Domestic Regulations and U.S. Exports

David Riker

Office of Competition and Economic Analysis

International Trade Administration

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ABSTRACT

The regulatory compliance costs of manufacturing firms often take the form of fixed costs of production. Yet most regulatory impact analyses are based on economic models with constant returns to scale, and they represent regulatory costs as variable costs of production. Together, these assumptions dictate the prediction of the economic analysis: an increase in regulatory costs reduces an industry's export competitiveness. In this paper, I reexamine this issue using a model of international trade with fixed costs of production, fixed costs of exporting, and firm heterogeneity based on Melitz (2003) and Chaney (2008). The model predicts that a country-specific increase in fixed costs of production will have little or no effect on an industry's exports, because exporting firms are generally more productive and better able to maintain profitability despite the increase in costs. The firms that lose profitability and exit the market are non-exporters. On the other hand, an increase in variable costs of production will reduce the industry's exports. The model also predicts that any increase in production costs (whether fixed or variable) will increase an industry's imports. I examine the sensitivity of the model's predictions to several of its simplifying assumptions. Then I embed the model within a GTAP CGE framework to more fully account for general equilibrium adjustments throughout the global economy. Finally, I test several of the model's predictions using data for 383 six-digit manufacturing industries from the 2002 and 2007 U.S. Economic Census.

Keywords: International Trade, Regulation, Economic Modeling

1. Introduction

Regulations can be costly. When an industry is open to international trade and compliance costs are added to producers in one country but not to their foreign competitors, this asymmetry can have a significant effect on international trade flows. The compliance costs associated with domestic regulations are usually a combination of fixed and variable costs of production. Fixed costs are expenses that do not vary with a firm's output level. They can include overhead expenses, monitoring and reporting requirements, and mandated updating of the technology embodied in plant and equipment. Variable costs, on the other hand, represent expenses that increase directly with a firm's output level. They can include fees or penalties for output-related environmental emissions, for example. Also, whenever smaller firms in an industry are exempted from the regulatory compliance costs that larger firms face, the compliance costs become variable costs of production.

Predicting the impact of regulatory compliance costs on international trade requires an economic model that includes both fixed and variable costs of production. Yet most regulatory impact analyses are based on economic models with constant returns to scale, and they represent regulatory costs as variable costs of production. Together, these assumptions dictate the prediction of the economic analysis: an increase in regulatory costs reduces an industry's export competitiveness. Trade models that assume constant returns to scale technologies and perfect competition are not equipped to address changes in fixed costs of production. Models with increasing returns to scale and monopolistic competition are arguably better suited.

The early "new trade" models of Krugman (1980), Helpman (1981), Helpman and Krugman (1985), and others include both fixed and variable costs of production. These models have been extended in Melitz (2003), Helpman, Melitz, and Yeaple (2004), Cheney (2008) to include fixed costs of exporting and heterogeneity in firms' productivity levels. These recent developments in the trade literature are motivated by evidence that fixed costs of exporting are an important determinant of international trade flows.[1]

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[1] Bernard, Jensen, Redding, and Schott (2007), Tybout (2003), Melitz (2003), and Helpman, Melitz, and Rubinstein (2008) provide examples.

The model of international trade with monopolistic competition in Melitz (2003), extended in Chaney (2008), provides a tractable theoretical framework for analyzing the impact of regulatory compliance costs on a country's export competitiveness, though Chaney (2008) does not use the model to address this specific issue. Section 2 presents an overview of the Melitz-Chaney model in a partial equilibrium setting. I derive the model's predictions for the impact of an increase in an industry's regulatory compliance costs on its exports and imports.

The model predicts that a country-specific increase in fixed costs of production will have little or no effect on the industry's exports, because exporting firms are generally more productive and better able to maintain profitability despite the increase in costs. The firms that lose profitability and exit the market are non-exporters. The model also predicts that any increase in production costs (whether fixed or variable) will increase an industry's imports. The cost increase reduces the number of domestic producers, which raises the sector's price index in the domestic market and increases the price competitiveness of imports.

If the increase in costs is global rather than country-specific, then it will generally increase every country's exports. The cost increase in export markets reduces the number of local producers, which increases the demand for imports. The result is an increase in the range of firms that export to every country and an increase in the total value of trade.

I also use the model to analyze the impact of a country-specific increase in a sector's variable costs of production. In the Melitz-Chaney model, an increase in variable costs reduces the sector's exports, because it reduces the number of firms that export (a change in the extensive margin) and also the value of exports from the firms that continue to export (a change in the intensive margin).

In Section 3, I embed the Melitz-Chaney model in a GTAP CGE model, and I use this extended model to simulate the effect of an increase in a sector's fixed costs of production on trade flows, employment, and the number of firms that sell in each market. I also model the general equilibrium adjustments in U.S. GDP and factor market prices. I explain the equations and variables that I add to the GTAP model, and then I report econometric estimates of the new model parameters based on U.S. bilateral import data. I use this extended GTAP model to simulate the effects of global and country-specific cost shocks.

Section 4 presents several empirical tests of the model's predictions, based on six-digit industry data from the U.S. Economic Census. The data support the model's predictions about the effect of changes in fixed costs of production on U.S. exports and imports. The manufacturing industries that recorded an increase in fixed costs were more likely to experience an increase in U.S. imports between 2002 and 2007 but were not more likely to experience a decline in exports. Section 5 provides concluding remarks.

2. Melitz-Chaney Model in a Partial Equilibrium Setting

I focus on the model of international trade with monopolistic competition, firm heterogeneity, and fixed costs of production and exporting in Melitz (2003), as it is extended in Chaney (2008). After introducing the assumptions of the Melitz-Chaney model, I derive the predicted changes in international trade flows that would result from an increase in a sector's fixed costs of production.

2.1. Overview of the Trade Model

In the Melitz-Chaney model, there are several sectors that produce differentiated goods and one sector that produces a homogeneous good. Labor is the only factor of production. Labor in country j earns the wage w_j. There are constant returns to scale and no fixed costs of production in the sector that produces the homogeneous good. In the extensions of the Melitz model in Helpman, Melitz, and Yeaple (2004) and Chaney (2008), the wage in each country is fixed by free trade in the homogeneous good. Under this assumption, each sector can be modeled in isolation. I maintain this simplifying assumption in this section, but I relax this restriction in the CGE analysis in Section 3. Likewise, I limit the model to two countries in this section, but extend the model to many countries in Section 3.

The cost structure for the differentiated goods includes fixed costs of production as well as variable costs. Within each of the differentiated goods sectors, the firms vary in their productivity parameter φ. $G(\varphi)$ is the cumulative distribution function of the productivity of firms in each sector in each country. Each firm in country j incurs a fixed overhead cost of production, f_{Dj}, regardless of its level of output. The fixed costs include, but are not limited to, regulatory compliance costs. There are increasing returns to scale in these sectors due to the fixed costs. The firms have constant returns to scale in their variable inputs and therefore constant marginal costs. Each firm in country j incurs an additional fixed cost, f_{Xj}, if it exports its product. This reflects the cost of establishing a distribution and servicing network in the export market. The fixed costs f_{Dj} and f_{Xj} are both measured in labor units.

In the models in Melitz (2003) and Helpman, Melitz, and Yeaple (2004), the number of potential producers is determined by entry decisions. Potential entrants weigh one-time entry costs against uncertain future profits. Once a firm pays the entry costs, it draws a value of its firm-specific productivity level. In contrast, the model in Chaney (2008) treats the number of potential producers as an exogenous parameter, though the numbers of firms that actively produce and sell in the domestic and export markets are endogenously determined, conditional on the set of potential producers. I adopt Chaney's assumption, since it is a better fit for the deterministic structure of the GTAP CGE model.

Equation (1) represents the domestic demand for the products of a firm in country j. Consumer demand in each country has a constant elasticity of substitution between varieties of the products within each sector, represented by σ.

$$q_{Dj}(\varphi) = \mu\, Y_j\, P_j^{\sigma-1} \left(p_{Dj}(\varphi)\right)^{-\sigma} \qquad \textbf{(1)}$$

The variable $p_{Dj}(\varphi)$ is the price of a firm with productivity φ. Y_j is aggregate expenditure in country j, P_j is the sector's price index in country j, and μ is the sector's share of aggregate expenditures.[2] In equilibrium, there is a continuum of varieties produced by a continuum of firms. Each producer takes the sector's price index, aggregate expenditure, and the sector's expenditure share as given when setting its own price. The firm's profit-maximizing price is characterized by the constant mark-up formula in equation (2).

$$p_{Dj}(\varphi) = \left(\frac{\sigma}{\sigma-1}\right)\frac{w_j}{\varphi} \qquad \textbf{(2)}$$

Equation (3) represents the firm's profits from domestic sales in country j.

[2] The constant expenditure shares of each sector reflect the model's assumption that the elasticity of substitution between the sectors is equal to one.

$$\pi_{Dj}(\varphi) = \left[p_{Dj}(\varphi) - \frac{w_j}{\varphi} \right] q_{Dj}(\varphi) - f_{Dj} \tag{3}$$

The firm's decision of whether to supply the domestic market or to exit the market depends on its profitability. The firm pays the fixed cost f_{Dj} and sells its product in the domestic market if the firm's productivity is high enough that $\pi_{Dj}(\varphi) > 0$. This is the case if the firm's productivity φ is greater than the cutoff level φ_{Di} defined in equation (4).

$$\varphi_{Dj} = \left(f_{Dj}\right)^{\frac{1}{\sigma-1}} \left(w_j\right)^{\frac{\sigma}{\sigma-1}} \left(\mu\, Y_j\right)^{\frac{1}{1-\sigma}} \left(\frac{1}{P_k}\right) \left(\frac{\sigma}{\sigma-1}\right) (\sigma)^{\frac{1}{\sigma-1}} \tag{4}$$

Equation (5) represents the demand in country k for the exports of a firm in country j with productivity φ.

$$q_{Xj}(\varphi) = \mu\, Y_k\, {P_k}^{\sigma-1} \left(p_{Xk}(\varphi)\right)^{-\sigma} \tag{5}$$

Exports to country k are subject to iceberg trade costs, represented by $\lambda_{jk} > 1$. The trade costs create a wedge between a firm's price in its domestic market and its price in its export market: $p_{Xj}(\varphi) = \lambda_{jk}\, p_{Dj}(\varphi)$. Equation (6) represents the firm's incremental profits from exporting, assuming that the firm has already incurred the fixed cost of production to sell in its domestic market.

$$\pi_{Xj}(\varphi) = \left(\left[p_{Xj}(\varphi) - \frac{w_j}{\varphi} \right] q_{Xj}(\varphi) \right) - f_{Xj} \tag{6}$$

The cutoff productivity level for exporting from country j, φ_{Xj}, is defined in equation (7).

$$\varphi_{Xj} = \left(f_{Xj}\right)^{\frac{1}{\sigma-1}} \left(w_j\right)^{\frac{\sigma}{\sigma-1}} \left(\lambda_{jk}\right) \left(\mu\, Y_k\right)^{\frac{1}{1-\sigma}} \left(\frac{1}{P_k}\right) \left(\frac{\sigma}{\sigma-1}\right) (\sigma)^{\frac{1}{\sigma-1}} \tag{7}$$

Exporting is profitable for firms with $\varphi > \varphi_{Xj}$.

Equation (8) is the sector's CES price index in country j, given the profit-maximizing prices of each firm.

$$P_j = \left[n_j \int_{\varphi_{Dj}}^{\infty} \left[\frac{w_j}{\varphi}\right]^{1-\sigma} dG(\varphi) + n_k \int_{\varphi_{Xj}}^{\infty} \left[\frac{w_k\, \lambda_{kj}}{\varphi}\right]^{1-\sigma} dG(\varphi) \right]^{\frac{1}{1-\sigma}} \tag{8}$$

The variable n_j is the number of firms that are potential producers in the sector in country j. The number of firms in the sector that actively produce and sell in their domestic market is equal to $n_j \int_{\varphi_{Dj}}^{\infty} dG(\varphi)$, and the number that export to country k is equal to $n_j \int_{\varphi_{Xj}}^{\infty} dG(\varphi)$. Equation (7) and the country k counterparts to equations (4) and (8) jointly determine φ_{Dk} , φ_{Xj}, and P_k for each of the differentiated products sectors, conditional on the sector's n_j and n_k, aggregate expenditure, and wages.

Melitz (2003) points to extensive evidence that exporting firms are generally more productive than non-exporting firms within the same industry. In terms of the model, this means that $\varphi_{Xj} > \varphi_{Dj}$. This is the case as long as the fixed costs of exporting are large relative to the fixed costs of production, aggregate expenditure and the sector's price index in the export markets are relatively small, and the variable trade costs are significant.

2.2 Comparative Static Analysis of Fixed Costs of Production and Exports

In this section, I derive the predicted changes in trade flows that would result from an increase in a sector's fixed costs of production in country j, f_{Dj}. Equations (1) through (8) imply the following closed-form solution for X_j, the value of exports from country j, aggregated across all of the firms in the sector in country j:

$$X_j = \mu Y_k \frac{n_j \int_{\varphi_{Xj}}^{\infty} \left[\frac{w_j \lambda_{jk}}{\varphi}\right]^{1-\sigma} dG(\varphi)}{n_k \int_{\varphi_{Dk}}^{\infty} \left[\frac{w_k}{\varphi}\right]^{1-\sigma} dG(\varphi) + n_j \int_{\varphi_{Xj}}^{\infty} \left[\frac{w_j \lambda_{jk}}{\varphi}\right]^{1-\sigma} dG(\varphi)} \qquad \textbf{(9)}$$

X_j is determined by the value of φ_{Dk} and by the value of φ_{Xj}, but not by the value of φ_{Dj}. A moderate increase in f_{Dj} will have no impact on X_j. The number of firms in country j that export is determined independent of f_{Dj} unless there is an increase in f_{Dj} that is so large that it would eliminate all non-exporting producers in country j. Specifically, it would have to raise the cutoff productivity level φ_{Dj} that prevails after the cost increase above the cutoff φ_{Xj} that prevailed before the cost increase. Otherwise, the exporting firms in country j would be unaffected, because they are relatively productive and remain profitable despite the cost increase. Since

82% of firms in the U.S. manufacturing sector are not exporters, this would require an improbably large increase in f_{Dj}.[3]

In contrast, the increase in fixed costs of production increases country j's imports in the sector. The cost increase reduces the number of firms that produce in country j. This raises the sector's price index P_j and increases the price competitiveness of the country's imports.

To this point, I have analyzed the changes in trade flows that would result from a country-specific increase in a sector's fixed costs of production, such as a unilateral increase in its regulatory compliance costs. In some cases, however, the increase in fixed costs of production will apply globally. For example, this could be the case if both countries enter into an international regulatory agreement. To model this case, I assume that the increase in f_{Dj} is matched by an increase in f_{Dk}. The increase in the fixed cost of production in country k reduces the number of local producers and raises the sector's CES price index. This makes country j's exports more price-competitive in country k, and there is an increase in the range of country j firms that export to country k. The global increase in fixed costs of production promotes every country's exports.

2.3. Comparative Static Analysis of an Increase in Variable Costs of Production

Next, I consider the changes in trade flows that would result from an increase in a sector's variable costs of production in country j. This is an apt characterization of some types of regulatory compliance costs. An country-specific increase in the variable costs of production clearly reduces the sector's exports, because it reduces the number of firms that export (the sector's extensive margin of exports) and the value of exports from the firms that continue to export (the sector's intensive margin of exports). Chaney (2008) emphasizes that the adjustment on the extensive margin amplifies the effect of variable costs on trade.[4]

In order to derive a reduced-form expression for X_j, I assume that firm productivity is drawn from a Pareto distribution with shape parameter γ, following Helpman, Melitz, and

[3] This statistic is from Bernard, Jensen, Redding, and Schott (2007).

[4] Chaney (2008) analyzes the impact of a change in variable costs of trade, rather than variable costs of production, but in the context of equation (9), the two are equivalent.

Yeaple (2004) and Chaney (2008). Therefore, $\varphi^{\sigma-1}$ has a Pareto distribution with shape parameter $-\gamma+(\sigma-1)$. Equation (10) is the reduced-form expression for X_j.

$$X_j = \mu Y_k \frac{n_j (w_j)^{\frac{\sigma-1-\gamma\sigma}{\sigma-1}} (\lambda_{jk})^{-\gamma} (f_{Xj})^{\frac{-\gamma}{\sigma-1}+1}}{n_k (w_k)^{\frac{\sigma-1-\gamma\sigma}{\sigma-1}} (f_{Dk})^{\frac{-\gamma}{\sigma-1}+1} + n_j (w_j)^{\frac{\sigma-1-\gamma\sigma}{\sigma-1}} (\lambda_{jk})^{-\gamma} (f_{Xj})^{\frac{-\gamma}{\sigma-1}+1}} \qquad \textbf{(10)}$$

A country-specific increase in the variable costs of production has the same effect on $X_j$as an increase in the ad valorem trade cost λ_{jk} in equation (10). It reduces the value of exports. The magnitude of the decline in exports is larger if there less dispersion in the distribution of the firms' productivity levels (a higher value of the parameter γ) and if aggregate expenditure in country k is higher.

3. Melitz-Chaney Sectors within a Computable General Equilibrium Framework

In this section, I embed several Melitz-Chaney sectors in a global CGE model (version 6.2 of the GTAP model) in order to provide a more complete accounting of the economic consequences of increasing the fixed costs of production, including the consequences for U.S. GDP, sector employment, and trade flows with third countries.

3.1 Modification of the Standard GTAP Model

To facilitate comparison to standard GTAP predictions, I leave most of the structure of the CGE model unchanged, including its multi-tiered demand system, the social accounting matrix that links the sectors of the economy, and the five-factor production technologies. The structure of the GTAP model is described in detail in Hertel (1997).[5] I aggregate the GTAP dataset to 51 regions, 13 commodity sectors, and 5 factor endowments.[6] Table 1 lists the aggregations of the data.

I assume that 3 of the 13 aggregated commodity sectors in each region are Melitz-Chaney sectors. The three sectors are Electronics, Transportation Equipment, and Other Machinery.[7] I

[5] For additional, updated documentation, see https://www.gtap.agecon.purdue.edu/.

[6] The aggregates of countries in the GTAP model are called regions, and so I adopt this terminology in the remainder of this paper.

[7] The Other Machinery sector is the same as GTAP sector Machinery and Equipment NEC.

assume that the rest of the economy has the constant returns to scale, perfect competition market structure of the standard GTAP model.

The first extension of the GTAP model involves defining price indices for the Melitz-Chaney sectors in each region. I replace the sector-level prices in the GTAP model with CES indices of the prices of the individual firms within the sector. The price indices in the Melitz-Chaney sectors reflect both marginal costs (as in the GTAP model) and the number of firms (the extensive margin from the Melitz-Chaney models). The following equation represents the percentage changes in these price indices in the extended model:

$$\frac{d\,(p_{jm})}{p_{jm}} = \frac{d\,(ps_j)}{ps_j} + \left[\frac{\gamma}{\sigma-1}\right]\frac{d\,(\varphi_{jm})}{\varphi_{jm}} \qquad \textbf{(11)}$$

The variable p_{jm} is the price index for the region m sales of region j producers, and φ_{jm} is the cutoff productivity level in region j for sales in region m. They are both endogenous variables in the extended model. ps_j is the sector's marginal cost of production in region j, as the variable is defined in the GTAP model.[8] Equation (11) applies in the three Melitz-Chaney sectors; for the other sectors, $p_{jm} = ps_j$ for all m.

The sector price indices vary by destination region, as well as the region of production, because there are different sets of firms serving each market. The following equation represents the percentage changes in the cutoff productivity levels in the extended model:

$$\frac{d\,(\varphi_{jm})}{\varphi_{jm}} = \left[\frac{1}{\sigma-1}\right]\left[\frac{d\,(freq_{jm})}{freq_{jm}} - \frac{d\,(q_{jm})}{q_{jm}} + \frac{d\,(fp_{jm})}{fp_{jm}}\right] - \left[\frac{\sigma}{\sigma-1}\right]\left[\frac{d\,(p_{jm})}{p_{jm}}\right] + \frac{d\,(ps_j)}{ps_j} \qquad \textbf{(12)}$$

The variable $freq_{jm}$ represents the factor requirements for the fixed costs of production in region j (if $j = m$) or the fixed costs of exporting (if $j \neq m$). It is an exogenous variable in the extended model. fp_{jm} is an index of factor prices associated with these fixed costs, and q_{jm} is the volume of the region m sales of region j producers.

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[8] There are five primary factors of production in the GTAP model, but labor is the only factor of production in the models in Melitz (2003) and Chaney (2008). However, this difference is not an obstacle to embedding the Melitz-Chaney model into the GTAP framework. I simply replace the sector's marginal cost of production ps_j for the wage rate in the Melitz-Chaney model.

The second extension of the GTAP model involves the distribution of the profits of the Melitz-Chaney sectors. I assume that the profits of firms in a region are distributed to households within the same region.[9] The following equation represents the percentage change in profits in the extended model:

$$\frac{d\,(prof_{jm})}{prof_{jm}} = \left[\frac{prof_{jm} + fix_{jm}}{prof_{jm}}\right]\left[\frac{d\,(p_{jm})}{p_{jm}} + \frac{d\,(q_{jm})}{q_{jm}}\right] - \left[\frac{fix_{jm}}{prof_{jm}}\right]\left[\frac{d\,(fp_{jk})}{fp_{jk}} + \frac{d\,(freq_{jm})}{freq_{jm}} - \gamma\frac{d\,(\varphi_{jm})}{\varphi_{jm}}\right] \quad \textbf{(13)}$$

$prof_{jm}$ is the dollar value of incremental profits of firms in region j from sales in region m, and fix_{jm} is the total dollar value of their incremental fixed costs of serving the market in region m. These are coefficients that are updated during the iterative solution of the linearized GTAP model.

The third extension of the GTAP model involves the use of factor endowments in the fixed costs of production and the fixed costs of exporting. The following equation represents the percentage changes in these additional factor demands in the extended model:

$$\frac{d\,(lfc_{jm})}{lfc_{jm}} = \frac{d\,(freq_{jm})}{freq_{jm}} - \gamma\frac{d\,(\varphi_{jm})}{\varphi_{jm}} \quad \textbf{(14)}$$

The variable lfc_{jm} is the sector's use of factor endowments for the fixed costs of production (if $j = m$) or the fixed cost of exporting (if $j \neq m$). It is an endogenous variable in the extended model. I also modify the market clearing conditions for the mobile factor endowments by adding the factor demands in equation (14).

3.2 Calibration of the Additional Model Parameters

There are two parameters in the extended model that are not in the standard GTAP model, the shape parameter γ for the Pareto distribution of firms' productivity levels and the elasticity of substitution between the products of different firms within the same sector. In this section, I describe how I calibrate these additional parameters.

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[9] In contrast, Chaney (2008) assumes that consumers in each region own shares in a global portfolio and therefore the profits of firms in each country are distributed globally. It is straightforward to incorporate this alternative assumption into the extended model.

First, I set the elasticity of substitution between the varieties of different firms within a sector equal to the elasticity of substitution between the sector's imports from different regions (the parameter ESUBM in the GTAP model), since differentiation between the products of individual firms is the source of differentiation by region in Dixit-Stiglitz models of trade.

Second, I use data on the value of U.S. bilateral imports to estimate the parameter γ for the Melitz-Chaney sectors. Equation (15) is an expression for U.S. imports from country k, based on the model in Section 2. The subscript u represents the United States. I add an index t to indicate time periods.

$$X_{kut} = \mu\,(Y_{ut})^{\frac{\gamma}{\sigma-1}}\,(P_{ut})^{\gamma}\,n_k\,\,(w_{kt})^{\frac{\sigma-1-\gamma\sigma}{\sigma-1}}\,(\,\lambda_{kut})^{-\gamma}(f_{kut})^{\frac{-\gamma}{\sigma-1}+1} \qquad \textbf{(15)}$$

Equation (16) is a log-linearization of equation (15). It is the regression specification.

$$ln(X_{kut}) = \alpha_k + \beta\,ln(\lambda_{kut}) + \delta_t + \varepsilon_{kt} \qquad \textbf{(16)}$$

Equations (17) through (20) define the coefficients in equation (16).

$$\alpha_k = ln(n_k) \qquad \textbf{(17)}$$

$$\beta = -\gamma \qquad \textbf{(18)}$$

$$\delta_t = \left(\frac{\gamma}{\sigma-1}\right) ln(Y_{ut}) + \gamma\,ln(P_{ut}) + \left(\frac{-\gamma}{\sigma-1} + 1\right)\,ln(f_{kut}) \qquad \textbf{(19)}$$

$$\varepsilon_{kt} = \left(\frac{\sigma-1-\gamma\sigma}{\sigma-1}\right) ln(w_{kt}) + \xi_{kt} \qquad \textbf{(20)}$$

The variable ξ_{kt} in equation (20) represents unobservable determinants of $ln(X_{kut})$ and any measurement error in the trade data. I assume that f_{kut}, the fixed cost of exporting to the U.S. market, is the same for all k.

Equation (16) applies separately to each of the Melitz-Chaney sectors. I construct a panel dataset that includes imports in the three sectors, from the 50 other regions in the extended model, on an annual basis from 2000 to 2009. Table 2 reports the pooled estimate of γ and sector-specific estimates for each of the three sectors for two alternative measures of international trade costs. The first column of estimates uses a measure of trade costs that is based on the difference between the landed duty-paid value of imports and their customs value, and therefore it includes both freight costs and import duties. The second column of estimates uses a measure of trade costs that is based on the difference between the CIF value of imports and their customs value, and therefore it only includes the freight costs. The second measure is preferable if import duties are endogenously determined but freight costs are not. The estimates in the second column are slightly larger, as I would expect if the endogeneity of import duties biases the estimates of β toward zero. Both of the specifications include industry-year fixed effects and industry-country fixed effects to control for the unobservable factors in equations (17) and (19). Tests of coefficient restrictions strongly reject the hypotheses that these fixed effects are jointly equal to zero. I also test the pooling restriction that γ is the same for all three of the Melitz-Chaney sectors. I cannot reject this pooling restriction, and so I use the pooled estimate based on the freight-only measure of trade costs, 8.030, in the simulations in Section 3.4.

3.3 Additional Data Inputs

The simulations also require a measure of the magnitudes of the share of factor endowments devoted to the fixed costs of production and the fixed costs of exporting. I do not have direct measures of these shares, so I use rough approximations. Fortunately, the magnitudes of the simulated changes in trade are not sensitive to these shares, as I demonstrate in Section 3.5.

I assume that the fixed costs require equal numbers of highly skilled and less skilled workers, and that the workers devoted to fixed costs account for approximately 38% of the labor employed in the Melitz-Chaney sectors in each region. 38% is the ratio of the sectors' non-production workers to total employment in the 2007 Economic Census. I allocate 75% of these non-production workers to the sector's fixed costs of production and 25% to the sector's fixed costs of exporting, divided equally among each region's export markets. These initial employment shares are updated as the model is solved. The employment shares enter the profit equations and the factor market clearing equations in the extended model.

In the extended model, a sector's revenues are no longer equal to the sum of its payments to variable factors of production, because its prices are marked-up above its marginal costs. However, the model does not require additional data on variable costs of production, because they are proportional to the sales values reported in the GTAP dataset, with a constant mark-up determined solely by the elasticity of substitution parameter σ.

3.4 Simulations

The extended GTAP model predicts sector-level changes in each region's exports, imports, output, employment, profits, factor prices, and the number of firms that serve each market. The shock in the simulation is a 10% increase in the highly skilled and less skilled workers devoted to the sector's fixed costs of production.[10]

Table 3 reports the simulation results for the Electronics sector. The first column of numbers in the table reports the percentage changes in several economic variables when the cost shock is specific to the United States. The second column reports the percentage changes when the cost shock is global rather than country-specific.

When the cost shock is specific to the United States, there is more than a 9% reduction in the number of firms that sell in the domestic market, but only a small decline in the number of firms that export to the major U.S. trading partners. There is a 0.025% decline in the sector's total exports and a 0.086% increase in its total imports. The sector's output declines by 0.080%, and its employment of highly skilled and less skilled workers declines by 0.065%. The percentage declines in output and employment are much smaller than the percentage decline in the number of domestic producers, because the firms that are eliminated are the least productive and therefore accounted for a relatively small share of the sector's output. The sector's profits decline by 0.033%. The value of U.S. GDP declines by 0.006%. There is a reduction in the prices of capital and labor in the United States, and there is a small increase in the U.S. output and exports of the other traded commodities.

When the 10% cost shock is global rather than country-specific, the negative impact on the output, employment, and profits of the shocked U.S. sector is mitigated, and the sector's total exports increase rather than decline. The number of firms that export to the major U.S. trading partners increases, and the value of the sector's total exports increases by 0.050%.

[10] This specific cost shock is illustrative. It is straightforward to modify the factor requirements of the fixed costs of production to fit an alternative policy scenario.

Table 4 reports the simulation results for a 10% increase in the fixed costs of production in the Transportation Equipment sector. An important difference from the simulation for the Electronics sector is that the cost shock now has a positive impact on the value of sector exports and the number of firms that export, even if the cost shock is country-specific. Another difference is that the increase in the fixed cost of production in the Transportation Equipment sector results in an increase in the sector's employment when the cost shock is global. There is also a slight increase in the sector's profits and in U.S. GDP. Table 5 reports the simulation results for a cost shock to the Other Machinery sector. The direction of change in most of the economic variables tracks the simulation for the Transportation Equipment sector, though the percentage changes are now smaller in absolute value.

3.5 Sensitivity Analysis

Table 6 reports the simulated percentage changes in the sectors' U.S. exports and imports for alternative values of the parameter γ. I report the simulation results for the estimated value of the parameter (8.030), and then I report the results using a parameter value that is 20% higher (9.636) or 40% higher (11.242) as a sensitivity analysis. These significant changes in the parameter value do not alter the direction of the changes in the U.S. exports and imports in the Melitz-Chaney sectors; however, the increases in γ substantially increase the absolute values of the changes in trade flows.

Table 7 reports the simulated percentage changes in U.S. exports and imports for alternative assumptions about the initial share of the sectors' employment that is devoted to the fixed costs of production. I report the simulation results for the baseline employment share (0.285), and then I report the results using an employment share that is 20% higher (0.342) or 40% higher (0.399) as a sensitivity analysis. These adjustments in the base data have only negligible effects on the changes in trade flows in the Melitz-Chaney sectors.

4. Econometric Analysis of Fixed Costs of Production and Trade

In the partial equilibrium model in Section 2, changes in fixed costs of production have no effect on a country's exports. In the CGE analysis in Section 3, there can be small effects on exports, though in many cases an increase in fixed costs of production actually increases the sector's exports. In this section, I test these predictions of the model using data from the 2002 and 2007 Economic Census.

4.1 Measuring Changes in Fixed Costs of Production

I develop a measure of fixed costs per firm that I can apply to a large number of U.S. manufacturing industries. It is difficult to quantify regulatory compliance costs except on an industry-by-industry basis; however, to test the predictions of the model, I do not need to separate an industry's costs of regulatory compliance from its non-regulatory fixed costs of production. If fixed costs that are unrelated to regulatory compliance do not affect exports, then fixed costs that are related to regulatory compliance will also not affect exports.

I use the average number of non-production workers per firm in each manufacturing industry as a proxy for the labor inputs that are devoted to the industry's fixed costs of production. These data are reported for manufacturing industries for census years 2002 and 2007. I analyze the public use data at the level of six-digit NAICS codes. I calculate the number of non-production workers as the difference between an industry's total employment and its number of production workers.

I assume that the number of production workers per firm varies with the firm's output level and that the number of non-production workers mostly reflects overhead and other fixed costs rather than output levels. However, I also adjust the measure of non-production workers per firm to try to remove any non-production workers that still vary with output levels. Specifically, I define Q as the total number of workers in the industry, F as the number of workers associated with overhead and other fixed costs, and θ as the share of all output-dependent workers that are classified in the Economic Census as production workers. Using these definitions, the number of production workers is $PW = \theta\ Q$, and the number of non-production workers is $NPW = (1-\theta)\ Q + F$. As long as F is independent of Q, the ratio of the covariance of NPW and PW to the variance of PW is equal to $(1-\theta)/\theta$. I calculate θ for each six-digit industry using the Economic Census data. Then I construct an adjusted $NPW^* = NPW - [(1-\theta)/\theta]\ PW$ as a proxy for F. Without this adjustment, there could be a spurious positive correlation between the number of non-production workers per firm and the industry's exports that does not reflect a correlation between the fixed costs per firm and the industry's exports. I constrain NPW^* to be non-negative, but this constraint is almost never binding.

The second measurement issue is that NPW^* will probably include workers that contribute to the fixed costs of exporting rather than the fixed costs of production. In this case, the effect of changes in NPW^* on the industry's exports would a downward biased estimate of the effect of a change in the fixed costs of production on the exports.

4.2 Difference-in-Difference Comparison

I use these data to test whether increases in the industries' fixed costs have been associated with changes in trade flows. There are many factors that can affect trade flows, and it is not possible to control for all of them at this level of industry disaggregation. By comparing many six-digit manufacturing industries, I can use a difference-in-differences approach that effectively controls for factors that are common to the U.S. manufacturing sectors, possibly varying over time (like the value of the dollar and the level of U.S. aggregate expenditures) and that also controls for industry characteristics that are fixed over time but vary across industries (like freight costs and barriers to the U.S. market).

First, I match industry-level data from the Economic Census for 2002 and 2007 to industry-level data on the value of U.S. domestic exports and U.S. imports for consumption from the U.S. International Trade Commission's Trade Dataweb. I focus on the six-digit U.S. manufacturing industries that engage in international trade. There are 383 six-digit industries with exports and imports in 2002 and 2007. Second, I categorize each industry by whether it recorded an increase in its non-production workers per firm between 2002 and 2007. 156 of the 383 industries recorded an increase in this measure of fixed costs between 2002 and 2007.

In the first set of tests, I focus on the direction of change in the industry's exports and imports, rather than the magnitude of these changes. Table 8 reports the comparison using the unadjusted non-production workers per firm measure and the adjusted measure described in Section 4.1.[11] Between 2002 and 2007, the constant dollar value of exports increased for 80% of the industries. If the change in fixed costs of production was country-specific, then I expect little

[11] I also reproduce these calculations using the number of establishments, rather than the number of firms, in the denominator. The results are similar.

or no change in the industry's exports, based on the predictions of the model. If the change in fixed costs was global rather than country-specific, then there could be an increase in U.S. exports rather than a decrease. In fact, the manufacturing industries that recorded an increase in fixed costs were not more likely to experience a decline in U.S. exports, despite the potential downward bias in NPW^* that I discussed in Section 4.1. A *smaller* share of the industries in this group recorded a decrease in exports between 2002 and 2007, 16.03% compared to 22.03% for the other group. This difference is not statistically different from zero.

During this same period, the constant dollar value of imports increase in 89% of the industries. The model predicts an increase in the U.S. imports of industries that recorded an increase in fixed costs of production. In fact, the industries that recorded an increase in fixed costs were more likely to experience an increase in U.S. imports between 2002 and 2007. A larger share of the industries in this group recorded an increase in imports between 2002 and 2007, 95.51% compared to 84.58% for the other group, and the difference in the groups' shares is statistically significant.

Table 9 applies the difference-in-difference analysis to the percentage changes in trade flows. The table reports the estimated coefficients of a regression of the industry's percentage change in exports, or its percentage change in imports, on a constant and a dummy variable that indicates whether the industry's fixed costs per firm increased between 2002 and 2007. Again, I report the results using both the unadjusted and adjusted measures of non-production workers per firm. The increases in fixed costs did not have a statistically significant effect on the growth in exports of the U.S. manufacturing industries between 2002 and 2007. The increases in fixed costs did have a significant positive effect on the growth of imports over this time period, averaging ten percentage points.

5. Conclusions

The Melitz-Chaney framework yields unconventional predictions about the economic impact of regulation and other fixed costs of production on international trade flows: an increase in overhead costs can have no effect or even increase exports. The form of the regulatory compliance costs determines both the direction and the magnitude of the resulting changes in an industry's exports and imports. The model generally predicts that an industry's exports will not be affected by a country-specific increase in regulatory compliance costs that are fixed costs of production. On the other hand, it predicts that a country-specific increase in variable costs of production will increase the industry's imports.

The model raises distinctions that are important for policy design, since fixed costs of production have very different implications than costs that vary with the level of a firm's output. Fixed costs of production have much less impact on export competitiveness. To draw policy conclusions in a specific case, it is important to evaluate the structure of compliance costs in these terms. Of course, it is also important to assess the non-economic benefits of a proposed regulation in addition to the economic consequences that are quantified in the extended model.

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Table 1: Aggregated Sectors and Regions

Sectors	**Regions**	
Grains and Crops	United States	Cyprus
Meats and Livestock	Oceania	Czech Republic
Extraction	China	France
Processed Food	Japan	Germany
Textiles and Wearing Apparel	Rest of East Asia	Greece
Electronic Equipment	Indonesia	Ireland
Machinery other than Electronic	Malaysia	Italy
Transportation Equipment	Philippines	Norway
Other Light Manufacturing	Singapore	Poland
Other Heavy Manufacturing	Rest of South East Asia	Portugal
Utilities and Construction	India	Russia
Transport Services	Rest of South Asia	Spain
Other Services	Canada	Switzerland
	Mexico	Turkey
	Argentina	United Kingdom
Factor Endowments	Brazil	Rest of Western Europe
Highly Skilled Labor	Chile	Eastern Europe
Less Skilled Labor	Venezuela	Egypt
Capital	Rest of South America	Rest of the Middle East
National Resources	Costa Rica	And Northern Africa
Land	Panama	Botswana
	Rest of Central America	Ethiopia
	and the Caribbean	South Africa
	Austria	Rest of Sub-Saharan Africa
	Belgium	Rest of the World

Table 2: Econometric Estimates of the Pareto Shape Parameter γ

	Using Freight plus Duties Measure of Trade Costs	Using Freight Only Measure of Trade Costs	Number of Observations
Pooled Estimate	7.50 (2.54)	8.03 (2.58)	1,516
Electronics	8.74 (2.25)	8.98 (2.29)	355
Other Machinery	7.95 (5.05)	8.15 (4.75)	354
Transportation Equipment	10.90 (3.39)	12.83 (3.52)	351
Test of Pooling Restrictions	F statistic = 0.33 P value = 0.7220	F statistic = 0.19 P value = 0.8268	

Note: t statistics are reported in parentheses under the point estimates. All regressions include country fixed effects and year fixed effects.

Table 3: Simulated Impact of a 10% Increase in a Firm's Fixed Cost of Production in the U.S. Electronics Sector

The table reports percentage changes in the variables.

	Country-Specific Shock	Global Shock
U.S. Value of Exports in the Sector (GTAP variable vxwgob)	-0.025%	0.050%
U.S. Value of Imports in the Sector (GTAP variable viwcif)	0.086%	0.094%
U.S. Output in the Sector (GTAP variable qo)	-0.080%	-0.051%
Sector Employment in the United States (GTAP variable qfe)		
Highly Skilled Labor	-0.065%	-0.036%
Less Skilled Labor	-0.065%	-0.036%
Value of U.S. GDP (GTAP variable vgdp)	-0.006%	-0.002%
Number of Firms in the Sector that Sell in the U.S. Domestic Market	-9.130%	-9.115%
Number of Firms in the Sector that Export from the United States		
to Canada	0.006%	0.042%
to the UK	-0.031%	0.023%
to Japan	-0.027%	0.115%
to Germany	-0.031%	0.030%
to China	-0.016%	0.058%
Profits of U.S. Producers in the Sector	-0.033%	-0.007%

Table 4: Simulated Impact of a 10% Increase in a Firm's Fixed Cost of Production in the U.S. Transportation Equipment Sector

The table reports percentage changes in the variables.

		Country-Specific Shock	Global Shock
U.S. Value of Exports in the Sector (GTAP variable vxwgob)		0.323%	1.760%
U.S. Value of Imports in the Sector (GTAP variable viwcif)		1.115%	1.215%
U.S. Output in the Sector (GTAP variable qo)		-0.711%	-0.202%
Sector Employment in the United States (GTAP variable qfe)			
Highly Skilled Labor		-0.475%	0.040%
Less Skilled Labor		-0.473%	0.042%
Value of U.S. GDP (GTAP variable vgdp)		-0.079%	0.002%
Number of Firms in the Sector that Sell in the U.S. Domestic Market		-9.297%	-9.091%
Number of Firms in the Sector that Export from the United States			
	to Canada	0.574%	1.464%
	to the UK	0.333%	1.705%
	to Japan	0.370%	2.907%
	to Germany	0.365%	2.007%
	to China	0.297%	3.162%
Profits of U.S. Producers in the Sector		-0.117%	0.199%

Table 5: Simulated Impact of a 10% Increase in a Firm's Fixed Cost of Production in the U.S. Other Machinery Sector

The table reports percentage changes in the variables.

		Country-Specific Shock	Global Shock
U.S. Value of Exports in the Sector (GTAP variable vxwgob)		0.191%	0.419%
U.S. Value of Imports in the Sector (GTAP variable viwcif)		0.366%	0.445%
U.S. Output in the Sector (GTAP variable qo)		-0.091%	-0.032%
Sector Employment in the United States (GTAP variable qfe)			
Highly Skilled Labor		-0.030%	0.024%
Less Skilled Labor		-0.031%	0.023%
Value of U.S. GDP (GTAP variable vgdp)		-0.031%	-0.002%
Number of Firms in the Sector that Sell in the U.S. Domestic Market		-9.088%	-9.075%
Number of Firms in the Sector that Export from the United States			
	to Canada	0.153%	0.279%
	to the UK	0.270%	0.504%
	to Japan	0.268%	0.725%
	to Germany	0.284%	0.607%
	to China	0.269%	0.650%
Profits of U.S. Producers in the Sector		-0.019%	-0.007%

Table 6: Sensitivity Analysis of the Value of γ

	Electronics Sector	Transport Equipment Sector	Other Machinery Sector
$\gamma = 8.030$ (baseline)			
Percentage Change in the Value of the Sector's U.S Exports	-0.025%	0.323%	0.191%
Percentage Change in the Value of the Sector's U.S Imports	0.086%	1.115%	0.366%
$\gamma = 9.636$ (alternative 1)			
Percentage Change in the Value of the Sector's U.S Exports	-0.220%	0.422%	0.474%
Percentage Change in the Value of the Sector's U.S Imports	0.606%	1.542%	0.891%
$\gamma = 11.242$ (alternative 2)			
Percentage Change in the Value of the Sector's U.S Exports	-0.445%	0.477%	0.713%
Percentage Change in the Value of the Sector's U.S Imports	1.107%	1.878%	1.318%

Table 7: Sensitivity Analysis of the Initial Labor Share of Fixed Costs of Production

	Electronics Sector	Transport Equipment Sector	Other Machinery Sector
$\boldsymbol{Share = 0.285}$ **(baseline)**			
Percentage Change in the Value of the Sector's U.S Exports	-0.025%	0.323%	0.191%
Percentage Change in the Value of the Sector's U.S Imports	0.086%	1.115%	0.366%
$\boldsymbol{Share = 0.342}$ **(alternative 1)**			
Percentage Change in the Value of the Sector's U.S Exports	-0.025%	0.320%	0.189%
Percentage Change in the Value of the Sector's U.S Imports	0.086%	1.117%	0.367%
$\boldsymbol{Share = 0.399}$ **(alternative 2)**			
Percentage Change in the Value of the Sector's U.S Exports	-0.025%	0.316%	0.187%
Percentage Change in the Value of the Sector's U.S Imports	0.086%	1.118%	1.368%

Table 8: Changes in Fixed Costs and Trade Flows in U.S. Manufacturing Industries

	Industries that recorded an increase in fixed costs per firm between 2002 and 2007	Industries that did not record an increase in fixed costs per firm between 2002 and 2007
Share of industries within each group with a decline in exports between 2002 and 2007	Unadjusted: 16.03% Adjusted: 18.00%	Unadjusted: 22.03% Adjusted: 22.06%
Share of industries within each group with an increase in imports between 2002 and 2007	Unadjusted: 95.51% Adjusted: 94.00%	Unadjusted: 84.58% Adjusted: 85.84%
Number of industries in the group	Unadjusted: 156 Adjusted: 150	Unadjusted: 227 Adjusted: 233

The adjustment to the fixed cost measure is described in Section 4.1.

Table 9: Regression Analysis of the Percentage Changes in Exports and Imports

		Constant	Dummy Variable if the Industry's Fixed Costs of Production Increased between 2002 and 2007
Percentage Change in the Value Of the Industry's U.S. Exports			
	Unadjusted	0.2348 (0.0321) [0.000]	0.0862 (0.0502) [0.087]
	Adjusted	0.2543 (0.0317) [0.000]	0.0400 (0.0507) [0.431]
Percentage Change in the Value Of the Industry's U.S. Imports			
	Unadjusted	0.3038 (0.0277) [0.000]	0.1187 (0.0433) [0.006]
	Adjusted	0.3151 (0.0274) [0.000]	0.0947 (0.0438) [0.031]

The table reports standard errors in parentheses and p values in square brackets.