\} = 1 - exp\left\{\sum_{i=1}^{N} -T^j_{s,i}\left(c^j_i \kappa^j_{s,ni}\right)^{-\theta^j} p^{\theta^j}\right\} \quad (85)$$

This is equivalent to the expression found in equation (18).

*Proof of equation (20)*:

We can represent $\pi^j_{s,ni}$ as $\pi^j_{s,ni} = Pr\left(p^j_{s,ni}(\omega^j) \leq min\left\{p^j_{s,nk}(\omega^j); k \neq i\right\}\right)$. Suppose that $p^j_{s,ni}(\omega^j) = p$; then, this probability can be represented as:

$$\begin{aligned}\prod_{k\neq i} Pr\left(p^j_{s,nk}(\omega^j) \geq p\right) = \prod_{k\neq i}\left[1 - G^j_{s,nk}(p)\right] &= exp\left\{\sum_{k\neq i} -T^j_{s,i}\left(c^j_i \kappa^j_{s,ni}\right)^{-\theta^j} p^{\theta^j}\right\} \\ &= exp\left\{-\phi^j_{s,n\neq i} p^{\theta^j}\right\}\end{aligned} \quad (86)$$

where $\phi^j_{s,n\neq i} = \sum_{k\neq i} -T^j_{s,i}\left(c^j_i \kappa^j_{s,ni}\right)^{-\theta^j}$. To find $\pi^j_{s,ni}$, we integrate (14) over all possible $p$'s times the density $dF^j_{s,i}(p)$, which is itself equal to:

$$dF^j_{s,i}(p) = -T^j_{s,i}\left(c^j_i \kappa^j_{s,ni}\right)^{-\theta^j} \theta^j p^{\theta^j - 1} exp\left\{-T^j_{s,i}\left(c^j_i \kappa^j_{s,ni}\right)^{-\theta^j} p^{\theta^j}\right\} dp \quad (87)$$

We can therefore solve for $\pi^j_{s,ni}$ as:

$$\begin{aligned}\pi^j_{s,ni} &= \int_0^\infty exp\left\{-\phi^j_{s,n\neq i} p^{\theta^j}\right\} dF^j_{s,i}(p) \\ &= \left(\frac{T^j_{s,i}\left[c^j_i \kappa^j_{s,ni}\right]^{-\theta^j}}{\phi^j_{s,n}}\right) \int_0^\infty \theta^j \phi^j_{s,n} exp\left\{-\phi^j_{s,n} p^{\theta^j} p^{\theta^j - 1}\right\} \\ &= \left(\frac{T^j_{s,i}\left[c^j_i \kappa^j_{s,ni}\right]^{-\theta^j}}{\phi^j_{s,n}}\right) \int_0^\infty dG^j_{s,n}(p) dp\end{aligned} \quad (88)$$

Since $\int_0^\infty dG^j_{s,n}(p)dp = 1$, equation (20) has been proven.

*Proof that $G^j_{s,n}(p)$ is the distribution of goods bought in $n$ conditional on source $i$:*

This firms operate in perfect competition, firms in $i$ will only sell to $n$ if they are the least cost supplier to $n$. Supposing that firms in $i$ offer a price $q$, then the probability of this occurrence is equal to equation (13) with $q$ substituted for $p$. Thus, the total probability across all prices $q$ is $exp\left\{-\phi^j_{s,n\neq i}p^{\theta^j}\right\}dG^j_{s,ni}$. Integrating this probability over all prices below $p$ yields the following:

$$\begin{aligned}
&\int_0^p exp\left\{-\phi^j_{s,n\neq i}q^{\theta^j}\right\}dG^j_{s,ni}(q)\\
&\qquad = \int_0^p exp\left\{-\phi^j_{s,n\neq i}p^{\theta^j}\right\}\theta^j T^j_{s,i}\left(c^j_i\kappa^j_{s,ni}\right)^{-\theta^j}\theta^j q^{\theta^j-1}exp\left\{-T^j_{s,i}\left(c^j_i\kappa^j_{s,ni}\right)^{-\theta^j}q^{\theta^j}\right\}dq\\
&\qquad = \left(\frac{T^j_{s,i}\left(c^j_i\kappa^j_{s,ni}\right)^{-\theta^j}}{\phi^j_{s,n}}\right)\int_0^p \theta^j\phi^j_{s,n}exp\left\{-\phi^j_{s,n}q^{\theta^j}\right\}q^{\theta^j-1}dq\\
&\qquad = \pi^j_{s,ni}G^j_{s,n}(p)
\end{aligned} \tag{89}$$

Since $\pi^j_{s,ni}$ denotes the probability that country $i$ provided the lowest price of a good to $n$, the distribution of (18) conditional on sourcing from $i$ can be represented as:

$$\frac{1}{\pi^j_{s,ni}}\int_0^p exp\left\{-\phi^j_{s,n\neq i}q^{\theta^j}\right\}dG^j_{s,ni}(q) = G^j_{s,n}(p) \tag{90}$$

*Proof of equation (12):*

Suppose that we rearrange the expression in (8) to be in terms of $\left(P^j_{s,n}\right)^{1-\sigma}$. Thus, $\left(P^j_{s,n}\right)^{1-\sigma} = \int_0^1 p^j_{s,n}(\omega^j)^{1-\sigma}d\omega = \int_0^\infty p^{1-\sigma}dG^j_{s,n}$. Expanding $dG^j_{s,n}$ yields the following:

$$\left(P^j_{s,n}\right)^{1-\sigma} = \int_0^\infty p^{1-\sigma}\phi^j_{s,n}\theta^j p^{\theta^j-1}exp\left\{-\phi^j_{s,n}p^{\theta^j}\right\}dp \tag{91}$$

Now, we can employ integration by substitution. Letting $x = \phi^j_{s,n}p^{\theta^j}$, find that $dx = \phi^j_{s,n}\theta^j p^{\theta^j-1}$ and $p = \left(x/\phi^j_{s,n}\right)^{1/\theta^j}$. Substituting these expressions into (18) yields the following:

$$\begin{aligned}
\left(P^j_{s,n}\right)^{1-\sigma} &= \int_0^\infty \left(\frac{x}{\phi^j_{s,n}}\right)^{\frac{1-\sigma}{\theta^j}} exp\left\{-x\right\}dx\\
&= \left(\phi^j_{s,n}\right)^{\frac{\theta^j}{1-\sigma}}\int_0^\infty x^{\frac{1-\sigma}{\theta^j}}exp\left\{-x\right\}dx
\end{aligned} \tag{92}$$

A second part of this expression can be simplified as $\int_0^\infty x^{(1-\sigma)/\theta^j}exp\left\{-x\right\}dx = \Gamma\left((\theta^j+1-\sigma)/\theta^j\right)^{1/(1-\sigma)}$ where $\Gamma$ denotes the Gamma function (a constant).[26] Sub-

[26]The general formula for the Gamma function is $\Gamma(a) = \int_{-}^{\infty} x^{a-1}e^{-x}dx$.

stituting this into (21) yields equation (12) (slightly rearranged):

$$\left(P_{s,n}^{j}\right)^{1-\sigma} = \left(\phi_{s,n}^{j}\right)^{\frac{\theta^{j}}{1-\sigma}} \Gamma\left(\frac{\theta^{j}+1-\sigma}{\theta^{j}}\right) \tag{93}$$

# 8 Appendix II: Gains from Trade with Different $\theta$

## 8.1 Classic Assumption: No Linkages, Different $\theta$

In the following subsection, I assume that $\theta^j$ differs across sectors using estimated values of $\theta^j$ from Caliendo and Parro (2015). These values are reported in Table 3.1 in Appendix B. Note that $\theta^j$ varies significantly for tradable sectors from 0.37 to 51.08. Lower values of $\theta^j$ translate to higher gains from trade in this model. For non-tradable sectors, I again assume that $\theta = 5$.

In Table 3.7, I report the gains from trade allowing for different values of $\theta^j$ across sectors. In general, it is clear that the impact of comparative advantage trade is significantly higher in this table than in Table 3.5 where $\theta^j$ was equal across sectors. This is seen by comparing the differences between Column 1 and 2, which depicts the impact of comparative advantage trade across sectors, across Tables 3.5 and 3.7.[27] In Table 3.7, the average gains rise from 4.5% to 14.2%; in Table 3.5, they only rise to 4.8%.

Why is the impact of traditional comparative advantage trade so much higher once we account for differences in $\theta^j$ across sectors? The reason is that international trade and consumption shares tend to be particularly high in sectors which, according to Caliendo and Parro (2015), have particularly low values of $\theta^j$. In general, consumption and trade tend to be high in the Food, Beverages & Tobacco, Chemicals, Machinery Nec. and Transport sectors. All four of these sectors have values of $\theta^j$ that are below the mean. In theory, this suggests that these sectors are less competitive, meaning that they have fewer firms in equilibrium, and the average firm is relatively large and productive. By trading in these sectors, countries benefit from receiving goods that are made by more productive firms abroad that, in turn, charge lower prices.

In considering the impact of adding intermediate goods trade (Column 3 for Table 3.7), we again see that the percentage change in gains from trade (depicted in Column 2 of Table 3.8) is, on average, very large at 180%. This is only slightly different than the percentage increase from the previous sub-section, where $\theta^j$ is assumed to be equal across countries, suggesting that there is not a strong relationship between the estimates of $\theta^j$ and the share of intermediate inputs across sectors.

Finally, I consider the percentage change in gains from trade after accounting for CSS, as depicted in Column 3 of Table 3.8. We see that, on average, the changes are very modest at just 1.4%. This is only slightly lower than the average in Column 3 of Table 3.6. In considering differences across countries, we again see that emerging economies -

[27] Again, Column 2 presents results from calculating gains according to (82) whereas Column 1 presents gains according to (84). Since I again assume that $\theta = 5$ for (84), the values in Column 1 are the same in Table 3.7 and Table 3.5.

Table 11: Gains From Trade (% of GDP), Different $\theta$

| | **One** $J$ | **Many** $J$ | **Inc.** $M$ | **Two** $S$ | **Inc.** $M, L$ | **Two** $S, L$ |
|---|---|---|---|---|---|---|
| **Country** | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** |
| AUS | 2.5% | 8.5% | 25.3% | 21.5% | 15.5% | 15.8% |
| AUT | 6.1% | 26.9% | 63.3% | 64.3% | 44.2% | 44.3% |
| BEL | 7.5% | 31.3% | 75.3% | 74.4% | 52.0% | 52.8% |
| BRA | 1.5% | 2.7% | 8.7% | 11.4% | 4.9% | 4.8% |
| CAN | 4.3% | 21.0% | 55.4% | 54.7% | 34.9% | 35.3% |
| CHN | 2.5% | 3.2% | 12.7% | 13.9% | 8.8% | 8.8% |
| CZE | 6.7% | 17.7% | 52.5% | 51.7% | 35.1% | 35.7% |
| DEU | 4.4% | 11.7% | 32.5% | 31.4% | 19.3% | 19.7% |
| DNK | 5.6% | 25.5% | 56.6% | 60.3% | 35.1% | 35.7% |
| ESP | 3.4% | 12.3% | 38.5% | 34.9% | 23.5% | 24.2% |
| FIN | 4.5% | 12.4% | 29.4% | 30.6% | 21.4% | 21.6% |
| FRA | 3.2% | 9.2% | 32.7% | 32.1% | 16.4% | 16.6% |
| GBR | 3.2% | 11.5% | 30.4% | 33.7% | 19.2% | 19.6% |
| GRC | 4.1% | 18.3% | 36.8% | 33.4% | 24.8% | 25.2% |
| HUN | 7.8% | 24.6% | 66.0% | 65.5% | 45.0% | 45.1% |
| IDN | 3.5% | 6.3% | 16.1% | 17.9% | 14.8% | 15.1% |
| IND | 2.5% | 3.3% | 11.4% | 13.9% | 7.1% | 7.3% |
| IRL | 8.8% | 27.2% | 50.9% | 48.7% | 40.8% | 41.4% |
| ITA | 2.9% | 8.6% | 29.8% | 26.6% | 15.5% | 15.7% |
| JPN | 1.4% | 1.3% | 3.8% | 3.6% | 3.4% | 3.6% |
| KOR | 3.6% | 3.0% | 10.0% | 9.8% | 8.8% | 9.3% |
| MEX | 3.7% | 10.6% | 27.3% | 33.9% | 18.5% | 19.5% |
| NLD | 6.1% | 20.6% | 49.4% | 47.7% | 34.2% | 35.3% |
| POL | 4.4% | 13.5% | 42.7% | 42.9% | 24.9% | 25.3% |
| PRT | 4.4% | 18.9% | 47.4% | 46.6% | 30.2% | 30.2% |
| ROM | 5.1% | 15.6% | 31.7% | 33.2% | 24.7% | 24.9% |
| RUS | 2.7% | 13.6% | 38.3% | 38.5% | 26.1% | 26.1% |
| SVK | 8.5% | 22.1% | 61.8% | 61.4% | 49.0% | 49.1% |
| SVN | 7.4% | 33.3% | 81.4% | 79.8% | 50.2% | 50.7% |
| SWE | 5.1% | 11.5% | 32.6% | 31.6% | 22.5% | 22.8% |
| TUR | 2.9% | 10.9% | 29.3% | 27.9% | 18.7% | 18.9% |
| TWN | 6.6% | 9.5% | 31.1% | 31.2% | 19.5% | 20.5% |
| USA | 1.8% | 4.6% | 14.5% | 13.2% | 8.5% | 8.5% |
| RoW | 5.1% | 13.4% | 40.7% | 46.1% | 29.6% | 31.9% |
| **Average** | 4.5% | 14.2% | 37.2% | 37.3% | 24.9% | 25.3% |
| **Average (Adv)** | 5.1% | 17.1% | 43.7% | 42.9% | 29.1% | 29.5% |
| **Average (Emer)** | 3.5% | 8.9% | 25.4% | 27.0% | 17.2% | 17.6% |

Table 12: % Change in Gains From Trade, Different $\theta$

| | **Gains** $J$ | **Gains** $M$ | **Gains** $S$ | **Gains** $M, L$ | **Gains** $S, L$ |
|---|---|---|---|---|---|
| **Country** | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** |
| AUS | 239.1% | 198.0% | -15.2% | 82.4% | 1.9% |
| AUT | 339.4% | 135.1% | 1.6% | 64.3% | 0.3% |
| BEL | 319.1% | 140.5% | -1.2% | 66.1% | 1.5% |
| BRA | 81.3% | 229.6% | 30.0% | 83.6% | -0.9% |
| CAN | 384.3% | 163.9% | -1.3% | 66.4% | 1.0% |
| CHN | 30.2% | 294.2% | 9.3% | 175.0% | 0.1% |
| CZE | 163.2% | 197.4% | -1.6% | 98.6% | 1.9% |
| DEU | 168.9% | 177.7% | -3.4% | 64.9% | 1.9% |
| DNK | 354.7% | 122.3% | 6.5% | 37.9% | 1.6% |
| ESP | 259.4% | 213.9% | -9.3% | 91.7% | 3.0% |
| FIN | 173.6% | 137.2% | 4.4% | 73.1% | 0.8% |
| FRA | 188.7% | 256.5% | -1.9% | 78.7% | 1.5% |
| GBR | 254.8% | 164.6% | 10.7% | 66.9% | 2.0% |
| GRC | 350.6% | 101.6% | -9.3% | 35.7% | 1.5% |
| HUN | 215.0% | 167.9% | -0.7% | 82.8% | 0.2% |
| IDN | 78.6% | 154.6% | 10.7% | 132.9% | 2.1% |
| IND | 34.0% | 247.4% | 21.4% | 116.7% | 1.9% |
| IRL | 207.7% | 87.3% | -4.4% | 50.1% | 1.5% |
| ITA | 192.9% | 248.1% | -10.8% | 80.7% | 1.2% |
| JPN | -8.7% | 193.0% | -5.7% | 157.7% | 5.3% |
| KOR | -17.6% | 236.1% | -2.3% | 195.1% | 5.7% |
| MEX | 187.3% | 156.8% | 24.3% | 74.4% | 5.1% |
| NLD | 237.8% | 139.3% | -3.4% | 65.5% | 3.2% |
| POL | 204.5% | 216.4% | 0.6% | 84.7% | 1.4% |
| PRT | 328.3% | 150.4% | -1.6% | 59.4% | 0.1% |
| ROM | 204.0% | 103.7% | 4.7% | 58.6% | 1.0% |
| RUS | 411.3% | 182.4% | 0.3% | 92.4% | -0.1% |
| SVK | 158.7% | 179.4% | -0.6% | 121.4% | 0.4% |
| SVN | 347.8% | 144.4% | -2.0% | 50.6% | 0.9% |
| SWE | 126.6% | 184.2% | -3.2% | 95.9% | 1.3% |
| TUR | 275.7% | 168.1% | -4.7% | 71.1% | 1.3% |
| TWN | 45.4% | 225.3% | 0.5% | 104.7% | 5.0% |
| USA | 159.8% | 211.9% | -8.9% | 82.2% | 0.1% |
| RoW | 161.0% | 203.8% | 13.3% | 121.3% | 7.7% |
| **Average** | 201.7% | 180.4% | 1.4% | 87.7% | 1.9% |
| **Average (Adv)** | 226.6% | 169.9% | -2.5% | 81.2% | 1.8% |
| **Average (Emer)** | 156.1% | 199.5% | 8.5% | 99.8% | 2.1% |

especially China, India, Indonesia, Brazil and Mexico - have fairly high added gains. As in the case when $\theta^j$ was equal across sectors, these magnitudes are large because these countries tend to import a relatively high share of intermediate goods in sectors that use a high share of intermediate inputs. As suggested by the model in Section 3.2, this leads to increases in measured gains from trade after accounting for CSS. Compared to the case where $\theta^j$ was equal across sectors, there are now numerous countries, particularly Australia, Italy, Spain and the United States, that experience significant reductions in gains from trade after accounting for CSS.

What explains these outliers? The sectors most heavily impacted by CSS tend to be Food, Beverages & Tobacco, Machinery Nec., Transport and Textiles. Amongst these, the first four all have values of $\theta^j$ that are below the mean, which translates into larger added gains after accounting for CSS. Again, since $\beta_n^j$ is greater than 0.5, CSS produces winners that import relatively more intermediate goods (*e.g.* China, India, Indonesia, Brazil, Mexico and Britain) and losers that import relatively more final goods (*e.g.* Australia, Italy, Spain and the United States).

At the other extreme, Coke & Petroleum now has a significantly higher $\theta^j$, which translates into a smaller impact when I consider CSS. The impact of this pattern leads to a stronger negative relationship between the added measured gains and a country's stage of economic development, since the added gains in the Coke & Petroleum sector are, if anything, highest among more developed economies. For example, in Denmark the percentage change in gains from trade after accounting for CSS is 25.1% in Table 3.6; in Table 3.8, this figure is much lower at 6.5%.

Overall, while the magnitudes are different, the same pattern emerges in Table 3.8 whereby emerging economies experience relatively higher average added gains due to CSS, at 8.5%, while developed economies experience lower average added gains, at -2.5%. Again, this pattern signifies the nature of global value chains whereby emerging economies specialize in processing trade and, as a result, tend to import intermediate goods and export final goods.

## 8.2 Refined Assumption: Including Sectoral Linkages, Different $\theta^j$

I now consider the impact of including sectoral linkages, as depicted in Columns 4 and 5 in Table 3.8. Compared to the same columns in Table 3.6, we see that the impact of sectoral linkages significantly reduces the gains from trade once we include different values of $\theta^j$. This is made clear by comparing Columns 3 and 5 in Table 3.7 with the same two columns in Table 3.5. In Table 3.7, the average gains from trade fall from

37.2% with no linkages to 24.9% with linkages. In contrast, the average gains fall from 13.6% to 12.2% in Table 3.5. In considering the percentage change in the gains from including intermediates goods trade with sectoral linkages depicted in Table 3.8, we see that the average gains are 88%. By comparison, the average gains are significantly higher in Table 3.6 at 168%.

The impact of accounting for CSS in Column 5 of Table 3.8, as in Table 3.6, is less significant when we include sectoral linkages. The average percentage change in gains is only 1.9%. Also, as we see in Table 3.6, there is noticeable regression to the mean across countries. In Column 3 of Table 3.8 there are many positive and many negative changes after accounting for CSS; once sectoral linkages are introduced, depicted in Column 5, the impact is smoothed so that almost all countries see modest positive added gains that are close to the cross-country average. As a result, the relationship between the added gains after accounting for CSS and a country's stage of economic development is once again significantly less dramatic once we include sectoral linkages. This is not surprising since, once sectoral linkages are introduced, the impact of differences in $\theta^j$ across sectors would predictably decline.

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