

MULTINATIONAL PRODUCTION AND EMPLOYMENT IN AN INDUSTRY-SPECIFIC MODEL OF TRADE

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Abstract

We develop an industry-specific model of international trade that quantifies the changes in employment in multinational firms when there is an increase in costs in one of their production locations. In the model, the effect on employment in each country is determined by the international sourcing patterns of the firms in the industry and the overlap of the markets in which the firms compete.

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1 Introduction

An increase in the costs of a firm's production in one country can spill over the border, affecting its employment in other countries. To study this issue, we develop an industry-specific model of international trade that quantifies the changes in employment in multinational firms in response to country-specific cost shocks.

The modeling framework highlights the data that are critical for quantifying these effects. The analysis requires not only the global input sourcing patterns of the multinational firms but also the overlap of the markets in which the firms compete. With these data and several simplifying assumptions, we can predict firm-level cross-border employment effects.

The model generates a variety of predictions about the changes in employment and other input use within each firm in each country, depending on the characteristics of the firm. At the industry level, the model demonstrates that there is a wide range of potential changes in industry employment, including positive net changes and negative net changes, depending on the mix of firms in the industry.

Section 2 describes the assumptions of the model and discusses the effects on prices and input demands. Section 3 discusses the data requirements of the model and practical methods for running model simulations. Section 4 discusses how effects on industry employment might be different in the medium to long run when firms can relocate production. Section 5 discusses other potential extensions of the modeling framework. Section 6 concludes.

2 Modeling Framework

We adopt several partial equilibrium and functional form assumptions to simplify the data requirements of the model.

2.1 Assumptions about Technology and Demand

Production in the industry combines intermediate inputs in fixed proportions, with constant unit requirements. Firms in the industry source their intermediate inputs from multiple countries. We assume that the set of countries supplying each firm's inputs is fixed in the short-run considered in the model. The inputs, indexed by i , are distinguished by type of input and source country. For example, input i might be labor in Mexico or raw materials in Canada.

Consumers have Cobb-Douglas demands across all sectors of the economy, and the specific industry in the model receives a constant share of aggregate expenditure in each country, γ . Products within the specific industry are differentiated by firm, with a constant elasticity of substitution σ .

2.2 Partial Equilibrium Assumptions

Aggregate expenditure in each country is exogenous to the model. In addition, the prices of inputs do not change with shifts in the firms' input demands. These simplifying assumptions are appropriate if the specific industry is small relative to the economy as a whole and inputs to production are not industry-specific.

2.3 Exogenous Shocks to Production Costs

We model the effects of country-specific and firm-specific exogenous shocks to production costs. For example, the shocks could reflect changes in wages due to changes in exchange rates or labor market policies, changes in taxes on production, or changes in other regulatory costs.

2.4 Firm Heterogeneity in the Industry

Each of the firms in the industry produces a unique, differentiated product. The firms have different costs of production, depending on the set of countries supplying their inputs.

There is monopolistic competition in the industry, and given the constant elasticity of substitution preferences, each firm's price is a fixed markup over its marginal costs of production, following Krugman (1980) and the related trade literature.

2.5 Labor Demand

Equation (1) represents the value of expenditure in national market m on the products of firm f , V_{fm} .

$$V_{fm} = \gamma Y_m P_m^{\sigma-1} (p_{fm} t_{fm} \beta_{fm})^{1-\sigma} \quad (1)$$

Y_m is aggregate expenditure in market m . The trade cost factor t_{fm} includes freight costs and tariffs specific to firm f in market m , and β_{fm} reflects market-specific preference asymmetries across the products of the firms. P_m is the industry CES price index in market m .

$$P_m = \left(\sum_f (p_{fm} t_{fm} \beta_{fm})^{1-\sigma} \right)^{\frac{1}{1-\sigma}} \quad (2)$$

p_{fm} is the producer price of firm f sales in market m .

$$p_{fm} = \left(\frac{\sigma}{\sigma-1} \right) \sum_i c_{fim} \quad (3)$$

c_{fim} is the marginal cost of input i in firm f production for market m .

Equation (4) represents the employment of input i in firm f production for market m , L_{fim} .

$$L_{fim} = \frac{\alpha_{fim} V_{fm}}{p_{fm}} \quad (4)$$

α_{fim} is the unit employment of input i in firm f production for market m .

Equation (5) represents the global employment of input i in firm f , and equation (6) represents the global employment of input i across all of the firms in the industry.

$$L_{fi} = \sum_m L_{fim} \quad (5)$$

$$L_i = \sum_f L_{fi} \quad (6)$$

2.6 Changes in Labor Demand

Next, we derive formulas for the changes in industry prices, trade, and employment due to the exogenous change in input costs, holding constant trade costs, aggregate expenditure levels, demand parameters γ , σ , and β_{fm} , and unit input requirements α_{fim} . Equation (7) is a linear approximation of the percent change in the producer price of firm f sales in market m from the initial equilibrium price.

$$\hat{p}_{fm} = \sum_i \theta_{fim} \hat{c}_{fim} \quad (7)$$

θ_{fim} is the cost share of input i in firm f production for market m .

Equation (8) is a linear approximation of the percent change in the industry price index in market m , based on equations (2) and (7).

$$\hat{P}_m = \sum_f x_{fm} \sum_i \theta_{fim} \hat{c}_{fim} \quad (8)$$

$x_{fm} = \frac{V_{fm}}{\sum_k V_{km}}$ is the initial expenditure share of firm f in market m , and $\theta_{fim} = \frac{c_{fim}}{\sum_k c_{fkm}}$ is

the initial cost share of input i in firm f production for market m .

Equation (9) is a linear approximation of the percent change in the value of firm k sales in market m , based on equations (1), (7), and (8).

$$\hat{V}_{km} = \sum_i (\sigma - 1) \left(\left(\sum_f x_{fm} \theta_{fim} \hat{c}_{fim} \right) - \theta_{kim} \hat{c}_{kim} \right) \quad (9)$$

Equation (10) is a linear approximation of the percent change in employment of input j in firm k production for market m .

$$\hat{L}_{kjm} = \sum_i \left((\sigma - 1) \left(\left(\sum_f x_{fm} \theta_{fim} \hat{c}_{fim} \right) - \theta_{kim} \hat{c}_{kim} \right) - \theta_{kim} \hat{c}_{kim} \right) \quad (10)$$

Equation (11) is a linear approximation of the percent change in the global employment of input j in firm f .

$$\hat{L}_{kj} = \sum_m z_{km} \sum_i \left((\sigma - 1) \left(\left(\sum_f x_{fm} \theta_{fim} \hat{c}_{fim} \right) - \theta_{kim} \hat{c}_{kim} \right) - \theta_{kim} \hat{c}_{kim} \right) \quad (11)$$

$z_{km} = \frac{V_{km}}{\sum_n V_{kn}}$ is the initial share of firm k production that supplies market m .

Equations (7) through (11) quantify the economic effects of small changes in production costs. The employment effects in equation (11) depend on the magnitude of the cost increases and the firms' exposure to the cost increases. Exposure is summarized by three sets of shares for each firm and its competitors: the cost share of each input in each firm's production for each market (θ), the expenditure share of each firm in each market (x), and the share of each firm's output of that is sent to each market (z).

The input demands of each firm, including its labor demand in each of its production locations, can be affected by cost shocks in several ways. Input demands can be affected directly by increases in the firm's own production costs. They can also be affected indirectly by increases in the production costs of the firm's competitors.

To illustrate the positive and negative effects on an individual firm's employment, we focus on an increase in the cost of one input, j , of one firm, g , that it uses to supply all of the firm's national markets, so $\hat{c}_{gjm} > 0$ for every market m , $\hat{c}_{gim} = 0$ for all m and $i \neq j$, and $\hat{c}_{fim} = 0$ for all m , $i \neq j$, and $f \neq g$. Equation (12) is the negative direct effect on the employment of input j within the firm that experiences an increase in its own costs of production, firm g .

$$\hat{L}_{gj} = \sum_m z_{gm}((\sigma - 1)(x_{gm} - 1) - 1)\theta_{gjm}\hat{c}_{gjm} < 0 \quad (12)$$

Equation (13) is the negative indirect effect on the employment of the other inputs of this firm.

$$\hat{L}_{gi} = \hat{L}_{gj} < 0 \quad (13)$$

In this case, there is complementarity in the demands for the different inputs of the firm, due to the fixed proportions technology, at least in the short run when the firm cannot adjust the set of countries that supply these inputs. For example, the firm's demand for labor in the United States would fall as the firm's costs of labor in other countries rise. Brainard and Riker (1997), Harrison and McMillan (2011), and the related econometric literature support this assumption: they find that the U.S. employees of multinationals are often complements for employees in the firms' foreign affiliates.

Equation (14) is the positive indirect effect on the demand for the inputs of a competing firm $f \neq g$ that does not experience an increase in its own costs of production.

$$\hat{L}_{fi} = \sum_m (\sigma - 1)(z_{fm}x_{gm}\theta_{gjm})\hat{c}_{gjm} > 0 \quad (14)$$

Cost shocks to firm g affect employment in firm f as long as the firms compete in at least

one overlapping national market ($z_{fm}x_{gm} \neq 0$ for some m) and firm g uses the input with the cost shock in its production for the overlapping market ($\theta_{gjm} > 0$).

The net employment effect on input i across the entire industry depends on the mix of competing firms. Equation (15) is a linear approximation of the percent changes in the employment of input i across all of the firms.

$$\hat{L}_i = \sum_f \left(\frac{L_{fi}}{L_i} \right) \hat{L}_{fi} \quad (15)$$

In the specific example above, the net effect on industry employment of input i depends on the mix of negative input demand effects in equations (12) and (13) and positive labor demand effects in equation (14).

3 Simulations of Employment Effects

The data inputs of the industry-specific model are defined by the variables in equations (10) and (11): the initial cost shares of the input with the cost increase, the unit input requirements of each firm, and the share of each firm's production that supplies each national market.

Though the model has a relatively simple mathematical structure, its nested constant elasticity of substitution assumption makes the model's structural equations non-linear, so the formulas for the percent changes in equations (10) and (11) are not exact. The linear approximations in equations (7) through (15) are useful for estimating the effects of very small cost shocks. They are not adequate for estimating the effects of large cost shocks. That requires a non-linear solution technique.

One solution is to use a Multi-step Euler Method (MEM) approach. To limit approximation error, this method divides the large cost shock into many small steps and calculates

the adjustment in the market equilibrium associated with each small step using equations (7) through (12), and updates z , x , and c . The cumulative changes after all of the steps accurately estimate the effect of the large cost shock. The updating equations are all reduced-form linear equations, so the MEM approach can simulate large cost shocks using simple cell formulas in spreadsheet software like Excel.

4 Relocation of Production

We have treated the locations of the firms' production as fixed, reflecting the short run horizon of the model. The firms adjust their prices and production levels in response to cost shocks, but they do not adjust the set of countries that supply their inputs.

In the medium to long run, the international pattern of production might adjust, depending on differences in production costs across the countries. Decisions about relocating production can be complicated to model, since they often involve long-lasting investment decisions under uncertainty, and they usually involve a comparison among alternative locations where there is no current production, and probably little data. Nevertheless, it is likely that shifts in the input demands of the multinationals will be magnified if the firms can relocate.

5 Potential Extensions

One extension of the modeling framework is to endogenize the costs of production, reflecting limitations on production capacity in the short run. This extension is useful for modeling industries with highly specialized inputs.

A second extension to the framework is to consider other forms of imperfect competition, such as Bertrand price competition with differentiated products. Changing the assumptions about competition will affect the modeled pass-through of cost shocks into prices. This

extension is useful for modeling industries with highly concentrated product markets.

6 Conclusion

The trade model illustrates the usefulness of firm-level data on production costs and market shares for quantifying the changes in employment in multinational firms when there is an increase in costs in one of their production locations. The model generates a variety of predictions about the changes in employment use within each firm in each country with production. At the industry level, the model demonstrates that there is a wide range of potential changes in industry employment, including positive net changes and negative net changes, depending on the mix of firms in the industry.

The next step is to apply the model to a specific industry that fits the characteristics of the modeling framework. The global motor vehicles industry is probably a good fit, because it has a small number of major firms with multinational production, and there is some firm-level information available on the location of their sales and the cost of their operations.

References

- Brainard, L. and Riker, D. (1997). US Multinationals and Competition from Low Wage Countries. NBER Working Paper No. 5959.
- Harrison, A. and McMillan, M. (2011). Offshoring jobs? multinationals and u.s. manufacturing employment, *Review of Economics and Statistics* **93**(3): 857–875.
- Krugman, P. (1980). Scale economies, product differentiation, and the pattern of trade, *American Economic Review* **70**(5): 950–959.