CHAPTER 2. EFFECTS OF TIMELINESS ON THE EXPORT PARTICIPATION AND COMPOSITION: A CGE ANALYSIS[1]

This paper examines the effect of timeliness in trade on the extensive and intensive margins of trade using a computable general equilibrium (CGE) analysis. To do this, we use the GTAP firm-heterogeneity CGE model (Akgul et al., 2016) complemented with the GTAP database version 9. We model the infrastructure reforms as an efficiency change in the variable and fixed costs of export using the econometric estimates in Baniya (2017). The direct impacts on export costs arise from the improved ability to access intermediate inputs and to deliver final products on time. Implementing a targeted shock in the transportation infrastructure of South and East Asia (with low LPI) in the CGE model, we compare the resulting general equilibrium trade impacts across primary and processed goods.

Authors: Suprabha Baniya[2] and Zeynep Akgul[3]

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[2] Baniya is a PhD student in the Department of Economics at Purdue University.

[3] Akgul is a Post-Doctoral Research Associate at the Center for Global Trade Analysis in the Department of Agricultural Economics at Purdue University, and a Visiting Scholar at the US International Trade Commission.

CHAPTER 2. INTRODUCTION

Recent development in the international trade literature indicates that the traditional trade barriers, such as tariffs, are no longer the key impediments to trade (Rousslang and To, 1993). Non-tariff trade barriers such as transport costs and infrastructure quality can affect extensive and intensive margins of trade through several channels: (i) direct monetary costs on freight, insurance and communication determined by physical and cultural distance between trade partners, and quality of infrastructure; (ii) time costs arising from just-in-time business practices, and international production chains and supply networks; (iii) inventory costs related to uncertain delivery time and shipment quality, and (iv) opportunity costs of lack of access to infrastructure of good quality.

Most importantly, Limao and Venables (2001) confirms that geography and infrastructure of countries are important determinants of transport costs and trade. In fact, remoteness and poor transportation isolate countries, which restrain their participation in global production networks. Moreover, Francois and Manchin (2007) shows that institutional quality and well-developed infrastructure are more important than tariffs in explaining the variations in North-South trade in terms of both levels and likelihood of trade.

In addition, Hausman, Lee and Subramanian (2005) shows that inefficiencies in logistics lower the probability of exporting to international markets and firm productivity. In fact, differences in the quality and cost of infrastructure services, policies, procedures and institutions lead to variations in trade-related transaction time and cost across countries, which significantly affect their trade competitiveness. Yeaple and Golub (2007) finds significant effects of infrastructure on industry-level productivity, sectoral composition of output across countries and international specialization by estimating the variations in sectoral total factor productivity. In addition, infrastructure investments reduce the cost of doing business over distance, facilitate firms to access markets and to establish contacts over larger distances, and improve the capacity of firms to compete in global markets (Albarran, Carrasco and Holl, 2009).

Furthermore, Deardorff (2004) relates trade costs with measures of comparative advantage and demonstrates how trade costs (transportation costs, in particular) can determine patterns of trade using both partial and general equilibrium models. Also, Li & Wilson (2009) shows that firms of time-sensitive industries in countries that cannot transport goods on time have lower likelihood of trading, and if they do trade, they have lower trade intensities. Time costs have disproportionately adverse effects on time-sensitive industries, implying the importance of transportation infrastructure in determining a country's comparative advantage. In this line of work, Baniya (2017) shows that countries with higher quality of infrastructure can transport intermediate inputs on time, and thus, participate and export relatively more in processed goods for which timely delivery of their intermediate inputs is relatively more important as opposed to primary commodities.

This paper extends the current literature by examining the effect of timeliness in trade on the extensive and intensive margins of trade using a computable general equilibrium (CGE) analysis. To do this, we use the newly developed GTAP firm-heterogeneity CGE model (Akgul et al., 2016), which explicitly models consumers' love-of-variety, endogenous changes in the number of varieties, and trade-induced productivity changes. We model the improvement in timeliness in trade via infrastructure reforms as efficiency changes in the fixed and variable export costs, which increase the number of firms entering into the export market (building on the established productivity threshold as in Melitz, 2003) and the export volume of existing exporters, respectively. To do this, we use the econometric estimates of the two-part model in Baniya (2017). The direct impacts on export costs arise from the improved ability to access intermediate inputs and to deliver final products on time. Implementing a targeted partial equilibrium shock resulting from improved transportation infrastructure in South and East Asia (low LPI) in the CGE model, we compare the resulting general equilibrium trade impacts across primary and processed sectors that vary in terms of time sensitivity of inputs.

Trade impacts of transportation infrastructure in the literature are mostly estimated using gravity and comparative advantage models similar to Baniya (2017). Although these empirical models might be on a solid econometric and theoretical foundation, they are only capable of providing estimates of the partial equilibrium impacts of infrastructure reforms on trade flows. However, if we are interested in fully assessing the endogenous effects on trade, aggregate welfare and distributional impacts of such reforms, and additional impacts transmitted through sectoral and regional linkages in the global economy, gravity econometric models may not be adequate. Hence, in this paper, we evaluate the complex trade impacts of the infrastructure reforms that materialize through numerous channels using a computable general equilibrium framework that is a genuine representation of the structure of the global economy and the transactions among economic agents.

The first channel which the general equilibrium framework allows us to fully lay out involves the transmission effects through the sectoral and regional (price and quantity) linkages. For instance, increased production in the processing sector due to improved timeliness in trade drives up the demand for primary goods (intermediate inputs), further increasing the prices of agricultural commodities. Similarly, growth in the availability of upstream activity in the local economies due to improved timeliness in trade drives up the production and exports of downstream goods. In so doing, this paper allows for a comprehensive assessment of the varying trade effects of infrastructure reform across sectors. These include endogenous effects on trade that come from the changes in prices of products and inputs, and number of varieties. CGE analysis is also useful to investigate wider economic impacts, including the changes in factor returns and redistribution of resources among sectors and countries. We are also able to track down contraction effects in some industries which arise due to general equilibrium resource constraints.

Although this paper is a first attempt in examining the effects of timeliness in trade on the export participation and composition in processed goods and time sensitive products using the firm-heterogeneity CGE framework, there have been some efforts in the past that studied the economy-wide effects of trade facilitation using CGE models. Hertel, Walmsley and Ikatura (2001) incorporates a dynamic GTAP model to examine the impacts of the "new age" free trade agreement (FTA) between Japan and Singapore on production, consumption, trade, international investment flows, GDP and welfare. Walkenhorst (2003) approximates the trade transaction costs and decomposes the world-wide welfare gains of border-related trade facilitation efforts, bearing in mind different countries, sectors and types of traders. They find that trade facilitation that decreases trade transaction costs by 1 percent of the value of world trade engenders aggregate welfare gains of $40 billion, with non-OECD countries accruing most of the benefits. Ivanic, Mann and Wilson (2006) estimates the net annual welfare gains of different types of trade-promoting policies in developing and developed countries, using the estimated effects of the aid on transaction costs and projections on future annual aid flows. Abe and Wilson (2008) examines the effects of lowering trade costs, through the reduction of corruption and improvement in transparency, on trade, production and welfare in APEC regions. Using partial and general equilibrium models, Mirza (2009) analyzes the cost and benefit of trade facilitation, including capital investments that improve trade related technology and quality of border efficiency, thereby stimulating trading capacities in developing countries. Finally, building on Hummels et al. (2007), Minor and Tsigas (2008) uses a GTAP database of bilateral tariff equivalent (product and country specific) of time to trade along with CGE models to study the impacts of simulated reductions in number of days to trade across borders on the GDP of different groups of countries characterized by income level. To do this, they use the MacMap (2004) database and compute the trade-weighted product-specific (HS4) estimates of value of time in trading across borders. They find that the benefits of reducing export and import lead times (modeled as iceberg costs) for a country is greatest when other countries make no such improvements. Moreover, reducing trade delays proliferates the share of exports of higher value added products and fosters intra-regional trade.

2. GTAP FIRM-HET CGE MODEL SUMMARY[4]

Previous CGE models incorporated Armington (1969) assumption to distinguish preferences for domestic and imported goods, and were only capable of capturing intensive margins of trade. Recent development in the international trade literature (Melitz, 2003; Eaton et al., 2004; Hummels and Klenow, 2005; Bernard et al., 2006; Chaney, 2008) related to the expansion of new varieties and productivity gains as a result of trade liberalization has inspired the development of the GTAP firm-heterogeneity CGE model, i.e. GTAP-HET (Akgul et al., 2016). Capturing self-selection of firms into export markets based on their productivity levels, as in Melitz (2003), GTAP-HET is able to explain both extensive and intensive margins of trade. GTAP-HET also captures inter-firm reallocations (entry into domestic market and export market, or market exit) based on productivity differences of firms within an industry post trade liberalization, generating a growth in aggregate industry productivity even with constant production technology in a country. In addition to the terms-of-trade gains and allocative efficiency effects, GTAP-HET is able to decompose the welfare impacts of trade policies into variety effects (number of firms in an industry), aggregate industry productivity gains (changes in the composition of firms within an industry) and the scale effects (output per firm).

GTAP-HET assumes a multi-region world, where exporters are indexed by r and importers are indexed by s. Each region comprises of two types of industries. The first assumes perfect competition with identical firms producing differentiated products only at the national level and with constant returns to scale technology. Here, all features of the standard GTAP model are preserved, with firm prices equal to marginal costs. For the policy experiment, we assume that primary goods are in this category, i.e. they are perfectly competitive. In the second type of industry, monopolistic competition is assumed with a continuum of firms, each producing a single unique variety that is an imperfect substitute in demand to other varieties. In this paper, we assume that processed goods and other higher value added goods are in this category.

[4] Akgul, Z., N. B. Villoria, & T. W. Hertel (2016): "Introducing Firm Heterogeneity into the GTAP Model," Journal of Global Economic Analysis, Volume 1, No. 1, pp. 111-180.

In the monopolistically competitive industry, firm entry into domestic and export markets necessitate covering fixed set-up costs of production and destination-specific fixed costs of trade (market access costs), respectively. The heterogeneous productivity levels across firms within an industry are revealed only upon firm entry, and this has a static nature. Productivity is defined as the quantity produced by a firm per composite input, which is inversely proportional to the marginal cost of production. Firms draw their productivity Φ from a Pareto distribution, where its CDF is denoted as G, with scale parameter $\Phi_{\min} \in [1, \infty)$, shape parameter γ, and support $[\Phi_{\min}, \infty)$. A firm's decision to operate in the domestic and export markets depends on the associated fixed cost of entry, and the potential to make non-negative profits given the productivity level of the firm. Market competition forces least productive firms to exit, more productive firms to supply only the domestic markets, and the most productive firms to serve the export market. In Armington-based CGE models, trade policies lead to inter-industry reallocation of resources, where scare resources shift towards more profitable industries. However, in the presence of firm heterogeneity, trade policies also lead to reallocation of limited resources across firms within an industry so that more productive firms expand their market shares by absorbing the resources released by less productive firms.

The demand structure in GTAP-HET incorporates consumers' love of variety and its implications on prices. First, bilateral trade flows of homogeneous products are characterized by Armington (1969) assumption, and products sourced from different countries are imperfect substitutes in demand. However, across heterogeneous products, consumers make a variety decision, i.e. imports from different regions are sourced to each agent, and they compete with domestic varieties directly. Following Dixit and Stiglitz (1977), the consumer preferences are given by a CES utility function over differentiated varieties, $\omega \in \Omega_{irs}$. The aggregate demand and price index are:

$$Q_{is} = \left[\sum_r \int_{\omega\in\Omega_{irs}} Q_{irs}(\omega)^{\frac{\sigma_i-1}{\sigma_i}}\, d\omega\right]^{\frac{\sigma_i}{\sigma_i-1}}\ ;\ P_{is} = \left[\sum_r \int_{\omega\in\Omega_{irs}} P_{irs}(\omega)^{1-\sigma_i}\, d\omega\right]^{\frac{1}{1-\sigma_i}},$$

$where\ \sigma_i > 1$ is the constant elasticity of substitution between different products, Q_{irs} is the consumer demand, and P_{irs} is the price in region s for variety ω of product i sourced from region r.

Based on Melitz (2003), in GTAP-HET, firm level variables are aggregated into industry level variables, by focusing on the behavior of an average firm (whose productivity equals the weighted average productivity in the industry), which incorporates productivity heterogeneity into the industry level variables without losing firm level understanding. Implementing the demand and price of the average firm into aggregate demand and price equations, we obtain:

$$Q_{is} = \left[\sum_r N_{irs}\tilde{Q}_{irs}(\omega)^{\frac{\sigma_i - 1}{\sigma_i}}\right]^{\frac{\sigma_i}{\sigma_i - 1}}\ ;\ P_{is} = \left[\sum_r N_{irs}\tilde{P}_{irs}(\omega)^{1-\sigma_i}\right]^{\frac{1}{1-\sigma_i}},$$

where $\tilde{Q}_{irs}$ is the demand for an average firm, $\tilde{P}_{irs}$ is the price of an average firm, and N_{irs} is the number of varieties (or number of active firms) of product i in region s sourced from region r. Consumer utility maximization yields:

$\tilde{Q}_{irs} = Q_{is}\left[\frac{P_{is}}{\tilde{P}_{irs}}\right]^{\sigma_i}$, and since $Q_{irs} = N_{irs}\tilde{Q}_{irs}$, we have the following.

$$Q_{irs} = N_{irs}Q_{is}\left[\frac{P_{is}}{\tilde{P}_{irs}}\right]^{\sigma_i}$$

Linearizing and writing the percentage changes in lower case letters, we get:

$$q_{irs} = n_{irs} + q_{is} - \sigma_i[\tilde{p}_{irs} - p_{is}].$$

The first component (n_{irs}) represents variety effect (consumer demand increases with more number of varieties); the second component (q_{is}) represents the expansion effect (larger market size or higher aggregate demand in the destination market raises the demand for each exporter's product), and the third component ($\sigma_i[\tilde{p}_{irs} - p_{is}]$) represents the substitution effect (demand increases with lower relative prices). Moreover, the price index is a decreasing function of the number of varieties; therefore, at constant prices, consumers spend less to attain the same level of utility with more number of varieties.

Finally, GTAP-HET incorporates consumers' preference bias for certain source regions (e.g. bias for domestic over imported varieties) using consumer expenditure shares following Venables (1987). Incorporating this, and linearizing the price index and writing the percentage changes in lower case letters, we get:

$p_{is} = \sum_r \theta_{irs}\tilde{p}_{irs} - \frac{1}{1-\sigma_i}\sum_r \theta_{irs}n_{irs}$, where θ_{irs} is the expenditure share of product i from source r in total expenditure of all varieties from all sources in region s. This demand system is incorporated in GTAP-HET for each economic agent (private household, firms and government, separately) as:

$$q_{irs} = -ams_{irs} + n_{irs} + q_{is} - \sigma_i[\tilde{p}_{irs} - ams_{irs} - p_{is}];$$

$$p_{is} = \sum_r \theta_{irs}(\tilde{p}_{irs} - ams_{irs}) - \frac{1}{1-\sigma_i}\sum_r \theta_{irs}n_{irs},$$

where ams_{irs} is the import augmenting technical change parameter in the GTAP model as introduced in Hertel et al. (2001).

The production technology (See Appendix) in this GTAP model distinguishes costs between variable component and fixed component (cost of entry into the industry and each trade market), and employment of labor and capital is essential to cover each type of cost. Hence, this model characterizes fixed costs as a demand for value added composite of capital and labor according to a CES technology. Note that land and natural resources are specific to primary goods sector. This model assumes a Leontief production technology combining demand for variable value added and intermediate inputs (both differentiated and Armington varieties as described above).

A profit maximizing firm with productivity Φ producing a differentiated product in a monopolistically competitive industry i of region r charges a constant markup $\frac{\sigma_i}{\sigma_i-1}$ over its marginal costs in market s as:

$$P_{irs}(\Phi) = \frac{\sigma_i}{\sigma_i - 1}\left(\frac{C_{ir}T_{irs}}{\Phi}\right),$$

where C_{ir} is the cost of input bundle required to produce a given level of output, and T_{irs} is the cost related to trade, transportation and taxes. The firm makes a profit of

$$\Pi_{irs}(\Phi) = \frac{P_{irs}(\Phi)}{T_{irs}} Q_{irs}(\Phi) - \frac{C_{ir}}{\Phi} Q_{irs}(\Phi) - W_{irs}F_{irs},$$

where W_{irs} is the price of value added and F_{irs} is the demand for value added required to cover the fixed costs of operating at the $r - s$ bilateral trade route. Highly productive firms earn higher profits by setting lower price levels, receiving higher markups, and producing more output. Firm profits increase with larger market size Q_{irs}, and lower variable costs C_{ir} (variable value added and intermediate inputs) and barriers to trade (T_{irs}; F_{irs}).

A firm (Φ) of industry i of region r self-selects to enter the export market s only if it is productive enough to make nonzero profits (i.e. if $\Phi_{irs} > \Phi^*_{irs}$), where Φ^*_{irs} is the minimum level of productivity required for export market entry determined by the marginal firm (productivity Φ^*_{irs}) that makes variable profit just enough to cover the fixed trading costs, i.e. $\Pi_{irs}(\Phi^*_{irs}) = 0$. This zero profit condition yields the productivity threshold as:

$$\Phi^*_{irs} = \frac{\sigma_i^{\frac{\sigma_i}{\sigma_i - 1}}}{\sigma_i - 1} \frac{C_{ir}}{P^*_{ir}} \left[\frac{P^*_{irs}Q^*_{irs}}{T_{irs}W_{irs}F_{irs}}\right]^{\frac{1}{1-\sigma_i}},$$

where variables with (*) are associated with the marginal firm. Productivity threshold decreases with larger market size (scale economies), lower variable costs C_{ir} and barriers to trade (T_{irs}; F_{irs}), and lower σ_i (heterogeneous preferences), thereby increasing the number of active firms in the market. The model relates marginal firm behavior to an average firm (defined as in Dixon et al., 2015) following the aggregation method in Melitz (2003) and using a CES functional form. Then, the average productivity of a firm in industry i and $r - s$ bilateral trade route is: $\widetilde{\Phi}_{irs} = \Phi^*_{irs}\left[\frac{\gamma_i}{\gamma_i - \sigma_i + 1}\right]^{\frac{1}{\sigma_i - 1}}$, where $\gamma_i > \sigma_i - 1$ is assumed to obtain a finite average productivity in the industry. Linearizing and writing the percentage changes in lower case letters:

$$\varphi^*_{irs} = c_{ir} - \tilde{p}_{ir} + \frac{1}{\sigma_i - 1}(f_{irs} - \tilde{q}_{irs}) + \frac{1}{\sigma_i - 1}(w_{irs} - \tilde{p}_{irs} + t_{irs}).$$

Let N^p_{ir} be the number of potential firms that pay fixed set-up costs to enter industry i of region r. Among these potential firms, only a subset N_{irs} has a high enough productivity level to supply the $r - s$ bilateral trade route, i.e. $N_{ir}^{p} > N_{irs}$. The probability that a firm participates on $r - s$ bilateral trade route is given by:

$$G(\Phi_{irs} > \Phi_{irs}^{*}) = 1 - G(\Phi_{irs}^{*}) = [\Phi_{irs}^{*}]^{-\gamma_i} = \frac{N_{irs}}{N_{ir}^{p}},$$

where G is the CDF of Pareto distribution as discussed above. Linearizing and writing the percentage changes in lower case letters, we get:

$$n_{irs} = n_{ir}^{p} - \gamma_i \varphi_{irs}^{*}$$

Thus, the participation in the export market rises with larger mass of potential firms in the industry (N_{ir}^{p}), and lower productivity threshold (Φ_{irs}^{*}). Further, the increase in export participation due to a fall in the threshold is enlarged by a higher γ_i (less dispersion of firm productivity within industry). This is because a larger mass of firms is at the margin in an industry with a larger γ_i. Finally, demand for fixed value added (required to cover both fixed setup costs and fixed trade costs) is directly proportional to the number of successful firms in the monopolistically competitive market. The proportionality of fixed export costs is implemented in GTAP-HET as: $f_{irs} = n_{irs}$.

3. TRADE FACILITATION IN THE GTAP-HET MODEL

Baniya (2017) examines the effect of a country's ability to transport goods on time on the export participation and composition in primary and processed goods. This paper distinguishes between two kinds of time cost faced by producers: (i) "direct" time costs that are incurred while transporting the final products to their consumers; (ii) "indirect" time costs that are incurred while accessing the intermediate inputs required to produce their products. She finds that, on average, processed goods producers face significantly larger indirect time costs than do primary goods producers. This is because processed goods undergo complex production chains, and thus, demand for timely delivery of intermediate inputs compared to primary goods. As a result, countries with higher ability to transport goods on time participate and export relatively more in those products for which timely delivery of their inputs is more valuable. In addition, this comparative advantage pattern is stronger for processed goods than for primary goods.

Trade facilitation in the standard GTAP model is incorporated as an efficiency change in the use of inputs required to cover variable export costs by considering its implications on the effective price ($\frac{P_{irs}}{AMS_{irs}}$) and the effective quantity of imports ($Q_{irs}AMS_{irs}$) from an exporter (Hertel et al., 2001). In particular, the impacts of trade facilitation is mimicked in GTAP using the trade-augmenting technical change variable (efficiency change in variable trade costs), AMS, which affects the total imports from the exporter applying the reform via three distinct effects: substitution towards this exporter, expansion effect (less is required to obtain the same composite aggregate import), and the import substitution effect. This model is extended in Mirza (2010) to link the logistics performance index (LPI) to the trade-augmenting technical change variable, AMS, in order to analyze the effect of investments in trade facilitation related capital goods on trade. We extend this development, first by incorporating both the direct and indirect partial equilibrium (PE) impacts of improvement in timeliness (LPI) on trade volume in the GTAP-HET model, which is mimicked by the trade-augmenting technical change variable, AMS using the empirical estimates from Baniya (2017). This informs the effects of trade facilitation on the variable trade cost. We then incorporate the direct and indirect PE impacts of trade facilitation on the fixed trade cost in GTAP-HET, which is mimicked by the efficiency change in fixed trade costs, $AVAFS$, using the empirical estimates from Baniya (2017).

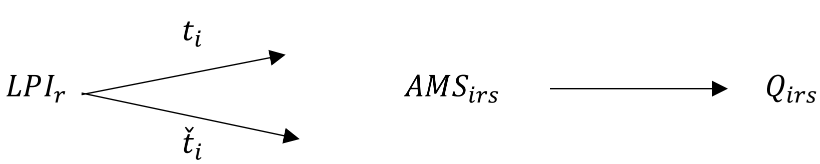
The partial equilibrium impact on the import demand, q_{irs}, due to the improvement in time to trade comes directly through the changes in variable export costs. And, the endogenous effects on trade volume come through the changes in prices (substitution effects) and the number of varieties in the general equilibrium framework. Next, the partial equilibrium impact of the improvement in time to trade on the number of varieties (n_{irs}), and hence, on the trade volume (q_{irs}) comes directly through the changes in fixed export costs. However, in a general equilibrium framework, the endogenous effects on the number of varieties, and thus, on the trade volume come through the changes in prices of value added and intermediate inputs that indirectly affect fixed export costs (f_{irs}), productivity threshold for export entry (φ^*_{irs}), and the number of potential entrants (n^p_{ir}).

In order to compute the required shock on the technical change variables that mimic the PE trade impacts of the improvement in LPI, it is important to isolate the factor input usage efficiency in fixed and variable components of export costs. On the one hand, trade facilitation affects variable export costs via reductions in input requirements, which has direct effects on prices. On the other hand, trade facilitation affects fixed export costs via reductions in factor input requirements, which has direct effect on productivity threshold for export entry, and thus, on number of varieties. In order to achieve that, we use the empirical estimates from Baniya (2017) that specifies the export volume based on a two-part model. The first stage estimates the effect of transportation infrastructure reforms on the probability of observing a positive trade volume. This informs the fixed cost component of trade facilitation effects. The second stage estimates the effect of infrastructure reforms on the trade volume conditional on participation in trade. This informs the variable cost component of trade facilitation effects after controlling for selection bias. Using these empirical estimates, we implement a targeted shock to the logistics performance index in the GTAP-HET model and compare the implications in the processed and primary goods industries for South and East Asia region with a low LPI. In addition to the impacts on export participation and composition, we analyze the effects on factor returns and reallocations, and decompose the welfare impacts.

1. *Export Participation:*

First, an improvement in country r's logistics performance index (LPI_r) lowers the fixed cost of entering into the export market (s) of product i from r ($AVAFS_{irs}$). This improvement due to exporter r's reform is uniform across all trade destinations s, which comes through two different channels: improvement in the (i) direct time cost ($LPI_r * t_i$), and (ii) indirect time cost ($LPI_r * \check{t}_i$). For each country, this resulting efficiency change (direct trade impacts) varies by product type; in fact, this effect is larger for products facing higher direct and/or indirect time cost. Now, a reduction in fixed export costs (mimicked by $AVAFS_{irs}$) leads to the changes in number of firms participating in the export market (s) of product i from r (N_{irs}), and thus, trade. A relation between $AVAFS_{irs}$ and N_{irs} is established in GTAP-HET, however, the relation between LPI_r and $AVAFS_{irs}$ is not present. Hence, we establish this latter relation to examine the effect of LPI_r on N_{irs}.

2. *Export Volume:*



Next, an improvement in LPI_r lowers the variable cost of exporting product i from country r to s. This direct trade impact due to exporter r's reform is mimicked by an import augmenting technical change variable (AMS_{irs}), which is uniform across all trade destinations s, and this comes through two different channels: improvement in the (i) direct time cost ($LPI_r * t_i$), and (ii) indirect time cost ($LPI_r * \check{t}_i$). Note that, for each country, this resulting efficiency change varies by product type; in fact, this effect is larger for products facing higher direct and/or indirect time cost. Now, lower variable export costs leads to changes in the export volume of product i from country r to s (Q_{irs}), and hence, the aggregate export volume of product i from country r. A relation between AMS_{irs} and Q_{irs} is established in GTAP-HET, however, the relation between LPI_r and AMS_{irs} is not present. Hence, we establish this latter relation to examine the effect of LPI_r on Q_{irs}.

Finally, the trade facilitation-induced changes in productivity threshold (See Appendix) stimulates average industry productivity (assumed endogenous in this model unlike standard GTAP model) even with constant production technology, thereby reducing input requirement in production and costs. There are three mechanisms through which this occurs: (i) inefficient firms in the domestic market exit due to higher import competition, which increases average productivity in the domestic market; (ii) as new exporters emerge, average productivity in the export market falls, because new exporters (entrants) are less productive than the existing exporters; (iii) the share of exporters rises, and the exporters are more productive on average than the domestic producers, thereby increasing the average industry productivity. Hence, the change in average industry productivity that we capture in this model is purely due to changes in the composition of firms within the industry, i.e. the expansion in the market share of more productive firms in the industry. In addition, as inefficient firms exit, the surviving firms expand their scale and production given the total industry output, thereby increasing output per firm (scale effect).

4. CGE ANALYSIS

The GTAP-HET model is a many country and many goods model that is developed to analyze various national and international policy issues incorporating consumers' love-of-variety, endogenous changes in the number of varieties, and trade-induced productivity changes. We complement this model by using GTAP database, version 9 in our analysis, which incorporates the production, consumption and trade data for 140 countries and 57 sectors. Country specific input-output tables at the GTAP sectoral level lay out the global and national sectoral linkages, while the data on international trade and transportation interlinks the countries and regions. Our regional aggregation for the purpose of this analysis is carried out to bring countries that are geographically proximate and similar in terms of logistics performance index together. Also, our sectoral aggregation is carried out so that sectors with similar degree of processing and indirect time sensitivity are classified under the same category. In particular, the aggregation used in this paper consists of 9 regions and 13 sectors (See Tables 1 and 2). This aggregation allows us to examine how the effect of infrastructure reforms vary across regions and sectors depending on the level of transport infrastructure of regions, and the product specific time intensity of inputs.

4.1 Calibration of Technical Shocks in GTAP-HET Model

1. Export Participation:

We first establish a relation between export participation, $\Pr(X_{irs} > 0)$, and fixed cost (F_{irs}) of exporting product i from country r to s. Following Akgul, et al. (2016), we write the following expressions (1) and (2) for a sector i with productivity Φ_{irs} that exports from country r to s if its productivity level exceeds the threshold level, Φ_{irs}^*, where

$$\Phi_{irs}^* = \frac{\sigma_i^{\frac{\sigma_i}{\sigma_i - 1}}}{\sigma_i - 1} \frac{C_{ir}}{P_{ir}^*} \left[\frac{P_{irs}^* Q_{irs}^*}{T_{irs} W_{irs} F_{irs}} \right]^{\frac{1}{1-\sigma_i}}, and$$

σ_i *and* γ_i are the elasticity of substitution and Pareto shape parameter as in Melitz (2003).

Here, $\Pr(X_{irs} > 0) = G(\Phi_{irs} > \Phi^*_{irs}) = 1 - G(\Phi^*_{irs}) = [\Phi^*_{irs}]^{-\gamma_i}$ (1)

Linearizing and writing the percentage change in lower case letters, we get:

$$pr(X_{irs} > 0) = \gamma_i(\tilde{p}_{ir} - c_{ir}) + \frac{\gamma_i}{1-\sigma_i}(f_{irs} - \tilde{q}_{irs}) + \frac{\gamma_i}{1-\sigma_i}(w_{irs} - \tilde{p}_{irs} + t_{irs}). \quad (2)$$

Then, the elasticity of $\Pr(X_{irs} > 0)$ w.r.t. fixed cost (ceteris paribus) is:

$$\frac{\%\Delta\,\Pr(X_{irs}>0)}{\%\Delta\,F_{i,r,s}} = -\frac{\gamma_i}{\sigma_i - 1} \quad (3)$$

Next, from the first stage econometric estimation (two-part model) in Baniya (2017), assuming uniform change across export destinations:

$$\frac{\%\Delta\,\Pr(X_{irs}>0)}{\%\Delta\,LPI_r} = (\beta_5 * t_i + \delta_5 * \tilde{t}_i)(1\text{-}\ \Pr(\widehat{X_{ir} > 0})), \quad (4)$$

where $\Pr(\widehat{X_{ir} > 0})$ is the predicted probability at the mean, t_i and $\tilde{t}_i$ are direct and indirect time sensitivity of product i, and β_5 and δ_5 are the corresponding coefficient estimates.

Thus, $\frac{\%\Delta\,F_{i,r,s}}{\%\Delta\,LPI_r} = -\left(\frac{\sigma_i - 1}{\gamma_i}\right) * (\beta_5 * t_i + \delta_5 * \tilde{t}_i)(1\text{-}\ \Pr(\widehat{X_{ir} > 0}))$ (5)

Hence, the percentage change in the value added demand by the monopolistically competitive industry i to cover fixed export costs from country $r\ to\ s$ is $-\left(\frac{\sigma_i - 1}{\gamma_i}\right)(\beta_5 * t_i + \delta_5 * \tilde{t}_i)$% due to a 1% shock in LPI, ceteris paribus. Using this, we obtain the required amount of shock in $AVAFS_{i,r,s}$ that will mimic the direct trade impact of a 1% shock in LPI_r, which we implement in the CGE analysis assuming a general equilibrium closure in order to estimate the total effects of infrastructure reforms on the export participation in processed and primary goods. That is, for each heterogeneous industry i,

$$(1 - \sigma_i)avafs_{irs} = \frac{\%\Delta\,F_{irs}}{\%\Delta\,LPI_r} = -\left(\frac{\sigma_i - 1}{\gamma_i}\right)(\beta_5 * t_i + \delta_5 * \tilde{t}_i)(1\text{-}\ \Pr(\widehat{X_{ir} > 0})) \quad (6)$$

2. *Export Composition:*

The change in the value added demand by industry i to cover the variable export costs from country $r\ to\ s$ is $(\lambda_5 * t_i + \gamma_5 * \tilde{t}_i)$% due to a 1% shock in LPI, ceteris paribus. Using this, we obtain the required amount of shock in AMS_{irs} that will mimic the direct trade impact of a 1% shock in LPI_r, which we implement in the CGE analysis assuming a general equilibrium closure in order to estimate the total effect of transportation infrastructure reforms on the export volume in processed and primary goods. Assuming a uniform change across export destinations, for each industry i,

$$(\sigma_i - 1)ams_{irs} = \frac{\%\Delta X_{irs}}{\%\Delta\, LPI_r} = \lambda_5 * t_i + \gamma_5 * \tilde{t}_i, \tag{7}$$

where λ_5 and γ_5 are the coefficient estimates of the two-part model in Baniya (2017). Note that we are investigating the impacts of an exporter's infrastructure reform on its exports only, although such reforms would facilitate its imports as well. This simplicity is maintained so that we can clearly assess the endogenous channels through which trade facilitation can affect exports in a general equilibrium framework.

4.2 Policy Scenario

Using the newly developed GTAP-HET model (Akgul et. al, 2016), we examine the trade impacts of transportation infrastructure reforms in the part of South and East Asia region which currently has a low LPI (SEA_L)[5]. We choose this region for our policy analysis, because it has one of the lowest levels (2.596) of logistics performance index (lowest after Sub-Saharan Africa). Also, most of its exports are composed of primary and processed goods, and it has a great potential to increase its export participation in processed agricultural commodities (See Chapter 1 summary statistics) and other higher value added goods, such as time sensitive textile and wearing apparel, with reasonable infrastructure reforms. Hence, such trade facilitating infrastructure reforms could possibly enable this region to reach its full potential of participation in the global production network.

Since infrastructure reform requires huge public investment, we realize that it has some trade-offs; in fact, investment in transportation infrastructure might take away resources from investments in human capital which is equally important for a country's growth.

[5] This region includes Mongolia, Brunei, Cambodia, Laos, Bangladesh, Nepal, Pakistan, Sri Lanka, Rest of South Asia (GTAP code: XSA), and Rest of East Asia (GTAP code: XEA).

Although we do realize the importance of such a cost-benefit analysis for a better policy analysis, we have not captured this cost side as done in Mirza (2010). However, realizing this, we incorporate a conservative policy shock similar to Mirza (2010). We implement an experiment, where the LPI of SEA_L is increased from its current level (2.596) to 2.76, which is the LPI level of the Latin American countries (LAC).

That is, we shock the LPI of SEA_L by 6.64% so that South and East Asia (with low LPI) region is brought to the level of Latin American countries. This corresponds to the changes in trade-augmenting technical changes reducing fixed and variable export costs uniformly across importing regions as described earlier, and the changes vary by sectors depending on their elasticity of substitution, Pareto shape parameters, and most importantly, direct and indirect time sensitivity measures. The elasticity of substitution and Pareto shape parameters by GTAP sector come from estimations in Akgul, et al. (2016), which are then aggregated to our sectors in this policy analysis.

5. RESULTS

5.1 Partial Equilibrium Impacts

We first report how the direct effects of timeliness in trade on the export participation and composition varies across sectors. The partial equilibrium impact on trade due to infrastructure reforms comes directly through the changes in variable export costs (which affects the export volume of existing exporters), and fixed export costs (which has a direct effect on the number of varieties and thus trade). Figures 1 and 2 show the PE impacts of the increase in LPI by 6.64% on the export participation and volume in South and East Asia region with a low LPI. This conservative policy shock increases the LPI level of this region (2.596) to the LPI level of Latin America and Caribbean (2.76), which has the next best level of LPI. We see that both the intensive and extensive margins are positive for all sectors. However, processed goods that value timely delivery of inputs (meat products; other manufacturing such as paper, metal, petroleum and coal products; chemicals, ferrous metals, rubber and plastic products) experience the largest trade effects. Also, livestock (primary good) that is both directly and indirectly time sensitive faces large trade gains due to improvement in timeliness in trade.

5.2 General Equilibrium Impacts

The endogenous effects on trade come from the changes in prices (substitution effects) and the indirect effects on the number of varieties in the general equilibrium framework. These indirect effects on number of varieties, which further affect trade, come from the changes in prices of value added and intermediate inputs that indirectly affect fixed export costs, productivity threshold for export entry and the number of potential entrants. The GE framework incorporates regional and sectoral linkages, and thus, the effects of reforms transmit through price and quantity linkages. Therefore, the GE impact on trade depends on the size of the direct effects of infrastructure reforms, the substitution effects and the indirect effects on the number of varieties. Finally, we expect that not all sectors can expand simultaneously as a result of infrastructure reforms under GE resource constraints; hence, the general equilibrium impact could potentially be different compared to the PE impacts.

The GE results are consistent to some extent in the sense that we observe larger impacts of the improvement in time to trade on the export participation (Figure 3) and export volume (Figure 4) for processed sectors that use more time sensitive inputs (meat products; chemicals, ferrous metals, rubber and plastic products). These results indicate a larger fall in the variable exports costs and the productivity threshold for export market entry (arising from lower fixed export costs) for such industries of South and East Asia region (low LPI), thereby increasing the export competitiveness and boosting the number of active firms in the export markets of these industries. Thus, less productive firms at the margin are now more competitive in the export markets due to the efficiency change in trade costs induced by the infrastructure reforms, and are now able to enter the export markets.

A contrasting result that we find using the CGE analysis compared to the PE results is that, while most of the primary goods experience some positive impacts on trade, other processed and higher value added sectors that are relatively less time sensitive compared to the highly time sensitive processed goods contract as a result of infrastructure reforms in South and East Asia region (low LPI). This was not evident in the PE analysis. In particular, we find that higher value added sectors such as machinery and electric shrink, and other less time sensitive processed goods see minimal impacts due to the reforms. This is because, first of all, the GE framework incorporates resource limitations, and under such GE constraints, it is not possible to experience expansion in all the sectors simultaneously as a result of the reforms. Thus, although this region sees positive PE impacts in all sectors, we see that some sectors cannot expand after the reforms, when all the PE impacts across all sectors are simultaneously incorporated in the CGE analysis.

To analyze the general equilibrium impact further, we now explore the endogenous effects of timeliness in trade across sectors in the GE framework, in particular, the changes in prices (substitution effects) and number of varieties. A shift in the comparative advantage pattern towards time sensitive processed sectors and away from primary goods (Figure 5) leads to a fall in the price of land and natural resources specific to primary goods (Figure 6). On the other hand, prices of labor and capital (mobile factors) rise (Figure 6). Hence, prices of primary goods fall (Table 3) due to the fall in prices of value added composite (Table 3) and the intermediate input bundle used in these goods (Figure 7). Therefore, most of the primary goods face positive substitution effects, and thus, the positive GE impact on trade. An exception in the primary goods sector is the extraction and mining sector that experiences a rise in product prices (negative substitution effects and GE trade impacts) due to the rise in the price of intermediate inputs (e.g. rise in the price of machinery and electric, which is intensively used in extraction, due to the rise in prices of labor and capital). Moreover, most of the processed and higher value added goods see a rise in product prices due to the rise in prices of value added composite (despite a fall in input prices; See Table 3 and Figure 7) leading to negative substitution effects on trade.

However, the most time sensitive processed goods (meat products; chemicals, ferrous metals, rubber and plastic products) have large positive impacts on trade (despite negative substitution effects) because of the growth in number of varieties (Figure 3). The endogenous effects on number of varieties for these sectors come from the rise in the number of potential entrants (Figure 8) and the endogenous fall in productivity threshold (Figure 9). This is because the fall in prices of value added composite lower the fixed set up costs of production, and the fall in the prices of bundle of intermediate inputs further lower the productivity threshold of export entry.

Figure 10 shows that the total welfare due to reforms rises in South and East Asia (low LPI), and most of the welfare gains comes from the direct impact on trade due to efficiency changes in export costs, and scale effect and terms of trade gains. However, the variety effect is negative, because consumers suffer from a loss in domestic varieties as they implicitly put more weight on domestic varieties (home bias). In fact, Figure 11 shows that most of the welfare from direct impacts on trade comes from the efficiency changes in variable export costs. Moreover, the average industry productivity effect is negative due to a large fall in the productivity threshold of export entry for time sensitive processed goods. In addition, Figure 12 shows that the output per firm increases more for time sensitive processed goods such as processed food; chemicals, ferrous metals, rubber and plastic products, and other manufacturing industries (paper, metal and mineral products). This is because, as inefficient firms exit, the surviving firms expand their scale and production given the total industry output. Further, these industries, and extraction, machinery/electric, and textile/wearing apparel see positive terms of trade gains (Figure 13).

6. CONCLUSION

This paper examines the effect of timeliness in trade on the trade volume of existing exporters and the number of new varieties being traded using a CGE analysis. To do this, we use the newly developed GTAP firm heterogeneity CGE model (Akgul et al., 2016), complemented with GTAP database, ver. 9. We model the improvement in transportation infrastructure as an efficiency change in the fixed and variable costs of export, which increase the number of firms entering into the export market and the export volume of existing exporters, respectively. The efficiency changes in trade costs (direct impacts on trade) come from the improvement in both the direct and indirect time costs of trade.

The partial equilibrium trade impacts of the infrastructure reform are mimicked in GTAP using the technical change variables. To do this, we isolate the variable and fixed costs components of the factor input usage efficiency change. In order to achieve that, we use the econometric estimates of the two-part model in Baniya (2017). The first stage estimates the effect of infrastructure reforms on the probability that we observe a positive trade flow. This informs the fixed cost component of the trade facilitation effects. The second stage estimates the effect of infrastructure reforms on the trade volume conditional on participation in trade. This informs the variable cost component of trade facilitation effects after controlling for the selection bias. Using this, we implement a targeted shock in LPI (partial equilibrium trade impacts) of South and East Asia region (low LPI) in the GTAP-HET model and compare the resulting GE impacts in the processed and primary goods that vary in terms of time sensitivity of inputs. In addition to the trade impacts, we analyze the effects on factor returns and reallocations, and decompose the welfare impacts.

Although the partial equilibrium trade impacts vary across sectors, they are all positive. However, a contrasting result that we find using the CGE analysis compared to the PE results is that while most of the primary goods experience some positive impacts on trade, other less time sensitive processed and higher value added goods contract as a result of infrastructure reforms. Thus, first of all, we see that some sectors cannot expand in this region after the reforms under GE constraints, when all the PE impacts across all sectors are simultaneously incorporated in the CGE analysis.

To analyze the GE impacts further, we explore the endogenous effects of timeliness in trade across sectors in the GE framework, in particular, the changes in prices and the number of varieties. A shift in the comparative advantage pattern towards time sensitive processed sectors leads to a fall in the price of land and natural resources specific to primary goods. On the other hand, prices of labor and capital rise. Hence, prices of primary goods fall due to the fall in prices of value added composite and the intermediate input bundle used in these goods. Therefore, most of the primary goods face positive substitution effects, and thus, the positive GE impact on trade. Most of the processed and higher value added goods see a rise in product prices due to the rise in prices of value added composite, leading to negative substitution effects on trade.

However, the most time sensitive processed goods have large positive impacts on trade (despite negative substitution effects) because of the growth in number of varieties. The endogenous effects on number of varieties for these sectors come from the rise in the number of potential entrants and the endogenous fall in productivity threshold. This is because the fall in prices of value added composite lower the fixed set up costs of production, and the fall in the prices of bundle of intermediate inputs further lower the productivity threshold of export entry.

The total welfare due to infrastructure reforms rises in South and East Asia (low LPI), and most of the welfare increase comes from the direct impact on trade due to efficiency changes in variable export costs, and scale effect (output per firm) and terms of trade gains. However, we see that the variety effect is negative, because consumers suffer from a loss in domestic varieties (home bias). Moreover, the average industry productivity effect is negative due to a large fall in the productivity threshold of export entry for time sensitive processed goods sectors. In addition, the output per firm increases more for time sensitive processed goods sectors, because, as the inefficient firms exit, the surviving firms expand their scale and production given the total industry output.

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CHAPTER 2. APPENDIX

Table 1: Regional Aggregation

Region Code	Region Name	Region	LPI
1	Oceania	OA	3.725
2	North America	NA	3.890
3	EU and EFTA (High Income)	EUEA_H	3.874
4	South and East Asia (High Income)	SEA_H	3.826
5	South and East Asia (Low Income)	SEA_L	2.596
6	Latin America	LA	2.768
7	Sub Saharan Africa	SSA	2.546
8	Rest of World (Middle Income)	ROM	3.273
9	Rest of World (Low Income)	ROL	2.658

Table 2: Sectoral Aggregation

Sector	Sector Description	Direct Time Cost (in ad-valorem terms)	Indirect Time Cost (in ad-valorem terms)
1	Grains, Fibers, Seeds	0.001855	0.002672
2	Veg, Fruits & Nuts	0.018299	0.001665
3	Livestock	0.024209	0.007155
4	Extraction & Mining	0.008478	0.003326
5	Meat Products	0.005716	0.010255
6	Processed Food	0.010999	0.003432
7	Textile, Leather & Apparel	0.008887	0.003038
8	Wood & Mineral Prods	0.013942	0.002841
9	Other Mnfcs	0.015971	0.005477
10	Chemicals & Fe Metals	0.019332	0.012633
11	Motor Vehicles	0.016778	0.003627
12	Machinery & Electric	0.010227	0.003233

Other manufactures include manufactures nec, paper, metal, petroleum and coal products; while chemicals and ferrous metals sector includes rubber and plastic products as well.

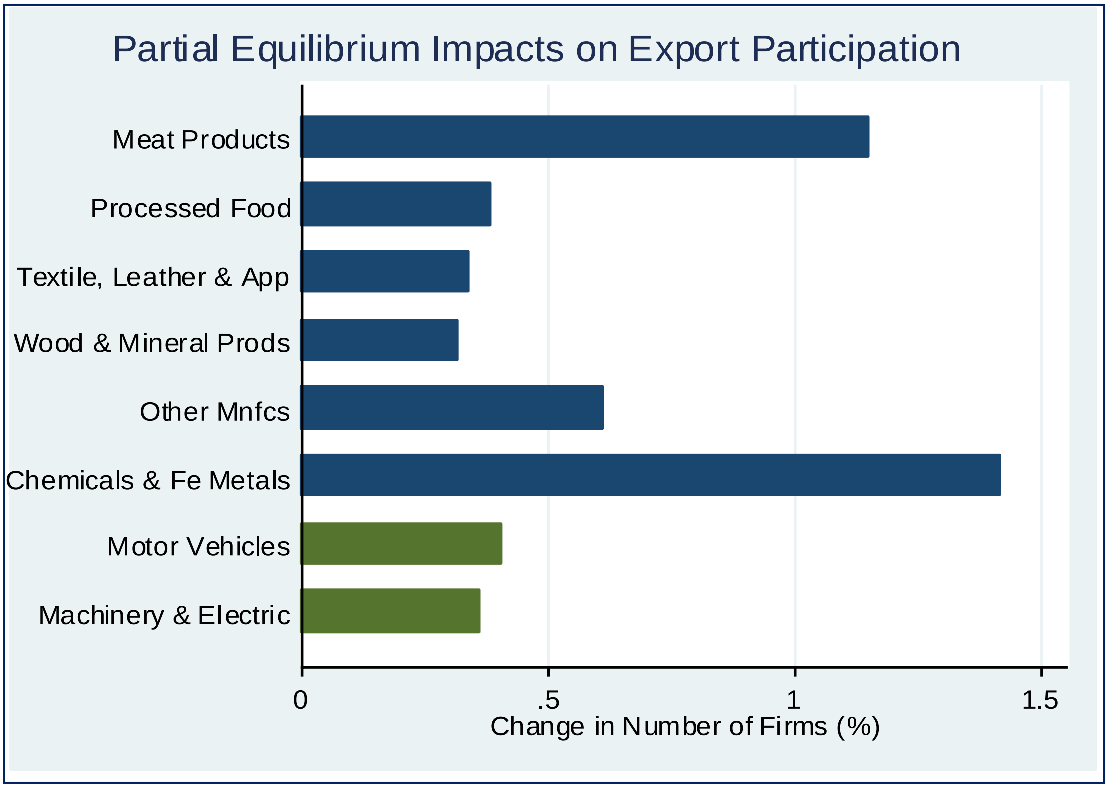

Figure 1: PE Impact of Timeliness in Trade on the Export Participation

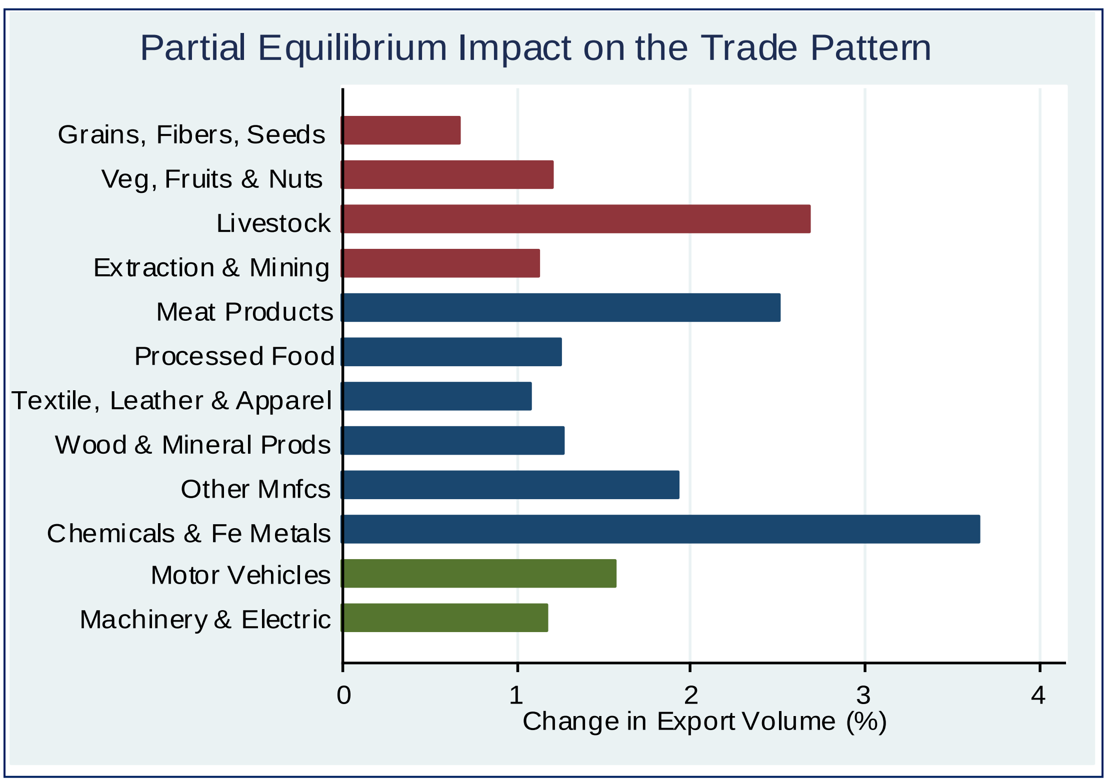

Figure 2: PE Impact of Timeliness in Trade on the Total Export Volume

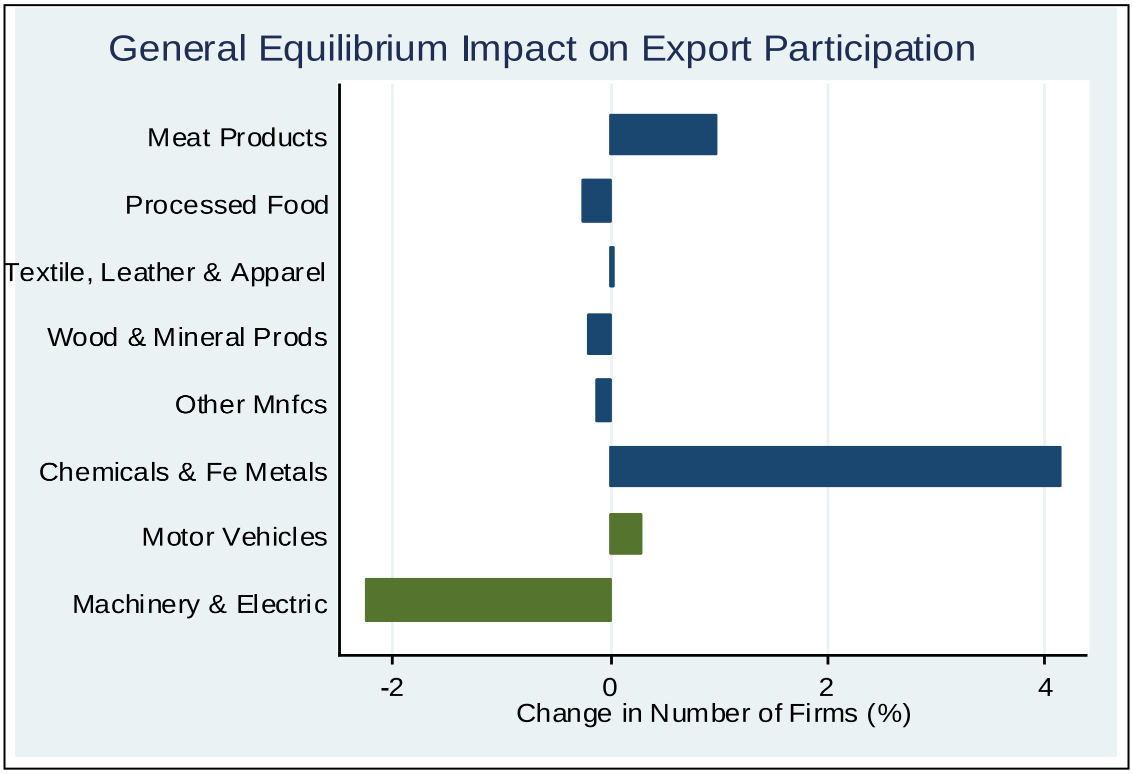

Figure 3: GE Effects of Timeliness in Trade on Number of Varieties

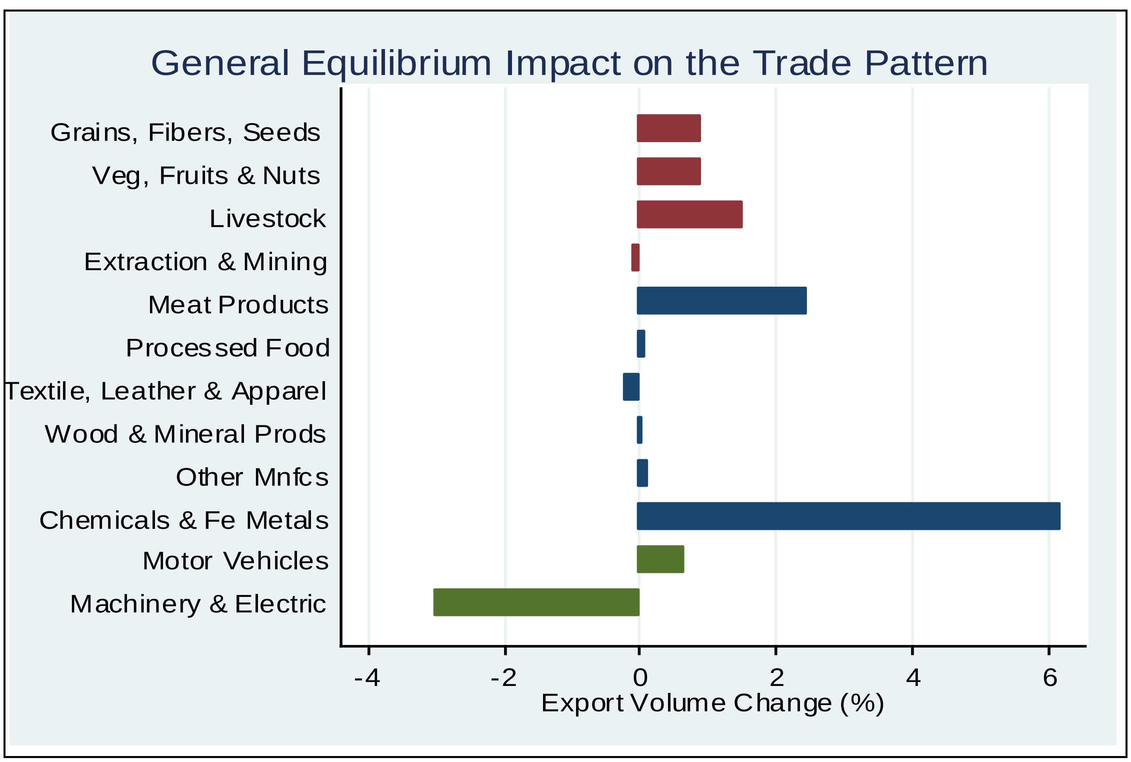

Figure 4: GE Effects of Improvement in Timeliness in Trade on the Export Volume

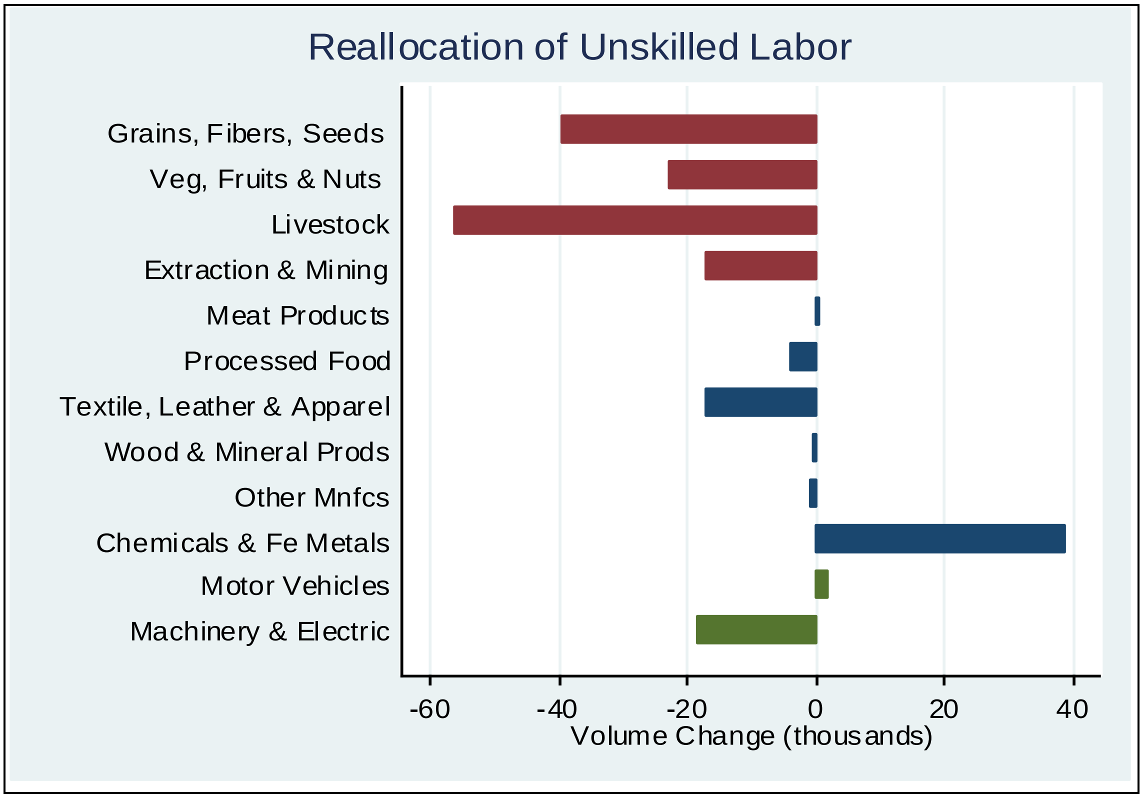

Figure 5: Effects of Timeliness in Trade on the Reallocation of Resources

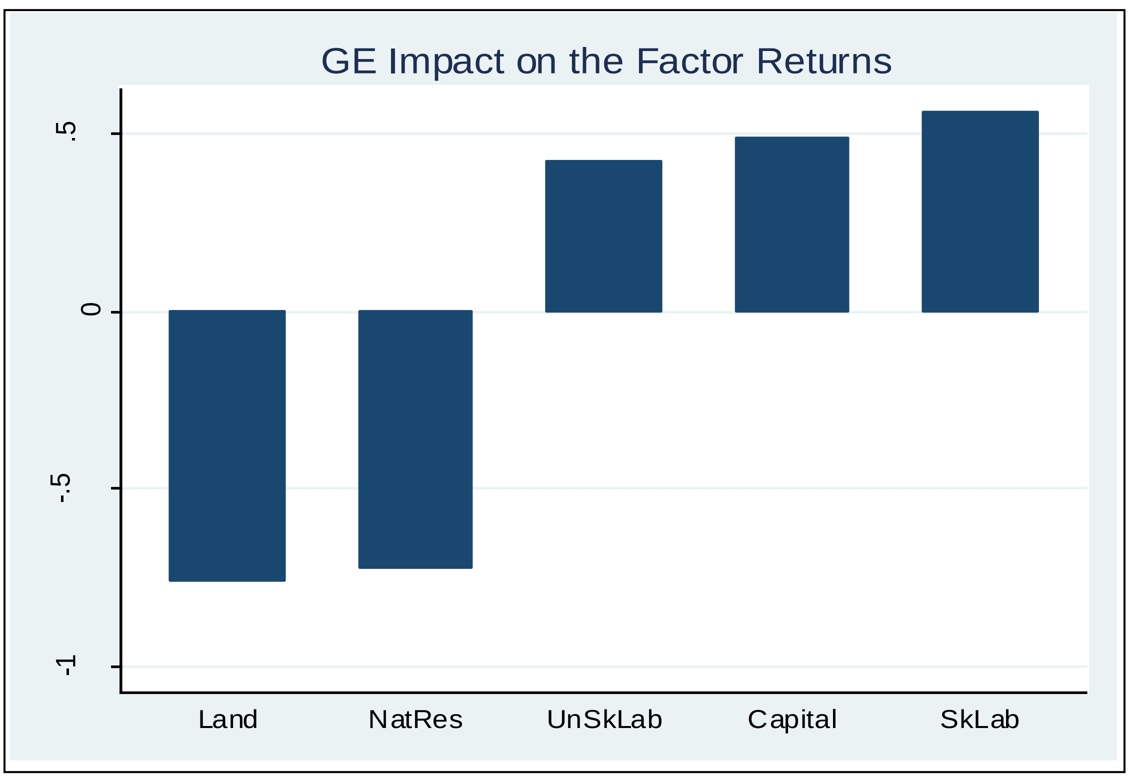

Figure 6: Effects of Timeliness in Trade on the Factor Returns

Table 3: Endogenous Changes in Prices

Sector	Product Price Change (%)	Composite Value Added Price Change (%)
Grains, Fibers, Seeds	-0.14	-0.15
Veg, Fruits & Nuts	-0.11	-0.12
Livestock	-0.20	-0.32
Extraction & Mining	0.10	0.04
Meat Products	0.01	0.47
Processed Food	0.12	0.48
Textile, Leather & Apparel	0.11	0.48
Wood & Mineral Prods	0.16	0.47
Other Mnfcs	0.14	0.47
Chemicals & Fe Metals	0.09	0.45
Motor Vehicles	0.16	0.47
Machinery & Electric	0.28	0.48

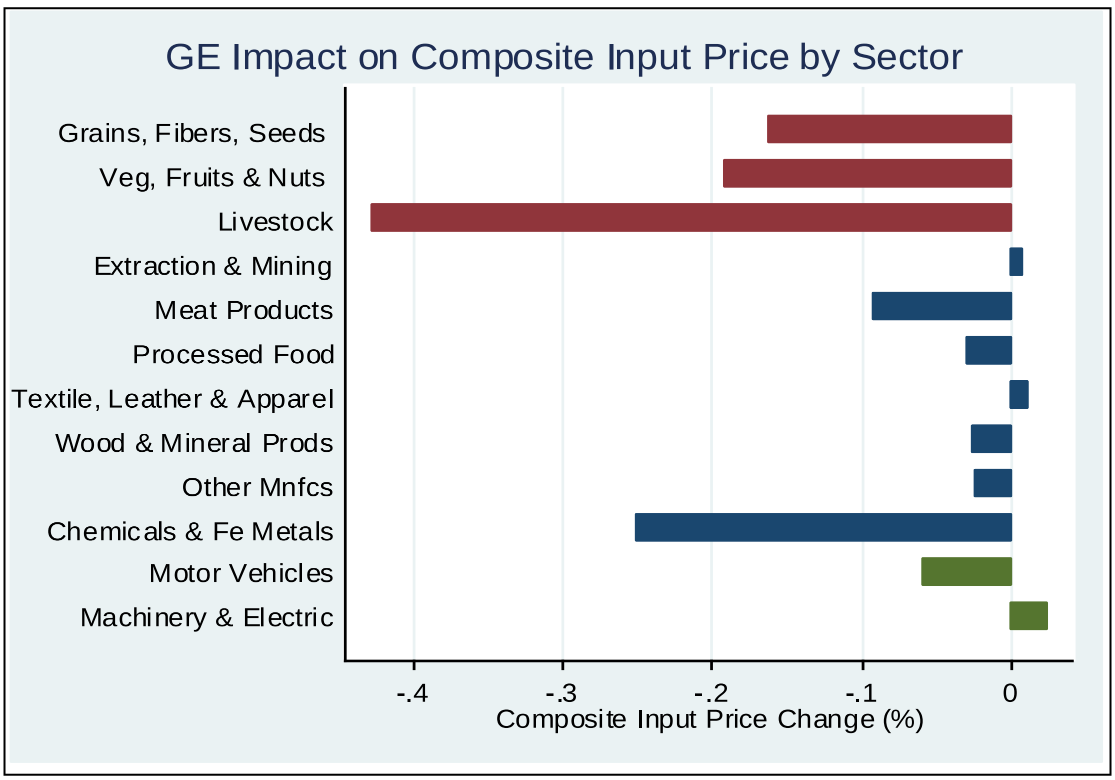

Figure 7: Endogenous Changes in Prices of Intermediate Inputs

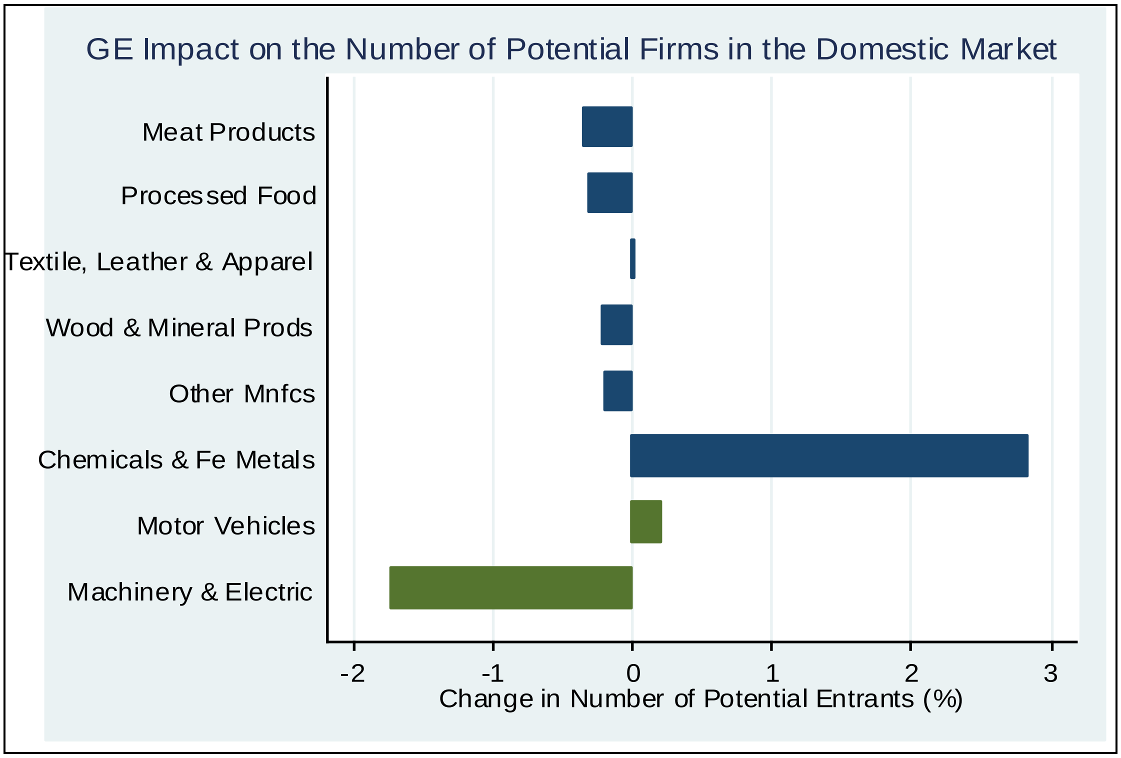

Figure 8: Endogenous Changes in Number of Potential Entrants

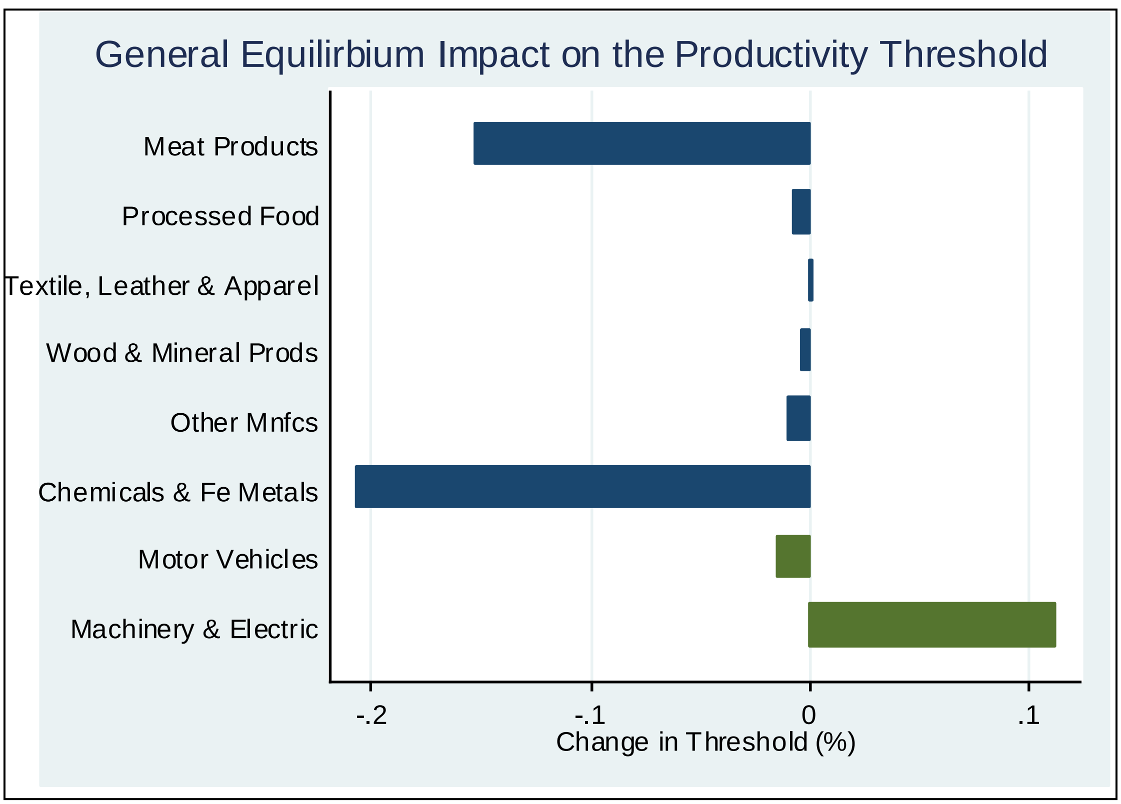

Figure 9: Endogenous Changes in Productivity Threshold for Export Entry

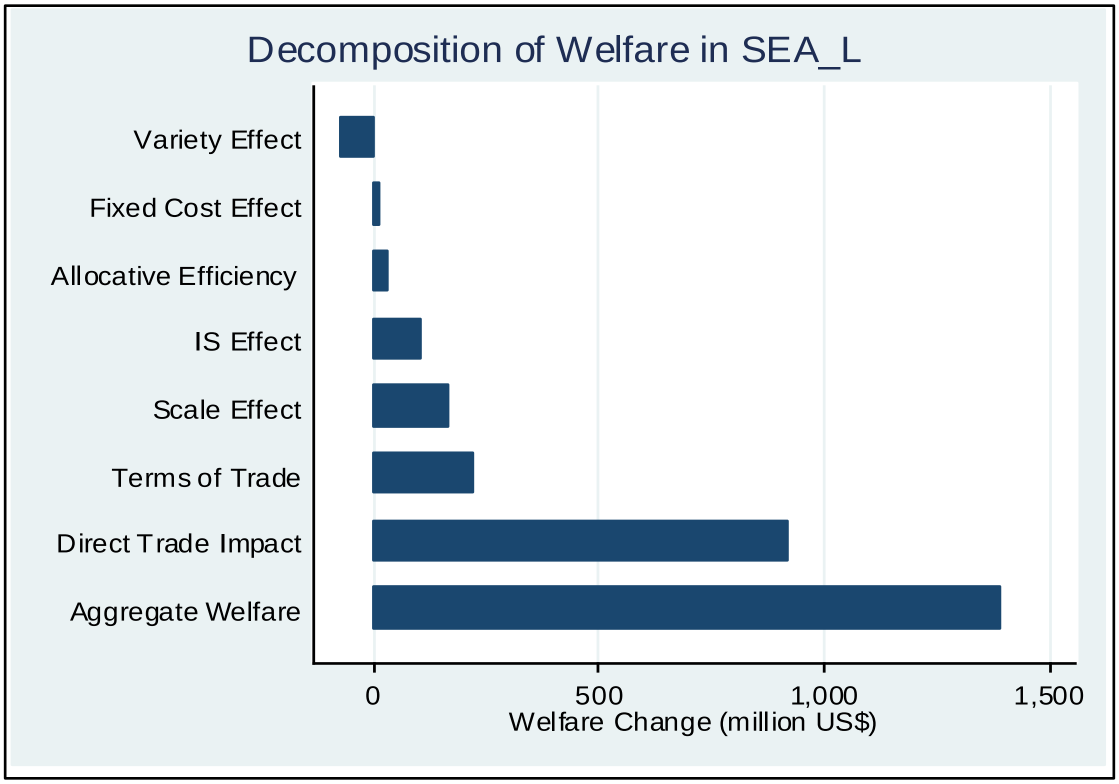

Figure 10: Welfare Impacts of Timeliness in Trade

Direct trade impacts of reforms come from efficiency changes in trade costs.

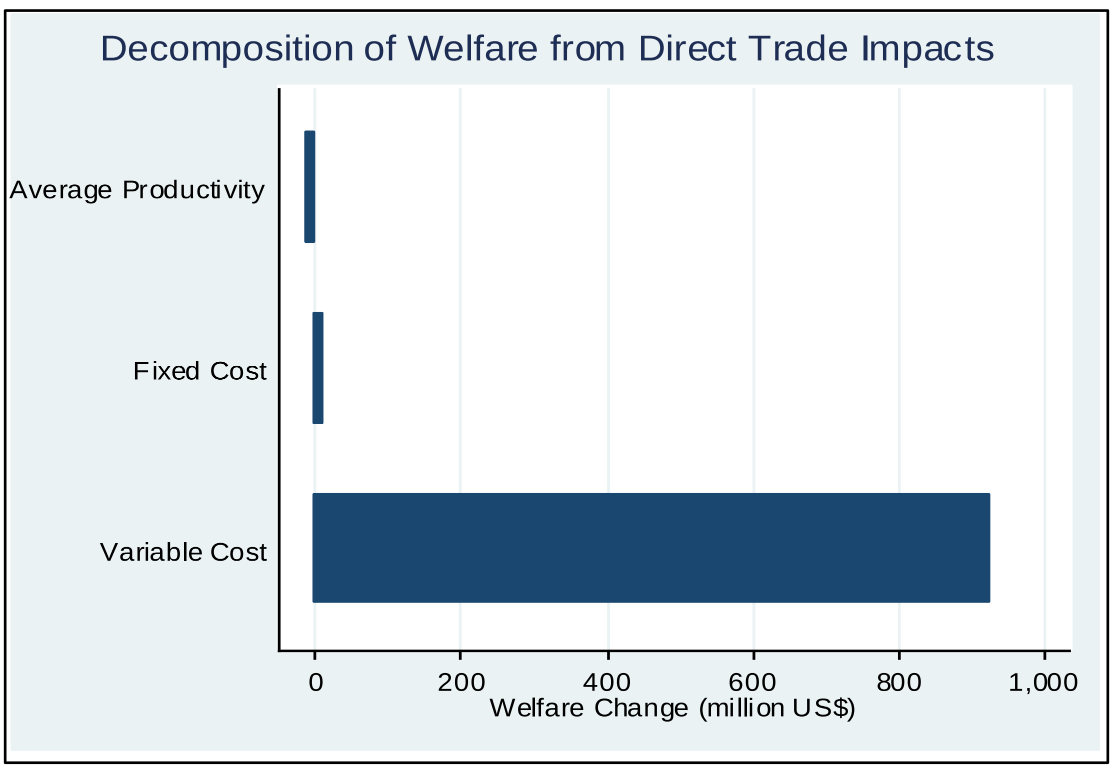

Figure 11: Decomposition of Welfare – Efficiency Changes

Most of the welfare due to direct trade impacts comes from lower variable export costs.

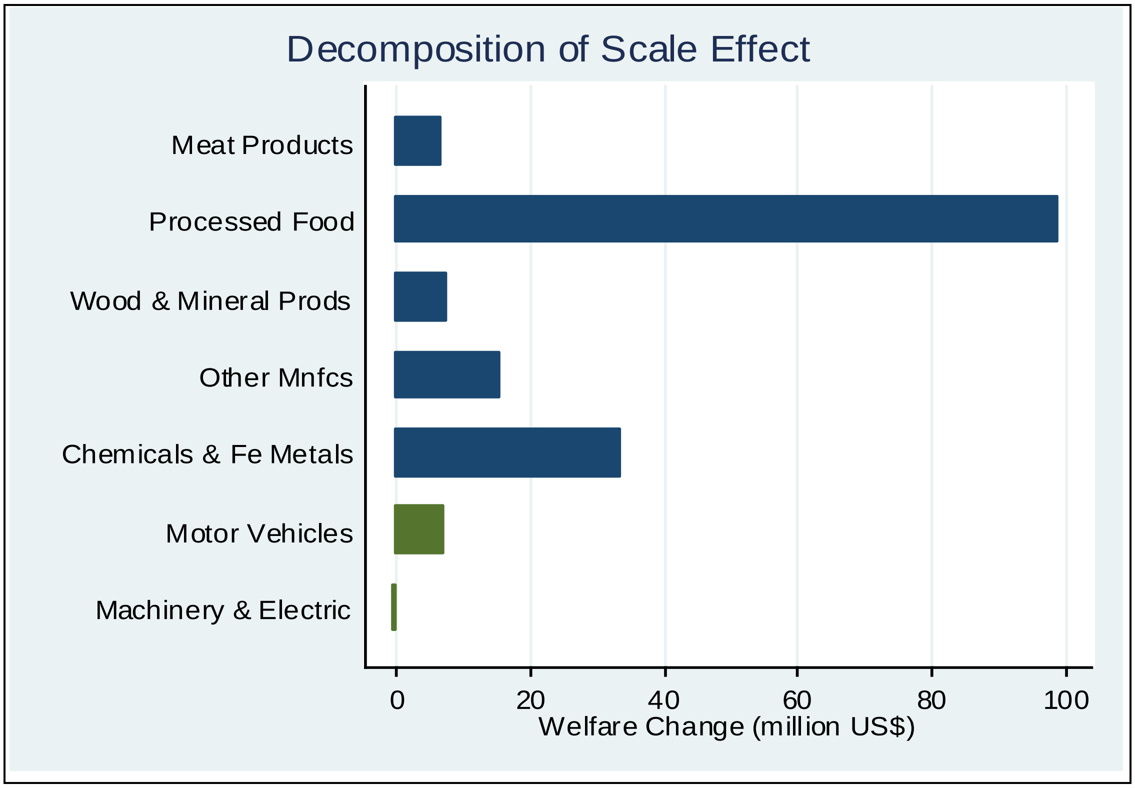

Figure 12: Decomposition of Welfare - Scale Effects

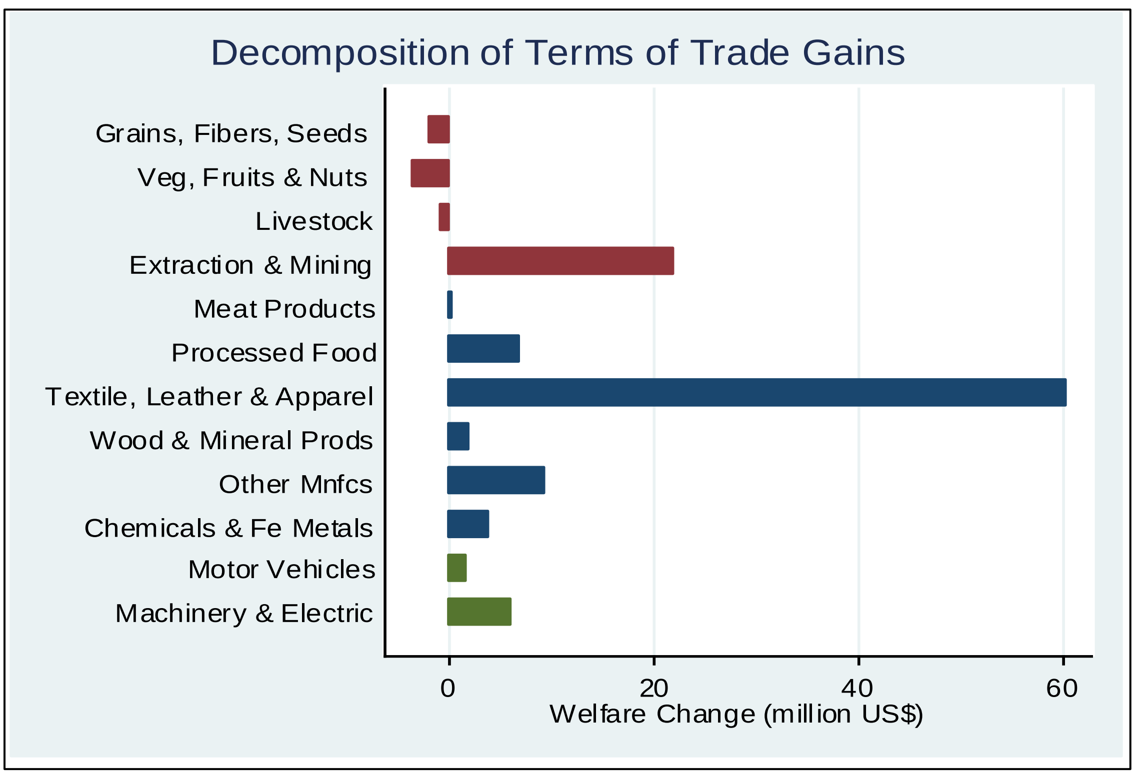

Figure 13: Decomposition of Welfare - Terms of Trade Gains

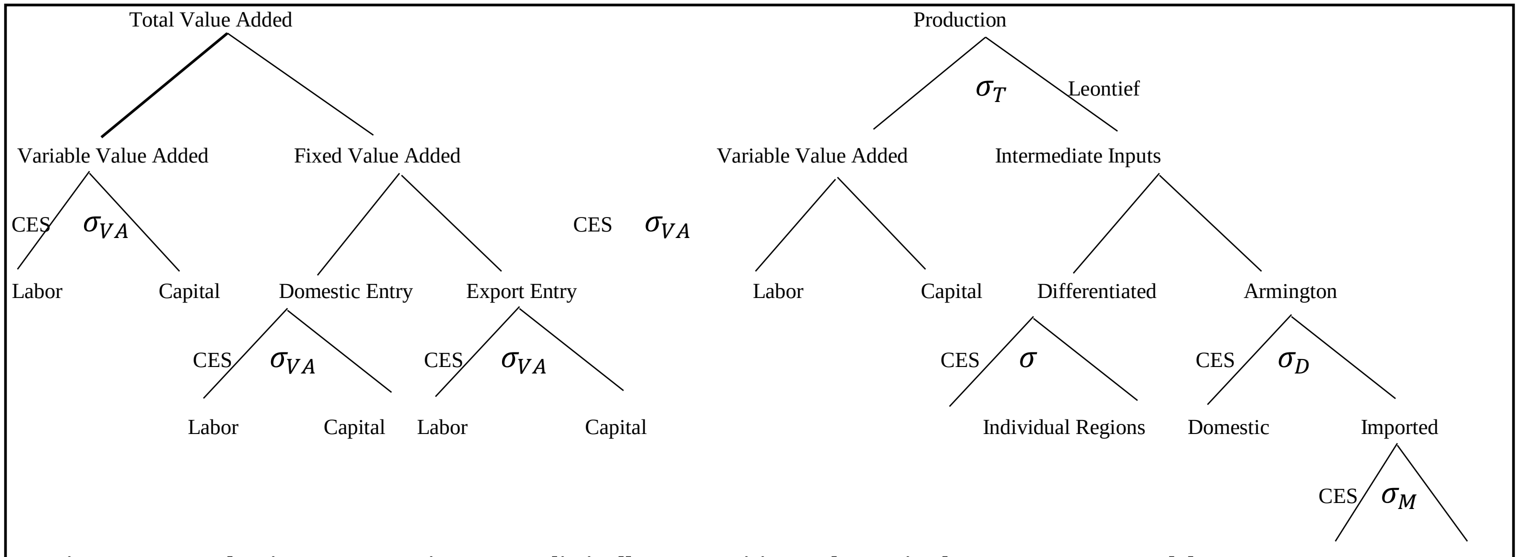

Figure 14. Production Structure in Monopolistically Competitive Industry in the GTAP-HET Model

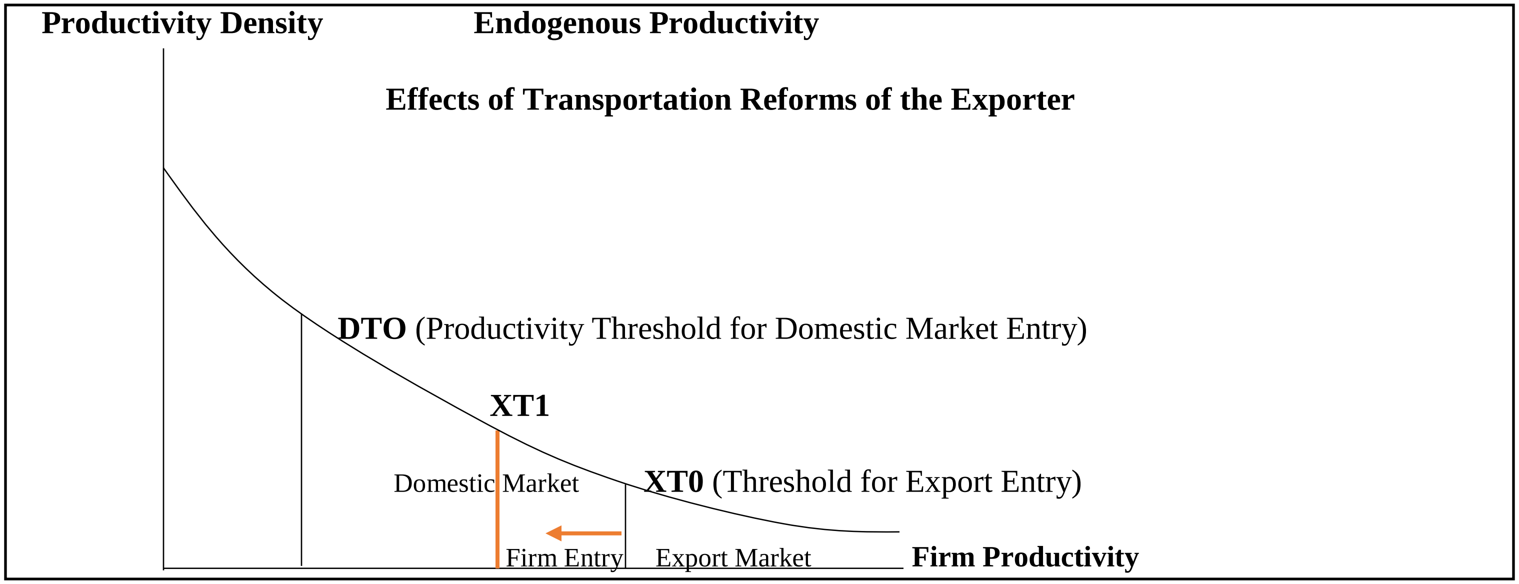

Figure 15. Effects of Trade Facilitation in the GTAP-HET Model