Effects of Trade on the United States Labor Market: Mobility and Market Structure[a]

ZEYNEP AKGUL[b], CAITLYN CARRICO[c], AND MARINOS TSIGAS[d]

Abstract: In this paper, we use a quantitative trade model to analyze the distributional effects of trade shocks across occupations in the United States (U.S.) under three different theoretical specifications of market structure and across a range of mobility assumptions based on a firm heterogeneity extension of the Global Trade Analysis Project (GTAP) Computable General Equilibrium (CGE) model (Hertel, 1997; Corong et al., 2017; Akgul et al., 2016). For the base specification, we use a framework of perfectly competitive firms and international trade at the bilateral country-level. For the first alternate specification, we introduce direct cross-border supplier-buyer linkages. For the second alternate specification, we additionally introduce monopolistic competition and heterogeneous firms. By considering a span of specifications, we can measure the difference which each successive theoretical innovation contributes to results.

JEL classification: C68, F12, F16, J31

Keywords: Global Supply Chains, Firm Heterogeneity, Labor, Occupation, Mobility, Wage

1. Introduction

As popular media highlights a backlash against globalization and trade, economic literature underscores the distributional effects of trade shocks on workers by skill, region, and time frame. In actuality, the extent to which workers are affected depends on the workers ability to adjust. In economic models, the extent to which we replicate trade shocks and their effects depends on theoretical specification of markets as well as implementation of worker mobility. In this paper, we use a quantitative trade model to analyze the distributional effects of trade shocks across occupations in the U.S. under three different market specifications and across a range of labor mobility assumptions.

---

[a] The views expressed in this paper are those of the authors alone and do not reflect the official view of the U.S. International Trade Commission, any of its Commissioners or the views of the OECD or of the governments of its member countries. The scenario analyzed in this paper is not directly related to a current policy initiative.

[b] Corresponding author: Post-doctoral Research Associate at the Center for Global Trade Analysis, Purdue University, 403 West State Street, West Lafayette, IN 47907 (zakgul@purdue.edu), Visiting Scholar at the U.S. International Trade Commission.

[c] Trade Policy Analyst and Economist, OECD (Caitlyn.Carrico@oecd.org)

[d] International Economist at the U.S. International Trade Commission, 500 E Street, SW, Washington, DC 20436 (marinos.tsigas@gmail.com).

For the base specification, we use a framework of perfectly competitive firms and international trade at the bilateral country-level. For the first alternate specification, we introduce direct cross-border supplier-buyer linkages. For the second alternate specification, we additionally introduce monopolistic competition and heterogeneous firms. By considering a span of specifications, we can measure the difference which each successive theoretical innovation contributes to results.

In each theoretical specification, we include heterogeneous workers which we distinguish by occupation. We use data from the U.S. Bureau of Labor Statistics and the U.S. Department of Agriculture to differentiate workers by occupation. For each specification, we alter elasticities governing labor mobility to analyze how labor adjustment contributes to results. We extend the GTAP data base to include twenty-two labor categories in the U.S. following Carrico and Tsigas (2014), while retaining the standard unskilled and skilled labor categories in the rest of the regions.

In this paper, we examine how trade shocks following a reduction in variable and fixed trade costs affect the U.S. labor market. With further economic integration workers in production occupations face the lowest gains from trade as import competition induces contraction in manufacturing sectors.

In the first alternate specification, we explore the compositional difference of fixed and variable costs of firms and its general equilibrium effects on the U.S. labor market. We contribute to this literature by taking firm heterogeneity and extensive margin effects prevalent in the manufacturing industry into account. For this purpose, we use the newly developed GTAP firm-heterogeneity model (Akgul et al., 2016), where we explicitly model monopolistic competition with heterogeneous firms based on the seminal work of Melitz (2003). In particular, the GTAP firm-heterogeneity model (i) accounts for fixed costs in domestic and export markets, (ii) traces out self-selection of firms into domestic and export markets based on productivity differences across firms, (iii) captures trade growth along the extensive margin, and (iv) incorporates consumer love-of-variety.

We assume that there are two types of fixed costs in the model: (i) sector-specific fixed set-up costs that firms face when entering the industry, (ii) source and destination specific fixed trading costs that firms face when they want to enter the domestic market or the export markets. In order to model and calibrate fixed costs, we assume that fixed costs are composed of value-added only - for example, capital and labor in manufacturing sectors (Akgul et al., 2016). These costs reflect the rents on capital utilized in the research and development of a unique product variety, or wages of professionals providing the services to comply with regulations of domestic and foreign markets. Based on this assumption, the value-added composite is split between fixed costs and variable costs. Therefore, a portion of factors are employed to cover fixed business costs and the rest is employed to cover variable costs.

The distinction between fixed and variable costs implies that the U.S. labor types introduced into the model and data base will have different consequences for extensive and intensive margins of trade. For example, legal occupations are more intensively employed in covering fixed business costs due to compliance with domestic and foreign rules and regulations in the heterogeneous industry, which is more about whether the firm can participate in the market rather than how much it can produce. Therefore, we expect the cost share of legal occupations to be larger in fixed costs than in variable costs. In addition, business and finance occupations as well as administrative support occupations are more intensively used in dealing with financial costs of starting up a business. Therefore, it is expected that legal, business and finance and administrative support occupations to have greater effects on the extensive margin of trade as opposed to the occupations that are more intensively used in variable costs of production. Our goal is to investigate the distinct factor composition of fixed and variable costs and its effects on the labor market.

We aggregate the model to seven regions (US, Japan, China, EU, Canada, Mexico, and Rest of the World), and six sectors using the GTAP 9 Data Base (Aguiar et al., 2016). We treat the light and heavy manufacturing sectors as monopolistically competitive with heterogeneous firms, while we retain the perfectly competitive structure as well as the Armington assumption in the rest of the sectors. Based on this aggregation, we explore the difference in labor composition of fixed and variable costs of firms and illustrate its effects on the U.S. labor market by examining a scenario where fixed costs in light and heavy manufacturing sectors are cut by 10% in the extended GTAP-HET model. In this model, reducing fixed costs implies an increase in the efficiency of inputs used in fixed business costs. This is an additional policy leverage introduced to the GTAP model in the context of firm heterogeneity. We center our discussion on the labor reallocation within the heterogeneous industries and labor employed to cover the fixed and variable costs of production.

Simulation results show that the policy-induced productivity changes have significant effects on prices, output and exports of light and heavy manufactures. In addition, they have significant effects on the demand for labor, where the mechanisms of change for labor demand differs between fixed and variable portions. Moreover, the fixed and variable portions respond in opposite ways in certain occupations, such as in production and architecture and engineering occupations.

2. Model and Data

2.1 Theoretical Model

We present a model of international trade with heterogeneous firms building on Melitz (2003). The model description follows from Akgul et al. (2015). Briefly, we consider the world to be composed of R countries, where we index exporters by $r = 1, 2, , R$ and importers by $s = 1, 2, , R$. Every country produces and consumes differentiated as well as homogeneous products. For the homogeneous goods industry, we retain the traditional assumption of national product differentiation (Armington, 1969) and the industry is characterized by perfect competition with constant returns to scale technology. On the other hand, we follow Melitz (2003) and assume that there are H differentiated industries indexed by $h = 1, 2, , H$. Each industry is composed of a continuum of firms where each firm produces a unique variety indexed by ω. Moreover, firms differ in their productivity levels and operate under monopolistic competition.

2.1.1 Consumers

We adopt a Dixit-Stiglitz treatment in the demand-side. In this setting, consumers are characterized by love-of-variety where they perceive each variety as a unique product and derive utility from that uniqueness. The utility function for the differentiated good h in country s, U_{hs}, is given by

$$U_{hs} = \left[\sum_r \int_{\omega_{hrs} \in \Omega_{hr}} q_{hrs}(\omega_{hrs})^{\frac{\sigma_h - 1}{\sigma_h}} d\omega_{hrs} \right]^{\frac{\sigma_h}{\sigma_h - 1}}, \tag{1}$$

where ω_{hrs} indexes the variety of good h imported by country s from the source country r, Ω_{hr} is the set of all varieties of good h available in country r, $q_{hrs}(\omega_{hrs})$ is the quantity demanded by a representative consumer in country s of variety ω_{hrs} of good h imported from country r and $\sigma_h > 1$ is the elasticity of substitution between the varieties of good h.

Let P_{hs} be the price index of good h in country s, i.e. the dual price index of the Dixit-Stiglitz composite of demand in equation (1), which is given by

$$P_{hs} = \left[\sum_r \int_{\omega_{hrs} \in \Omega_{hr}} p_{hrs}(\omega_{hrs})^{1-\sigma_h} d\omega_{hrs} \right]^{\frac{1}{1-\sigma_h}}, \tag{2}$$

where $p_{hrs}(\omega_{hrs})$ is the price in country s of variety ω_{hrs} of good h imported from country r (gross of trade costs). Based on these demand and price aggregates, we can find the demand for each variety of good h shipped from country r to s to be as follows:

$$q_{hrs}(\omega_{hrs}) = \frac{p_{hrs}(\omega_{hrs})^{-\sigma_h}}{P_{hs}^{1-\sigma_h}} Y_{hs}, \tag{3}$$

where Y_{hs} is the total expenditure in country s on industry h (equal to income in the relevant industry in country s)[1].

2.1.2 Producers

Producer behavior is based on Melitz (2003). In this setting, there are N_{hr} varieties of the differentiated good h produced in the exporting country r. A corollary to this is that there are N_{hr} active firms in the monopolistically competitive industry h in country r. Each firm produces a unique variety, ω, with different productivity, φ. In addition, varieties produced by firms in the exporting country r are distinct from the varieties produced by firms in the importing country s. Each country exports only a subset of its unique varieties because only some firms find it profitable to export into a given market. As a result, exports from country r to s includes only $N_{hrs} < N_{hr}$ varieties being shipped on the r-s trade route. This means that the total number of varieties of good h available to consumers in country s is N_{hs} domestic varieties plus $\sum_r N_{hrs}$ imported varieties.

[1] Please note that

$$Y_{hs} = P_{hs} U_{hs} = \int_{\omega_{hrs} \in \Omega_{hs}} p_{hrs}(\omega_{hrs})\, q_{hrs}(\omega_{hrs})\, d\omega_{hrs}$$

Firms in industry h incur variable and fixed costs of production and of exporting. There are two types of fixed costs: sunk-entry costs to produce in the domestic market and fixed export costs to enter export markets. Fixed export costs are source-destination specific and are assumed to be identical across firms on the same bilateral trade route. There are two types of variable costs: marginal cost of production and transportation costs for export shipments. We adopt the standard assumption of iceberg transportation costs, in which $\tau_{hrs} > 1$ units of good h must be shipped from country r in order for one unit of good h to arrive in country s.

The only type of cost that is firm-specific in this setting is the marginal cost of production which equals c_{hr} / φ_{hr} for an active firm in industry h of country r. Here, c_{hr} is the cost of the input bundle that is used for producing one unit of output in industry h of country r and φ_{hr} is the productivity of an active firm in industry h of country r which measures the amount of output produced by one bundle of input. Given the input bundle cost, let f_{hrs} measure the number of bundles that is used by firms in industry h to cover the fixed costs of exporting from country r to country s. Then, the fixed export costs on this particular bilateral trade route equals $c_{hr} f_{hrs}$.

The profit-maximizing price in a monopolistically competitive industry is a constant markup over marginal cost. Hence the delivered price in country s of the variety produced by a firm in country r with productivity φ is given by

$$p_{hrs}(\varphi) = \frac{\sigma_h}{\sigma_h - 1} \frac{\tau_{hrs} c_{hr}}{\varphi_{hrs}} \tag{4}$$

where $\frac{\sigma_h}{\sigma_h - 1}$ is the markup that decreases with a larger elasticity of demand. If preferences are more homogeneous (large σ_h), the industry becomes more competitive and firms have to charge a lower markup for their respective varieties. Using the profit maximizing prices in equation (4) and utility maximizing level of sales in equation (3), the profit from exporting $q_{hrs}(\varphi)$ units of good h into country s is found to be

$$\pi_{hrs}(\varphi) = \frac{p_{hrs}(\varphi)\, q_{hrs}(\varphi)}{\sigma_h} - c_{hr} f_{hrs} = \left[\frac{\sigma_h}{\sigma_h - 1} \frac{\tau_{hrs} c_{hr}}{\varphi_{hrs} P_{hs}} \right]^{1-\sigma_h} Y_{hs} - c_{hr} f_{hrs}. \tag{5}$$

Firm export participation is determined by the potential profit to be made in each bilateral market based on equation (5). Firm profit increases with market size in the destination country (Y_{hs}), lower marginal costs (c_{hr} / φ_{hr}), and lower barriers to trade (τ_{hrs} and f_{hrs}). Productivity level of the firm plays a key role in determining the potential profit to be made on a particular trade route based on fixed costs associated with exporting. Particularly, destination-specific fixed export costs limit the number of exporters from source country r since only the firms with high productivity levels can cover fixed export costs and make positive profits in the export market. The cutoff productivity level of exporting is destination-specific and is determined by the zero profit condition on each bilateral trade route. The revenue made by the marginal exporting firm is just enough to cover total costs of exporting and determines the productivity threshold. Let the productivity threshold for firms in industry h to export from country r to s be φ^*_{hrs}, which is governed by the following equation

$$\varphi_{hrs}^{*} = \frac{\sigma_h}{\sigma_h - 1} \frac{\tau_{hrs} c_{hr}}{P_{hs}} \left[\frac{c_{hr} f_{hrs}}{Y_{hs}} \right]^{\frac{1}{\sigma_h - 1}}. \tag{6}$$

Firms that have a higher productivity level than φ_{hrs}^{*} will successfully export on the *r*-*s* route, while the rest of the firms, which have lower productivity levels than φ_{hrs}^{*}, will only supply the domestic market. This self-selection mechanism determines the number of firms in export markets which can differ across destinations. As mentioned above only a subset N_{hrs} firms out of the total N_{hr} firms are able to export into country s and the mass of firms in this subset depends on the productivity distribution in the industry.

We assume that firm productivity follows the Pareto distribution with support $[\varphi_{\min}, \infty)$ and shape parameter γ_h that satisfies the condition $\gamma_h > \sigma_h - 1$. The associated density function, $g(\varphi)$, and cumulative distribution function, $G(\varphi)$, are then as follows:

$$g(\varphi) = \gamma \frac{\varphi_{\min}^{\gamma}}{\varphi^{\gamma+1}}, G(\varphi) = 1 - \left(\varphi_{\min}/\varphi\right)^{\gamma} \tag{7}$$

where $\varphi_{\min} \in [1, \infty)$ is assumed in this paper.[2] Given the productivity distribution, $1 - G\left(\varphi_{hrs}^{*}\right)$ measures the proportion of firms that have productivity levels higher than the threshold φ_{hrs}^{*}. Therefore, the fraction of active exporters to all firms in the industry N_{hrs}/N_{hr} equals $1 - G\left(\varphi_{hrs}^{*}\right)$.[3]

2.2 Labor Market in the GTAP Firm Heterogeneity Model

In the first alternate specification we use the firm heterogeneity model of GTAP (GTAP-HET) developed by Akgul et al. (2016). The standard GTAP model (Hertel, 1997) is extended in the GTAP-HET model to incorporate monopolistic competition and heterogeneous firms. In particular, GTAP-HET endogenously determines changes in the total factor productivity of industries through the response of productivity thresholds to policy changes. In addition, GTAP-HET captures extensive margin effects through firm entry/exit to domestic and export markets.

Figure 1 illustrates the structure of production and fixed costs in the monopolistically competitive industry with heterogeneous firms in the GTAP-HET model. The solid lines specify CES nests, while the dashed lines distinguish between the respective types of the top level variables.

Production (`QO(j,r)`) in the heterogeneous sector industry uses intermediate inputs and variable value-added in a Leontief nest as depicted in Figure 1. A distinct feature of the production structure is the difference between fixed and variable costs. Firms invest in research and develop-

[2] Helpman et al. (2008) uses a truncated Pareto distribution by imposing upper and lower bounds to productivity. The reason for these bounds is to construct a model that can explain zero trade flows in the country level data with firm behavior. But, using a truncated Pareto distribution brings about nonlinearities into the model which we do not attempt to solve in this paper. For analytical tractability purposes we choose to impose only a lower bound for productivity. An implication of this assumption is that because there is a continuum of firms in the industry, there is a positive mass of exporters for all country pairs as noted in Head and Mayer (2014).

[3] This follows from $N_{hrs} = \int_{\varphi_{hrs}^{*}}^{\infty} N_{hr} g(\varphi) d\varphi$

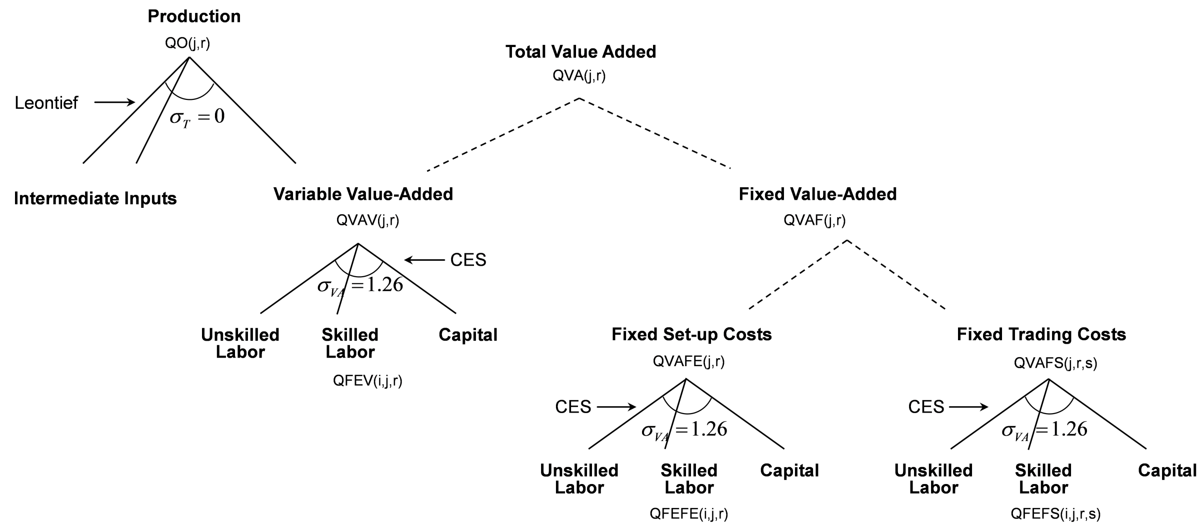

Figure 1. Production Tree and Value-Added in the Monopolistically Competitive Sector in GTAP-HET

Source: Adapted from Figure 1 in Akgul et al. (2016).

ment as well as advertising and distribution in order to differentiate their varieties for domestic and export markets. They learn about the rules and regulations on shipping, packaging, and labeling specific to each market they plan to supply. They adapt their production lines to ensure that their products are in line with the market regulations. Each of these activities requires the employment of labor and capital.

In GTAP-HET fixed costs are assumed to be attributed solely to non-traded primary factors. This is illustrated in Figure 1 with dashed lines, where a portion of the value-added is utilized in fixed costs (`QVAF(j,r)`, henceforth fixed value-added), for market entry, while the rest of the value-added is utilized in variable costs (`QVAV(j,r)`, henceforth variable value-added) for production. Variable value-added is used in production and therefore is proportional to output such that demand for variable value-added increases as firms expand production. On the other hand, fixed value-added is invariant to how much a firm produces.

There are two types of fixed costs at the firm level in a heterogeneous industry: (i) fixed costs to enter into the industry (`QVAFE(j,r)`), i.e. "fixed set-up costs", and (ii) fixed costs to enter bilateral markets (`QVAFS(j,r,s)`), i.e. "fixed trading costs". This is shown at the bottom level of the tree in Figure 1 where both set-up and trading components of fixed value-added are CES functions of labor and capital.

In GTAP-HET the labor/capital intensity in fixed and variable value-added composites is assumed to be the same (Akgul et al., 2016). In addition, the substitution elasticity between primary factors, σ_{VA} (`ESUBVA(j)` in GTAP), is identical in each value-added nest. These simplifying assumptions are partly due to a lack of data availability pertaining to the composition of fixed costs as opposed to variable value-added. In this paper, we distinguish between the composition of fixed and variable value-added in the light and heavy manufacturing industries in the U.S. and we map the compositional difference to the 22 labor occupations incorporated in the data base.

2.3 Data

We calibrate the model to the GTAP Version 9 Data Base (Aguiar et al., 2016) with base year 2011. GTAP 9 Data Base identifies 140 regions with 57 sectors and 8 factors. In order to illustrate the effect of fixed costs on labor in U.S. manufacturing, the number of regions has been aggregated into six single countries and one aggregated region as presented in Table 1. There are six aggregated sectors in the model with light manufactures and heavy manufactures characterized as monopolistically competitive with heterogeneous firms. The rest of the sectors in the aggregation are treated as perfectly competitive with identical firms. The sectoral mapping of the six aggregated sectors to the 57 GTAP sectors is provided in the appendix in Table A.1.

Table 1. Sectors and Regions in the Aggregated Version

Sectors	Regions
Agriculture	U.S.
Extraction	Japan
Textiles and Wearing Apparel	Canada
Light Manufactures	Mexico
Heavy Manufactures	China
Services	Europe
	Rest of the World

In order to implement the new aggregation to the GTAP-HET model, the aggregated data base needs to be compatible with the firm heterogeneity model. As a result, we transform the new aggregation of the standard GTAP Data Base to a Multi-Region Input-Output (MRIO) Data Base by sourcing each imported commodity to the GTAP agents of firms, private household, and government. For sourcing, we use the import share of each source country in the import bill of each destination country following Swaminathan and Hertel (1996) and Akgul et al. (2016), while retaining the underlying values of the standard GTAP Data Base. Sourcing of imports to agents is required in GTAP-HET as each source-destination pair corresponds to a particular set of firms from the source country, specifically the firms that can export since they are more productive than the threshold level. By transforming the data base, we can track these particular exporters to each agent and capture the impact of the extensive margin on demand for imports by agent.

The GTAP 9 Data Base identifies eight primary factors, of which there are five labor categories. In this paper, we extend the data base beyond the five labor categories and disaggregate the labor data in the U.S. into 22 occupations following Carrico and Tsigas (2014) based on the labor shares developed by Carrico et al. (2012). Using these labor shares, the labor payments in the current GTAP 9 Data Base is allocated to 22 occupations for the U.S. only. The employment and wage data for manufacturing and services are based on the Bureau of Labor Statistics (BLS) Occupational Employment Statistics (OEM) survey, for May 2007. The labor data for agriculture is based on the 2007 Census of Agriculture from the U.S. Department of Agriculture (2012). Table 2 lists the 22 occupations focused in this paper. The labor market extension is carried out only for the U.S., while the standard GTAP data base treatment of using eight primary factors is applied to the rest of the regions in our aggregation.

Table 2. Standard Occupational Classification (SOC) Groups and Cost Category

SOC Group	SOC Code	Description	Cost Category
11	management	Management Occupations	Fixed and Variable
13	bus_finance	Business and Financial Operations Occupations	Fixed and Variable
15	comp_math	Computer and Mathematical Occupations	Variable
17	arch_enginr	Architecture and Engineering Occupations	Fixed and Variable
19	sciences	Life, Physical, and Social Science Occupations	Variable
21	social_serv	Community and Social Service Occupations	Variable
23	legal	Legal Occupations	Fixed and Variable
25	education	Education, Training, and Library Occupations	Variable
27	entertain	Arts, Design, Entertainment, Sports, and Media Occupations	Variable
29	health_prac	Healthcare Practitioners and Technical Occupations	Variable
31	health_sup	Healthcare Support Occupations	Variable
33	protective	Protective Service Occupations	Variable
35	food_service	Food Preparation and Serving Related Occupations	Variable
37	build_maint	Building and Grounds Cleaning and Maintenance Occupations	Variable
39	pers_care	Personal Care and Service Occupations	Variable
41	sales	Sales and Related Occupations	Variable
43	admin_supp	Office and Administrative Support Occupations	Fixed and Variable
45	farm_occup	Farming, Fishing, and Forestry Occupations	Variable
47	constructn	Construction and Extraction Occupations	Variable
49	maint_repr	Installation, Maintenance, and Repair Occupations	Variable
51	production	Production Occupations	Fixed and Variable
53	transport	Transportation and Material Moving Occupations	Variable

Source: Adapted from Table 1 in Carrico and Tsigas (2014) that is based on May 2007 Bureau of Labor Statistics (BLS) Occupational Employment Statistics (OES) Survey.

2.4 Composition of Fixed Business Costs

While there are a few studies regarding the labor market in general equilibrium (Dixon et al., 2013) and under firm heterogeneity (Luong and Chen, 2016), there is a lack of information in the empirical trade literature on the nature and magnitude of fixed business costs. In general, fixed business costs are often considered as the upfront investment costs that firms have to incur in order to start a business. A study by Kneller and Pisu (2011) provides details as to the nature and magnitude of fixed costs associated with exporting. In particular, they investigate fixed export costs based on a survey conducted by the U.S. Office of Management and Budget between May and July 2005. In the survey, firms were asked about the difficulties they faced when exporting overseas. There are three groups of issues that are indicated as barriers to exporting: (i) networks and marketing, (ii) procedural and exchange rates, and (iii) cultural. The fixed costs under the networks and marketing group include, obtaining basic information about an export market, identifying who to make contact with in the first instance, building relationships with key influencer or decision-makers, establishing an initial dialog with prospective customers or business partners, and marketing costs associated with doing business in an overseas market. The fixed costs under the procedural and exchange rates group include dealing with legal, financial, and tax regulations and standards overseas, logistical problems, exchange rates, and foreign currency. Finally, the fixed costs under the cultural group include language barriers, cultural differences, not having an office or site in an export market, and a bias or preference on the part of overseas customers for doing business with firms established in their own country. Although these categories are listed as barriers to exporting in Kneller and Pisu (2011), it can be argued that firms also face similar challenges to enter into the industry.

While these categories provide a broad idea about what fixed business costs are, it is challenging to map them to factors of production and estimate their magnitude. In this paper, we map fixed costs to twenty-two occupations, by using the information provided in a survey conducted by the U.S. Office of Management and Budget (OMB) on National Association of Manufacturers (NAM) members between March 24, 2014, and April 7, 2014. The goal of the survey was to evaluate the effect of federal regulations on U.S. manufactures. A report by Crain and Crain (2014) for NAM summarizes the findings of the survey and estimates the costs of U.S. federal government regulations.

A notable feature of the survey is that it breaks down the direct cost of complying with federal regulations into its components, which provides the information on how much of the costs are due to labor and capital payments. The survey further allows for a break down of labor payments of regulatory compliance costs by occupation. We use this information to determine the factor composition of fixed business costs and map these costs to payments to capital as well as payments to capital labor by occupation.

The survey results indicate that labor payments contribute the most to the total direct cost of regulation in U.S. manufactures. In particular, out of the nine categories of regulatory compliance costs, respondents of the survey ranked labor as the highest cost regulations. The survey results

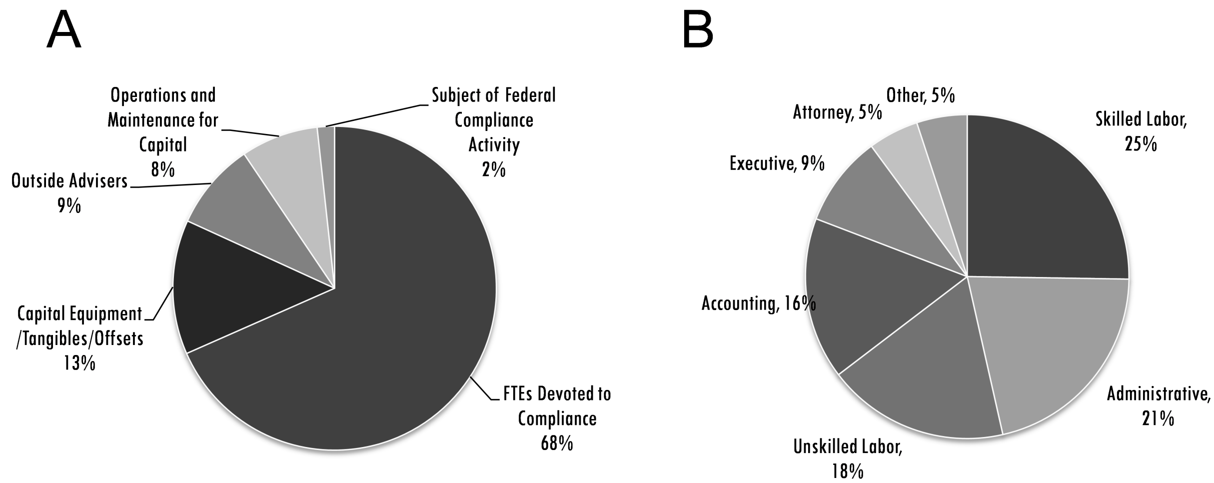

Figure 2. Distribution of Costs of Complying with U.S. Regulations in Manufacturing. (A) Estimates of Direct Regulatory Costs on U.S. Manufactures (B) Estimates of In-House Labor Costs Devoted to Regulatory Compliance on U.S. Manufactures by Occupation.

Source: Adapted from Chart 8 and Chart 15 of 2014 survey by The U.S. Office of Management and Budget (OMB) on members of National Association of Manufacturers (NAM) reported in Crain and Crain (2014).

further suggest that regulatory compliance costs in the manufacturing sector amounts to $138.6 billion in the year prior to the survey (Crain and Crain, 2014). While there are other additional costs not included in this total, we only focus on the decomposition of this regulatory compliance cost in this paper.

The decomposition of the cost is presented in Figure 2A, where there are five categories. It is observed that 68% of the direct regulatory cost estimate is due to in-house full-time equivalents (FTEs) devoted to compliance, i.e. payments to labor employed within the firm to perform tasks to ensure compliance with the regulations. It is followed by capital equipment, tangibles and offsets, which makes up 13% of the estimate. The rest is outside advisers with 9%, operations and maintenance for capital with 8%, and subject of federal compliance activity with 2%. The largest cost category is the labor payments (FTEs in the figure).

Figure 2B further breaks down the in-house FTEs to occupational categories. Respondents of the survey indicated that 25% of the time spent on compliance activities are by skilled labor, 21% is administrative, 18% is unskilled labor, 16% is accounting, 9% is executive, 5% is attorneys and the rest 5% is other occupational categories. The occupational categories are more specific in Figure 2B than the 22 occupations listed in Table 2. Crain and Crain (2014) map the occupations in Figure 2B to broader categories in order to estimate annual wages. In their report, skilled and unskilled labor are mapped to "production occupations", executives are mapped to "top executives", attorneys are mapped to "lawyers", administrative is mapped to "administrative service managers", accounting is mapped to "accountants and auditors" and other is mapped to "all occupations".

We adjust their mapping based on the nature of fixed business costs and on the 22 occupational categories in our study. In this paper, skilled and unskilled labor are mapped to "production occupations", attorneys are mapped to "legal occupations", executives are mapped to "management occupations", administrative is mapped to "office and administrative support occupations", accounting is mapped to "business and finance occupations" and other is mapped to "architecture and engineering occupations".

Table 3. Labor Categories Devoted to Fixed Costs in the U.S. and non-U.S. Manufacturing Sector

Fixed Costs in U.S. Manufactures	**GTAP Code**
Management Occupations	management
Business and Financial Operations Occupations	bus_finance
Architecture and Engineering Occupations	arch_enginr
Legal Occupations	legal
Office and Administrative Support Occupations	admin_supp
Production Occupations	production
Fixed Costs in non-U.S. Manufactures	**GTAP Code**
Unskilled Labor	UnSkLab
Skilled Labor	SkLab

We map executives to management occupations, i.e. "management", which are comprised of workers who plan, coordinate, and direct operational activities of firms to establish business contacts and build relationships in the market. We map accounting to business and financial operations occupations, i.e. "bus_finance". This category encompasses accountants, financial analysts, and compliance officers among others. Accountants and financial analysts prepare financial statements and provide advice on firm's budget by analyzing accounting records. Compliance officers investigate conformity with laws and regulations in a market and performs compliance and enforcement inspection. These tasks are also carried out by attorneys. We map attorneys to legal occupations, i.e. "legal", who deal with legal, financial, and tax regulations and standards in domestic and overseas markets. Tasks related to obtaining basic information in markets, overcoming bureaucratic barriers and performing the necessary communication and paper work are considered as administrative tasks which are mapped to office and administrative support occupations, i.e. "admin_supp". In addition to all these tasks, starting a business requires setting up the production line and undertaking the actual compliance to standards which are performed by unskilled and skilled labor. There may also be tasks performed on a regular basis such as crating, packing, storage etc. (Castro et al., 2016). We map these labor category to production occupations, i.e. "production". Although production workers are employed, it does not mean that fixed costs vary with production. The tasks that production workers perform under fixed costs have no effect on output. It only affects whether a firm participates in the market or not. Finally, the "other" category in Crain and Crain (2014) is mapped to architecture and engineering occupations, i.e. "arch_enginr", in this paper. This category is associated with the research and development activities undertaken to invent new products and distinguish them in different markets.

Using this mapping, we sum the estimate of labor and capital payments for complying with domestic regulations found in Crain and Crain (2014). Then, we use the shares given in Figure 2 to obtain the estimate of labor payments to each occupation in fixed costs. Based on the labor payments to each occupation and capital costs, we recalculate the shares of each factor in fixed costs. This calculation results in the factor shares in Figure 3. We find that 36% of the fixed costs is payments to production workers, 18% is administrative support, 16% is capital, 13% is business and finance, 8% is management, 5% is architecture and engineering, and 4% is legal. We use the shares in Figure 3 to distinguish the composition in fixed set-up costs as well as fixed export costs from variable costs of production in the US.

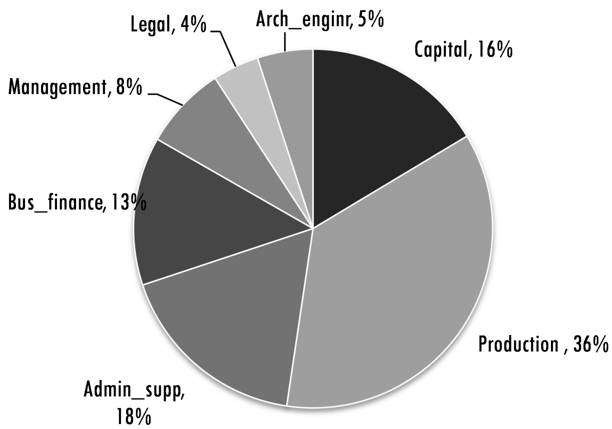

Figure 3. Factor Composition of Fixed Costs of Market Entry

Source: Author calculations based on information in Crain and Crain (2014).

For the non-U.S. regions, we retain the standard GTAP primary factors, namely unskilled and skilled labor. Therefore, in non-US regions both the fixed and variable value-added are composed of unskilled and skilled labor as well as capital. The compositions of the fixed and variable portions are assumed to be the same.

2.5 Modified Labor Market in GTAP-HET

The modified production tree and fixed cost specification in the U.S. with new labor categories and factor composition are illustrated in Figure 4. Production follows the same nesting as in Figure 1. The main difference incorporated in the model is the compositional change between fixed and variable value-added. All the occupations listed in Table 2 are used in the variable value-added for actual production. However, fixed cost nests only employ the six occupations listed in Table 3 and capital. Moreover, the intensity of labor/capital based on the new occupations in fixed costs is as given in Figure 3.

3. Policy: Impact of Reduced Regulations in the U.S.

To illustrate how the compositional difference between fixed and variable value-added affects the labor market, we examine a scenario of a 10% cut in U.S. fixed set-up costs to enter the light and heavy manufacturing sectors. In the GTAP-HET model, this policy is administered as a technical change, where the shock corresponds to a 10% decrease in the required amount of primary factors (i.e. efficiency of inputs) that are used in covering fixed set-up costs.

Figure 5 shows the percentage change in U.S. output and supplier price in each sector as a result

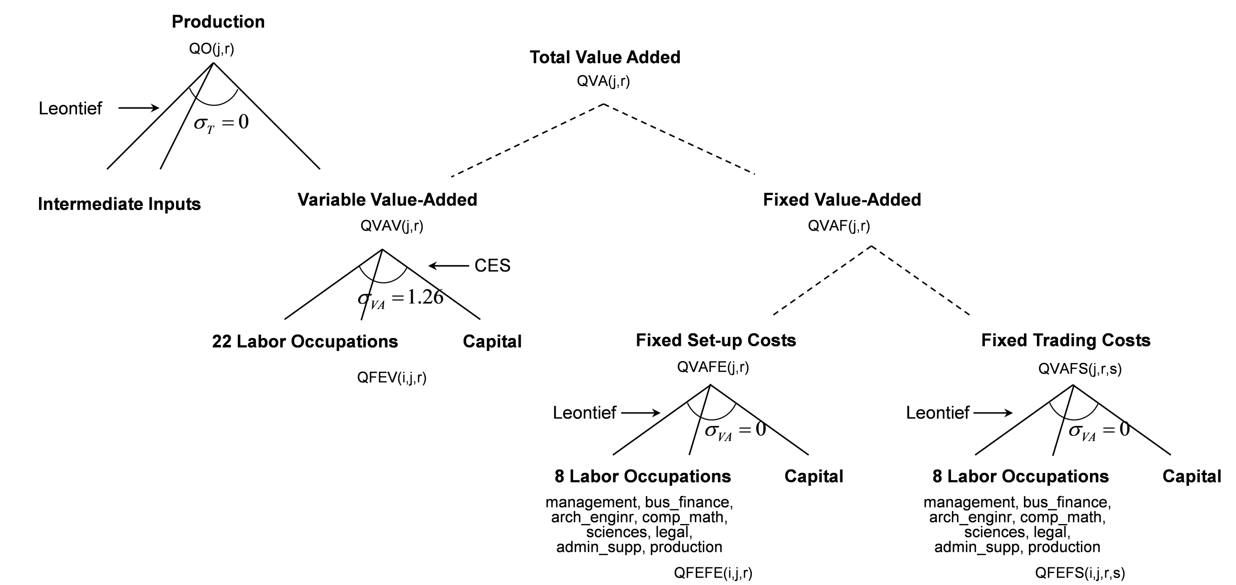

Figure 4. Modified Production Tree and Value-Added with Changed U.S. Labor Categories

of lower fixed set-up costs. We observe that only the light manufacturing and services sectors expand, while the rest of the sectors contract. Moreover, we observe that the supplier prices in the light and heavy manufacturing sectors decrease as a result of the shock. These changes can be best explained by tracing the effects of lower fixed costs on productivity thresholds and average industry productivity.

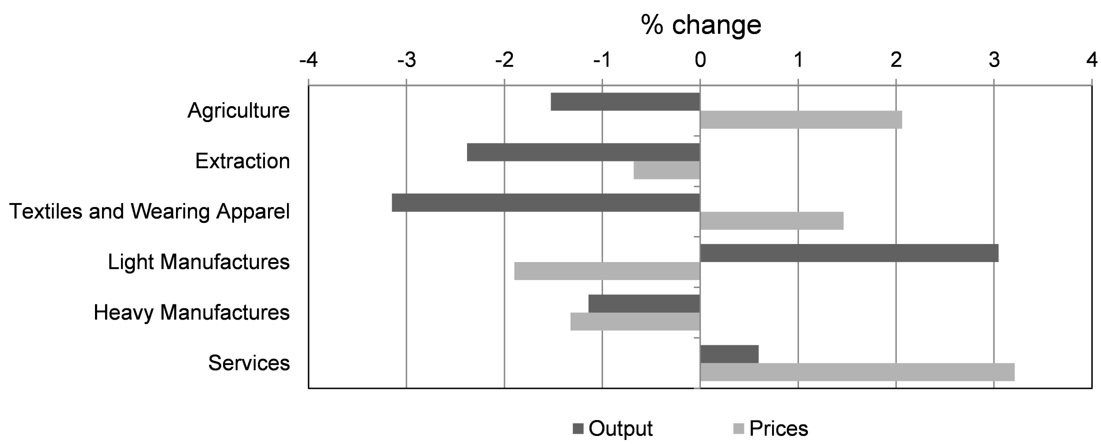

Figure 5. Percent Changes in Output and Prices in the U.S.

Source: Author calculations based on simulation results.

Figure 6 focuses on the light and heavy manufacturing sectors and presents the changes in productivity thresholds for U.S. firms to enter into each destination market, number of active U.S. firms in corresponding markets, and the U.S. sales to those markets. We observe that the fixed cost shock increases all productivity thresholds, to enter the domestic market as well as export markets. It is tempting to expect the domestic productivity threshold to decrease with lower fixed set-up costs. However, this expectation does not take the general equilibrium effects into account. Due to higher wages and lower supplier prices, the profitability in the industry declines and raises the domestic productivity threshold despite lower fixed costs. As a result, the number of U.S. producers in the light and heavy manufacturing sectors decreases with less productive firms dropping out, as shown in Figure 6.

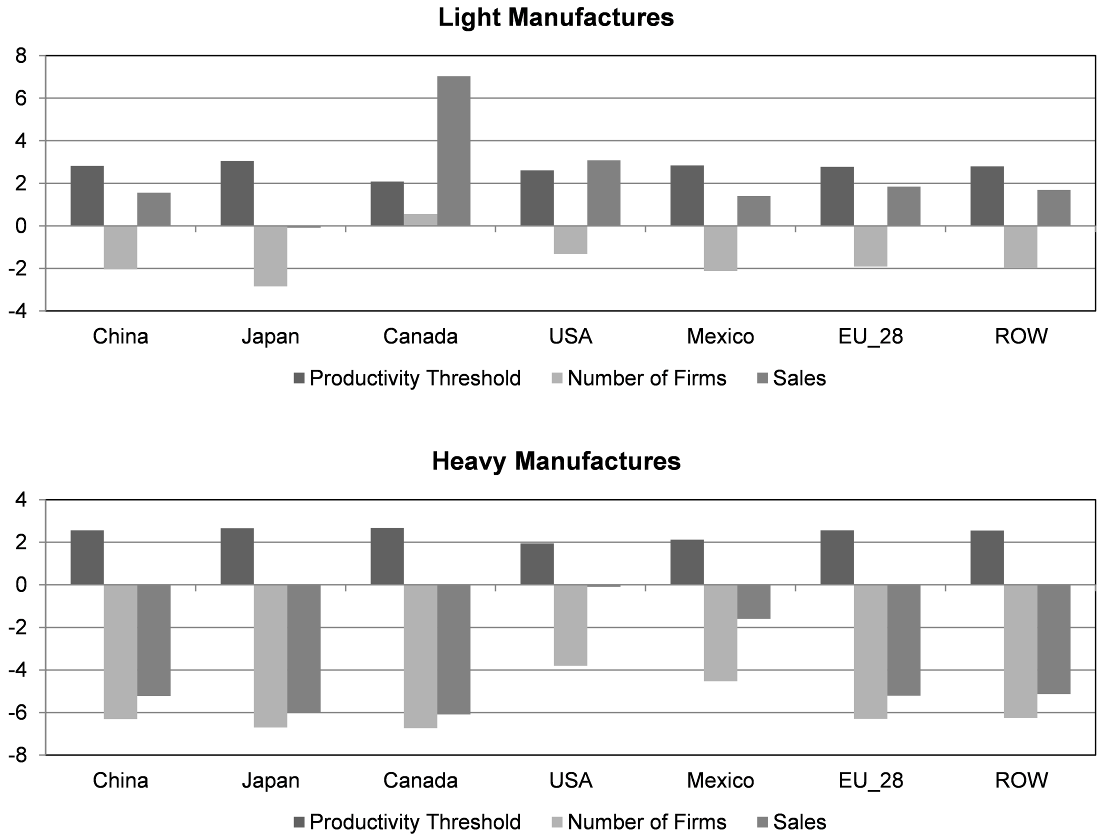

Figure 6. Percent Changes in Productivity Threshold, Number of Firms, and Sales from the U.S. in Light and Heavy Manufactures

Source: Author calculations based on simulation results.

The increase in thresholds also applies to the export markets, where both the light and heavy manufacturing sectors experience an increase in thresholds to sell in all destinations, resulting in a drop of the number of U.S. firms selling to those destinations. The only exception to this result is the number of U.S. firms in the light manufacturing sector exporting to Canada. We observe that, despite the higher productivity threshold, the number of U.S. exporters to Canada increases. Due to lower prices as shown in Figure 5, the U.S. light manufactures are more competitive in export markets, especially in Canada where the majority of the U.S. light manufactures are used in the Canadian heavy manufacturing industry. This higher demand results in a lower increase in the productivity threshold relative to other destinations and attracts more U.S. firms into the Canadian market.

Figure 6 shows that the sales of U.S. light manufactures increases in all regions despite the decreasing number of U.S. exporters. In fact, the surviving exporters expand their scales to satisfy the increasing demand, resulting in their fixed costs being spread over more output. As a result, the profits of high productivity firms increase at the expense of low productivity firms in the light manufacturing sector.

As the least productive firms contract and exit the market, more productive firms survive and expand, increasing their market shares. Consequently, the overall productivity in the light manufacturing sector increases. This is depicted in Figure 7. Higher productivity leads to lower average variable costs, which is the reason why the supplier price decreases in the light manufacturing sector as shown in Figure 5.

While similar changes in productivity and prices are observed in the heavy manufacturing sector, there are a number of differences in production and sales. Foreign demand for the U.S. heavy manufacturing goods decreases which results in a contraction in the U.S. heavy manufacturing sector. Since Canadian manufactures become more competitive compared to the U.S., foreign markets switch to Canadian heavy manufacturing goods.

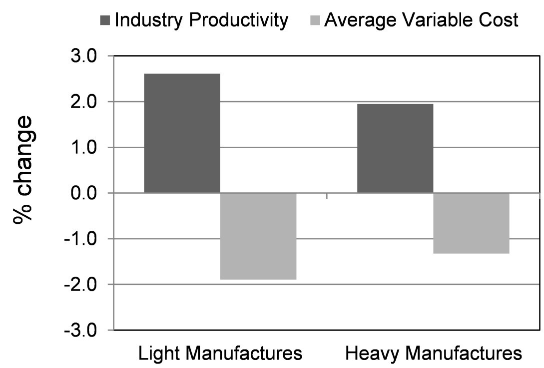

Figure 7. Percentage Change in Industry Productivity in Light and Heavy Manufactures in the U.S.

Source: Author calculations based on simulation results.

Figure 8 shows simulated wage results in the U.S. for the twenty-two occupations. Upon the fixed cost cut, wages of twenty one occupations increase, while wages of production workers decrease slightly. The twenty-one occupations are mostly employed in the services sectors and experience wage increase as a result of sector expansion. On the other hand, the production occupation is mostly employed in the heavy manufacturing sector, specifically 38% of the payments to labor in production occupation are from the heavy manufacturing sector in the U.S.. Therefore, the contraction in the heavy manufacturing sector causes the wages of production workers to decrease.

Table 4 presents the effect of reducing fixed set-up costs on the demand for all labor occupations in U.S. light and heavy manufacturing sectors. We observe that labor demand for the majority of the occupations in the light manufacturing sector decreases. For the occupations that are only involved in the actual production of light manufactures, the demand decline is entirely due to the variable portion of labor demand. For the occupations that are involved in firm entry into the

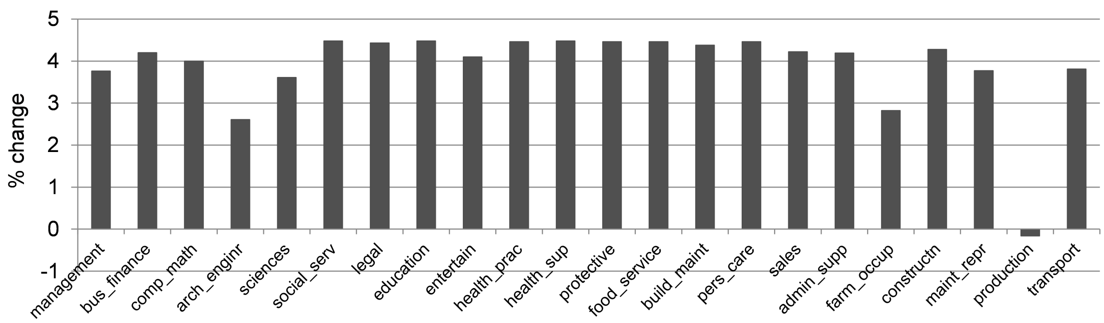

Figure 8. Percent Changes in Wages in the U.S.

Source: Author calculations based on simulation results.

industry as well as production, we observe that both the variable and fixed portions contribute to the reduced labor demand in light manufactures.

It is appealing to think that the variable portion of demand change should be positive since the light manufactures sector expands. While the expansion effect on labor demand is indeed positive, what drives the decline in the variable portion is the negative substitution effect due to higher wages. As wages increase relative to the price of total value-added, firms substitute away from these occupations in light manufactures.

In contrast, there is no substitution effect in the fixed portion nest due to the Leontief assumption. There are two components that affect the fixed portion of labor demand: (i) the efficiency of labor that is employed to cover fixed costs and (ii) the number of firms that incur fixed costs. The contribution of the former component is negative. In GTAP-HET, the efficiency of labor in fixed costs is captured by a technical change variable, which is the same variable that we used to implement the fixed cost shock. We decreased the fixed costs in light manufactures by increasing the efficiency of labor employed in fixed costs. As a result, there is less demand for labor in covering fixed costs.

The contribution of the latter component to fixed portion of labor demand is positive, as there are more firms that pay the initial fixed costs following the shock. While these firms commit their workers to covering fixed costs, they eventually find it too costly to produce. Despite the positive effect of the number of firms on labor demand, the negative effect of the shock dominates, culminating in a decrease in the fixed portion of labor demand in light manufactures.

It is important to note that the change in fixed portion of demand for labor in the light manufacturing sector is the same across occupations that are employed in fixed costs. They all decrease by 1.35%.This is due to the Leontief assumption, where there is no substitution between primary factors. Since there is no substitution effect for fixed costs and the other two effects are the same across occupations, the fixed portion changes by the same percentage for the six occupations.

There are three occupations, namely architecture and engineering, production, and farming, fishing, and forestry, that stand out in light manufactures with different fixed and variable portion contributions deviating from the rest of the occupations. This difference stems from the positive changes in the variable portion of labor demand.

Table 4. Percentage Change in Input Demand by Occupation: Variable and Fixed Components

	Light Manufacturing			Heavy Manufacturing		
Factor Demand	**Total**	**Variable**	**Fixed**	**Total**	**Variable**	**Fixed**
management	-1.19	-1.01	-1.35	-4.56	-4.25	-4.81
bus_finance	-1.38	-1.54	-1.35	-4.80	-4.76	-4.81
comp_math	-1.29	-1.29		-4.52	-4.52	
arch_enginr	-0.60	0.39	-1.35	-3.88	-2.89	-4.81
sciences	-0.83	-0.83		-4.07	-4.07	
social_serv	-1.86	-1.86		-5.07	-5.07	
legal	-1.36	-1.80	-1.35	-4.81	-5.02	-4.81
education	-1.86	-1.86		-5.07	-5.07	
entertain	-1.41	-1.41		-4.64	-4.64	
health_prac	-1.84	-1.84		-5.06	-5.06	
health_sup	-1.86	-1.86		-5.07	-5.07	
protective	-1.84	-1.84		-5.05	-5.05	
food_service	-1.84	-1.84		-5.05	-5.05	
build_maint	-1.74	-1.74		-4.96	-4.96	
pers_care	-1.84	-1.84		-5.06	-5.06	
sales	-1.56	-1.56		-4.78	-4.78	
admin_supp	-1.39	-1.52	-1.35	-4.80	-4.75	-4.81
farm_occup	0.13	0.13		-3.14	-3.14	
constructn	-1.63	-1.63		-4.85	-4.85	
maint_repr	-1.02	-1.02		-4.26	-4.26	
production	0.67	3.91	-1.35	-3.23	0.51	-4.81
transport	-1.07	-1.07		-4.30	-4.30	

Source: Author calculations based on simulation results.

While demand for the architecture and engineering occupation in the light manufacturing sector declines (-0.60%) in a way similar to the discussion above, the driving force in this case is the negative fixed portion rather than the variable portion. In fact, labor demand for the variable portion increases (0.39%) as a result of the expansion in light manufactures. Since the wage increase for architecture and engineering is relatively low compared to the rest of the occupations, the negative substitution effect is dominated by the positive expansion effect in the variable portion. On the other hand, the contribution of the fixed portion is negative (-1.35%) and it determines the total demand for architecture and engineering in light manufactures. Since architecture and engineering workers become more efficient as a result of the fixed cost shock, demand for architectures and engineers decreases in the fixed portion.

The production occupation stands out as the total demand for it increases in light manufactures (0.67%). Despite the decrease in the fixed portion (-1.35%), there is a significant increase in the variable portion (3.91%) which drives the total demand for production occupation in this sector. As shown in Figure 8, the wage for production workers decreases relative to other occupations, which makes the production workers more competitive against other occupations in production of light manufactures. As a result, the substitution effect is positive as well as the expansion effect in the variable portion of demand for production workers.

The farming, fishing, and forestry occupation also stands out with an increase in demand (0.13%). Since this occupation is only employed in the variable portion, the increase in labor demand is entirely due to the expansion of the light manufactures sector.

In heavy manufacturing, the contraction of the sector results in lower demand for all occupations. Both the fixed and variable portions have a negative impact on the total demand for occupations. A notable difference is that the magnitudes are much larger than in the light manufacturing sector. The larger magnitude in the variable portion of labor demand is due to the fact that contraction in heavy manufactures contributes to the negative substitution effect. On the other hand, larger magnitude in the fixed portion of labor demand is due to the modest increase in the number of firms that pay the fixed costs relative to the shock.

In a way similar to the light manufacturing sector, the production occupation stands out due to the increase in demand for the variable portion (0.51%), while the fixed portion is negative (-4.81%). However, unlike in the light manufactures sector, the increase in the variable portion is not sufficient to overcome the decrease in demand for the fixed portion. As a result, the total demand for production occupation decreases in the heavy manufacturing sector (-3.23%).

4. Concluding Remarks

In this paper we provide a closer look at the labor composition of fixed business costs and expand the GTAP firm heterogeneity model to include twenty-two labor occupations in the United States. We, then, illustrate the effect of fixed costs on the U.S. labor market by examining a scenario where fixed costs in light and heavy manufacturing sectors are cut by 10%. We observe that the policy-induced productivity changes have significant effects on prices, output and exports of light and heavy manufactures. In addition, they have significant effects on the demand for labor, where the mechanisms of change for labor demand differs between fixed and variable labor costs. Moreover, fixed and variable labor costs may respond in opposite ways in certain occupations, such as in production and architecture and engineering occupations.

The potential differences of factor composition in fixed and variable costs have not been previously investigated in firm heterogeneity models at the occupational level. This is largely because of the limited information on what fixed costs and their magnitudes are. As the results indicate, the impact of a policy change may vary across occupations and across the fixed and variable portions of labor demand.

One of the avenues to further investigate the composition of fixed costs is intermediate input use. Currently fixed costs in GTAP-HET do not include any intermediate input use. However, part of the input used in fixed costs can be thought of as external labor services, i.e. intermediate input. The OMB survey discussed in Crain and Crain (2014) indicate that 71% of the firms in the survey hired outside advisers to assist the firm in complying with federal regulations. In particular, attorneys (84%), accountants (70%) and consultants (65%) are the top three most frequently sought external services for compliance with federal regulations. This corresponds to the firms getting financial or business services, and can be registered as intermediate input in the model. Incorporating this type of intermediate input use in fixed costs in GTAP-HET is an important future extensions with implications for the labor market.

References

Aguiar, A., B. Narayanan, and R. McDougall. 2016. "An Overview of the GTAP 9 Data Base." *Journal of Global Economic Analysis*, 1(1): 181–208. doi:10.21642/JGEA.010103AF.

Akgul, Z., N.B. Villoria, and T.W. Hertel. 2015. "Theoretically-Consistent Parameterization of a Multi-sector Global Model with Heterogeneous Firms." 18th Annual Conference on Global Economic Analysis. https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=4731.

Akgul, Z., N.B. Villoria, and T.W. Hertel. 2016. "GTAP - HET: Introducing Firm Heterogeneity into the GTAP Model." *Journal of Global Economic Analysis*, 1(1): 111–180. doi:10.21642/JGEA.010102AF.

Armington, P.S. 1969. "Theory of Demand for Products Distinguished by Place of Production." *International Monetary Fund Staff Papers*, 16(1): 159–178. doi:10.2307/3866403.

Carrico, C., L. Jones, and M.E. Tsigas. 2012. "Disaggregate U.S. Labor Statistics for the USAGE 2.0 and GTAP Applied General Equilibrium Models." U.S. International Trade Commission, Report. doi:10.2139/ssrn.2169415.

Carrico, C., and M.E. Tsigas. 2014. "Enriching U.S. labor results in a multi-regional CGE model." *Economic Modelling*, 36: 268 – 281. doi:http://dx.doi.org/10.1016/j.econmod.2013.09.030.

Castro, L., B.G. Li, K.E. Maskus, and Y. Xie. 2016. "Fixed Export Costs and Export Behavior." *Southern Economic Journal*, 83(1): 300–320.

Corong, E., T. Hertel, R. McDougall, M. Tsigas, and D. van der Mensbrugghe. 2017. "The Standard GTAP Model, Version 7." *Journal of Global Economic Analysis*, 2(1): 1–119. doi:10.21642/JGEA.020101AF.

Crain, W., and N. Crain. 2014. "The Cost of Federal Regulation to the U.S. Economy, Manufacuring and Small Business." A Report for the National Association of Manufactures, Report.

Dixon, P.B., R.B. Koopman, and M.T. Rimmer. 2013. "The MONASH Style of Computable General Equilibrium Modeling: A Framework for Practical Policy Analysis." In *Handbook of Computable General Equilibrium Modeling*, edited by P. B. Dixon and D. W. Jorgenson. Elsevier, vol. 1, pp. 23–103. doi:10.1016/B978-0-444-59568-3.00002-X.

Helpman, E., M. Melitz, and Y. Rubinstein. 2008. "Estimating trade flows: Trading partners and trading volumes." *Quarterly Journal of Economics*, 123(2): 441–487. doi:10.3386/w12927.

Hertel, T.W., ed. 1997. *Global Trade Analysis:Modeling and Applications*. Cambridge: Cambridge University Press.

Kneller, R., and M. Pisu. 2011. "Barriers to Exporting: What are They and Who do They Matter to?" *The World Economy*, 34(6): 893–930. doi:10.1111/j.1467-9701.2011.01357.x.

Luong, T.A., and W.C. Chen. 2016. "Extensive and Intensive Margins of Exports and Labor Heterogeneity." *Review of Development Economics*, 20(1): 201–213. doi:10.1111/rode.12199.

Melitz, M.J. 2003. "The impact of trade on intra-industry reallocations and aggregate industry productivity." *Econometrica*, 71(6): 1695–1725. doi:10.3386/w8881.

Swaminathan, P., and T.W. Hertel. 1996. "Introducing Monopolistic Competition into the GTAP Model." GTAP Technical Paper, Report No. 6. https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=309.

USDA. 2012. "Census of Agriculture." U.S. Department of Agriculture, Report.

Appendix. Data

Table A.1. List of GTAP Sectors

No	Description	GTAP Code
1	Paddy rice	pdr
2	Wheat	wht
3	Cereal grains nec	gro
4	Vegetables, fruits, nuts	v_f
5	Oil seeds	osd
6	Sugar cane, sugar beet	c_b
7	Plant-based fibers	pfb
8	Crops nec	ocr
9	Bovine cattle, sheep and goats, horses	cl
10	Animal products nec	oap
11	Raw milk	rmk
12	Wool, silk-worm cacoons	wol
13	Forestry	frs
14	Fishing	fsh
15	Coal	coa
16	Oil	oil
17	Gas	gas
18	Minerals nec	omn
19	Bovine meat products	cmt
20	Meat products nec	omt
21	Vegetable oils and fats	vol
22	Dairy products	mil
23	Processed rice	pcr
24	Sugar	sgr
25	Food products nec	ofd
26	Beverages and tobacco products	b_t
27	Textiles	tex
28	Wearing apparel	wap
29	Leather products	lea
30	Wood products	lum
31	Paper products, publishing	ppp
32	Petroleum, coal products	p_c
33	Chemical, rubber, plastic products	crp
34	Mineral products nec	nmm
35	Ferrous metals	i_s
36	Metals nec	nfm
37	Metal products	fmp
38	Motor vehicles and parts	mvh
39	Transport equipment nec	otn
40	Electronic equipment	ele
41	Machinery and equipment nec	ome
42	Manufactures nec	omf
43	Electricity	ely
44	Gas manufacture, distribution	gdt
45	Water	wtr
46	Construction	cns
47	Trade	trd
48	Transport nec	otp
49	Water transport	wtp
50	Air transport	atp
51	Communication	cmn
52	Financial services nec	ofi
53	Insurance	isr
54	Business services nec	obs
55	Recreational and other services	ros
56	Public Administration, Defense, Education, Health	osg
57	Dwellings	dwe

Table A.2. Mapping of Aggregate Sector to GTAP Sectors

Aggregate Sector	Regions
Agriculture	pdr, wht, gro, v_f, osd, c_b, pfb, ocr, pcr, ctl, oap, rmk, wol, cmt, omt, vol, mil, sgr, ofd, b_t
Extraction	frs, fsh, coa, oil, gas, omn
Textiles and Wearing Apparel	tex, wap
Light Manufactures	lea, lum, ppp, fmp, mvh, otn, omf
Heavy Manufactures	p_c, crp, nmm, i_s, nfm, ele, ome
Services	ely, gdt, wtr, cns, trd, otp, wtp, atp, cmn, ofi, isr, obs, ros, osg, dwe