Technology, Trade costs and Export Sophistication

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Abstract

This paper uses a disaggregated version of the Eaton and Kortum (2002) model to analyze the relative importance of technology and trade costs for export sophistication and welfare in a general equilibrium framework. It uses a structural estimation method to identify key parameters of the model that fit the observed trade pattern. The calibrated parameters vary across commodities consistent with their expected level of sophistication. The results are robust to alternative specifications of the calibration. Using fitted data, it also show that export sophistication is highly correlated with GDP per capita. Overall, the parameters are comparable with estimates from other studies. Finally, counterfactual experiments are conducted to quantify the effects of changes in technology and trade costs for the countries in the bottom quintile. The findings imply that these countries have a huge technological disadvantage, particularly in more sophisticated commodities.

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1 Introduction

The new economic geography literature explores the importance of technology and geography in determining specialization patterns and comparative advantage of countries. In particular, Eaton and Kortum (2002), henceforth referred to as EK, provide a general equilibrium model to analyze the relative importance of technology and geography. Fieler (2011) extends the model by assuming that technology (productivity) varies more widely across countries for high income elasticity goods. Since richer countries produce and consume these goods more intensively, the variability of their technology gives them greater incentive to trade. This implies that the composition of exports is directly related to the level of productivity that exists in a country. Similarly, the composition of exports also determines the level of export sophistication, which indicates the similarity of export bundles of a country with exports of high income countries (Hausmann et al., 2007).

This paper explores the relative importance of technology and trade costs on export sophistication and welfare in a general equilibrium framework. It uses an estimation strategy developed by Balistreri and Hillberry (2007) that employs a structural estimation technique to calibrate a general equilibrium model. It also incorporates non-homothetic preferences using a Stone-Geary utility function. The tradable sector is modelled using a disaggregated EK framework that estimates bilateral trade at commodity level.[1] Key parameters of the model are calibrated.

The result shows that the marginal expenditure shares exhibit substantial variation across commodities, with the highest share in services. It is comparable with fitted expenditure shares for the median income estimated using the Chenery (1979) method. Moreover, the efficiency dispersion parameter varies moderately across commodities consistent with their expected spread of efficiency. That is, more (less) sophisticated commodities have larger (smaller) spread of efficiency. The result is robust to restricting the trade costs parameter to be equal to an average estimate from Hummels (2001) for all commodities. Similarly, there is variation in the trade costs pa-

[1] I use eight aggregated commodities.

rameter across commodities, which indicates a difference in sensitivity. For example, commodities such as machinery and electrical equipment are less sensitive than others. Furthermore, the implied distance elasticities from the calibrated model are similar to estimates from a log-linear regression for most of the commodities.

With regard to the country-specific technology parameter, the result shows that it varies across commodities within a country and also across countries. A country can have a large value in some commodities, but not in others. The overall pattern indicates that low income countries are at the bottom end in the ranking. Similarly, the average weighted income of a commodity (PRODY) varies consistently with its level of sophistication. Moreover, export sophistication shows a clear upward trend with GDP per capita.

Further, counterfactual experiments are also conducted to assess the effect of changes in technology and trade costs. A 100% increase in the country-specific technology parameter across commodities for the bottom quintile of the sample increases the export share of the countries. It has also increased welfare significantly ranging from 10% to 60%. In contrast, although exports increase, there is only a small effect on export sophistication. Further examination shows that an increase in productivity in less sophisticated commodities has a negative effect on export sophistication, offsetting the positive effect from more sophisticated commodities. Alternatively, the country-specific technology parameter is raised to 5% of China's technology parameter in each commodity. Consequently, export sophistication increases significantly in most countries, as high as 30%.

The second experiment reduces trade costs of the countries in the bottom quintile by decreasing bilateral distance with all their trading partners by 25%.[2] Surprisingly, the effects on the price index, welfare, and export sophistication are very similar to the increase in technology. The equivalent effect of the two shocks indicates that these countries relatively have a greater technological disadvantage, particularly in more sophisticated commodities. This finding has a crucial policy implication for low income countries that

[2]Equivalent to about an 8% to 9% reduction in trade costs.

strive to enhance their export sophistication. Currently, there are many challenges associated with technology transfer and lowering aspects of trade costs for these countries. They need to focus on the underlying determinant factors, such as FDI, human capital, institutional quality, infrastructure, and other policy barriers. Finally, for both shocks, there are no significant effects on the countries in other quintiles. Comparatively, however, the countries in the second quintile are affected slightly more than others.

This paper contributes to the literature in three ways. It calibrates key parameters of a disaggregated EK model at commodity level for a bigger sample consistent with general equilibrium conditions. It also quantifies the relative importance of technology and trade costs in shaping the composition of exports of poorer countries. Moreover, similar to a growing number of studies, it incorporates non-homothetic preferences for the purpose of welfare analysis. The paper is related to the work of Fieler (2011) on non-homotheticity, but it differs in methodology. Fieler (2011) uses an aggregate data and fixes the efficiency dispersion parameter for a hypothetical high income elasticity good. In contrast, this paper uses a disaggregated dataset and estimates the technology parameters at commodity level. Similar to Shikher (2004), it applies a disaggregated EK model. However, it identifies both technology parameters jointly from a bigger sample. Broadly, it is related to recent papers that use a modified version of the EK model to explore important issues in the trade literature (see, for example, Waugh, 2010; Chor, 2010; Costinot et al., 2010; French, 2011; Tombe, 2011; Xu, 2011).

The rest of the paper is organized as follows. Section 2 reviews the literature. Section 3 presents the disaggregated EK model in a general equilibrium framework. The methodology is outlined in section 4. Section 5 discusses the empirical results. The counterfactual experiments are presented in section 6. Finally, section 7 concludes.

2 Literature Review

In the Ricardian model, technological differences explain trade and specialization patterns between countries. Although the basic framework is set up as a two-good and two-country model, Dornbusch, Fischer, and Samuelson (1977) generalize it to include more goods in a continuum. The level of technology dictates the comparative advantage of producing each good and determines which goods a country should specialize in. With trade, countries produce and export goods in which they are relatively more productive. As a result, countries with a low level of technology end up exporting unsophisticated goods. Hufbauer (1970) argues that the commodity composition of exports reflects the advantages of a country in certain national characteristics and technology.

However, the Ricardian model is silent about the existence of a wide variation in technology across countries. Many studies explore the factors that explain the process of accumulation of technical capabilities. Grossman and Helpman (1995) discuss three main modes of technology acquisition: learning by doing, investment in research and development, and diffusion and spillover effects. Learning by doing is an outcome of engaging in production and improving ways of combining inputs more efficiently through experience. In particular, improving the quality of intermediate goods enhances productivity growth. Moreover, new innovations are a result of purposeful investment in research activity (see, for example, Helpman, 1993; Eaton and Kortum, 1997, 2001; Keller, 2004). Firms invest in research and development in an environment where intellectual property rights are protected. However, many developing countries fail to provide adequate protection of intellectual property rights. Consequently, the level of innovation and technology adoption varies widely among countries (Hausmann and Rodrik, 2003). In a similar vein, Levchenko (2007), Nunn (2007), Martincus and Gallo (2009), Costinot (2009), and Krishna and Levchenko (2009) show the role of institutions as an important determinant of specialization patterns and highlight the extent of the institutional requirements to produce complex products.

Other common ways of technology acquisition in developing countries are through diffusion and spillover effects (Keller, 2004). Krugman's (1979) 'product life cycle' model shows how the diffusion of technologies from North to South changes the pattern of trade and comparative advantage. Similarly, multinational enterprises (MNEs) transfer technology to developing countries through FDI, joint ventures, and licensing to domestic firms. In addition, the existence of MNEs confers spillover benefits, easing the transfer of know-how through backward and forward linkages, or demonstration effects (Keller, 2004; Harrison and Rodriguez-Clare, 2009).

Recently, a novel contribution by EK extended the Ricardian theory to explain important features of a bilateral trade patterns. Following Dornbusch, Fischer, and Samuelson (1977), they assume that productivity levels are treated as random variables drawn from a parameterized distribution.[3] While the value of technology, T_i, is country specific, θ controls the level of heterogeneity in efficiency. They also derive a variant of the gravity model that explicitly captures the differences in absolute and comparative advantages across a continuum of goods in a multi-country framework. The model is very handy and has been widely used for empirical analysis. In principle, the value of θ could differ depending on the sample size and level of aggregation. For example, EK use OECD data and estimate θ equal to 8.28 using a simple method of moments.[4] Waugh (2010) also finds a value for θ of 5.5 using a sample of OECD and non-OECD economies. Similarly, Fieler (2011) estimates a value for θ of 14.34 and 19.27 for a sample of 162 countries using two different methods.

Many papers have extended the EK model to explore interesting issues in the international trade literature. Costinot et al. (2010) develop a theoretical foundation to test the prediction of the Ricardian model. Their findings confirm the importance of Ricardian comparative advantage on exports. Waugh (2010) proposes asymmetric trade costs between rich and poor countries to reconcile bilateral trade volumes and aggregate price data with the standard gravity model. He incorporates the asymmetry by allowing

[3] From a trade context, the two key parameters of the Frechet distribution, T_i and θ, govern absolute and comparative advantages respectively (Eaton and Kortum, 2002:1747).

[4] While $\theta = 8.28$ is their preferred result, they also find $\theta = 3.6$ using wage data, and $\theta = 12.86$ using price data (Eaton and Kortum, 2002:1765).

trade costs to vary by exporter and finds that the fit of predicted bilateral volumes is better relative to standard approaches. However, his focus is primarily on showing the significance of the asymmetry in trade costs and abstracts from commodity level differences. Fieler (2011) explores the role of non-homotheticity in bilateral trade. She assumes that technology is more variable across countries for high income elasticity goods. Since rich countries consume and produce these goods more intensively, it implies that the variability in their technology increases the incentive to trade. In contrast, the opposite is true for poorer countries and consequently they trade little with each other. As a result, she provides a better prediction of bilateral trade patterns. However, she assumes the existence of two goods with different income elasticities from aggregate data and does not identify the parameters of the model from commodity level data.

Shikher (2004) also adds an industry dimension and inter-industry trade in intermediate goods. This allows simulation of the effect of changes in industry-level technology and trade barriers on prices, costs of production, employment, specialization, and welfare. In addition, Shikher (2009) develops a general equilibrium model of international production and trade. The model allows producers to draw on productivity in their home country, which can also be taken to the country where they choose to produce. This extension endogenizes technology used in production and measures the level of technology transfer associated with FDI. Similarly, French (2011) argues that trade costs parameters are not identified by aggregate bilateral trade data if systematic patterns of comparative advantage exist. He uses a product level EK model to estimate bilateral trade costs and finds that the estimated parameters are about half the size of those estimated using aggregate data.

Chor (2010) also extends the model to quantify the importance of different sources of comparative advantage. He finds that countries specialize in industries whose input requirements best match with their factor endowments and institutional strengths. Finally, Tombe (2011) and Xu (2011) use the EK framework to explain the low intensity of trade in the agricultural sector. They investigate whether the observed low level of trade is due to low productivity dispersion or high trade barriers. Both studies find that there is higher trade barrier in agriculture relative to manufacturing. However, they differ in their conclusion about the productivity in agriculture due to a difference in their treatment of the key parameter, θ. While Tombe (2011) imposes $\theta = 7$, Xu (2011) estimates $\theta = 4.16$ using data on producer prices of individual agricultural goods. With the slight exception of Xu (2011), all the papers that apply a disaggregated EK framework assume away differences in θ across commodities or sectors.

On the other hand, trade costs are central to understanding trade and specialization patterns.[5] EK show that technology and geography compete in determining comparative advantage in the presence of finite trade costs. Hummels (2001) provides a detailed characterization of trade costs. Most trade models incorporate the effect of trade costs, and empirical studies show that trade costs have a significant effect on bilateral trade patterns including home market bias (Anderson and van Wincoop, 2004). Moreover, trade costs could vary widely across commodities, which has important implications for trade composition. Several studies show that the trade response to geographic frictions is mainly on the extensive margin vis-à-vis the intensive margin (Hummels and Klenow, 2005; Hillberry and Hummels, 2008; Chaney, 2008; Helpman et al., 2008). This implies that some goods are more sensitive to trade costs than others. Consequently, it could be a source of comparative advantage affecting the composition of exports.

Greenaway et al. (2009) also show that industry export shares are greater in trade costs-sensitive industries for countries with relatively low national trade costs. Similarly, Batchford et al. (2011) find that industries located in countries with low trade costs capture significantly higher shares of world exports in trade costs-intensive industries. This finding alludes to the idea of local comparative advantage proposed by Deardorff (2004). Moreover, Harrigan and Deng (2008) find evidence supportive of local comparative advantage, where China has a comparative advantage in heavy goods in nearby

[5] Trade costs include all the costs incurred in delivering a good from the point of production to the final user. These are transport and time costs, tariff and non-tariff policy barriers, information costs, contract enforcement costs, regulatory and compliance costs, and distribution costs (Anderson and van Wincoop, 2004:692).

markets, and lighter goods in more distant markets. Therefore, it is important to incorporate difference in trade costs sensitivity across commodities in a disaggregated EK model in general equilibrium modelling.

3 Model

Recent studies move away from the traditional homothetic preferences assumption in modelling international trade towards an empirically consistent non-homothetic assumption[6] (see, for example, Markusen, 2010; Fieler, 2011; Dalign et al., 2008; Hunter, 1991; Hunter and Markusen, 1988). The literature provides robust evidence that the income elasticity of demand varies across goods. Markusen (2010) adds non-homothetic preferences to a traditional trade model to explain many issues in international trade, such as home bias.[7] Moreover, non-homotheticity has a direct implication to the composition of trade. In line with these literature, this paper incorporates non-homothetic preferences using a Stone-Geary utility function.

The Stone-Geary utility function is widely used to represent international preference structures in many global computable general equilibrium (CGE) models.[8] The linear expenditure system (LES) is used to model household consumption behaviour and conduct welfare analysis. The LES has the advantage of theoretical flexibility, since it is not as restrictive as the Cobb-Douglas functional form.[9] Moreover, it is computationally easier than others, such as the AIDADS (An Implicitly Directly Additive Demand System), as

[6] With homothetic preferences, it is assumed that a consumer spends the same share of his budget on each commodity as his income increases, which implies unitary income elasticity. However, this is not consistent with Engel's law that states the share of necessities (such as, food) on consumer's budget declines as income increases, an indication of non-homotheticity (Barnett, 1983:216-218; and Lewel, 2006:1-4).

[7] Using non-homothetic preferences in a traditional competitive Hecksher-Ohlin model, he shows that several issues including the growing wage gaps, the mystery of the missing trade, home bias in consumption, and the role of intra-country income distribution can be explained by the demand side of a general equilibrium (Markusen, 2010:3-10).

[8] Among others, MIRAGE of CEPII (Center d'Etudes Prospectives et d'Informations Internationales), LINKAGE of the World Bank, and GTAP (Global Trade Analysis Project) (Boer and Paap, 2009:369).

[9] With the Cobb-Douglas homothetic preferences, price and income elasticities are always unity.

it requires relatively fewer parameters to be estimated. The disadvantage, however, is that the Engel curves are straight lines, although with a positive intercept. In addition, it rules out the existence of inferior commodities, and all commodities are considered gross substitutes. Consequently, it is only appropriate to broadly defined composite commodities (Boer and Paap, 2009; Balk, 2001; Deborger, 1985; Phipps, 1990).

3.1 Utility

There are J countries with two sectors, non-tradable and tradable. The non-tradable sector produces one commodity (s), which consists of one good (services). The tradable sector produces several composite commodities (k), where $k \in \{1, 2, ..., K\}$. Consumer welfare is represented by a nested two-tier structure. At the top tier, consumers choose commodities to maximize a Stone-Geary utility function. At the lower tier, goods within each tradable commodity are aggregated by a CES function. I assume identical but non-homothetic preferences. The utility function is the same for all consumers in the world, and they choose the quantity of each commodity, q_j^c, to maximize their utility. The utility function, $U_j(q)$, is

$$U_j(q) = \prod_c \left(q_j^c - \chi_j^c\right)^{\beta^c}, \tag{1}$$

where $c \in \{s, k\}$, $\beta^c > 0$, and $\sum_c \beta^c = 1$. β^c is the share of expenditure of commodity c (the marginal expenditure share), and χ_j^c is the subsistence level of consumption. The utility function is reduced to Cobb-Douglas when $\chi_j^c = 0, \forall_c$. The demand function is derived by maximizing the utility function subject to income ($Y_j = \sum_c q_j^c p_j^c$). Accordingly, the demand function with the Stone-Geary preferences is

$$q_j^c = \chi_j^c + \frac{\beta^c}{p_j^c}\left(Y_j - \sum_c \chi_j^c p_j^c\right). \tag{2}$$

The term in the parentheses is the residual income[10], after the subsistence (minimum) levels are met. The amount of quantity the residual income buys is influenced negatively by price, and positively by the commodity's importance. This implies that, due to non-homotheticity (quasi-homotheticity), the Engel curves and income expansion paths are straight lines, but which start away from the origin (with an intercept). In addition, I derive an expenditure function using the demand function and indirect utility function:

$$e(p_j, U_j) = U_j . \prod_c \left(\frac{p_j^c}{\beta^c} \right)^{\beta^c} + \sum_c \chi_j^c p_j^c . \tag{3}$$

Equation (3) has two components. Since the sum of β^c is equal to unity, the first term on the right hand side represents a weighted geometric mean of the prices. It is also equivalent to a marginal cost of living.

Similarly, at the lower tier, a tradable commodity is a composite of all varieties of goods in the market, $v^k \in [0, 1]$. The varieties can be either domestically produced or imported and are aggregated by a CES function. This assumes that the top tier Stone-Geary utility function is weakly separable in the composite commodities (De Melo and Tarr, 1992; Feldstein and Poterba, 1996). The CES quantity index, q_j^k, is

$$q_j^k = \left[\int_0^1 \tilde{q}_j(v^k)^{(\sigma^k - 1)/\sigma^k} dv^k \right]^{\sigma^k/(\sigma^k - 1)} , \tag{4}$$

where $\tilde{q}_j(v^k)$ is the quantity of a variety in k in country j, and σ^k is the elasticity of substitution across goods. Hence, I also have a CES price index for each commodity. The weak separability assumption combined with the price index of composite commodities implies that the consumer's problem is a two-stage budgeting decision.[11] The price index is discussed in the next sub-section.

[10] Also known as the supernumerary income.

[11] In the first stage, given income and composite prices, a consumer maximizes a separable Stone-Geary utility function. In the second stage, a consumer maximizes separate sub-utility functions subject to expenditure allocated to consumption of each composite commodity (De Melo and Tarr, 1992:54).

3.2 Technology

For simplicity, labour is the only factor of production. It is mobile across commodities and goods within a country, but not across countries. The production function for the non-tradable commodity (services) in country i is

$$q_i^s = T_i^s L_i^s, \tag{5}$$

where T_i^s denotes an exogenous productivity parameter, and L_i^s is the labour devoted to production of services. The production function for the tradable commodities is a disaggregated EK model at commodity level. I denote the input cost (wage) in country i as w_i, and $z_i(v^k)$ as the efficiency of labour in country i in producing good v^k. With constant returns to scale, the unit cost of producing good v^k in country i is $\frac{w_i}{z_i(v^k)}$. Trade costs are specified as iceberg costs, where delivering one unit of good v^k from country i to country j requires shipping d_{ij}^k units. In line with recent literature, trade costs vary by type of commodity to incorporate differences in the sensitivity of commodities to geographic barriers.

Following the perfect competition assumption of EK, the price consumers in country j pay for good v^k is the minimum of the offered prices:

$$p_j(v^k) = \min\left\{p_{ji}(v^k);\ i = 1, ..., N\right\}. \tag{6}$$

Further, country i's efficiency in producing good v^k is drawn randomly from a type and country-specific probability distribution. Accordingly, for any $z > 0$, $F_i^k(z) = pr\left[z_i(v^k) \leq z\right]$. Assuming that the efficiency distribution is Frechet, the expression becomes

$$F_i^k(z) = \exp\left(-T_i^k z^{-\theta^k}\right), \tag{7}$$

where T_i determines the level of the distribution, and θ controls the dispersion of the distribution. These distributions are assumed to be independent across types and countries. From a trade perspective, T_i^k measures the level of efficiency in producing a variety of goods of each type. A country could be more efficient in some types, but less efficient in others. In contrast, parameter θ^k is not country specific, but it could differ across types depending on the spread of labour efficiency in each type. That is, smaller values of θ^k implies that there is a wider variation in efficiency across goods and countries.

The above assumptions enable us to derive the distribution of prices for all countries. Since each exporting country i presents country j with a distribution of prices, it can also be aggregated into a price distribution:

$$\Phi_j^k = \sum_i T_i^k \left(w_i d_{ij}^k\right)^{-\theta^k}. \tag{8}$$

Φ_j^k summarizes the state of technology, input costs, and geographic barriers for all trading partners. It is a key parameter necessary to derive a CES price index (p_j^k) with an elasticity of substitution parameter, σ^k. Assuming $\theta^k > \sigma^k - 1$, then

$$p_j^k = \left[\Gamma(\frac{\theta^k + 1 - \sigma^k}{\theta^k})\right]^{1/(1-\sigma^k)} \left(\Phi_j^k\right)^{\frac{-1}{\theta^k}}, \tag{9}$$

where Γ is the gamma function. The price index is not the same across countries due to the effect of geographic barriers.

3.3 Trade Flows and Equilibrium

Similar to the EK model, I also derive a variant of the gravity model by exploiting the properties of Φ_j^k. It shows how country j's spending is allocated amongst suppliers. The probability that country i is the lowest price seller in country j for type k is

$$\pi_{ij}^k = \frac{T_i^k \left(w_i d_{ij}^k\right)^{-\theta^k}}{\Phi_j^k}. \tag{10}$$

This is also equivalent to the fraction of commodities that country j buys from country i :

$$\frac{X_{ij}^k}{X_{j^k}} = \pi_{ij}^k = \frac{T_i^k \left(w_i d_{ij}^k\right)^{-\theta^k}}{\Phi_j^k}, \tag{11}$$

where X_j^k is country j's total spending on commodity k, and X_{ij}^k is the amount spent on country i. Further, I assume that the price of the non-tradable commodity is one, $p_j^s = 1$. Consequently, its output in country i, Y_i^s, is equal to q_i^s. Additionally, the total labour income is equal to the income from traded and non-traded commodities. Since income from traded commodities is equal to total exports, the labour market clearing condition is

$$L_i w_i = \sum_k \sum_j X_{ij}^k \; + \; Y_i^s, \tag{12}$$

where L_i is the total number of workers in the economy.

4 Data and Methodology

4.1 Data

I use data from several sources. The bilateral trade data in the agricultural sector is from GTAP, and manufacturing bilateral trade data is from CEPII.[12] I have nine commodities: services is assumed to be non-tradable, and there are eight traded commodities. These are agriculture, processed food, non-metallic manufactures, metallic manufactures, chemicals, machinery, electrical equipment, and transport equipment.[13] I also source output and expenditure data from GTAP, bilateral distance from CEPII, and GDP per capita from the Penn World Tables. Due to data limitations and computational challenges, I chose the commodity aggregation that maximizes country sample size and captures distinct commodity characteristics (refer, Table 7). The sample includes 91 countries for 2004. For a list of countries in the sample, refer to Table 8.

[12] The advantage of the CEPII dataset in comparison with other datasets is that it has a wider coverage of bilateral trade data, particularly for developing countries (Mayer et al., 2008:2).

[13] Initially I included the mining sector, but the model does not solve properly, and I thus decided to exclude it. I observe that trade in mining and mineral products is not well distributed across countries and has more bilateral zeroes than in other commodity categories. This could probably be the reason that an optimal solution can not found.

4.2 Estimation Strategy

Similar to the literature, I specify trade costs as an exponential function of bilateral distance ($Dist_{ij}$):

$$d_{ij}^k = (Dist_{ij})^{\rho^k}. \tag{13}$$

I divide $Dist_{ij}$ by the smallest bilateral distance in the sample, so that the minimum d_{ij}^k is 1. The parameter ρ^k denotes the varying distance sensitivity of trade costs for commodity k. In other words, it captures the distance elasticity of trade costs for each commodity. I use a two-step estimation procedure developed by Balistreri and Hillberry (2007). The first step is to set up an econometric model to calibrate the parameters. I search for the value of the parameters that minimize the squared deviations between log of the observed (x_{ij}^k) and fitted ($\widehat{x}_{ij}^k$) trade flows.[14] The objective function is expressed as

$$\min \sum_{o \in I} \sum_{d \in J} \sum_{k} \left[\log(x_{ij}^k) - \log(\widehat{x}_{ij}^k)\right]^2, \tag{14}$$

where o and d represent respectively exporting and importing countries which have positive bilateral trade between them. Because of the prevalence of zeroes and unobserved domestic trade, I introduce notations (o and d) to distinguish between the econometric sample and the full set in the general equilibrium. Accordingly, the econometric sample includes only bilateral pairs with positive trade. The estimation minimizes the objective function subject to labour market clearance and other fixed constraints.

To ease computational difficulty and find a sensible optimal solution, I fix subsistence income ($\sum_c \chi_j^c p_j^c$), and subsistence expenditure on each commodity ($\chi_j^c p_j^c$), and CES elasticity of substitution (σ^k). Hummels (2001) estimates σ^k at two digit level and finds an average value of 5.6, with a range from 3 to 8. Given the level of aggregation and sample size, it is expected that the elasticity of substitution between commodities could be smaller than the average. For parsimony, I assume the same elasticity of substitution for

[14] I use optimization programs available in GAMS software.

all commodities and fix it at 4, which is also close to the estimate of Bernard et al. (2003).[15]

To determine subsistence consumption (χ_j^c) endogenously within the model, I need to know the subsistence income of the countries. In the literature, there is no clear guidance on subsistence income due to varying meanings and definitions. Steger (2000) provides two broad definitions of subsistence income. One definition is related to a standard of living that allows for the provision of basic needs. The alternative definition is the level of production for home consumption purposes. I choose the first definition and set subsistence income to 40% of Malawi's total manufacturing expenditure; that is, the lowest expenditure in the sample. Further, I assume that the share of each commodity in the subsistence income is equal to the average expenditure share of each commodity for the lower half of the sample.[16] This is done to make it more representative of the expenditure pattern of low income countries. Furthermore, it ensures that subsistence expenditure at commodity level is lower than the actual expenditure on each commodity for each country. The calibrated model, in turn, determines χ_j^c depending on the price index (p_j^c).

4.3 Calibration Specifications

I conduct three calibrations of the model and compare the results. In the first calibration, I free four parameters (T_i^k, θ^k, β^c, and ρ^k), although ρ^k is bounded. Using freight data, Hummels (2001) finds an average estimate of $\rho^k = 0.27$, with commodity-specific estimates clustered mostly in the range between 0.2 to 0.3. Similarly, I use $\rho^k = 0.27 \pm 0.05$ (0.22 to 0.32) as a bound and estimate it within the model. The econometric model determines the values of the four parameters that minimize the objective function.

For robustness, the second calibration constrains β^c equal to the expenditure shares estimated using the Chenery method for the median income

[15] Using plant level data, their estimated elasticity of substitution is 3.79 (Bernard et al., 2003).

[16] The average expenditure share of each commodity for the lower half of the sample, 45 countries, is: agriculture (0.14), processed food (0.11), non-metallic (0.11), metallic (0.04), chemicals (0.05), machinery (0.02), electrical (0.015), transport (0.015), and services (0.50).

Table 1: Summary of the calibration specifications.

Calibration Specification	**(I)**	**(II)**	**(III)**
Free parameters	$T_i^k, \theta^k, \beta^c, \rho^k$	T_i^k, θ^k, ρ^k	T_i^k, θ^k
Fixed parameters	σ^k	σ^k, β^c	$\sigma^k, \beta^c, \rho^k$
Common constraints	$\sum_k \chi_j^c p_j^c = 40\%$ of Malawi expenditure. $\chi_j^c p_j^c = Sh^c \sum_k \chi_j^c p_j^c$, where Sh^c is an average expenditure share of the lower half of the sample.		

(Chenery, 1979; USITC, 1997).[17] The method depicts the relationship between expenditure shares and income by fitting smooth curves to the data, known as 'Chenery curves'. For each commodity, the share of expenditure (e_j^c) is regressed on expenditure per capita ($EXPND\text{-}pc_j$) and the square of expenditure per capita (Chenery, 1979). The specification is

$$e_j^c = \alpha + \beta_1 EXPND\text{-}pc_j + \beta_2 (EXPND\text{-}pc_j)^2. \tag{15}$$

Since I do not include the mining sector, I modify the variables to satisfy the adding up condition.[18] The fitted expenditure shares for the median income range from 2% in transport equipment to 51% in services.[19] In the third calibration, I further constrain both β^c and ρ^k for an additional sensitivity check. I fix β^c the same as in calibration two, while ρ^k is fixed at 0.27, equal to the average estimate of Hummels (2001).

[17] Other studies also use a similar approach. For example, Tombe (2011) fixed β^c equal to the long-run US employment shares of three sectors: agriculture, manufacturing, and services (Tombe, 2011:13).

[18] Expenditure shares are calculated by dividing expenditure on each commodity by total expenditure net of expenditure in the mining sector.

[19] The expenditure shares for the median income are: agriculture (0.12), processed food (0.10), non-metallic manufacture (0.10), metallic manufacture (0.04), chemicals (0.06), machinery (0.03), electrical equipment (0.03), transport equipment (0.02), and service (0.51).

4.4 Outcome Variables

After calibrating the parameters from the econometric model, I fix them to calibrate a general equilibrium model. The model determines equilibrium levels of income, utility, price index, quantity index, and specialization. I measure specialization using export sophistication index (EXPY), which is constructed as follows. The income level associated with commodity k, $PRODY^k$, is defined as

$$PRODY^k = \sum_i \left\{ \frac{(\frac{X_i^k}{X_i})}{\sum_i (\frac{X_i^k}{X_i})} Y_i \right\}, \tag{16}$$

where $\frac{X_i^k}{X_i}$ is the share of exports of commodity k, and Y_i denotes GDP per capita of country i. Similarly, EXPY measures the average PRODY of a country weighted by the expenditure shares of each commodity (see, for details, Hausmann et al., 2007:9-10):

$$EXPY_i = \sum_k (\frac{X_i^k}{X_i}) PRODY^k. \tag{17}$$

EXPY is an aggregate indicator of the commodity composition of exports. It measures the similarity of export bundles of a country with exports of rich countries. Hausmann et al. (2007) also show that EXPY is highly correlated with GDP per capita.

Finally, using the benchmark model, I also simulate counterfactual experiments about the effects of shocks in country-specific technology and trade costs on equilibrium outcomes and specialization pattern.

5 Empirical Results

In this section I present results of the three calibrations. I also compare the calibrated parameters of the three specifications with each other, and with estimates in the literature. First, I assess how well the calibrated model fits the observed trade pattern using a log-linear regression of the observed trade flows on fitted trade flows. The overall fitness of the calibrated model is similar in the three specifications, with the regression coefficient equal to 0.75 and R^2 of 0.48. These results indicate that the calibrations produce reasonable replications taking into consideration the large sample size, the level of disaggregation, and the high prevalence of zeroes.

5.1 Marginal Expenditure Shares

The calibrated marginal expenditure shares β^c show a substantial variation across commodities. Column 1 of Table 2 shows that services have a very high β^c, followed by agriculture and machinery. The remaining commodities each have β^c close to 0.01 or 1%. While the values for services and agriculture are within a reasonable range, I expect higher β^c for commodities such as processed food and non-metallic manufactures. Relatively, these commodities represent a bigger share of the expenditures of most low income countries. I also compare the calibrated values of β^c with the expenditure shares estimated using the Chenery method for the median income (column 2 of Table 2).[20] Overall, the marginal expenditure shares are similar to the expenditure shares of the median income for many commodities. However, there are also considerable differences in processed food, non-metallic manufactures, and machinery.

5.2 Technology Parameters

As discussed in the literature, the size of θ^k determines the dispersion of efficiency among goods. Bigger θ^k implies less spread in efficiency. The calibration results are reported in Table 3. Column 1 shows that θ^k varies across commodities. The more sophisticated commodities such as machinery and electrical equipment have lower θ^k. In contrast, processed food has the highest θ^k, followed by non-metallic manufactures. The pattern of variation of θ^k seems consistent with the expected spread of efficiency in the commodities. Column 2 also reports estimates of θ^k when β^c is fixed at the values estimated using the Chenery method. The results are very similar to the θ^k

[20] Also note that the expenditure shares for the mean income are very similar to the expenditure shares for the median income.

Table 2: Estimated marginal expenditure shares for each commodity.

Commodity Classification	**Calibration I** β^c	**Chenery estimation** β^c *(median income)*
Agriculture	0.14	0.12
Processed food	0.01	0.10
Non-metallic manufactures	0.01	0.10
Metallic manufactures	0.01	0.04
Chemicals	0.01	0.06
Machinery	0.10	0.03
Electrical equipment	0.01	0.03
Transport equipment	0.01	0.02
Service	0.69	0.51
Fixed Parameter	σ^k	
No. of observations	66,248	66,248
Objective function	346,011.8	346,011.8

values in calibration I. Similarly, the last column shows θ^k estimates when both β^c and ρ^k are fixed. The results show that when ρ^k is constrained at lower value, θ^k increases slightly for all the commodities in comparison to the other two calibrations. This finding is expected due to the fact that the product of ρ^k and θ^k is the implied distance elasticity of trade. Further, the pattern of dispersion of θ^k is maintained across the commodities.

In the literature, to the best of my knowledge, no previous study has estimated the variation in θ^k at commodity level in the EK framework. The estimates of θ in the existing literature are mostly at aggregate level for the manufacturing sector, and they range between 3.60 and 19.27 (see, for example, Eaton and Kortum, 2002; Bernard et al., 2003; Anderson and van Wincoop, 2004; Waugh, 2010; Fieler, 2011; Balistreri et al., 2011; Eaton et al., 2011). Although direct comparisons may not be appropriate, the above results are within the range of the findings in the literature. Similarly, Xu (2011) finds an estimate of θ equal to 4.76 for agriculture using a sample of 46 countries. He argues that there is a wider spread of efficiency in agriculture than in manufacturing. I also find slightly higher dispersion of productiv-

Table 3: Estimation results of efficiency distribution parameter for each commodity.

Commodity classification	Calibration (I)	(II)	(III)
Agriculture	6.46	6.46	7.66
Processed food	7.89	7.87	9.32
Non-metallic manufactures	7.14	7.25	8.46
Metallic manufactures	6.82	6.85	8.08
Chemicals	6.78	6.79	8.02
Machinery	5.18	4.97	5.61
Electrical equipment	5.10	5.10	5.44
Transport equipment	6.41	6.49	7.60
Fixed Parameter(s)	σ^k	σ^k, β^c	$\sigma^k, \beta^c, \rho^k$
No. of observations	66,248	66,248	66,248
Objective function	346,011.8	346,011.8	346,011.8

ity in agriculture relative to processed food and non-metallic manufactures. Eaton and Kortum (2002) also believe that agriculture could have a higher productivity dispersion. Overall, the results seem to be reliable estimates of productivity dispersion across commodities.

With regard to country-specific technology, Table 17 reports T_i^k values of the first calibration normalized to the U.S. level. It shows that T_i^k varies across commodities within a country and across countries. A country can have higher T_i^k in some commodities, but not in others. For example, Australia and Mozambique have their highest T_i^k score in agriculture, while Germany's highest T_i^k is in machinery. Similarly, both Malaysia and Korea have their highest T_i^k in electrical equipment. This is an indication of the different levels of productivity embedded on export commodities of a country. The overall distribution shows that low income countries are at the lower end of the T_i^k rank, although there is variation among them. I also compare T_i^k values with estimates from the other two calibrations and find a near perfect correlation coefficient for each commodity (0.99 to 1).

5.3 Trade Costs Parameter

Table 4 reports calibration results of ρ^k. In calibration I, ρ^k values are almost equal to the upper bound (0.32) for all commodities with the exception of machinery and electrical equipment. This implies that the latter two commodities are less sensitive to trade costs. The result is also robust to fixing β^c, with only small differences for some commodities. The ρ^k values are almost equal to the upper bound for agriculture, processed food, metallic manufactures, and chemicals. Similarly, non-metallic manufactures and transport equipment have slightly lower ρ^k. In contrast, electrical equipment has the lowest, followed by machinery. Overall, the results indicate that the values are above the average estimate of Hummels (2001), and closer to the upper bound.

Table 4: Calibration results for the trade costs parameter.

Commodity Classification	**Calibration (I)**	**Calibration (II)**
Agriculture	0.3200	0.3200
Processed food	0.3190	0.3198
Non-metallic manufactures	0.3200	0.3152
Metallic manufactures	0.3200	0.3186
Chemicals	0.3195	0.3191
Machinery	0.2923	0.3045
Electrical equipment	0.2882	0.2877
Transport equipment	0.3199	0.3161
Fixed Parameter(s)	σ^k	σ^k, β^c
No. of observations	66,248	66,248
Objective function	346,011.8	346,011.8

The product of ρ^k and θ^k determines the distance elasticity of trade at commodity level.[21] Using results from calibration I, the implied distance elasticity ranges from -1.47 to -2.52 (refer, column 1 of Table 5). Processed

[21]Referring to equation (11) and (13), the distance elasticity of trade is: $\frac{d \ \log \ (X_{ij}^k)}{d \ \log \ (Dist)} = \rho^k\theta^k$.

food has the highest distance elasticity, followed by non-metallic manufactures. In contrast, machinery and electrical equipment have lower values, -1.52 and -1.47 respectively. Moreover, the implied distance elasticities are the same when ρ^k is fixed. For comparison, I estimate a gravity regression of the observed trade on distance with fixed effects. Column 2 of Table 5 shows that the distance elasticities range from -1.13 to -1.92. Generally, the pattern is similar in both methods for all commodities except agriculture. However, the elasticities from the gravity regression are slightly smaller than the elasticities from the calibration. This could probably be due to differences in sample size, since I have many zeroes in the matrix of observed bilateral trade.[22]

Table 5: Distance elasticity at commodity level.

Commodity Classification	**Distance elasticity**	
	Calibration I	**Gravity regression**†
Agriculture	-2.07	-1.13
Processed food	-2.52	-1.81
Non-metallic manufactures	-2.28	-1.75
Metallic manufactures	-2.18	-1.92
Chemicals	-2.17	-1.83
Machinery	-1.52	-1.61
Electrical equipment	-1.42	-1.67
Transport equipment	-2.05	-1.78

†with importer and exporter fixed effects.

Further comparison with other studies also indicates that the elasticity estimates are within a close range of other sector or industry level gravity estimations. For example, Belenkiy (2009) found distance elasticity of trade between -0.78 to -1.0 for agricultural, forestry, and fishery products and between -1.63 to -2.57 for light and heavy manufacturing. Similarly, Siliverstovs and Schumacher (2007) found an average distance elasticity equal to -1.15

[22]A gravity regression of the predicted bilateral trade on distance with fixed effects shows the same distance elasticity as in calibration I.

for three digit manufacturing industries. Balistreri et al. (2011) also found distance elasticity between 0.8 to 1.81 for the manufacturing sector.

5.4 Income Effect

Since Stone-Geary preferences are non-homothetic, income and price elasticity of demand are not unity. I examine Engel effects across commodities, which shows how the quantity demanded varies with the level of income. A scatter plot of quantity index with GDP shows an upward sloping trend for all commodities. Furthermore, the correlation coefficient of the quantity index and GDP is around 0.9 for each commodity.

Given the linearity of Engel curves in the LES, I further explore the pattern of expenditure at different levels of income using the estimated Chenery curves. Figures 2, 3, and 4 plot the fitted expenditure share and expenditure per capita for each commodity. Consistent with other empirical observations, the less sophisticated commodities have downward sloping curves. These indicate that the less sophisticated commodities are income inelastic. In contrast, expenditure curves for machinery, electrical, and transport equipment exhibit upward trends, followed by a slight decline. Similarly, services have an increasing upward trend.

A Chenery curve also indicates the income elasticity of a commodity at different levels of income. For example, the inverted 'U' shape pattern is indicative of an income elastic response, followed by an income inelastic response. From a consumption side, the results imply that commodity composition changes as countries develop. It shifts away from less sophisticated towards more sophisticated commodities, and services.

5.5 Export Sophistication

As briefly explained in section 4, the measure of income of a commodity (PRODY) depends on the average importance of a commodity for all the exporters. It represents the export-weighted average GDP per capita of the countries that export a commodity. Relatively, PRODY of a commodity is low when the export share of a commodity is higher among low income countries than among high income countries. Conversely, PRODY of a commodity is high when it is mainly exported by high income countries. I calculate and compare PRODY of all commodities using fitted data. Table 6 shows wide variation among the commodities ranging from 7251 to 20134. Interestingly, the variation shows a clear pattern of increasing PRODY with the level of sophistication of the commodities. That is, PRODY is higher for electrical equipment, transport equipment, and machinery. On the lower end lies the remaining commodities, such as agriculture, processed food, and non-metallic manufactures respectively. Chemicals and metallic manufactures have a medium level of PRODY.

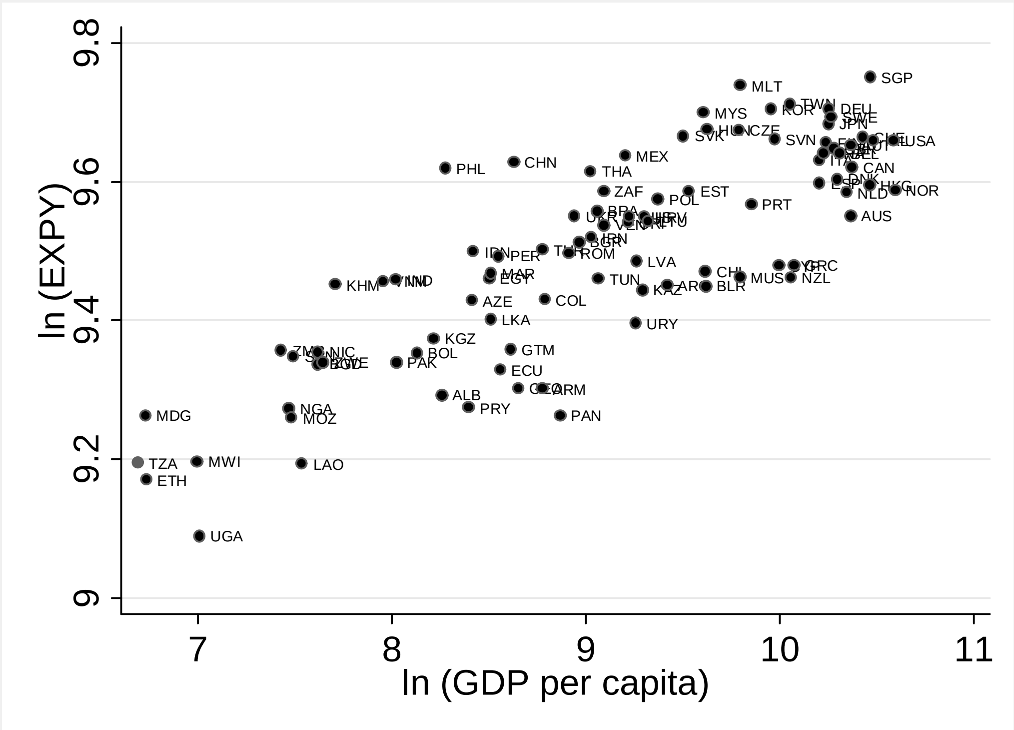
Table 6: Estimated PRODY for each commodity using main estimation.

Commodity classification	**PRODY**
Agriculture	7251
Processed Food	11255
Non-metallic manufactures	13826
Metallic manufactures	14919
Chemicals	15685
Machinery	20134
Electrical equipment	18956
Transport equipment	19033

With regard to EXPY, I find that it is moderately distributed with the mean and standard deviation equal to 13465 and 1977 respectively. The mean represents countries such as Turkey and Indonesia. In general, poorer countries have a lower EXPY. For example, Uganda (8858) and Ethiopia (9604) lie at the bottom rank. In contrast, richer economies (example, Germany and Malta) and some Asian economies (example, Taiwan and Singapore) have high EXPY. Singapore and Malta are on the top rank of the sample with EXPY of 17174 and 16968 respectively (refer, Table 9).

I also examine how EXPY varies with GDP per capita using fitted data. Figure 1 depicts a positive relationship between EXPY and GDP per capita,

Figure 1: Scatter plot of EXPY (fitted) and GDP per capita.



with a correlation coefficient of 0.64. Comparatively, the dispersion is slightly narrower than in Hausmann et al. (2007) and Weldemicael (2011). This could probably be due to aggregation effects, since I consider only eight commodities, while those studies use the four digit commodity classification.

6 Counterfactual Analyses

In this section, I present counterfactual scenarios using country-specific technology and trade costs. The aim is to show their relative importance in determining specialization patterns and welfare effects. In particular, in the context of low income developing countries, it sheds light on the challenges of enhancing their EXPY. The benchmark results indicate that these countries have low EXPY. Therefore, I focus on the bottom quintile of the sample ordered by GDP per capita.[23] My preferred choice of parameters are from calibration II, where β^c is fixed to the median expenditure share estimated using the Chenery method. I analyze the effect of these shocks on the price index, quantity index, income, utility, PRODY, and EXPY.

6.1 Technology Shock

The calibration results show that low income countries are at the lower end of the T_i^k distribution. In the first scenario, I increase the technology parameter T_i^k by 100% for the bottom quintile. Table 10 shows that an increase in T_i^k reduces the price index across commodities for all the countries in the bottom quintile. An improvement in T_i^k lowers the unit cost of production, but the effect varies depending on the initial level of T_i^k of a commodity relative to T_i^k of other countries. Relatively, I observe a moderate effect on the price index of agriculture, processed food, and non-metallic manufacture commodities. This implies that the countries have a higher T_i^k in those commodities, which magnifies the effect. In contrast, it has a small effect on the price indices of machinery and electrical equipment. The average decrease in the price index for all commodities ranges from -2.5% to -7.4%. Among the countries, India, Pakistan, and Bangladesh gain the most, while Uganda, Bolivia, and Mozambique gain the least.

The fall in the price index increases the export competitiveness of these countries and enables them to achieve a higher export share. Consequently, income increases in all the countries ranging from 6.1% (Uganda) to 42.3% (Vietnam), as shown in Table 11. Similarly, the quantity index increases significantly for all the commodities in response to lower prices. The changes in the price index also have a similar pattern across the commodities (refer, Table 12). Moreover, the average effect is considerable for many countries, such as Laos (107.5%), Vietnam (52.8%), Cambodia (44.9%), and Bolivia (43.2%). With regard to welfare effects, utility increases in all the countries due to an increase in quantities, although there is significant variation among

[23] The bottom quintile countries are: Tanzania, Ethiopia, Madagascar, Zambia, Malawi, Uganda, Mozambique, Nigeria, Senegal, Laos, Cambodia, Bangladesh, Nicaragua, Vietnam, India, Pakistan, Zimbabwe, and Albania.

them. For example, doubling T_i^k has a smaller welfare effect in Uganda (10.3%) and Bangladesh (12.4%). In contrast, countries that have a bigger increase in their quantity index also have a higher welfare gain. Overall, the welfare effect ranges between 10.3% to 60.0% (refer, Table 11). On the other hand, I observe little changes in price indices and incomes of the countries in other quintiles. Similarly, there are only marginal effects on quantity index and utility. In general, geographic spillovers tend to be small in trade models with large trade costs (Hanson, 2004).

In terms of its effect on specialization, the effect of a shock in technology parameter T_i^k on EXPY works in two ways. One is through the contribution of these countries to PRODY, and another is through their respective composition of exports. I find that the shock in T_i^k has only a small effect on EXPY. It implies that there is no significant effect on economic growth. One possible explanation is that there could be offsetting effects, if the increase in T_i^k has varying effects on PRODY and the export share of each commodity. Consequently, the individual effects of each commodity may be concealed in the aggregate effect. To further explore this, I examine the separate effect of an increase in T_i^k of each commodity on EXPY. The results are summarized in Table 13.

When the T_i^k for agriculture increases PRODY falls, indicating that the export share of agriculture increased among poorer countries. Consequently, EXPY declines in all the bottom quintile countries, ranging from -5.4% (Cambodia) to -15.2% (Nigeria). Since agriculture has the lowest PRODY score, an increase in its export share lowers EXPY. I also find similar effects when T_i^k for processed food increases, although EXPY does not decline as much and even increases slightly in a few countries. In contrast, EXPY increases in most countries when T_i^k increases in non-metallic manufactures. For example, Ethiopia, Uganda, and Laos gain around 4%. The T_i^k shocks in metallic manufactures and chemicals also result in a small increase in EXPY for all the bottom quintile countries. In a slight contrast, there are only marginal increases in EXPY when T_i^k increases in machinery, electrical equipment, and transport equipment. These small effects are due to low initial levels of T_i^k on relatively more sophisticated commodities. It implies that the improvement in comparative advantages on these commodities are negligible. Therefore, the evidence supports that the insignificant aggregate effect is due to offsetting effects.

To further illustrate the point, I raise the T_i^k of the bottom quintile to 5% of China's level. The countries have much lower T_i^k than 5% of China's T_i^k in each commodity. Since China is relatively productive in more sophisticated commodities, it essentially means giving a higher technology shock to more sophisticated commodities. The result shows that EXPY increases in all the bottom quintile countries except Cambodia, with higher gains for poorer countries. For example, EXPY increases by 29.2% in Laos, 20.1% in Nigeria, 18.9% in Mozambique, and 17.3% in Uganda (refer, the last column of Table 13). This implies that the shock in T_i^k improves the revealed comparative advantages of these countries in relatively more sophisticated commodities. Consequently, the increase in EXPY generates higher economic growth.

6.2 Trade Costs Shock

Anderson and van Wincoop (2004) document that trade costs in developing countries are higher than in developed countries.[24] Further, they note that policy-related border costs average between 10% and 20% for most developing countries, whilst being about 8% for developed countries. In the second scenario, I reduce trade costs of the countries in the bottom quintile. That is, a decrease in bilateral distance by 25% with all their trading partners, which is equivalent to an 8.0% to 8.78% reduction in trade costs depending on ρ^k. This is analogous to about a 40% reduction in policy-related trade costs for developing countries.[25] The effect of this depends on existing T_i^k and trade costs of each commodity. The countries with relatively higher T_i^k but which face significant trade costs gain the most.

Lowering trade costs reduces the price index of all the commodities in the bottom quintile. However, the size of the effect also varies across commodities

[24] Their rough estimate of the tax equivalent of trade costs for developed countries is 170%, and it breaks down into transportation costs (21%), border costs (74%), and retail and distribution costs (55%) (Anderson and van Wincoop, 2004: 692).

[25] That is, taking the upper bound of policy-related border costs, 20%. It is also equivalent to about 40% of the transport costs of developed countries, 21%.

depending on the level of T_i^k in those countries. Table 14 shows a significant decrease in the price indices for agriculture, processed food, and non-metallic manufactures. These are commodities in which the countries have relatively higher comparative advantages. In contrast, price indices decrease slightly for machinery, electrical equipment, and transport equipment. This indicates that these countries do not have significant contributions to the price distribution parameters of the latter commodities. The average change in price index of all commodities ranges from -2.2% (Mozambique) to -6.3% (India). As a result, I observe significant income changes in all the bottom quintile countries (refer, Table 15). That is, the income level of half of the countries increase by over 20%.

Similarly, there is a considerable increase in the quantity indices across commodities in most countries (refer, Table 16). On average, all the bottom quintile countries show a double digit increase (10% to 99.7%). Finally, welfare also increases in all the countries in a similar fashion to the quantity and income changes. Table 15, shows that some of these countries gain the most; that is, Laos (55.6%), Vietnam (40.9%), and Cambodia (37.5%). Similar to the shock in the T_i^k, the trade costs shock does not have a big effect on EXPY. The variation at commodity level is also hidden in the aggregate effect. The commodity level counterfactual experiment shows that the effect of a trade costs shock is similar to the effect of changes in T_i^k at commodity level. Moreover, the trade costs shock does not have significant effect on the countries in other quintiles. Comparatively, however, the countries in the second quintile are affected slightly more than others.

6.3 Discussion

The findings indicate the importance of technology and trade costs in shaping the composition of exports of a country. Particularly, export sophistication is determined by the interaction of both factors, and this paper identifies key parameters of the EK model that are consistent with general equilibrium conditions. The counterfactual analyses indicate that the two shocks have similar effects on the price index, income, quantity index, and welfare across commodities and countries. The experiments illustrate by how much each variable, technology and trade costs, needs to change to bring an equivalent effect on the bottom quintile countries. This has crucial policy implications for low income countries that strive to enhance their gains from trade and specialization. Therefore, the question revolves around the challenges associated with technology transfer and lowering trade costs for these countries. It is also worth noting that some components of trade costs are easier to reduce than others, although I do not distinguish between them in the model.

Keller (2004) indicates that foreign technology accounts for over 90% of domestic productivity growth in most countries. However, there are several constraints that hinder faster technology transfer to low income countries. Keller (1996), Glass and Saggi (1998), and Xu (2000) show that absorptive capacity enhances technology transfer. However, these countries have low level of human capital stock which limits their ability to adopt foreign technology. In addition, the policy environment, such as intellectual property rights, incentive system, and information support in many poor countries is poorly defined and implemented. Consequently, MNEs find it difficult to engage in investment and production activities that would facilitate technology transfer to local firms (Sagai, 2002; Bigsten and Söderbom, 2006; Moreira, 2009). Moreover, most local firms are small and do not have adequate research and development facilities to expedite the adoption of foreign technology (Rankin et al., 2006; Söderbom and Teal, 2003; Teece, 1977).

With regards to trade costs, there are several major constraints facing low income countries.[26] Delays associated with moving goods from production centers to on board for export are very costly, particularly for African countries (Djankov et al., 2010; Portugal-Perez and Wilson, 2008; Hummels, 2001). These delays could be due to bureaucracy in documentation, transit times, and customs and port clearance.[27] Similarly, transport costs are

[26] Portugal-Perez and Wilson (2008) categorize trade costs into border related costs, transport costs, institutional (behind the border) costs, and compliance costs from preferential agreements.

[27] Comparatively, Freund and Rocha (2009) find that transit delays have a far greater negative effect on exports than the others and believe that the high uncertainty involved makes on-time delivery difficult. They argue that transit delays, mostly due to border delays, road quality, fleet type, competition and security, are primarily institutional rather

very expensive both within Africa and from Africa to other regions. This is mainly due to poor infrastructure, lack of competition, and limited modes. For example, the cost to ship a standard container to major world markets is significantly higher for African countries than for other regions (Amjadi and Yeats, 1995; Hummels, 2007; Portugal-Perez and Wilson, 2008). Although the challenges are huge, improving these conditions could have significant trade and growth benefits (Buys et al., 2006).

On the other hand, unilateral reduction of tariff and non-tariff barriers by rich countries also lowers trade costs, which could potentially boost exports of low income countries. Trade preferences, such as the Africa Growth and Opportunity Act (AGOA) and Everything but Arms (EBA), are examples of such initiatives. However, the effectiveness of such schemes depend on the extent of the preference, product (industry) coverage, and restrictions on rules of origin (Collier and Venables, 2007; Portugal-Perez and Wilson, 2008). Collier and Venables (2007) show that AGOA is more successful than EBA in enhancing apparel and textile exports of many African countries due to a more relaxed rules of origin regime. Given the global trend towards product fragmentation, they argue that preferential arrangements that feature wider industry coverages and less restrictive rules of origin would have considerable effect on Africa's exports. In addition, such opportunities could serve as a catalyst to transform specialization patterns towards more sophisticated commodities.

7 Conclusion

This paper explored the relative importance of technology and trade costs on export sophistication and welfare in a general equilibrium framework. It employs a disaggregated EK model with non-homothetic preferences and calibrates key parameters using a structural estimation method. The findings show that the parameters, marginal expenditure shares, technology parameters, and trade costs parameter vary across commodities. Moreover, the pattern of variation is consistent with the expected spread of efficiency of

than geographic impediments (Freund and Rocha, 2009:4).

the commodities. That is, more sophisticated commodities exhibit greater heterogeneity in labour efficiency and are less sensitive to trade costs. The results are robust to alternative specifications where more parameters are fixed. The values of parameters are also comparable with estimates from similar studies. Moreover, the implied distance elasticities from the calibrated model are similar to estimates from a log-linear regression for most of the commodities.

Further, counterfactual analyses of changes in country-specific technology parameter and trade costs show significant effects on export sophistication and welfare. However, comparing the two experiments, an equivalent effect in export sophistication requires a significantly higher percentage increase in technology parameter than the decrease required in trade costs. This indicates that these countries relatively have a huge technological disadvantage, particularly in more sophisticated commodities. Overall, the findings shed light to the challenges of low income countries that endeavor to increase the sophisitication of their exports. Concerted effort is required to improve the state of their technology and reduce aspects of their trade costs.

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Appendix:

Figure 2: Chenery curves for less sophisticated commodities.

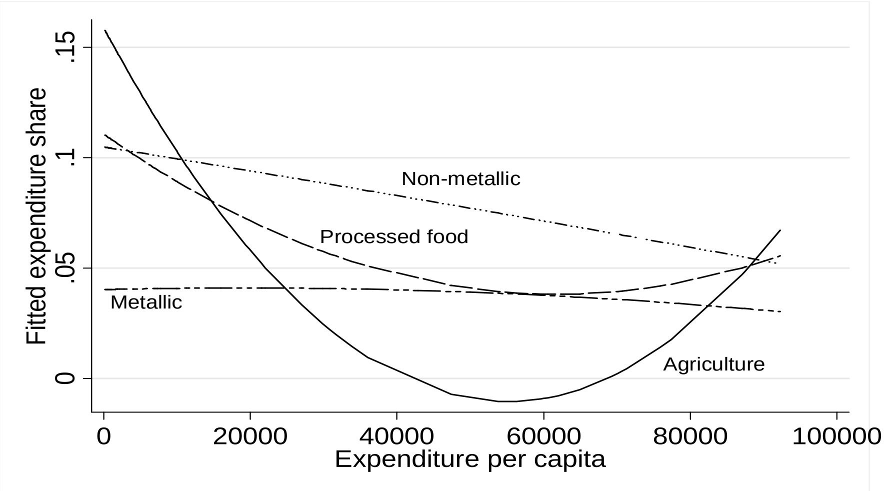

Figure 3: Chenery curves for more sophisticated commodities.

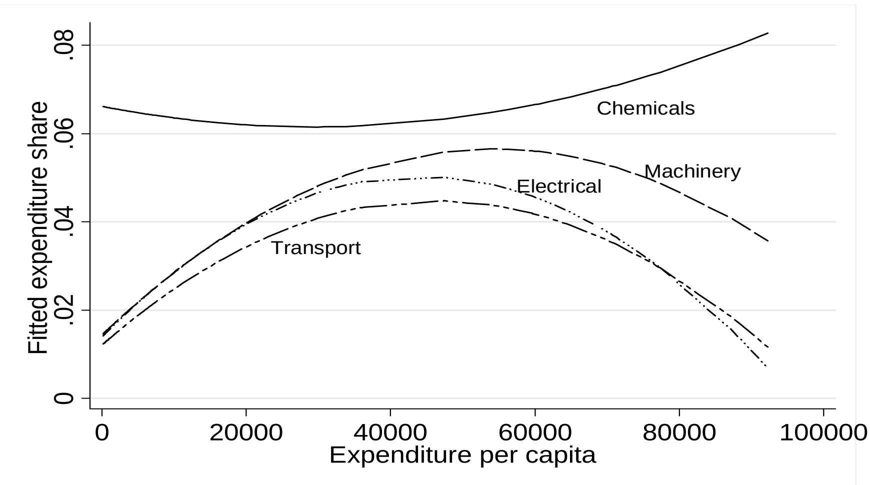

Figure 4: Chenery curve for services.

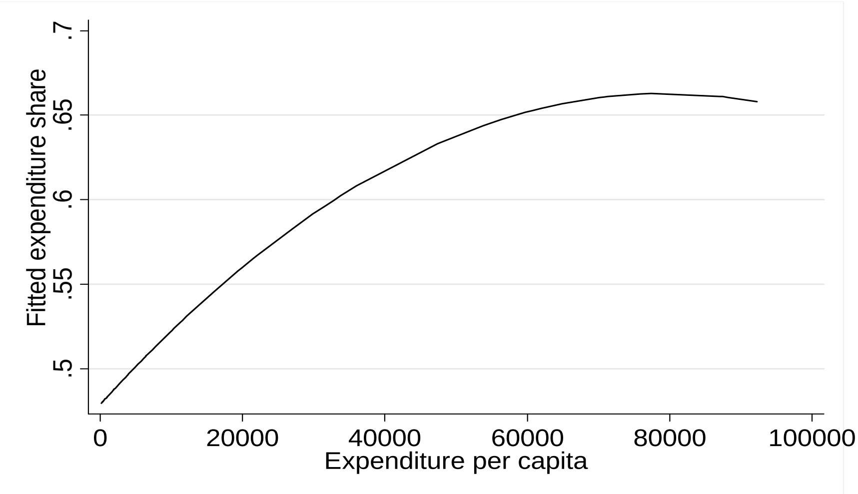

Table 7: Commodity aggregates and their corresponding description.

	Commodity	**Description**
1	Agriculture	Unprocessed Agricultural, Forestry and Fishery products
2	Processed food	Processed food, Tobacco, and Beverages
3	Non-metallic manufactures	Textiles, Apparel, Leather, Wood, and Paper
4	Metallic manufactures	Ferrous Metals, Metal products
5	Chemicals	Chemicals, Rubber, and Plastics
6	Machinery	Machinery, and specialized equipment
7	Electrical equipment	Electrical and Electronic equipment
8	Transport equipment	Transport equipment
9	Service	All services

Table 8: List of countries in the sample, with their ISO code.

ISO	COUNTRY	ISO	COUNTRY	ISO	COUNTRY
ALB	Albania	GRC	Greece	NOR	Norway
ARG	Argentina	GTM	Guatemala	NZL	New Zealand
ARM	Armenia	HKG	Hong Kong	PAK	Pakistan
AUS	Australia	HRV	Croatia	PAN	Panama
AUT	Austria	HUN	Hungary	PER	Peru
AZE	Azerbaijan	IDN	Indonesia	PHL	Philippines
BEL	Belgium	IND	India	POL	Poland
BGD	Bangladesh	IRL	Ireland	PRT	Portugal
BGR	Bulgaria	IRN	Iran	PRY	Paraguay
BLR	Belarus	ITA	Italy	ROM	Romania
BOL	Bolivia	JPN	Japan	RUS	Russia
BRA	Brazil	KAZ	Kazakhstan	SEN	Senegal
CAN	Canada	KGZ	Kyrgyzstan	SGP	Singapore
CHE	Switzerland	KHM	Cambodia	SVK	Slovak Rep.
CHL	Chile	KOR	Korea, Rep.	SVN	Slovenia
CHN	China	LAO	Laos	SWE	Sweden
COL	Colombia	LKA	Sri Lanka	THA	Thailand
CRI	Costa Rica	LTU	Lithuania	TUN	Tunisia
CYP	Cyprus	LVA	Latvia	TUR	Turkey
CZE	Czech Rep.	MAR	Morocco	TWN	Taiwan
DEU	Germany	MDG	Madagascar	TZA	Tanzania
DNK	Denmark	MEX	Mexico	UGA	Uganda
ECU	Ecuador	MLT	Malta	UKR	Ukraine
EGY	Egypt	MOZ	Mozambique	URY	Uruguay
ESP	Spain	MUS	Mauritius	USA	United States
EST	Estonia	MWI	Malawi	VEN	Venezuela
ETH	Ethiopia	MYS	Malaysia	VNM	Vietnam
FIN	Finland	NGA	Nigeria	ZAF	South Africa
FRA	France	NIC	Nicaragua	ZMB	Zambia
GBR	United King.	NLD	Netherlands	ZWE	Zimbabwe
GEO	Georgia				

Table 9: EXPY using fitted data.

ISO	EXPY	ISO	EXPY	ISO	EXPY
ALB	10856.1	GRC	13088.7	NOR	14591.1
ARG	12710.6	GTM	11591.2	NZL	12860.7
ARM	10955.9	HKG	14701.7	PAK	11386.1
AUS	14065.5	HRV	14038.9	PAN	10536.8
AUT	15571.0	HUN	15922.8	PER	13272.5
AZE	12438	IDN	13348.5	PHL	15063.2
BEL	15395.8	IND	12816	POL	14404.4
BGD	11353	IRL	15672.1	PRT	14299.1
BGR	13537.4	IRN	13619.4	PRY	10659.9
BLR	12704.2	ITA	15238.4	ROM	13319.5
BOL	11542.9	JPN	16065.3	RUS	14033.2
BRA	14162.1	KAZ	12640.6	SEN	11474
CAN	15087.1	KGZ	11775	SGP	17174
CHE	15749.2	KHM	12727.5	SVK	15783.5
CHL	12976.6	KOR	16409.5	SVN	15712.7
CHN	15192.1	LAO	9823.8	SWE	16219.3
COL	12460.6	LKA	12109.8	THA	14994.1
CRI	13926.6	LTU	13952.4	TUN	12837.2
CYP	13083	LVA	13170.2	TUR	13382.6
CZE	15911	MAR	12943.9	TWN	16526.8
DEU	16416.6	MDG	10534.8	TZA	9839.6
DNK	14832.3	MEX	15330.4	UGA	8858.3
ECU	11249.9	MLT	16968.1	UKR	14051.3
EGY	12846.0	MOZ	10501.6	URY	12045.6
ESP	14735.3	MUS	12874	USA	15672.4
EST	14569.1	MWI	9860.6	VEN	13874
ETH	9603.9	MYS	16310	VNM	12792.6
FIN	15622	NGA	10642.3	ZAF	14567.8
FRA	15387.9	NIC	11557.1	ZMB	11574.8
GBR	15495.6	NLD	14535.7	ZWE	11384.6
GEO	10956.4				

Table 10: The effect of technology shock on prices (percentage change).

ISO	Agriculture	Processed food	Non-metallic	Metallic	Chemicals	Machinery	Electrical	Transport
BGD	-9.51	-8.14	-8.56	-8.09	-8.00	-4.48	-1.86	-7.48
BOL	-5.01	-5.60	-3.90	-1.80	-3.62	-0.37	-0.21	-0.62
ETH	-6.32	-6.43	-4.91	-2.69	-3.77	-1.35	-0.78	-1.66
IND	-9.05	-7.74	-7.93	-7.97	-8.15	-6.52	-3.63	-7.79
KHM	-6.87	-6.20	-6.87	-3.19	-3.60	-1.72	-0.87	-4.37
LAO	-5.36	-4.87	-4.23	-1.89	-2.33	-1.51	-0.68	-2.34
MDG	-6.19	-5.78	-4.23	-3.14	-3.21	-1.30	-0.73	-1.42
MOZ	-5.62	-3.92	-2.49	-3.75	-1.71	-0.93	-0.63	-0.75
NGA	-8.56	-6.13	-6.25	-6.74	-6.64	-0.84	-0.50	-3.76
NIC	-7.14	-6.94	-6.40	-3.75	-4.64	-0.73	-0.20	-1.09
PAK	-8.75	-7.50	-7.87	-6.55	-7.25	-4.75	-3.24	-6.74
SEN	-8.71	-7.93	-7.06	-5.05	-7.74	-0.93	-0.73	-4.47
TZA	-5.90	-5.25	-3.92	-3.21	-3.06	-1.24	-0.73	-1.45
UGA	-5.55	-5.06	-3.68	-2.62	-2.91	-1.14	-0.67	-1.35
VNM	-5.79	-5.48	-5.48	-2.20	-3.05	-1.59	-0.77	-3.22
ZMB	-8.34	-7.34	-6.76	-7.61	-5.72	-1.41	-1.00	-2.78
ZWE	-8.18	-7.12	-6.76	-6.88	-4.72	-1.22	-0.88	-1.69

Table 11: The effect of technology shock on welfare and income (percentage change).

	Technology	
ISO	**Income**	**Utility**
BGD	7.81	12.45
BOL	34.52	40.27
ETH	10.27	14.96
IND	16.14	20.95
KHM	33.77	41.67
LAO	41.53	59.99
MDG	17.09	26.54
MOZ	27.66	33.35
NGA	17.60	21.89
NIC	27.45	36.00
PAK	14.42	18.93
SEN	12.72	18.68
TZA	9.67	13.35
UGA	6.05	10.38
VNM	42.32	46.14
ZMB	22.31	29.15
ZWE	25.10	33.80

Table 12: The effect of technology shock on quantities (percentage change).

ISO	**Agriculture**	**Proc. food**	**Non-metallic**	**Metallic**	**Chemicals**	**Machinery**	**Electrical**	**Transport**	**Service**
BGD	19.16	17.34	17.88	17.18	17.11	12.79	9.80	16.42	8.10
BOL	41.91	42.13	39.64	35.22	38.43	33.40	33.58	33.74	47.58
ETH	17.95	17.58	15.71	12.23	13.90	10.91	10.51	11.21	18.66
IND	27.70	25.88	26.14	26.18	26.44	24.24	20.51	25.94	16.20
KHM	44.06	42.14	43.16	35.84	37.32	33.98	33.37	37.55	52.43
LAO	50.78	47.41	46.45	37.88	40.81	37.60	37.90	38.71	522.74
MDG	25.47	23.55	21.61	17.98	19.08	16.20	16.14	16.33	114.86
MOZ	35.62	32.49	30.57	30.56	28.72	27.10	27.14	26.88	44.02
NGA	28.68	25.22	25.37	25.70	25.73	18.32	17.99	21.88	19.21
NIC	37.73	36.41	35.62	29.78	31.96	26.15	26.04	26.60	53.36
PAK	25.40	23.68	24.17	22.35	23.31	20.05	18.20	22.60	14.76
SEN	23.71	22.17	21.04	17.54	21.33	12.94	12.92	16.91	20.14
TZA	16.72	15.55	13.99	12.49	12.64	10.43	10.03	10.64	14.66
UGA	12.58	11.41	9.87	7.81	8.57	6.50	6.21	6.68	18.94
VNM	51.14	50.51	50.51	45.16	46.58	44.28	43.17	46.70	44.30
ZMB	33.73	31.67	30.86	30.55	28.70	22.75	22.57	24.41	33.21
ZWE	36.72	34.15	33.65	31.52	29.71	24.52	24.62	25.10	49.16

Table 13: The effect of technology shock on EXPY (percentage change).

ISO	Agricul	Proc. food	Non-metallic	Metallic	Chemicals	Machinery	Electrical	Transport	China's T^k *
BGD	-9.83	-1.28	1.46	1.24	2.08	0.83	0.21	0.91	5.32
BOL	-8.26	-4.21	1.77	1.03	3.57	0.75	0.24	0.55	13.85
ETH	-12.46	1.21	4.91	1.38	2.70	0.40	0.15	0.35	15.31
IND	-9.58	-2.04	-0.23	0.46	1.70	3.02	0.67	1.79	2.19
KHM	-5.38	-1.01	-3.13	0.69	1.33	0.65	0.84	1.65	-1.27
LAO	-10.67	-0.52	4.74	1.03	1.47	0.22	0.11	0.45	29.22
MDG	-8.88	-2.96	3.48	1.05	2.50	0.34	0.14	0.28	2.37
MOZ	-12.58	-0.23	2.96	4.77	1.75	0.36	0.15	0.24	18.91
NGA	-15.19	2.79	2.83	2.60	4.73	0.83	0.23	1.55	20.06
NIC	-8.82	-3.23	1.30	1.02	2.55	1.89	0.39	0.57	4.21
PAK	-10.79	-0.67	1.37	0.94	2.49	0.44	1.08	1.41	13.71
SEN	-9.67	-3.93	2.11	0.93	4.02	1.11	0.48	1.12	2.12
TZA	-10.70	-0.91	4.15	1.25	2.71	0.37	0.14	0.30	7.07
UGA	-12.28	2.92	4.74	1.45	2.24	0.35	0.13	0.28	17.29
VNM	-6.03	-2.91	-2.28	0.65	1.42	1.75	1.30	1.63	3.53
ZMB	-10.61	-1.72	1.72	2.34	2.12	1.04	0.40	0.62	3.68
ZWE	-9.79	-1.98	1.72	2.16	2.00	0.76	0.28	0.42	6.84

*5% of China's T^k for all the countries in the bottom quintile.

Table 14: The effect of trade costs shock on prices (percentage change).

ISO	**Agriculture**	**Proc. food**	**Non-metallic**	**Metallic**	**Chemicals**	**Machinery**	**Electrical**	**Transport**
BGD	-8.19	-8.49	-8.11	-7.33	-7.18	-2.60	-1.00	-6.32
BOL	-4.20	-5.87	-3.66	-1.59	-3.19	-0.20	-0.11	-0.50
ETH	-5.35	-6.74	-4.61	-2.39	-3.32	-0.75	-0.42	-1.35
IND	-7.78	-8.09	-7.50	-7.22	-7.32	-3.89	-2.01	-6.59
KHM	-5.83	-6.50	-6.49	-2.83	-3.17	-0.96	-0.46	-3.62
LAO	-4.51	-5.12	-3.97	-1.67	-2.04	-0.84	-0.36	-1.92
MDG	-5.24	-6.06	-3.97	-2.79	-2.82	-0.72	-0.39	-1.15
MOZ	-4.74	-4.12	-2.33	-3.34	-1.49	-0.52	-0.33	-0.61
NGA	-7.34	-6.43	-5.89	-6.07	-5.92	-0.46	-0.26	-3.10
NIC	-6.07	-7.26	-6.03	-3.34	-4.10	-0.40	-0.11	-0.88
PAK	-7.50	-7.83	-7.44	-5.90	-6.49	-2.77	-1.78	-5.67
SEN	-7.47	-8.28	-6.67	-4.52	-6.94	-0.52	-0.39	-3.71
TZA	-4.98	-5.51	-3.68	-2.85	-2.68	-0.69	-0.39	-1.18
UGA	-4.68	-5.32	-3.45	-2.32	-2.55	-0.63	-0.36	-1.09
VNM	-4.89	-5.75	-5.16	-1.94	-2.68	-0.89	-0.41	-2.65
ZMB	-7.14	-7.67	-6.38	-6.88	-5.09	-0.79	-0.53	-2.28
ZWE	-7.00	-7.44	-6.38	-6.20	-4.18	-0.68	-0.47	-1.38

Table 15: The effect of trade costs shock on welfare and income (percentage change).

	Trade costs	
ISO	**Income**	**Utility**
BGD	6.91	11.09
BOL	31.49	36.71
ETH	9.29	13.55
IND	13.40	17.62
KHM	30.44	37.53
LAO	38.62	55.64
MDG	15.94	24.67
MOZ	24.88	29.96
NGA	15.30	19.14
NIC	24.43	32.09
PAK	12.74	16.76
SEN	11.10	16.45
TZA	8.97	12.32
UGA	5.49	9.42
VNM	37.52	40.90
ZMB	19.80	25.91
ZWE	22.70	30.56

Table 16: The effect of trade costs shock on quantities (percentage change).

ISO	Agriculture	Proc. food	Non-metallic	Metallic	Chemicals	Machinery	Electrical	Transport	Service
BGD	16.46	16.82	16.33	15.26	15.12	9.70	7.95	14.03	7.17
BOL	37.53	39.35	36.17	32.00	34.78	30.29	30.53	30.68	43.40
ETH	15.68	16.92	14.35	10.98	12.42	9.37	9.20	9.96	16.88
IND	22.97	23.38	22.60	22.21	22.35	17.98	15.73	21.39	13.45
KHM	38.89	39.07	39.05	32.15	33.41	29.83	29.65	33.27	47.26
LAO	46.29	44.80	43.11	35.07	37.72	34.24	34.89	35.60	486.05
MDG	22.94	22.72	20.13	16.58	17.57	14.60	14.74	15.04	107.14
MOZ	31.40	29.90	27.54	27.33	25.73	23.96	24.12	24.08	39.59
NGA	24.49	23.16	22.46	22.41	22.36	15.61	15.44	18.72	16.70
NIC	32.90	33.67	31.94	26.40	28.27	22.97	23.09	23.54	47.50
PAK	21.90	22.31	21.80	19.73	20.52	15.89	14.75	19.44	13.04
SEN	20.27	20.89	18.82	15.33	18.64	10.97	11.00	14.45	17.58
TZA	14.83	15.13	12.98	11.42	11.53	9.18	8.99	9.68	13.60
UGA	10.92	11.13	9.04	7.01	7.66	5.50	5.39	5.93	17.19
VNM	44.64	45.86	44.94	39.93	41.12	38.46	37.87	40.95	39.28
ZMB	29.26	29.45	27.67	27.02	25.31	19.61	19.59	21.37	29.47
ZWE	32.35	32.07	30.59	28.29	26.63	21.67	21.86	22.49	44.46

Table 17: Country specific technology, calibration I.

ISO	Agri.	Pr. food	Non-met	Metallic	Chem.	Mach.	Electr.	Trans.
ALB	6.6E-06	4.7E-08	2.9E-07	4.4E-07	1.8E-07	2.8E-06	2.5E-06	7.6E-08
ARG	0.3879	0.0389	0.0658	0.0729	0.1195	0.2686	0.2496	0.1147
ARM	1.2E-04	3.3E-06	8.0E-06	1.8E-05	3.0E-06	7.7E-05	3.6E-05	2.4E-06
AUS	530.54	286.97	295.83	423.05	270.66	280.28	162.72	281.71
AUT	19.21	8.65	17.21	18.41	12.14	44.60	26.52	18.74
AZE	2.9E-05	4.2E-07	6.3E-07	2.1E-06	7.5E-06	1.5E-05	2.9E-05	5.1E-06
BEL	8.36	3.87	6.38	9.26	10.86	23.09	20.15	11.44
BGD	8.7E-07	3.4E-09	4.4E-08	5.5E-08	4.6E-08	2.4E-06	8.8E-07	9.3E-08
BGR	1.5E-03	6.7E-05	2.4E-04	5.4E-04	4.6E-04	4.2E-03	2.0E-03	2.0E-04
BLR	0.3195	0.0203	0.0449	0.0236	0.0556	0.1398	0.1462	0.0774
BOL	1.4E-05	2.2E-07	7.3E-07	6.2E-07	1.8E-06	7.3E-06	4.9E-06	4.5E-07
BRA	0.1483	0.0117	0.0303	0.0575	0.0553	0.4189	0.3567	0.0865
CAN	437.82	230.68	288.79	328.37	261.55	200.25	147.73	437.10
CHE	19.42	11.23	16.19	32.91	25.13	69.14	39.98	9.59
CHL	0.8357	0.1224	0.2019	0.5091	0.2911	0.2708	0.3062	0.0957
CHN	0.0182	0.0006	0.0037	0.0082	0.0062	0.1634	0.2130	0.0099
COL	3.5E-03	1.2E-04	3.5E-04	6.4E-04	7.3E-04	3.4E-03	1.7E-03	6.1E-04
CRI	0.0055	0.0002	0.0007	0.0007	0.0011	0.0163	0.0709	0.0007
CYP	0.3237	0.0600	0.0952	0.0884	0.0831	0.3088	0.2758	0.1225
CZE	0.3295	0.0724	0.1715	0.2977	0.1987	1.7024	1.7502	0.4090
DEU	62.16	33.93	52.39	73.04	67.38	265.40	156.85	125.50
DNK	14.32	5.29	6.64	6.54	7.10	25.52	11.51	5.04
ECU	3.4E-04	6.0E-06	2.3E-05	2.4E-05	4.0E-05	2.2E-04	2.0E-04	4.0E-05
EGY	2.4E-04	4.5E-06	2.8E-05	4.4E-05	5.1E-05	2.7E-04	1.3E-03	5.9E-05
ESP	76.24	29.29	44.15	51.04	39.80	77.58	46.20	63.18
EST	0.0155	0.0019	0.0061	0.0075	0.0036	0.0344	0.0625	0.0080
ETH	3.7E-10	5.9E-13	6.7E-12	4.8E-12	1.7E-11	4.2E-10	2.6E-10	4.4E-12
FIN	15.14	4.54	12.06	13.22	8.99	34.96	56.15	7.66
FRA	89.58	37.91	45.15	62.40	55.57	134.08	100.35	96.69
GBR	38.27	25.37	37.64	41.62	39.18	116.14	98.11	55.34
GEO	1.3E-04	2.2E-06	3.2E-06	1.7E-05	4.2E-06	7.0E-05	5.6E-05	2.3E-05
GRC	5.20	1.16	1.75	1.71	1.85	3.58	2.59	1.19
GTM	1.3E-04	2.5E-06	1.1E-05	1.3E-05	1.5E-05	1.3E-04	2.2E-04	1.8E-05
HKG	3.74	1.00	4.25	3.50	2.60	10.46	18.93	2.25
HRV	0.0147	0.0007	0.0017	0.0015	0.0045	0.0252	0.0222	0.0027
HUN	0.1344	0.0199	0.0387	0.0507	0.0563	0.5778	1.6370	0.1225
IDN	1.3E-03	3.1E-05	1.4E-04	2.3E-04	3.2E-04	3.5E-03	6.7E-03	3.7E-04

IND	2.3E-04	2.3E-06	1.5E-05	3.8E-05	3.9E-05	1.5E-03	8.2E-04	6.2E-05
IRL	38.41	19.76	16.53	13.41	52.40	65.47	136.66	11.74
IRN	0.0236	0.0011	0.0024	0.0066	0.0082	0.0284	0.0416	0.0103
ITA	66.77	32.66	63.87	67.69	51.40	178.55	81.33	52.34
JPN	150.53	75.28	104.80	158.92	132.67	362.28	556.36	206.11
KAZ	0.1021	0.0088	0.0080	0.0438	0.0217	0.0268	0.0567	0.0072
KGZ	6.5E-06	4.0E-08	2.4E-07	1.6E-06	1.2E-07	1.5E-05	1.4E-06	2.4E-07
KHM	2.4E-07	1.2E-09	2.7E-08	8.8E-09	1.2E-08	4.3E-07	1.1E-06	6.2E-08
KOR	4.05	0.77	1.84	3.69	3.64	19.62	27.39	5.13
LAO	1.2E-07	7.1E-10	2.1E-09	4.8E-12	1.7E-11	4.2E-10	2.6E-10	8.1E-10
LKA	1.4E-04	2.2E-06	1.4E-05	1.0E-05	2.2E-05	2.9E-04	2.1E-04	1.9E-05
LTU	0.0080	0.0008	0.0021	0.0014	0.0053	0.0120	0.0182	0.0017
LVA	0.0039	0.0005	0.0011	0.0011	0.0006	0.0064	0.0045	0.0010
MAR	3.4E-04	6.2E-06	3.5E-05	3.8E-05	5.5E-05	9.6E-04	1.8E-03	4.3E-05
MDG	3.7E-10	5.9E-13	6.7E-12	4.8E-12	1.7E-11	4.2E-10	2.6E-10	4.4E-12
MEX	0.1842	0.0186	0.0468	0.0709	0.0764	0.7169	1.0711	0.1761
MLT	0.0077	0.0005	0.0020	0.0013	0.0027	0.0457	0.2558	0.0052
MOZ	3.0E-07	1.1E-09	2.3E-09	4.8E-08	3.0E-09	4.7E-08	5.5E-08	6.6E-10
MUS	0.0292	0.0029	0.0087	0.0048	0.0064	0.0648	0.0801	0.0088
MWI	3.7E-09	5.9E-12	6.7E-11	4.8E-11	1.7E-10	4.2E-09	2.6E-09	4.4E-11
MYS	0.6351	0.1367	0.3227	0.3753	0.5151	2.2424	9.7663	0.3940
NGA	8.1E-07	9.4E-10	1.6E-08	6.5E-08	6.2E-08	6.3E-07	4.1E-07	6.7E-08
NIC	1.4E-07	6.4E-10	6.0E-09	5.4E-09	9.5E-09	5.3E-07	2.0E-07	5.1E-09
NLD	22.79	7.95	9.34	10.92	17.25	20.96	33.42	10.55
NOR	163.67	126.23	109.97	122.18	95.53	90.19	40.43	98.03
NZL	15.28	3.76	4.71	4.93	4.26	9.05	9.62	4.25
PAK	4.8E-05	4.0E-07	3.8E-06	8.9E-07	3.1E-06	1.4E-05	1.4E-04	5.4E-06
PAN	8.2E-04	2.2E-05	4.6E-05	3.7E-05	4.1E-05	2.3E-04	3.6E-04	6.5E-05
PER	9.6E-04	2.8E-05	1.3E-04	2.2E-04	2.6E-04	2.9E-03	2.5E-03	2.8E-04
PHL	1.1E-04	1.9E-06	8.0E-06	1.7E-05	1.6E-05	9.5E-04	4.0E-03	3.4E-05
POL	0.0922	0.0105	0.0248	0.0363	0.0304	0.2395	0.1610	0.0561
PRT	1.48	0.28	0.75	0.56	0.60	2.16	3.09	0.78
PRY	5.2E-05	6.2E-07	2.7E-06	2.4E-06	3.5E-06	3.8E-05	5.2E-05	2.4E-06
ROM	0.0045	0.0001	0.0006	0.0008	0.0008	0.0117	0.0039	0.0010
RUS	0.3584	0.0319	0.0533	0.1805	0.1540	0.5502	0.0934	0.1038
SEN	1.0E-07	4.3E-10	2.4E-09	2.9E-09	1.2E-08	2.6E-07	3.1E-07	1.1E-08
SGP	1.15	0.52	1.22	1.86	3.27	15.36	43.44	2.23
SVK	0.0258	0.0035	0.0103	0.0226	0.0171	0.1484	0.1037	0.0458
SVN	0.2296	0.0516	0.1588	0.2108	0.1274	1.0732	0.4500	0.3159
SWE	19.16	9.17	19.05	23.55	19.14	62.02	55.10	34.67
THA	0.0109	0.0006	0.0023	0.0024	0.0044	0.0683	0.1554	0.0075

TUN	0.0055	0.0002	0.0008	0.0006	0.0008	0.0067	0.0050	0.0007
TUR	0.0072	0.0002	0.0010	0.0016	0.0012	0.0188	0.0244	0.0025
TWN	4.39	0.89	2.47	4.53	4.50	20.75	42.37	3.36
TZA	3.7E-10	5.9E-13	6.7E-12	4.8E-12	1.7E-11	4.2E-10	2.6E-10	4.4E-12
UGA	3.7E-10	5.9E-13	6.7E-12	4.8E-12	1.7E-11	4.2E-10	2.6E-10	4.4E-12
UKR	0.0052	0.0003	0.0005	0.0029	0.0021	0.0123	0.0034	0.0018
URY	0.0094	0.0007	0.0014	0.0007	0.0022	0.0083	0.0021	0.0009
USA	10000	10000	10000	10000	10000	10000	10000	10000
VEN	0.0186	0.0013	0.0033	0.0073	0.0091	0.0155	0.0161	0.0100
VNM	1.6E-05	2.0E-07	2.0E-06	6.4E-07	1.4E-06	4.8E-05	6.3E-05	3.7E-06
ZAF	0.0482	0.0039	0.0126	0.0277	0.0223	0.2302	0.1020	0.0385
ZMB	1.3E-07	4.8E-10	4.0E-09	2.5E-08	8.5E-09	3.4E-07	3.8E-07	8.6E-09
ZWE	3.2E-07	1.7E-09	1.5E-08	4.6E-08	1.6E-08	4.4E-07	4.3E-07	9.3E-09