Essays on Multinationals, Trade,
and International Labor Demands

by

DAVID A. RIKER

B.A. Williams College, 1992

Submitted to the Department of Economics
in partial fulfillment of the requirements of the degree of

DOCTORATE OF PHILOSOPHY IN ECONOMICS
AT THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

MAY 1996

©1996 David A. Riker
All Rights Reserved

The author hereby grants to MIT permission to reproduce
and distribute publicly paper and electronic copies
copies of this thesis document in whole or in part.

Signature of Author: ...........................................

Department of Economics
May 16, 1996

Certified by: ......................................................

Andrew Bernard
Assistant Professor of Economics

Accepted by: ......................................................

Professor Richard Eckaus
Chairman, Department Committee on
Graduate Students

ARCHIVES
MASSACHUSETTS INSTITUTE
OF TECHNOLOGY

JUN 10 1996

LIBRARIES
Essays on Multinationals, Trade, and International Labor Demands
by
David A. Riker
Submitted to the Department of Economics
on May 16, 1996 in Partial Fulfillment of the
Requirements for the Degree of Doctorate of Philosophy
in Economics

ABSTRACT

These essays examine the roles of international trade and multinational enterprises in linking the demands for labor across national borders. In doing so, they contribute to the trade-and-wages literature by addressing the issue of firm relocation that arbitrages wage differentials between developing and industrialized countries.

The first essay is a theoretical model of trade and factor mobility that contrasts the protectionist and altruistic results of attaching labor standards to trade liberalization pacts. The essay focuses upon the policy alternatives suggested by the model.

The second and third essays are empirical analyses of the relationship between offshore production of U.S. multinationals and the demand for labor in the United States. The studies utilize a firm-level panel dataset covering the period 1983 to 1992. The results indicate that the firms do relocate production across affiliates in response to fluctuations in local product and factor market conditions. The marginal relationship between factor demands in different countries depends upon the decomposition of production processes across these affiliates. The empirical results indicate that labor demands are complementary between workers in industrialized countries and workers in developing countries, consistent with the multinationals' vertically decomposing production into stages and locating these stages according to comparative advantage. The implications of a significant North-South trade liberalization for labor demands are discussed.

Thesis Supervisors:

Andrew Bernard
Assistant Professor of Economics

Rudiger Dornbusch
Ford International Professor of Economics
Table of Contents

Acknowledgements 4

Introduction 5

Firm Relocation, Trade, and Labor Standards

Chapter 1: Labor Standards and the International Mobility of Differentiated Firms 13

Empirical Studies of the Labor Demands of U.S. Multinationals

Chapter 2: Translog Estimates of the Elasticities of Labor Substitution Across Affiliate Production Sites and Literature Review 34

Chapter 3: Structural Model, Industry-level Estimation of Labor Demand Relationships of Horizontally and Vertically Integrated Multinationals, and Discussion of Policy Implications 70

References 105
Acknowledgements

I would like to thank Professors Andrew Bernard and Rudiger Dornbusch for supervising my thesis work. They have motivated me to ask clear-minded questions and to articulate the answers in a persuasive manner. I am grateful for their support during trying times.

I would also like to acknowledge the helpful comments from Professors Lael Brainard, Avinash Dixit, Steve Pischke, and Jaume Ventura and my classmates, especially Mark Moore, who have helped my understanding of international economics to progress over the past four years.

I gratefully acknowledge the financial support of the National Science Foundation, through a graduate fellowship, and the research resources provided by Lael Brainard and the Bureau of Economic Analysis at the U.S. Department of Commerce.

Finally, I would like to thank Debra and my family for their hospitality, love and support throughout this research effort.
Introduction

National labor markets are increasingly connected by trade, capital flows, and multinational firms. With the dismantling of trade barriers and advances in communications technology, differences in relative factor endowments and productivities are clearer determinants of the pattern of production and trade among countries. Theories of comparative advantage suggest that this globalization of manufacturing implies a diminishing demand for unskilled workers in industrialized countries, as labor-intensive production processes are relocated to developing countries. However, the extent to which outsourcing and trade are actually responsible for recent trends in the U.S. labor market remains an unresolved empirical puzzle.

This is the focus of the recent empirical literature on trade and wages: specialists in trade and in labor economics debate whether H. Ross Perot's "great sucking sound" is an empirically accurate description of the American economy rather than a rhetorical scare tactic. Motivated by a number of striking trends in U.S. labor markets -- the recent stagnation of real wage growth, the considerable widening of the wage differential between skilled and unskilled workers, and the thirteen percent decline in the number of production workers employed in the manufacturing sector over the last fifteen years -- this line of research attempts to test whether these trends can be explained by the increased accessibility of low-cost foreign production made possible through trade and the foreign investment of multinational firms.¹ A compelling casual-empirical argument against the importance of trade in explaining the labor market trends is the relative size argument: according to Krugman and Lawrence (1993), international trade is too

¹For an overview of the trade and wages literature, see Deardorff and Hakura (1994).
small of a share of the entire U.S. economy to have a quantitatively significant effect on the aggregate domestic labor market.²

The essays in this dissertation contribute to this trade-and-labor debate while focusing attention on the role of multinational firms, which in fact control a majority of international trade. The firms' labor demands in different affiliates are linked by intrafirm trade. This firm-level connection makes multinationals choice subjects for studying the impact of trade on labor markets, from both a theoretical and an empirical standpoint. These firms' foreign affiliates may have access to the proprietary technologies, financing and markets of their U.S. parent and consequently are accessible supply sources of either the same set of final products or different complementary inputs. On the other hand, unaffiliated LDC producers likely lack the technology and trade networks necessary to effectively supply most manufactured goods to the OECD countries. The multinationals' intra-firm relationship of labor demands is not subject to the "quantitative insignificant" critique of Krugman and Lawrence: the production location decisions of multinational firms are expected to respond to relative wage fluctuation across countries even if the general equilibrium effects of arm's-length trade are not distinguishable in the aggregate data. From an empirical standpoint, the interconnection of labor demands across countries can be estimated using firm-level surveys of the Department of Commerce, thus isolating employment shifts in response to wage and demand fluctuations across each firm's set of affiliate locations while controlling for inevitable heterogeneities across firms.

In particular, the essays examine whether workers in industrialized and developing

²A more compelling argument, though, is Learner's theoretical counterpoint that factor prices are set on the margin and therefore the "size" of trade is not relevant per se (Learner, 1995).
countries are in competition with each other for the jobs of multinational firms, or more formally, whether their employees in different countries are substitute factors of production, such that conditions in local product and factor markets lead to the relocation of production across borders. The essays discuss the effect of trade policy on the choice of production locations of multinationals, addressing such questions as: What does the evidence on outsourcing over the last decade imply about these firms' expected response to NAFTA and similar multi-lateral and regional trade liberalizations? What effect will international labor standards have on internationally mobile firms, and why do unions in the United States advocate labor side agreements to trade pacts?

Chapter 1 is a theoretical essay that examines explanations for American unions' advocacy of international labor standards as side agreements to NAFTA and ratification of the World Trade Organization (WTO). In a two-country trade model with imperfect competition, labor standards are formally modeled as either a redistribution of rents in collective bargaining, fixed costs, or variable costs per unit of employment. The effects of the policies depend upon whether the countries are linked by trade, capital flows, or the movement of firms with rent-generating assets. If labor standards do not impose variable costs, then the policies will not have cross-border effects on union wages through trade in goods or international movement of competitively-hired factors: policies that do not impose variable costs do not distort the production margin, which is the basis of pricing and competitive factor demands. On the other hand, if employers with rent-generating assets are internationally mobile, standards that impose non-marginal costs on employers (and therefore affect rents) have cross-border effects on union wages and achieve a protectionist outcome. The model demonstrates that the counter-argument
that international labor standards are a form of altruism or labor solidarity is likely undermined by the mobility of differentiated firms: workers in the South may be worse-off with union bargaining power if a significant number of Northern firms are deterred from relocating.

The implications of the model for policy are then discussed. In particular, Bhagwati (1993) proposed that American-owned firms operating abroad be held to American labor standards. This policy was recommended as a more politically feasible alternative to a social clause in NAFTA, which would mandate labor standards to be applied to all producers in all three countries. The model indicates that targeting U.S. multinationals is not only a more politically feasible alternative but also an effective means of achieving the same protection afforded by international labor standards without stepping on national sovereignty or limiting trade in goods or capital flows.³

For the sake of simplicity, the model of Chapter 1 focuses upon single-country firms and their location choice in response to trade liberalization and international differences in labor standards. The model in Chapter 3, on the other hand, explicitly addresses the implications of multinational firms that decompose or fragment production across countries, locating complementary intermediate production stages in industrialized and developing countries. As a result, the labor demands in different affiliate locations are characterized by complementarity rather than competition.

Chapters 2 and 3 are empirical essays that investigate the relationship between offshore production of U.S. multinationals and the demand for labor in the United States. They report

³Of course, there are practical problems with this policy, such as the cost of monitoring the firms’ workplace conditions across borders.

Chapter 2 fits translog cost functions to the data to estimate the elasticity of substitution of employment among affiliate locations in response to fluctuations in relative wages. The estimates show that substitution between parent and affiliate labor is low, and well below substitution between labor employed at different affiliates. Substitution is particularly strong between labor employed in different developing countries, which accords with anecdotal descriptions of these LDC affiliates as export platforms. Substitution between labor employed in industrialized and developing countries is low, and even complementary between the affiliates in the western hemisphere, which suggests a vertical decomposition of production.

Chapter 2 is based on a paper jointly written with Lael Brainard and presented at the 1995 NBER Summer Institute (International Trade and Investment) under the title "Are U.S. Multinationals Exporting U.S. Jobs?" Chapter 3 is a continuation of this empirical research using microdata at the BEA.

Chapter 3 addresses a similar set of questions, though using a significantly different methodology. The analysis is based on a simple structural model of the firm's decision of how many workers to employ in each affiliate location. The firm's response to fluctuations in local wages and product demands is tempered by costs of international trade. The relationship between labor demands in different locations depends upon the relationship between the production processes in which the workers are employed. If affiliates are horizontally integrated, meaning that the same good is produced in many countries to avoid trade costs in supplying local markets, then workers in these different affiliates will be substitute factors of
production. If affiliates produce different component inputs, labor demands may be complementary or even unrelated.

This pattern of labor complementarity and substitution is apparent in the data. The econometric analysis indicates that affiliate employees in developing countries with low average educational attainment are complements rather than substitutes for the multinationals' employees in industrialized countries; on the other hand, workers in countries with similar levels of educational attainment are substitutes. The results indicate a clear North-South separation of multinational production into complementary intermediate stages that differ by skill intensity, such as parts production and assembly. In addition, the size of local markets, proxied by GDP in each country, is a significant determinant of the relative labor demands of the firms across countries, indicating the importance of barriers to trade. In fact, proximity to product markets is the primary consideration in the choice of affiliate location: the majority of foreign direct investment of the United States is located in other OECD countries.

These results go against the presumption of the trade-and-wages literature that foreign production is a substitute for domestic production. They suggest that empirical researchers should more carefully construct measures of foreign competition. For example, measures of import prices should be decomposed between trade in complementary inputs and trade in substitute final goods. If this distinction is not made, the effects of the two may offset each other in a composite measure, leading to the frequently reported result that international trade has no discernible effect on U.S. labor markets.

The model in Chapter 3 also illustrates the difficulty in inferring the wage and employment effects of NAFTA from this 1983-1992 historical sample: the observed North-South
complementarity of the multinationals' labor demands is consistent with a variety of outcomes in the aftermath of a significant liberalization of international trade and investment, including a "great sucking sound" on the one hand and an employment boom associated with more efficient assembly on the other.

So have American firms been relocating manufacturing jobs to developing countries? The results of the empirical work reported in this dissertation indicate that this is not the case, at least for a certain class of firms.⁴ Specialization in complementary intermediate stages of production between industrialized and developing countries implies that employees in industrialized countries need not fear the multinationals' search for ever-cheaper assembly sites. The North-South relationship in labor demands is one of complementarity rather than competition. In other words, a collapse of the Mexican peso and the resulting decline in the dollar value of Mexican manufacturing wages is a boon to the firms' employees in the United States, who benefit from cheaper assembly abroad (but is a negative labor demand shock for the multinationals' affiliate in Malaysia, for example). This result is not based on a counterfactual claim that multinationals employ only skilled workers in the United States; rather, it is consistent with the story that vertically-decomposed firms have for the most part already moved most decomposable jobs to developing countries. The remaining unskilled support staff, the janitors of the scientists, are therefore not substitutable.

On the other hand, H. Ross Perot's "great sucking sound" may be an appropriate description of firms not in the set of multinationals examined. Anecdotal evidence suggests that

---

⁴The sample of firms studied have equity shares in foreign affiliates. For the purpose of studying international links in labor demands, one would ideally look at producers connected by significant trade in intermediate and final goods, regardless of ownership.
this is the case. Firms that outsource (i.e., trade intermediate goods) at arms'-length dominate many of the industries where foreign competition is claimed to be most damaging to domestic labor demand, such as the apparel industry. In addition, firms which produced exclusively in the United States prior to 1992 may relocate production to Mexico in response to the trade and investment opportunities afforded by NAFTA, and this will not appear in the historical dataset of multinationals which have, by definition, already geographically decomposed production.
Chapter 1:

Labor Standards and the International Mobility of Differentiated Firms

1.1. Introduction

NAFTA and the latest round of GATT negotiations have been accompanied by a campaign for environmental and labor side agreements intended to temper the impact of trade liberalization by "leveling the playing field." It is argued that lower labor and environmental standards in developing countries provide them an unfair advantage and provoke a race to the bottom -- a cost competition in which safety and human rights are on the chopping block.

The call for international labor standards is not new. It has been articulated by organized labor in industrialized countries since the establishment of the International Labour Organization seventy-six years ago. However, there is controversy over the intentions of these standards. There is a clear protectionist benefit to workers in industrialized countries from raising the production costs of low-wage foreign competitors. It is counter-argued that the standards are altruistic rather than protectionist, that the labor standards are an act of labor solidarity intended to raise working and living standards in developing countries rather than protect workers in the North. However, in a competitive world with liberalized trade and capital flows, these protectionist and altruistic objectives are likely at odds.

The debate over including social clauses in trade liberalization agreements raises the following questions: Are international labor standards, in their various possible forms, an effective way to protect U.S. wages from foreign competition? Are they an effective way to improve the welfare of workers in developing countries? We address these questions in the
context of a stylized trade model with factor mobility and a variety of forms of labor standards.

The model imbeds labor standards, represented by McDonald-Solow union bargaining, fixed costs of production and regulatory costs per-worker, within a model of trade with imperfect competition developed by Krugman et alia. There are two countries, the North and the South, with differing labor standards but liberalized trade. Rents are available to the firms with differentiated products, which are in fixed number due to unspecified barriers to entry. Therefore, the returns to labor in each country are particularly sensitive to the location of these differentiated firms.

The model is analyzed with respect to the impact of labor standards in the South on union wages in the North and in the South in order to highlight the distinction between protectionist and altruistic motivations. The results depend crucially on both the form of the labor standards and the international mobility of factors of production. If labor standards do not impose variable costs, then the policies will not have cross-border effects on union wages through trade in goods or international movement of competitively-hired factors of production. On the other hand, if employers with assets that generate rents are internationally mobile, standards that impose non-marginal costs on employers have cross-border effects on union wages and achieve a protectionist outcome.

These simple results of the model are then applied to a discussion of policy design in Section 1.3. In the context of the 1993 debate over the role of labor and environmental standards in NAFTA, Jagdish Bhagwati proposed that American-owned firms operating abroad be held to American labor standards. This policy was recommended as a more feasible alternative to a social clause in NAFTA, which would mandate that standards be applied to all
producers in all three countries. The model of this paper demonstrates that Bhagwati's policy, which targets U.S.-owned firms, would achieve the same degree of protection for Northern workers as an increase in Mexican union bargaining power or other non-marginal labor standards applied to all Mexican producers. The policy will not hinder flows of competitively-hired capital or cheap exports of Mexican-owned firms in the aftermath of trade liberalization, but it will achieve a "level playing field" for the relevant players -- the internationally mobile assets that generate rents, most of which are owned by U.S. parent companies. When international links, such as trade and the flow of non-differentiated factors of production, are not relevant to policy objectives (in this case, protectionism), then an effective policy need not address them, and this is of great practical benefit.

The model indicates that the altruistic argument for labor standards is likely undermined by the mobility of differentiated firms. The benefits to Southern workers of labor standards are as insecure as the mobile firms that employ these workers. Southern workers may be made worse-off in pecuniary terms by a leveling of the playing field if it deters the relocation of firms from the North.

1.2. The Model

Consider a world economy with two countries, North and South, which have liberalized trade such that prices in product markets are fully-arbitraged across countries. In each of these two countries there are two industries, Manufactures and Agriculture. Agriculture is assumed to be a perfectly competitive industry that employs labor (L) according to a constant returns to scale technology that is identical in both countries.
\[ A = L_A \quad [1.1] \]

Manufactures are differentiated products that require a specific factor of production, a knowledge asset which we call *blueprints*. The defining characteristic of these specific factors are that they give an exclusive advantage to the firms possessing them (i.e., they are proprietary). The specific factors may be alternatively interpreted as proprietary technology, uniquely skilled managers, or even brandname recognition. Each variety, indexed by \( i \), is produced using the non-rival blueprint and labor according to the following technology:

\[ m_i = L_i \quad [1.2] \]

There is a large number of blueprints in the world, \( B \) in total, that are used by \( B \) manufacturing firms. Though the productive use of blueprints is non-rival, we assume that they are used to produce only in the North or in the South.\(^5\)

The varieties of manufactures are imperfect substitutes in consumer demands. We adopt the Dixit-Stiglitz specification of preferences:

\[ U = A^{\gamma}M^{1-\gamma} \quad [1.3] \]

where \( A \) is the quantity of food consumed and \( M \) is a sub-utility index of the differentiated manufactures:

\(^{5}\)An extension of the model to include multinational production is discussed in the Appendix.
\[ M = \left( \sum_j m_j^\frac{s-1}{\sigma} \right)^\frac{\sigma}{\sigma-1} \quad [1.4] \]

j indexes the varieties of manufactures, \( \sigma > 1 \), and preferences are identical in both countries. The number of blueprints is assumed to be fixed. Market power of firms in the manufacturing sector, sustained by the fixed number of differentiated blueprints, generates rents available to the owners of the blueprints. These rents are not competed away through entry but are divided through bargaining if workers are organized.\(^6\) The product market for agricultural goods, on the other hand, is competitive. The price of food is the numeraire.

The product demands implied by [1.3] and [1.4] are

\[ A = \gamma I, \quad m_i = \frac{p_i^\sigma (1-\gamma) I}{\sum_j p_j^{1-\sigma}} \quad [1.5] \]

where I is world income in terms of the numeraire good.

Labor markets for agricultural workers in each country are competitive, so factor demands satisfy the following classical condition:

\[ VMPL = 1 = w_c \quad [1.6] \]

where \( w_c \) is the competitive wage in country \( c \).

\(^6\) The underlying assumption is that replication or innovation is an unprofitable activity for potential entrants, possibly because of barriers. Relaxation of this assumption of a fixed number of blueprints is addressed below.
The model departs from standard trade models by considering the effects of three categories of labor standards in the manufacturing sector of each country: (i) policies that redistribute rents, such as enforced rights to collectively bargain; (ii) policies that impose fixed costs, such as factory safety standards; and (iii) policies that impose additional variable costs per worker, such as safety helmets or minimum wages. The model follows the trade literature in focusing upon the impact of these policies on the relative pattern of production and factor returns across countries while abstracting from non-pecuniary benefits of these labor policies.

If allowed to organize, workers will do so in the manufacturing sector, where there are rents. Manufacturing employment is modeled as the result of firm-level wage-employment bargaining in the form of McDonald-Solow efficient bargaining with a Nash sharing rule. The outcome of the firm-level bargaining process is the level of employment $L_t$, earnings per union employee $\omega_t$, and the residual rent to the owner of the blueprint. The total rents generated by each blueprint is the firm's revenue net of the opportunity or competitive factor cost of the labor resources employed in manufacturing the product and any costs arising from labor regulations. The union's objective is assumed to be maximization of returns to its membership in excess of the competitive wage

$$\left[ L_t \omega_t + (Z_t - L_t) \omega_c \right] - Z_t \omega_c \quad [1.7]$$

where $Z_t$ is the union's membership, $\omega_t$ is the bargained wage, and full-employment is ensured by labor market-clearing in the orchards and farms (i.e., through variations in the relative price

---

7The efficient bargaining model, developed from the work of McDonald and Solow (1981) and others, is a common representation of unions in the international trade literature, e.g., Brander and Spencer (1988) and Mezzetti and Dinopoulos (1991).
of agricultural goods). The subscript c indicates variables that are determined at the country-level, whereas the subscript f indicates firm-level variables. Workers bargain against the owner of the blueprint, whose objective is to maximize residual rents.

The efficient bargaining solution for firm f maximizes the following program with respect to the union wage and the level of firm employment:

\[
\text{MAX} \quad [L_{t}(\omega_{t}-w_{c})]^{\beta} \quad [p_{t}(L_{t}) \cdot m(L_{t}) - \omega_{t} \cdot L_{t} - \tau_{c} \cdot L_{t} - F_{c}]^{1-\beta} \quad \text{s.t.} \quad \omega_{t} - w_{c} \geq 0; \quad p_{t}(L_{t}) \cdot m(L_{t}) - \omega_{t} \cdot L_{t} - \tau_{c} \cdot L_{t} - F_{c} \geq 0
\]  

\[1.8\]

\(\tau_{c}\) is a marginal tax on the level of employment. \(F_{c}\) is a fixed cost. \(\beta_{c}\) is the bargaining power of workers.\(^8\) The solution to [1.8] is that the value marginal product of labor in manufacturing variety i is equal to its marginal cost:

\[
p_{t}'(L_{t}) \cdot m(L_{t}) + p_{t}(L_{t}) \cdot m'(L_{t}) = w_{c} + \tau_{c}
\]  

\[1.9\]

The firm and its employees maximize the joint surplus, \(p_{t}(L_{t}) \cdot L_{t} - w_{c} \cdot L_{t} - \tau_{c} \cdot L_{t} - F_{c}\), by choice of the level of production and the resulting product price regardless of the distribution of these rents between the workers and owners. Bargaining in [1.8] is efficient in the McDonald-Solow sense that the outcome is on the contract curve defined by the tangencies of the two parties' objectives. Moreover, the result is **strongly efficient** as defined by Brown and Ashenfelter.

\[^{8}\text{If workers have bargaining power, e.g., they have enforced rights to collectively bargain, then } \beta > 0.\text{ Binmore, Rubinstein and Wolinsky (1986) suggest as alternative determinants of } \beta \text{ the bargaining parties' risk aversion or their relative patience.}\]
the production margin is not distorted by bargaining, as illustrated in [1.9]. Our interest is not this efficiency result per se, but rather the result that the mark-up pricing is not affected by bargaining over rents nor is it affected by fixed cost $F_c$.

Combining [9] with product demand [1.5] and technology [1.2] imply that

$$P_f = \left( \frac{\sigma}{\sigma - 1} \right) (w_c + \tau_c) \quad [1.10]$$

for firm $f$. Production of each symmetric manufacturer in country $c$ is therefore

$$m_{c} = \left( \frac{\sigma - 1}{\sigma} \right) \frac{(w_c + \tau_c)^{-\sigma}}{B \left[ \lambda_{B} (w_{N} + \tau_{N})^{1-\sigma} (1-\gamma) \right] \left[ (1-\lambda_{B}) (w_{S} + \tau_{S})^{1-\sigma} \right]}$$

where $\lambda_{B}$ is the share on the world supply of blueprints $B$ that is located in the North. The price of the differentiated manufacture is a constant mark-up over the opportunity cost of the workers employed in production. The mark-up price in [1.10] is not based on the bargained wage paid to the union employees, which is the competitive alternative plus the union's share $\beta_{c}$ of the firm's price mark-up net of average fixed costs.

---

9Of course, production is still distorted (relative to the competitive benchmark) by imperfect competition in the market for varieties of manufactures. The strongly efficient result is sensitive to the specification of union preferences; we address this issue below.

10The derivation of [1.10] is based on the standard monopolistic competition assumption that each of the large number of individual firms consider its effect on the aggregate price index in the denominator of [1.5] to be negligible.
\[
\omega_t = w_c + \beta_c \left( \frac{\omega_t}{\omega_c} - \tau_c - \frac{F_c}{L_t} \right) = \left( 1 + \frac{\beta_c}{\sigma - 1} \right) \omega_c + \left( \frac{\beta_c}{\sigma - 1} \right) \tau_c - \frac{\beta_c F_c}{L_t} \tag{1.12}
\]

The union wage is increasing in the competitive alternative wage, the worker's bargaining power \( \beta \), and the market power of their employers (which is inversely related to the substitutability of the varieties of manufactures in consumer demands). It is decreasing in fixed costs.

The world endowments of labor and blueprints are \( L \) and \( B \), respectively. \( \lambda_B \) and \( \lambda_L \) represent the shares of these factors of production that are employed in the North. Resource constraints for each country determine the amount of agricultural production in country \( c \), \( A_c \):

\[
A_N = \lambda_L L - \lambda_B B m_B \\
A_S = (1 - \lambda_L) L - (1 - \lambda_B) B m_S \tag{1.13}
\]

We close the model with the identity that total consumer expenditure is equal to the sum of competitive factor returns and rents generated in manufacturing differentiated products:

\[
I = [\lambda_B B m_B] \omega_H^+ [\lambda_L L - \lambda_B B m_B] \omega_H^+ + \lambda_B B \pi_H^+ [(1 - \lambda_B) B m_S] \omega_S^+ (1 - \lambda_L) L w_S - (1 - \lambda_B) B m_S \omega_S^+ (1 - \lambda_B) B \pi_S \tag{1.14}
\]

where the residual rents accruing to each blueprint in country \( c \), \( \pi_c \), are

\[
\pi_c = (1 - \beta_c) \left[ \frac{(w_c + \tau_c) m_c}{(\sigma - 1)} - F_c \right] \tag{1.15}
\]

Equation [1.14] can be rewritten using [1.6], [1.11], [1.12], and [1.15] to show that the
bargaining parameters $\beta_N$ and $\beta_S$ in [1.15], as well as the marginal taxes, have no net effect on aggregate expenditure when $\lambda_B$ is fixed.

$$ I = \frac{\sigma}{\sigma - (1 - \gamma)} \left[ L - B \left[ \lambda_B F_N + (1 - \lambda_B) F_S \right] \right] \quad [1.14'] \]

$I$ is declining in the number of manufacturing firms $B$ and the fixed costs that they incur.

We use this model to study the impact of labor policies in the two countries on union wage premia in the North. The returns to workers in the North in excess of competitive wages, denoted $\Omega_N$, are the bargained wage premium multiplied by the number of manufacturing employees:

$$ \Omega_N = (\omega_N - w_N) (\lambda_B B m_N) \quad [1.16] $$

**When factors are immobile, but trade is free**

We first consider trade equilibrium with no factor mobility. Owners of blueprints cannot choose in which country to produce, so $\lambda_B$ is fixed. $\Omega_N$ is therefore fully-determined by equations [1.6], [1.11], [1.14'] and [1.16]:

$$ \Omega_N = \lambda_B \beta_N \left[ \frac{(1 - \gamma) (1 + \tau_N)^{1 - \sigma} \left[ L - B (\lambda_B F_N + (1 - \lambda_B) F_S) \right] - BF_N}{[\sigma - (1 - \gamma)] \left[ \lambda_B (1 + \tau_N)^{1 - \sigma} + (1 - \lambda_B) (1 + \tau_S)^{1 - \sigma} \right]} \right] \quad [1.16'] \]

The comparative static effects of bargaining power ($\beta_c$), marginal taxes on employment ($\tau_c$), and fixed costs ($F_c$) on returns to labor in the North in the case of factor immobility are reported in Table 1.1.
TABLE 1.1 ($\lambda_b$ fixed)

<table>
<thead>
<tr>
<th>Labor policies</th>
<th>$\beta_N$</th>
<th>$\tau_N$</th>
<th>$F_N$</th>
<th>$\beta_S$</th>
<th>$\tau_S$</th>
<th>$F_S$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact on Returns to Labor $\Omega_N$</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>+</td>
<td>-</td>
</tr>
</tbody>
</table>

Marginal taxes on labor have relative price effects, but no effect on disposable income; on the other hand, fixed costs in either country have a negative effect on disposable income, but no relative price effect. Bargaining, in the strongly efficient form specified above, has neither effect and therefore does not have a cross-border effect on union wages.

With $\lambda_b$ fixed, the returns to unionized labor in the North does not depend on the bargaining power in the South, as the redistribution of rents in the South does not affect international trade prices. This point seems to be unclear in popular discussions of labor standards: higher wages in the South due to unionization is not sufficient to protect workers in the North from cheap imports from the South, i.e., since higher labor costs may not be passed-on into import prices.

Fixed costs in each country affect pricing to the extent that they lower disposable income I in the integrated world market. Higher fixed costs in the South, $F_S$, does not make low-cost producers in the South relatively less cost-competitive (a criterion which is based on marginal costs), though it does reduce the disposable income with which Southern consumers import manufactures from the North.

A higher marginal cost of labor in the South, $\tau_S$, is transmitted positively onto factor
returns in the North through a pure relative price effect, raising the demand for Northern manufactures at the expense of Southern exports. \( \tau_N \) has the opposite effect.

The effect on workers in the South is simply a relabeling of Table 1.1. With immobile manufacturing firms, workers in the South benefit from a positive \( \beta_S \) and are hurt by marginal taxes that produce no pecuniary benefits but nevertheless make their products more costly to produce.

The pattern of trade is therefore determined by the location of firms with blueprints and the relative marginal costs imposed by labor standards. The impact of labor policies may change, however, when factors of production are internationally mobile.

**When capital and workers are mobile, but blueprints are not**

Consider briefly an extended version of the model which includes physical capital in the competitive sector that is competitively and flexibly rented. Capital mobility is modeled by modifying the production function in the competitive sector

\[
A_c = L_{A(c)}^\alpha K_c^{1-\alpha}, \quad \alpha \in (0, 1) \\
(1-\alpha) L_{A(c)}^\alpha K_c^{-\alpha} = r_c
\]  

[1.1']

and allowing capital to move freely between countries until factor returns are equalized,

\[
r_N = r_S = r
\]  

[1.17]

while maintaining the assumption that blueprints are immobile.

The share of the mobile factor employed in each country is determined by [1.6], [1.11],
[1.13], [1.14] and [1.17]. Relative demands for physical capital, and thus capital flows, are still determined from marginal conditions as is the pattern of trade; therefore, any non-marginal standard is not transmitted in factor flows as \( \mu \) is not transmitted in the prices of traded goods. In this respect, there is an equivalence between international trade and factor mobility, similar to Mundell (1957). The point is that there is a type of capital flow distinct from movement of multinational firms: this form of capital is not specific but moves flexibly and is hired competitively, and looks and acts like trade in goods. Similar results apply if \( K \) is interpreted as immobile land and there is labor migration until competitive wages are equalized. In general, by allowing mobility of competitively-hired factors we do not change the qualitative results of Table 1.1. Fixed costs still reduce overall spending without affective relative prices, and bargained redistributions similarly have no effect on the pattern of production. The pattern of trade is still determined by the location of blueprints and marginal taxes.

For collective bargaining or fixed costs in the South to raise union wages in the North, the residual claimants to the rent-generating blueprints, the owners of differentiated firms, must exercise a choice between locations. The "great sucking sound" ought to be formally modeled as differentiated firms moving to the South rather than the reallocation of resources associated with competitively-hired capital flows. And the implication is that Labor opposition to the NAFTA would not have focused as intensely on labor standards if the trade liberalization had not been coupled with a pact facilitating international investment.

**When firms choose where to produce differentiated goods**

Blueprint mobility provides a cross-border protectionist role for both collective bargaining and fixed costs. The location of manufacturing, \( \lambda_B \), is determined by the condition that
manufacturing firms move to the country where their residual rents will be higher. The location of differentiated production is implicitly defined by the following condition in terms of relative labor market policies:

\[ \pi_N(\lambda_B) = \pi_S(\lambda_B) \]  

[1.18]

where

\[ \pi_c = (1 - \beta_c) \left[ \frac{(1 + \tau_c)^{1-\sigma} (1-\gamma) \left[ L - B \left( \lambda_B F_N + (1 - \lambda_B) F_c \right) \right]}{\sigma - (1-\gamma) B \left[ \lambda_B (1 + \tau_N)^{1-\sigma} + (1 - \lambda_B) (1 + \tau_c)^{1-\sigma} \right] - F_c} \right] \]

The results from combining equations [1.6], [1.11], [1.13], [1.14'], [1.16] and [1.18] which are reported in Table 1.2 differ substantially from those in Table 1.1, since the imposition of non-marginal costs now affect the differentiated firm's choice of location.

<table>
<thead>
<tr>
<th>TABLE 1.2 (Mobile Blueprints)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Labor policies</strong></td>
</tr>
<tr>
<td>Share of Blueprints in North ( \lambda_B )</td>
</tr>
<tr>
<td>Impact on Returns to Labor ( \Omega_N )</td>
</tr>
</tbody>
</table>

Increases in bargaining power in the South now have two offsetting effects: they raise the share of rents that union workers receive but they also reduce the size of total rents in the
country, as firms with differentiated products relocate to the North (or are deterred from moving to the South).

Marginal taxes maintain a clear relative price effect. For example, higher minimum wages in the South that are binding will make Southern production more costly and will similarly deter firms from relocating.

Labor standards that impose fixed costs will lead to a relocation of blueprints in addition to the overall reduction in disposable income coming from the expenditures on "safety". The net effect on union wages in the North is ambiguous, though it may easily be negative.

We have abstracted from conventional sources of comparative advantage by assuming that technologies in both countries are identical and that labor and blueprints are the only factors of production. When blueprints are mobile, the pattern of trade is determined only by relative labor standards: collective bargaining and fixed costs are the basis of comparative disadvantage.

Extensions

Even redistributinal labor standards may harm Southern workers

Sengenberger and Campbell (1994) and Hansson (1983) emphasize that efforts to achieve international labor standards are motivated by altruistic objectives and a sense of labor solidarity as well as protectionism. If we narrowly construe the altruistic motivation as the provision of pecuniary benefits to workers in the South, the case for altruism is not at all clear-cut: workers in the South may be worse-off if they have protected rights to bargain as unions. Indeed,

---

11Markusen (1983) provides a series of models in which comparative advantage in trade is created by international factor flows.
representatives of Southern countries have generally resisted international labor and environmental standards in multi-lateral forums, and workers in these countries have not agitated to the contrary.

With bargaining power, Southern employees receive a larger share of the rents, but there are fewer firms to employ them as mobile firms see an end to cheap labor. If there are decreasing returns to labor in the competitive sector, as in [1.1'], then a smaller manufacturing sector will unambiguously drive down the competitive wage, leaving agricultural workers in the South worse-off. Even union employees with bargaining power are not guaranteed to be better-off at the expense of their employers: if they have enforced rights to bargain, they likely cannot credibly commit not to demand higher wages once the firms have moved to the South, and so the movement of firms may be unavoidably deterred.

Therefore when there is blueprint mobility, an altruistic interpretation of international labor standards must rely heavily on the non-pecuniary benefits to workers.

Sensitivity to union preferences

We have modeled bargaining as a non-distortionary redistribution of rents on the premise that unions' objectives are to maximize the overall payroll. The specification of the objectives of union bargainers is a primitive assumption of the model that has some mixed empirical support, e.g., Brown and Ashenfelter (1986). The results of the model vary depending on both the bargaining game played and the objectives of the unions. For example, if there were a bias toward higher employment or "feather-bedding," union bargaining would actually lead Southern firms to increase production, reducing the price of their exports.
Endogenous creation of blueprints

We have assumed that the only choice for owners of blueprints is the location of production. The simple static framework suggests that (i) labor standards in the South lowers the residual rents in the South and therefore lowers the potential rents available to mobile innovators of new products; (ii) if the number of blueprints B is determined endogenously by the size of these rents relative to costs of innovation, unionization will affect the pattern of trade, even if (existing) blueprints are not mobile across jurisdictions (i.e., bargaining power of workers will deter local innovation). Alternatively, one might look explicitly at the resources that go into the creation of new blueprints in a dynamic context following Grossman and Helpman (1993). However, a fixed number of blueprints may be a reasonable approximation over the span of a decade, a time period in which the set of differentiated firms like GE, GM, and Coca-Cola remains more or less constant. A complication with a free entry condition is that the role of bargaining is unclear when rents are dissipated through entry.

1.3. Policy Implications: Bhagwati's Proposal

The model of section 1.2 provides a framework for thinking about international labor standards by drawing distinctions among different types of policies and different types of factor mobility or international transmission. The analysis can be usefully applied to discussions of policy design. If certain international links, such as trade and the flow of non-differentiated factors of production, are not relevant to policy objectives (in this case, protectionism), then an effective policy need not address them.

In the context of the 1993 debate over the role of labor and environmental standards in
NAFTA, Jagdish Bhagwati proposed the following policy alternative:

"We can address the chief concern of U.S. labor unions that our investments will flow to Mexico in industries where standards are lower than our own. For U.S. companies in Mexico, whether fully owned subsidiaries or joint ventures, we can legislate, not just exhort, that they act entirely up to our [labor and environmental] standards.

... Such a policy, reminiscent of the Sullivan Principles urging U.S. companies in South Africa to comply with American laws against racial discrimination, would respond to the fears of the unions about the loss of jobs to Mexico. It would thus strengthen the ability of the Clinton Administration to reject the outlandish demands that Mexico, despite its poverty, do much more for the environment and labor than it can currently afford and that it replicate our regulations and standards on each industry.

This policy is in our jurisdictional powers: our industries should be subject to our legislation, especially as no conflict with Mexican laws is at stake.

Proponents of tough environmental and labor standards, who desire them as good values that should apply to Mexican citizens, should also realize that the presence in Mexico of our companies adhering to the higher standards would serve as a demonstration for Mexican industries and would encourage Mexican nongovernmental organizations to agitate for an extension of such standards to all Mexican companies eventually."


The policy responds to the protectionist "fears of the unions about the loss of jobs to Mexico," while at the same time respecting the political infeasibility of dictating social conditions in sovereign Mexico. Bhagwati's proposal provides a policy alternative intended to avoid a derailing of the NAFTA.

An interesting implication of the stylized model of Section 1.2 is that Bhagwati's policy, which targets U.S.-owned firms, would achieve as much protection as unionization or other non-marginal labor standards applied to all Mexican producers. It will not staunch flows of competitively-hired capital or cheap exports of Mexican-owned firms in the aftermath of trade liberalization, but it will achieve a "level playing field" for the relevant players -- the
internationally mobile knowledge assets that generate rents, most of which are owned by U.S. parents. And in the process it effectively obviates comparative advantages based on international differences in non-marginal labor standards. Therefore, the model supports Bhagwati's proposal for meeting protectionist objectives without appending cross-jurisdictional social clauses to trade agreements.

Bhagwati's proposed policy might not achieve altruistic objectives. He argues that it would set an example for Mexican producers and thus stir political agitation. But, as illustrated in the model, the benefits to Southern workers of labor standards are as insecure as the mobile firms that employ them. Southern workers may be worse-off in pecuniary terms by a leveling of the playing field.

Of course, implementation of Bhagwati's proposal would be difficult, even though it's implementation is within national jurisdiction. Difficulties in monitoring decentralized workplaces make labor standards a complicated form of protectionism relative to positioning customs agents at the border to impose tariffs and quotas.

1.4. Conclusions

The model in this chapter provides a framework for thinking about international labor standards by distinguishing among policies that impose marginal costs, fixed costs, or non-distortionary redistributions under various forms of factor mobility. It combines a public finance emphasis on the distortionary impact of taxes with an emphasis on international transmission and then applies the analysis to policy alternatives. The model emphasizes the particular character of firms that lie at the center of policy discussions: fears of the "great sucking sound" refer to
the relocation of firms that sell differentiated products and able to protect and relocate their rent-generating assets.

With trade and factor mobility, policies such as tariffs or marginal taxes have an effect on the location of production. However, the international mobility of firms with proprietary assets brings a whole new set of policies, including standards that impose fixed costs or redistributions of wealth, to the fore in determination of the location of production and factor returns. Whether labor standards are well-characterized by redistribution and fixed costs or by marginal costs per worker is an unresolved empirical matter.

In addition to its policy implications, the model has distinct empirical predictions. Neither fixed costs nor income taxes should affect pricing, and therefore implementation of these types of standards is not expected to raise export prices. Moreover, the relationship of these labor policy innovations in the South to union wages in the North should come only through the relocation of multinational firms producing differentiated products.

1.5 Appendix: Multinationals and Bargaining over Revenues

A more realistic specification of the mobility of non-rival blueprints is multinational production. Firms that move to the South typically maintain production facilities in the North. If the common employer faces separate, non-cooperative unions in the two countries, the model requires a bargaining game that specifies the rule by which the revenues of the firm are divided. One alternative is the common agency framework of Bernheim and Whinston, which has been applied to international economics by Grossman and Helpman (1994). In a menu auction, each union demands the largest a share of the rents that maintains the firm's incentive to not shift
production completely to workers in the other country, i.e., the other principal. The ability of any union to extract rents depends on the employer's alternative, which depends in turn on the other union's bargaining power, i.e., the extent to which the wage implicit in the competitor's proffered menu exceeds the competitive wage in its secondary market. It can be shown that bargaining power and fixed costs in the South affects returns to Northern unions that are employed by the same multinational firms. This is not surprising, since multinationality is a generalization of the single-country firm modeled above.
Chapter 2

The Labor Demands of U.S. Multinationals: Part I

2.1. Introduction

Several prominent labor organizations undertook a massive political campaign to oppose NAFTA on the grounds that it would facilitate the relocation of American plants south of the border, substituting cheap Mexican workers for costly American workers. This is only the latest instance of recurring allegations that offshore production is tantamount to exporting American jobs.

These allegations receive substantial support from economic theory. The dominant economic models explain multinational expansion as a means of exploiting factor price differentials, predicting that FDI should flow from relatively capital abundant to relatively labor abundant countries. However, this is at odds with casual empiricism - in recent years more than 80 percent of FDI has been directed at industrialized countries (Graham and Krugman, 1990). More formal investigations also suggest that multinational activity is more likely between countries the greater are their similarities in factor proportions and per capita income, contrary to both the dominant economic models and popular perceptions (Brainard, 1993a).

The increasing attention paid to multinationals in both the international economics literature and popular discussion stands in marked contrast to the relative dearth of detailed empirical work on the subject, reflecting in part a lack of appropriate data. To this point, there has been no attempt to directly quantify the firm-level relationship between offshore production, domestic parent employment, and relative labor costs. This research makes a first attempt. The
theory of multinationals formalized by Caves (1982) and subsequent researchers is based on the theory of the firm, implying that firm-level data should shed the most light on international employment decisions. Using a detailed firm-level panel dataset of U.S. foreign affiliate and parent employment spanning the period 1983-92, we examine the response of the allocation of employment within the firms across borders to changes in relative wages.

The paper first describes the data set and empirical regularities. We note that the allocation of employment across broad categories of locations has moved with rather than against wage movements, increasing most in areas where wages have increased most relative to parent wages; moreover, we note that simple ratios of net to gross employment changes across locations do not provide strong evidence of offsetting employment changes within firms, either across all locations or across particular categories of locations. However, we argue that such simple measures, while confirming results in the empirical literature, do not accurately capture the notion of price-induced factor substitution: the former measures are not firm-level correlations and do not account for the multi-lateral complexity of relative wages, while the latter measures focus upon the international correlation of employment rather than its relationship to relative factor costs.

Therefore, we then go on to link the changing allocation of employment to relative labor costs by estimating elasticities of substitution of multinational labor demand. In a partial equilibrium framework, we jointly estimate the factor demand equations that derive from a translog cost function. This estimation strategy in effect allows for the possibilities first that each firm has a global production function and, second, that labor inputs in different locations are imperfectly substitutable inputs.
We employ various aggregations of the affiliate locations, taking advantage of the multilateral nature of the data set. We distinguish the level of development, geographic proximity, and the extent to which production is destined for re-export to the home market as opposed to local sale, as well as industry value added. The analysis confirms that labor employed by affiliates overseas substitutes for labor employed by parents at home. However, the degree of substitution is much stronger among affiliates than between parents and affiliates in general. Substitution is most apparent between workers at affiliates in different developing countries, suggesting that there is a strong vertical separation of activities to take advantage of factor price differentials, with workers in developing countries performing the activities that are most sensitive to labor costs. The story that U.S. jobs are "exported" to low cost production sites is supplanted by the result that employment-shifting takes place predominantly between offshore affiliates in less developed countries. Along geographical lines, there is little substitution between industrialized and developing countries, and even complementarity among western hemisphere (predominantly Canada and Mexico) affiliates.\(^\text{12}\)

Price elasticities reinforce these conclusions. Although employment at affiliate locations is fairly sensitive to parent wages, parent employment responds very little to variations in foreign affiliate wages. Thus, for example, while affiliates in Canada or Mexico experience a reduction of over 7 percent in affiliate employment when U.S. parent wages fall 10 percent, parent employment only falls one-third of one percent in response to a 10 percent fall in wages in Mexico or Canada.

\(^{12}\)This finding is elaborated upon in Chapter 3.
2.2. Related Literature

We have found no papers that directly estimate the elasticity of substitution between overseas affiliate employment and U.S. parent employment; however, a few papers have investigated related questions. Using data from 1966 and 1970, Kravis, Lipsey, and Roldan (1982) show that the labor intensity of affiliate production (relative to physical plant) exceeds that of parent production and is greatest for affiliates in developing countries. They also show that labor intensity is negatively correlated with the local market wage. In both cases, the paper provides evidence that these factor intensity differences are attributable to within-industry and possibly within-firm differences rather than to industry selection, suggesting that firms vary their choice of production techniques to exploit factor price differences or that different activities are undertaken in different locations.

In regressions of parent employment on parent sales and sales by overseas affiliates using cross-section 1989 data, Lipsey (1994) finds that parent employment is inversely related to affiliate employment, and more so for manufacturing affiliates. However, the regression likely reflects a simultaneity bias.

Slaughter (1993) compares industry-level affiliate employment data from BEA surveys to aggregate manufacturing employment in the U.S. in 1977 and 1989 for production and nonproduction workers. The aggregate measures of employment yield little to no support to claims that expansion by U.S. multinationals overseas was an important cause of the reduced demand for production workers at home over the 1980s. While total U.S. manufacturing employment shrank 10 percent between 1979 and 89, total overseas affiliate employment shrank 14 percent between 1977 and 1989. Further, while the quantity of production labor employed
in the U.S. declined by 15 percent between 1979 and 1989, overseas affiliate employment declined by 21 percent. Using a similar approach, Lawrence (1994) confirms these findings.

Slaughter (1993) also uses a cost function approach to estimate substitution between total overseas affiliate employment, aggregate measures of U.S. industry-wide capital and overseas affiliate capital, and total industry-wide domestic employment for 1977 and the period 1982 to 1989. He finds that domestic industry employment and overseas affiliate employment are complementary, but only weakly related.

2.3. Conceptual Approach

The growing number and importance of multinational firms suggests an important international link in factor demands related to but conceptually separate from trade. We are interested in whether multinationals’ labor demands across locations are interrelated, either through technological synergy (a vertical decomposition of production across locations) or through common product demand (a horizontal decomposition). To the extent that either of these conditions holds, and there is a link in factor demands across countries within the firm, the cost-minimizing multinational is expected to shift production and employment across borders in response to changing relative costs of production. For example, an appreciation of the dollar would imply an increase in relative production costs and an accompanying shift of production offshore.

We adopt a partial equilibrium framework for analyzing multi-factor demand and fit a global cost function specified in terms of relative wages. The estimation procedures developed in the literature on multifactor demands are used to estimate the relationship between overseas
affiliate employment and U.S. employment by treating them as distinct factors of production. Two aspects of this estimation strategy deserve particular attention. First, each multinational is permitted to have a single production function across all its plant locations. Second, labor inputs in different locations are treated as potentially differentiated inputs. This estimation strategy is designed to impose as little structure as possible on the relationship between labor inputs employed at home and abroad.

We assume highly elastic national labor supplies, reflecting the conventional assumption of competitive labor markets that are nationally segmented by legal and cultural restrictions on immigration. In contrast, labor demand is linked by firms that produce in a number of countries (as well as by international trade in goods). Foreign investment by multinationals facilitates a flow of firm-specific proprietary advantages across borders, possibly in the form of trademarks, product or process designs, or marketing networks.

Consider the extreme case where labor is perfectly substitutable across countries. Here, we would expect the cost-minimizing firm to shift all employment radically to the lowest cost location. However, there are a number of frictions that impede this type of wage-chasing employment reallocation. The distribution of skills vary widely across locations, there are likely large fixed costs or considerable adjustment costs associated with plant capacity, and there are proximity considerations such as tariffs, local content requirements, or transport costs that impede trade.

We are interested in quantifying the extent of labor substitution across locations. We focus on wage-induced marginal shifts in labor demand among the firms' production locations - - which we consider to be the relevant "options" of the firm -- conditional on the international
configuration of plant capacity. Based on the assumptions of segmented labor supplies and location-specific plant capacity, we treat labor in different countries as separate factors and estimate substitution among them.

In principle, it would be possible to include a separate equation for the labor demand in each of the countries in which affiliates potentially operate. However, this would be intractable, since there is a multiplicity of possible affiliate configurations with a data set covering ninety countries. Even if it were tractable, it is not clear that estimating a cross-elasticity for every pair of locations would be illuminating. An alternative, which we will adopt, is to aggregate affiliate employment (at the firm level) across subsets of countries that share certain economic characteristics.

We restrict the country dimension of the data in order not only to estimate a tractable relationship but also to transform the firms' options toward conformity, such that we can pool across firms in fitting a common specification. Otherwise, we would face the problem of "zero demands" that arises in multifactor demand estimation when pooling over a sample of firms that use a different set of factors rather than different quantities of the same set of factors.

Although our restriction of the country dimension of the data is a practical compromise, our approach to partitioning this country dimension is grounded in economic theory. The literature on multinationals suggests the following aggregations:¹³

*Export Intensity:* There is a clear distinction in the multinational literature between vertical expansion across borders for purposes of factor access and horizontal expansion across borders

---

¹³ Markusen (1995) is a survey of the theories of multinational production activity.
for purposes of market access (Brainard, 1993b). These different motivations for overseas expansion yield very different predictions for intra-firm trade (Brainard, 1993a). When overseas investment is motivated by proximity to the consumer, the overseas affiliate is much more likely to sell locally than to export its output back to the parent market. When factor access is the primary motivation, multinationals may establish plants abroad with the express purpose of exporting back to the home market. This is a clear case where activity abroad directly substitutes for activity in the home market. Affiliates that export back to their parent market are likely to be more sensitive to variations in relative factor costs: labor substitution is likely to be greater between affiliates whose output is highly tradeable. Thus, we distinguish between affiliates that produce for export back home and affiliates that produce for local sale.14

*Geography:* Similarly, we expect that production is more footloose among geographically proximate countries, the more that distance restricts international trade (an empirical regularity documented by gravity equations). For this reason, we would expect to see more vertically-decomposed activity across production sites that are located nearby and more horizontal activity in markets that are located farther away, all else equal. Therefore, we distinguish between affiliates that are located close to parents in the western hemisphere (defined as the Americas), and affiliates located in the more distant eastern hemisphere (defined as the rest of the world).15

14 More precisely, we define export-intensive affiliates as those whose ratio of exports to total sales exceeds ten percent. The results are not sensitive to moderate variations in this ratio.

15 We experimented with other geographical splits that are described in greater detail below.
Factor Supplies/Development: Clearly, the proportions of skills and other factors of production vary across countries. The BEA panel data set measures total employment per firm per country, which aggregates across various types of labor, and compensation per employee, which averages across various types of labor. By treating different types of labor as a composite factor of production, we run the risk of finding spurious substitution relationships that actually reflect changes in the composition of labor. For instance, if affiliates add production workers to a fixed core of white collar workers as they expand production, then employment expansion may lead to a declining composite wage even if the underlying wages for each type of worker do not change. In this case, we would see a negative correlation between employment and firm-level wages for reasons other than international labor demand cross-elasticities. Therefore we estimated the equations reported below by both substituting BLS industry-level production worker wages for the BEA firm wages directly, and also use the BLS industry wages to instrument for BEA firm wages. The estimates based on BLS industry wages yield similar results in terms of the relative size and significance of substitution between various locations, but generally magnify the estimated substitution between parents and affiliates relative to that between affiliates.

And finally, we differentiate between affiliates located in advanced industrial countries and those located in developing countries as a way of proxying differences in the relative supply of skills. To the extent that multinationals locate different stages of production in countries

---

The BEA data distinguish production and nonproduction workers for benchmark survey years (1982, 1989), but this data is unavailable at the firm level.

The country rankings are taken from the World Development Report. The "high income" category is taken directly from the World Development Report, while our "low income" category
according to relative factor costs, as in Helpman and Krugman (1985), we expect to see more substitution between countries with similar factor proportions, proxied by per capita income differences.

2.4. The Data and Empirical Regularities

This study uses firm-level data from the *Annual Survey of U.S. Direct Investment Abroad*, which is administered on a mandatory basis and audited by the Bureau of Economic Analysis.\(^\text{18}\) The data set is a three-dimensional panel, in which each firm's production activities in up to 90 countries are tracked over a ten-year period ending in 1992, yielding approximately 70,000 firm-country-time observations. We include all firms whose parent industry is part of the manufacturing sector.

The data are business confidential. This is the first study in which this panel is subjected to formal econometric analysis. The panel includes data on an annual basis for each reported affiliate and parent on employment, employee compensation, exports, sales, location, and a three-digit industry identifier.\(^\text{19}\)

To this data set we append economic development rankings of countries from the *World Development Report* (based on per capita income) and BLS measures of country-industry-level wages.

\(^{18}\) Due to the business-confidential status of the firm-level data, the data are not available from the authors of this study.

\(^{19}\) U.S. parents are required to report this data for any affiliates whose sales exceed $15 million.
Changes in Firm-Level Employment Shares over Time

Before presenting the formal econometric estimates, we first examine a number of simple firm-level relationships of labor allocation and wages across locations, while noting that limitations of such statistics motivate our multi-factor demand analysis in Section 2.6. Figure 2.1 shows the evolution of the allocation of employment within firms across parent and affiliate locations (averaged across firms in the sample) over time. Employment at affiliates in the eastern hemisphere has expanded from 23 percent of firm total employment in 1983 to 28 percent in 1992. It consistently exceeds employment at affiliates in the western hemisphere, which has risen only marginally to 15 percent in 1992. There is less contrast between the change in employment in developing and advanced industrial countries. The share of employment located in countries with high per capita incomes has expanded over the decade from 21 to 24 percent of total firm employment, while the share at affiliates in countries with low per capita incomes\textsuperscript{20} has expanded similarly, rising from 18 to 20 percent of employment.

Aggregating across firms, parent employment in the U.S. declined fairly substantially as a share of total U.S. manufacturing employment over the 1980s, from roughly half to 45 percent (not shown). And there has been a corresponding but more modest change within multinationals: on aggregate across firms, the parent share of firm global employment has fallen from 76 to 73 percent. Thus, the popular perception that U.S. multinationals have expanded their overseas employment at the expense of domestic employment is supported by the evidence on overall levels and average within-firm shares, but much of the growth of the share of employment abroad has occurred in advanced industrial countries especially outside the western hemisphere,

\textsuperscript{20}We classify middle income per capita countries in our low income group.
contrary to conventional wisdom.

**Relative Wage Developments**

Corresponding changes in relative wages\(^{21}\) are portrayed in Figure 2.2. While the ratio of wages paid by affiliates in less developed countries to parent wages has remained remarkably flat at roughly 30 percent over the decade, the ratio of wages in high per capita income countries has risen substantially, reaching over 90 percent by 1992. Similarly, the relative wage at affiliates in the eastern hemisphere has risen from slightly over half to 80 percent, while the relative wages of affiliates in the western hemisphere have remained relatively flat around 50 percent.

Together, the data in Figures 2.1 and 2.2 suggest the rather surprising conclusion that the employment share has expanded most over the decade in precisely those areas where the relative wage has also grown the most, and is closest to unity. However, the timing differs somewhat: while most of the wage expansion occurred during the period of dollar appreciation, 1985 to 1988, much of the employment expansion occurred in the late and early 1980s. Furthermore, simple correlations between averages of broad aggregates across firms may be misleading; a more appropriate measure in an average of firm-level employment and wage correlations. We suspect that the simple wage ratios do not sufficiently capture the multilateral nature of the firms' allocation decisions.\(^{22}\)

---

\(^{21}\) Unless otherwise noted, the term wages refers to the BEA measure of compensation per employee.

\(^{22}\) Another shortcoming, which is remedied in the empirical work in Chapter 3, is that there is no control for the growth of product demands in each country which significantly affect local
Distribution of Affiliates across Locations

Next we shed some light on the degree of substitution among labor in different locations by examining the degree to which employment changes at particular locations within multinationals have been offset by opposite changes at other locations. We use an index that measures the ratio of the absolute value of net employment changes across all locations within a firm to the sum of the absolute values of gross employment changes across all locations. The measure is calculated as follows (where a indexes the countries in which affiliates are located):

\[ \phi = \frac{\sum_a dL_a}{\sum_a |dL_a|} \]

If employment changes in different locations completely offset each other, then \( \phi \) is zero, whereas if employment contracts or expands uniformly across locations, \( \phi \) goes to one.

The first row of Table 2.1 reports the value of \( \phi \) for all locations within each firm averaged across all firms in the sample. The value of 0.8 provides evidence against simple one-to-one offset of employment among locations. The next row measures the extent of offset only among affiliates that are located in high per capita income countries, and the third row measures offset among affiliates located in low per capita income countries. There is very little difference between these two categories, and both are similar to the aggregate index, again suggesting little offset. Splitting affiliates along geographical lines in rows 5 and 6 yields slightly more differentiation, with lower offset among western hemisphere affiliates than on aggregate. Splitting affiliates by export intensity in rows 7 and 8 yields very little differentiation between labor demands.
the two categories, and again the offset is low.

Table 2.2 investigates the degree of substitution by examining bilateral employment change offsets within firms. The histogram presented in the first panel compares employment changes at parent locations with employment changes aggregated across all affiliates within firms. Over one-fifth of the observations entail large, complementary expansions of roughly equal magnitudes by both affiliates and parents. Roughly one-tenth of the observations entail small expansions of affiliate employment offset by small contractions of roughly equal magnitudes at the parent.

The second panel matches employment changes across all affiliates in high per capita income countries with changes across affiliates in low per capita income countries. There is a small mass of roughly one-eighth of the observations that experienced small complementary expansions of roughly equal magnitudes in both types of affiliates, and a smaller mass of one-twelth of the observations that experienced complementary expansions in both types, with relatively greater expansion across low income locations. Another one-twelfth of the observations experienced small expansions in low income locations offset by small contractions in high income locations.

The third panel compares affiliates in the western and eastern hemispheres. Here again, the changes are fairly evenly spread. Roughly one-eighth of the firms experienced complementary expansions in the west and the east of equal magnitudes, while another one-twelfth experienced a small contraction in the west offset by expansion in the east.

Thus, Table 2.2 suggests that most changes have entailed complementary expansions of employment across different types of locations. In addition, a number of firms have experienced
small offsetting reallocations of labor, from parents to affiliates, and within affiliates from the western hemisphere to the eastern hemisphere, and from advanced industrial countries to less developed countries.

Together, Tables 2.1 and 2.2 suggest that the degree of one-for-one *quantity shifting* across borders is relatively low. These findings at the firm level are consistent with conclusions based on aggregate data (Lawrence, 1994; Slaughter, 1993; Lipsey, 1994). However, it is a big leap to conclude from these quantity movements that the price responsiveness of employment across locations within firms is low. Even when we observe uni-directional employment changes across all sites of the firm, there may be considerable shifting of *shares* in response to relative factor price movements. Such subtleties motivate our estimation of multifactor demand relationships.

2.5. **Methodology**

The most widely used methodology for estimating multi-factor demands is to fit the factor demand equations that derive from a cost function.\(^{23}\) The translog form of the cost function, initially proposed by Christenson, Jorgenson, and Lau (1973), has been applied extensively in estimating both macro and microeconomic production relationships. It is essentially a second-order log-linear approximation to a general cost function. Its popularity stems from its generality: the functional form imposes few restrictions on factor substitution.

By Shepard's Lemma, differentiation of the cost functions with respect to the \(n\) factor prices yields \(n\) factor demands, which are typically converted to the following system of \(n\) linear

\(^{23}\) For a detailed discussion of the literature, see Hamermesh, 1993.

\[ S_{t}^{(nx1)} = \alpha^{(nx1)} + \beta^{(nxn)} W_{t}^{(nx1)} + \Gamma^{(nxn)} K_{t}^{(nx1)} + \epsilon_{t}^{(nx1)} \]

S is a vector of cost shares, which is expressed as a linear function of a vector of constants, \( \alpha \), the coefficient matrix, \( \beta \), multiplied by the \( (nx1) \) wage vector (in logs), a vector of firm fixed effects, \( K \), and a vector of residuals, \( \epsilon \), satisfying the standard assumptions for SUR estimation. An output term can also be added on the right-hand side to allow for variable returns to scale. The only restriction that is imposed in the estimates below is symmetry of the \( \beta \) matrix, which follows from the assumption of a twice-differentiable global cost function at the firm-level.

The size of the system, \( n \), depends upon the aggregation of affiliates across countries. The elements of the factor price vector are composed of the log geometric weighted average of compensation per employee (weighting by relative employment) across a particular subset of locations. In the estimates below, we report three levels of disaggregation, partitioning the affiliates into one, two, and four subsets along the economic dimensions discussed above.

We take advantage of the time dimension of our panel data to control for firm fixed effects; reported estimates are based on "within firm" estimation. Although firm fixed effects may capture a variety of possible heterogeneities among firms' international production relationships, we have a particular interpretation in mind. Berndt and Hesse (1986) propose a variant to the standard translog called a variable or short-run cost function, where the stocks of relatively fixed factors such as physical capital are included in the share equations in lieu of the price of capital. Multi-factor demands may be best estimated conditional on the capital stock for short time horizons in which capacity adjustment is not an important consideration.

With regard to multinational production, we expect that the relatively fixed configuration
of plant capacity across locations, which is firm-specific, should have an important role in bounding wage-chasing labor substitution across borders. Though we do not have satisfactory firm-country-level measures of plant capacity with which to address this consideration, the firm fixed effects may go part way in addressing this concern.\textsuperscript{24} Therefore, we interpret the results as substitution conditional on the firm's relatively fixed plant configuration.

From the SUR estimates of the $\beta$ matrix, we construct Allen partial cross-elasticities of substitution, $ES_{ij}$, and price elasticities, $PE_{ij}$, using the following formulae, respectively:

$$ES_{ij} = 1 + \frac{\beta_{ij}}{S_i S_j} \quad PE_{ij} = \frac{\beta_{ij} + S_i S_j}{S_i}$$

Although the $\beta$ are constrained to be constant across the sample by pooling assumptions implicit in the specification, the cost shares $S_i$ and $S_j$ vary by firm and over time. In calculating these statistics for the sample, we follow the translog estimation approach of Anderson and Thursby (1986) in using the mean shares of the actual data, rather than the fitted shares, a common alternative.

In Tables 2.4 and 2.5, we report restricted versions of equation (2) with 4 subsets of affiliates. We impose linear restrictions on the $\beta$ estimates and calculate the elasticities using the mean shares over the restricted subsets.\textsuperscript{25}

\textsuperscript{24} The BEA database includes plant and equipment measures, but differences in valuation make comparability across countries somewhat suspect.

\textsuperscript{25} The results are not sensitive to the approach for calculating the shares.
For each of the Allen cross partials, we report confidence (half) intervals. We used both Delta Method and bootstrap resampling techniques in estimating the half-intervals.\textsuperscript{26} The results were similar, so we report only the bootstrapped estimates of the confidence intervals.

We also check whether substitution relationships vary with industry value added. We separate the firms based on whether their production is characterized by relatively high value added or low value added.\textsuperscript{27} The translog is estimated for these two subsets; in effect, this imposes pooling restrictions whereby the slope terms, $\beta$, as well as the intercepts, $\alpha$, are allowed to vary by industry grouping.

The translog estimation approach effectively imposes the hypothesis that factor demands are linked across borders. If there were no relationship between factor demands, this \textit{would not} imply a testable set of restrictions on the estimated $\beta$ matrix.\textsuperscript{28} Therefore, we ran a preliminary set of hypothesis tests, regressing labor demand (in levels rather than shares) in each location or aggregation of locations against "own" and "offshore" wages. We were able to reject the null that factor demands are not linked across borders at a very high level of significance.

2.6. Elasticities of Substitution across Affiliates

We next turn to the elasticity estimates. The first panel of Table 2.3 presents elasticities

\textsuperscript{26} Bootstrap estimates were based on one hundred resamplings from the empirical distribution of the fitted residuals.

\textsuperscript{27} The categorization is based on a ranking of parent industry value added, defined as the ratio of gross margins to employment.

\textsuperscript{28} The denominator of the left-hand side of the equation for factor $i$, the share of payments to factor $i$ in global costs, changes with variations in the price of factor $j$ even if the demand for factor $i$ were entirely unrelated to the price of factor $j$. 51
derived from the simplest formulation of the translog cost function, which aggregates across all affiliates. The parent, ES_{pp}, and affiliate, ES_{aa}, own-elasticities are negative as predicted (not reported). The cross-elasticity of substitution, ES_{pa}, is slightly below one, implying that labor abroad substitutes one-for-one for parent labor. When the sample is split into high value added and low value added industries, as in the second and third rows of the first panel, the elasticity does not change.

Development

The second panel in Table 2.3 splits the affiliate locations into two groups based on their level of per capita income, which is used to proxy relative skill endowments. The cross-elasticity between the parents and both the low per capita income subset of affiliates, ES_{pl}, and the high per capita income subset, ES_{ph}, drops below one, with labor at the low income affiliates substituting relatively more closely for parent labor. However, the greatest cross-elasticity is between affiliates in high and low per capita income countries, ES_{hl}. This suggests that the activities undertaken by affiliates in more and less developed economies are more similar than those undertaken by parents and either type of affiliates.

Separate equations are estimated for firms in low and high value added industries in the second and third rows. This distinction makes apparent that low value added industries are characterized by a much higher degree of substitution between labor at affiliates in high and low income countries relative to substitution between parents and either type of affiliate than are high value added industries. This is consistent with the greater labor intensity of low value added industries that makes them more sensitive to labor costs.
Geography

The third panel of Table 2.3 splits the set of affiliates along geographical rather than per capita income lines to proxy proximity differences. Affiliate locations are divided into western and eastern hemispheres. Similar results were obtained using a split between countries adjacent to the United States and other countries.29

The results suggests that proximity has little effect on substitution between parents and affiliates. The cross-elasticities between parents and both types of affiliates are below 1, with the cross-elasticity with eastern hemisphere affiliates, ES_{pc}, slightly larger than that with affiliates in the same hemisphere, contrary to a simple proximity story and consistent with greater vertical differentiation in the hemisphere closer to the parent. Similar to the development breakdown, the cross-elasticity between affiliates in the eastern and western hemispheres, ES_{we}, is significantly higher than that between parents and either type of affiliate. This suggests, as above, that affiliates in different hemispheres tend to undertake activities that are more similar to each other than to parent activities, and that the differentiation is somewhat greater for affiliates located in the same hemisphere.

Export Intensity

The fourth panel in Table 2.3 shows the results obtained by splitting affiliates according

---

29 When instead a three-way split between Asia, Europe, and the Western Hemisphere is used, substitution between Asian affiliates and parents looks similar to that between Western Hemisphere affiliates and parents, and larger than that between European affiliates and parents. There is also strong substitution between Asian affiliates and Western hemisphere affiliates, but somewhat weaker substitution between the western hemisphere and Europe, and complementarity between Asian and European affiliates. Combining Asia and Europe moderates some of the relationships because of this contrast.
to whether or not they export back to the home market. The results once again suggest that substitution between affiliates exceeds that between parents and either group of affiliates. In addition, substitution between parents and exporting affiliates (called $f$ for factor access) is slightly smaller than that between parents and affiliates that sell locally (called $m$ for market access). This latter result is counter to the logic above that would predict higher substitution between parents and foreign affiliates the greater is the share of their production that is exported to the parent market.

Development and Geography

We next allow for a more complicated pattern of substitutability among affiliates by further dividing the aggregates of affiliate locations. We investigate relationships among affiliates in different high income countries and separately among affiliates in different low income countries by dividing each income group by geographical location (i.e., eastern and western hemispheres). This permits us to estimate a cross-elasticity of substitution within the set of high income affiliates, $ES_{hi}$, and within the set of low income affiliates, $ES_{lh}$, as reported in the top panel of Table 2.4.

Interestingly, the elasticity of substitution among affiliates in low income countries in different hemispheres is very high. The cross-elasticity between labor in high and low income countries is well above one and similar in magnitude to the estimate in Table 2.3. Substitution among labor in different high income countries is more moderate at unity. The cross-elasticity of substitution between parents and low income affiliates is somewhat greater than that between parents and high income affiliates, and both are below one, similar to Table 2.3.
The results suggest that the expansion of labor in a low-income country such as Mexico threatens labor at home in the United States and labor at affiliates in advanced industrial countries outside the U.S. such as Canada much less than it does labor at affiliates in low income countries in Asia.

We next reverse the division of affiliates in order to estimate the cross-elasticity among affiliates at different income levels within the western and eastern hemispheres separately. The middle panel of Table 2.4 suggests that the cross-elasticity between affiliates in the western and eastern hemispheres, $\text{ES}_{we}$, is high. Cross-elasticities between parents and both groups of affiliates are below one, with the cross-elasticity between parents and affiliates in the eastern hemisphere, $\text{ES}_{pe}$, marginally above that with affiliates located in the same hemisphere, similar to Table 2.3. Interestingly, the results also establish that labor at affiliates in high income countries in the western hemisphere is weakly complementary to labor in low income western hemisphere countries, and that substitution between these groups in the eastern hemisphere is relatively low, suggesting a vertical separation of activities.

These equations effectively impose a number of important constraints. The development equation in panel 1 constrains the cross-elasticity between parents and affiliates of a particular income category to be equal, regardless of their geographical location. And the geography equation in panel 2 constrains the geographical relationship to be equal across income groups.

We next use the same disaggregation of the data to estimate separate cross-elasticities for each of the four groups of affiliates, which are reported in panel 3 of Table 2.4.

The results affirm the conclusions we have drawn so far. The substitution among low income locations is very high, as is substitution between high income locations in the western
hemisphere and low income locations in the eastern hemisphere. Substitution among eastern hemisphere locations is lower but still strong, similar to substitution between high income countries in the eastern hemisphere and low income countries in the western hemisphere. Substitution among affiliates in high income countries in the two hemispheres is roughly unity. The cross-elasticity between parents and all groups of affiliates is positive but below one. The elasticity between parents and affiliates in low income countries in the eastern hemisphere exceeds that with affiliates both in low income countries in the western hemisphere and high income countries in the eastern hemisphere, and substitution with affiliates in high income countries in the western hemisphere is lowest. And finally, labor at western hemisphere affiliates of different income levels is somewhat complementary.

Together, the results indicate that labor at parent locations in the U.S. is barely competing at the margins with labor at affiliates in low income countries, suggesting a strong vertical separation of activities and possibly quality differentials. At the same time, labor at different low income locations is competing intensely. There appears to be only mild competition between high income affiliates across the hemispheres, and a strong division of labor among high and low income affiliates in the western hemisphere.

**Income and Export Intensity**

Next, we estimate a four-way split replacing the geographical distinction with the distinction between exporters and local sellers. Panel 1 of Table 2.5 reports results for different income categories, where the within terms now measure substitution between exporters and local sellers within each income group. As above, substitution is very strong among low income
affiliates. The substitution between high and low income affiliates is well in excess of one, similar to Tables 2.3 and 2.4. Substitution among high income affiliates is lower but above one. Comparable to earlier results, the cross-elasticities between parents and affiliates of each income group are lower and below one. However, here substitution between parents and high income affiliates is marginally greater.

The middle panel reports results comparing high exporters with local sellers, which suppress income differences. The results suggest that labor at exporting affiliates at different income levels compete more directly than labor at affiliates at different income levels that sell locally, but only marginally. The cross-elasticity between exporting affiliates and affiliates that sell locally is greater than one, similar to Table 2.3. The cross-elasticity between parents and each type of affiliates is below one, and substitution is greater for affiliates that export. The results are in line with the hypothesis that affiliate exports displace home production. However, the size of the elasticities suggest the degree of substitution is relatively low, and as above, the strongest competition takes place among affiliates of similar types rather than between affiliates and the parent.

The lower panel reports the unrestricted estimate. Similar to earlier results, it shows that labor competes most fiercely between different low income locations. Substitution is also strong among both exporting affiliates and affiliates that sell locally, but substitution is marginally greater among local sellers, contrary to prediction. Substitution among affiliates at different high income locations is relatively lower, but in excess of one. The cross-elasticities between parents and each group of affiliates is below one, with greater substitution between parents and exporting affiliates in both income groups than between parents and affiliates that sell locally, as would
be expected.

The results provide only weak evidence that affiliates that export are more directly in competition with each other than those that sell locally. They provide stronger evidence that labor at the U.S. parent has more to lose from expanding employment at exporting affiliates than at affiliates that sell locally in their foreign location. The results also confirm once again that labor from different less developed countries competes most directly, suggesting a combination of a vertical separation of activities between locations at different development levels and possibly labor quality differences.

Robustness

As described above, we resolve the zero demands problem by aggregating across locations into economically meaningful groupings. However, even after aggregating, some firms do not employ workers in every category. The equations estimated above cover only those firms that have employment in all included categories. Thus, for instance, the equations that estimate cross elasticities between affiliates split into both development and geography categories only include firms that have at least one affiliate in a less developed eastern hemisphere country, one in a less developed western hemisphere location, one in a more developed western hemisphere location, and one in a more developed eastern hemisphere location. We checked whether this estimation was robust by running similar equations for the excluded subsets of firms that have no affiliates in one or more of these four categories. Both the size and significance of cross-elasticities were remarkably similar across firm configurations, so we did not report those results separately.
Following the production function literature, we included controls for scale both at the level of the plant and the firm. In both cases, as long as firm fixed effects are included, the results are essentially unchanged (although the fit of the equations improves), so we do not report the results here. In effect, although there are scale effects, they do not affect the cross-elasticities of substitution in a way not captured by the firm fixed effects.

The BEA data are comprised of a subset of firms that is surveyed every year and a second subset that is surveyed only in benchmark years and estimated by BEA statisticians in other years. We performed the estimations for both the full sample and the subsample of firms that are surveyed every year to ensure that the sampling techniques do not in some way bias the results. The results were essentially the same, so we report only the full sample results above.

Linear homogeneity of the cost function is often assumed in translog production function estimation. In the equations reported above, this restriction occasionally changes the size of coefficients moderately, but rarely affects the relative size of the coefficients. Thus, we do not report the results for the linear homogeneity restriction. Moreover, we do not see a compelling economic rationale for imposing the restrictions in this setting.

2.7. Conclusion

Labor in the United States does compete with labor abroad via multinational production. But interestingly, substitution tends to be lower between labor employed by parents and affiliates than between labor employed by affiliates of different types. And substitution is often greatest among labor employed at affiliates of similar types.

The greatest degree of competition arises among labor at different low income locations.
Substitution among labor in different high income locations is much more moderate. This suggests that there is a strong vertical separation of production activities across countries to take advantage of factor price differentials, with low income affiliates performing the activities that are most sensitive to labor costs. This result would appear to support findings by Lipsey et al. (1982) that factor intensities vary among locations with relative wages.

Workers at different eastern hemisphere affiliates have low substitution, while workers at different western hemisphere locations are consistent complements. This suggests a division of labor along development lines in affiliates in the same hemisphere.

Price elasticities are greatest for export-intensive affiliates in both high and low income countries in response to changes in parent wages. Employment at exporting affiliates in both high and low income countries falls by roughly 6.5 percent for every 10 percent decrease in the U.S. parent wage. But the reverse is not true. A ten percent decrease in the wage in Singapore or Hong Kong, for instance would result in a decrease of only 0.6 percent of labor in home locations. This asymmetry reflects the much larger share of parent employment.

Price elasticities are also high for affiliates in the eastern hemisphere in both high and low income countries with regard to parent wages. Price elasticities of affiliate employment with respect to parent wages are greatest for low income affiliates in the eastern hemisphere, suggesting a 6 percent reduction in employment in locations such as Thailand and Korea for every 10 percent decrease in the U.S. wage. The reverse is not true, however. A ten percent reduction in the affiliate wage results in only a 0.13 percent reduction in labor employed by parents in the United States. And although affiliates in low income, western hemisphere countries such as Mexico lay off nearly 5 percent of their workforce when U.S. parent wages
fall 10 percent, parent employment only falls one-fifth of one percent in response to a 10 percent fall in wages in Mexico.
The evolution of firm employment proportion.
The evolution of affiliate wages
relative to parent wages
Table 2.1

EMPLOYMENT OFFSET INDEX

<table>
<thead>
<tr>
<th>Sample</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firm-wide</td>
<td>Mean 0.807 (Std. Dev. 0.279)</td>
</tr>
<tr>
<td>High Income Affiliates</td>
<td>Mean 0.8202 (Std. Dev. 0.2892)</td>
</tr>
<tr>
<td>Low Income Affiliates</td>
<td>Mean .8226 (Std. Dev. 0.2893)</td>
</tr>
<tr>
<td>Western Hemisphere Affiliates</td>
<td>Mean .8630 (Std. Dev. 0.2617)</td>
</tr>
<tr>
<td>Eastern Hemisphere Affiliates</td>
<td>Mean .8056 (Std. Dev. 0.2956)</td>
</tr>
</tbody>
</table>

Note: Table 2.1 reports the ration of the absolute value of net employment changes within a firm to the sum of the absolute varoues of gross employment changes for the categories of affiliates listed. The index is calculated as follows:

\[ \phi = \frac{\left| \sum_a dL_a \right|}{\sum_a |dL_a|} \]

where \(dL_a\) is the change in employment in location \(a\). If employment changes in different locations completely offset each other, then \(\phi\) is zero, whereas if employment contracts or expands uniformly across locations, \(\phi\) goes to one.
### EMPLOYMENT CHANGE OFFSET HISTOGRAM

**Parent (horizontal) versus Affiliate Aggregate (vertical)**

<table>
<thead>
<tr>
<th>Change in Parent Employment</th>
<th>&lt;-800</th>
<th>&lt;-200</th>
<th>&lt;0</th>
<th>&gt;0</th>
<th>&gt;200</th>
<th>&gt;800</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.53</td>
<td>1.67</td>
<td>6.56</td>
<td>3.61</td>
<td>1.71</td>
<td>21.57</td>
<td>&gt;1000</td>
</tr>
<tr>
<td>1.53</td>
<td>1.33</td>
<td>1.22</td>
<td>1.34</td>
<td>1.39</td>
<td>1.93</td>
<td>&gt;150</td>
</tr>
<tr>
<td>1.53</td>
<td>2.28</td>
<td>11.49</td>
<td>6.75</td>
<td>3.05</td>
<td>1.6</td>
<td>&gt;0</td>
</tr>
<tr>
<td>1.53</td>
<td>1.85</td>
<td>6.5</td>
<td>4.04</td>
<td>1.81</td>
<td>1.07</td>
<td>&lt;0</td>
</tr>
<tr>
<td>2.22</td>
<td>1.38</td>
<td>1.18</td>
<td>0.94</td>
<td>0.87</td>
<td>0.93</td>
<td>&lt;150</td>
</tr>
<tr>
<td>1.99</td>
<td>0.41</td>
<td>0.17</td>
<td>0.16</td>
<td>0.37</td>
<td>0.66</td>
<td>&lt;1000</td>
</tr>
</tbody>
</table>

**Change in Employment**

### EMPLOYMENT CHANGE OFFSET HISTOGRAM

**High Income Affiliate (horizontal) versus Low Income Affiliate (vertical)**

<table>
<thead>
<tr>
<th>Change in &quot;High&quot; Employment</th>
<th>&lt;-800</th>
<th>&lt;-80</th>
<th>&lt;0</th>
<th>&gt;0</th>
<th>&gt;80</th>
<th>&gt;800</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>1.28</td>
<td>0.55</td>
<td>0.62</td>
<td>1.52</td>
<td>2.62</td>
<td>&gt;850</td>
</tr>
<tr>
<td>1.31</td>
<td>3.14</td>
<td>1.86</td>
<td>1.38</td>
<td>3.69</td>
<td>1.79</td>
<td>&gt;200</td>
</tr>
<tr>
<td>2</td>
<td>6.86</td>
<td>8.48</td>
<td>12.93</td>
<td>8.86</td>
<td>1.69</td>
<td>&gt;0</td>
</tr>
<tr>
<td>1.28</td>
<td>5.38</td>
<td>4.55</td>
<td>4.34</td>
<td>4.24</td>
<td>1.03</td>
<td>&lt;200</td>
</tr>
<tr>
<td>1.97</td>
<td>2.76</td>
<td>1.24</td>
<td>1.31</td>
<td>2.28</td>
<td>0.59</td>
<td>&lt;200</td>
</tr>
<tr>
<td>2.17</td>
<td>2.07</td>
<td>0.55</td>
<td>0.41</td>
<td>1.31</td>
<td>0.83</td>
<td>&lt;850</td>
</tr>
</tbody>
</table>

**Change in "Low" Affl. Employment**

### EMPLOYMENT CHANGE OFFSET HISTOGRAM

**West Hem. Affiliate (horizontal) versus East Hem. Affiliate (vertical)**

<table>
<thead>
<tr>
<th>Change in W.H. Employment</th>
<th>&lt;-800</th>
<th>&lt;-80</th>
<th>&lt;0</th>
<th>&gt;0</th>
<th>&gt;80</th>
<th>&gt;800</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.73</td>
<td>0.181</td>
<td>0.81</td>
<td>1</td>
<td>2.89</td>
<td>2.73</td>
<td>&gt;850</td>
</tr>
<tr>
<td>1.19</td>
<td>2.54</td>
<td>2.27</td>
<td>3</td>
<td>3.85</td>
<td>0.85</td>
<td>&gt;200</td>
</tr>
<tr>
<td>0.62</td>
<td>4.12</td>
<td>5.16</td>
<td>12.44</td>
<td>5.93</td>
<td>0.62</td>
<td>&gt;0</td>
</tr>
<tr>
<td>0.85</td>
<td>4.54</td>
<td>4.43</td>
<td>7.89</td>
<td>4.08</td>
<td>0.65</td>
<td>&lt;-200</td>
</tr>
<tr>
<td>1.58</td>
<td>4.16</td>
<td>2.23</td>
<td>2.54</td>
<td>3.62</td>
<td>0.77</td>
<td>&lt;-200</td>
</tr>
<tr>
<td>2.89</td>
<td>2.39</td>
<td>1.04</td>
<td>1.04</td>
<td>1.62</td>
<td>1.12</td>
<td>&lt;-850</td>
</tr>
</tbody>
</table>

**Change in E.H. Affl. Employment**
Table 2.3

TRANSLOG RESULTS FOR THE TWO AND THREE CATEGORY DISAGGREGATIONS

Compensation per employee measures, with geometrically-weighted average aggregation and firm fixed effects

**All Affiliate Aggregation** (p)arent, (a)ffiliate

<table>
<thead>
<tr>
<th></th>
<th>ES(pa)</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Firms</td>
<td>0.95 (.047)</td>
<td>10,435</td>
</tr>
<tr>
<td>Firms in</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Value Added</td>
<td>0.969 (.065)</td>
<td>4,642</td>
</tr>
<tr>
<td>Industries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Value Added</td>
<td>0.955 (.071)</td>
<td>4,895</td>
</tr>
<tr>
<td>Industries</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Three Category Disaggregations**

**Development** (p)arent, (h)igh income, (l)ow income

<table>
<thead>
<tr>
<th></th>
<th>ES(ph)</th>
<th>ES(pl)</th>
<th>ES(hl)</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Firms</td>
<td>0.656 (.047)</td>
<td>0.863 (.0979)</td>
<td>2.024 (.267)</td>
<td>4,024</td>
</tr>
<tr>
<td>Firms in</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Value Added</td>
<td>0.786 (.063)</td>
<td>1.06 (.148)</td>
<td>1.56 (.336)</td>
<td>2,281</td>
</tr>
<tr>
<td>Industries</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Value Added</td>
<td>0.557 (.080)</td>
<td>0.743 (.142)</td>
<td>2.53 (.446)</td>
<td>1,493</td>
</tr>
</tbody>
</table>
TABLE 2.3 continued

**Geography (p)arent, (w)estern hemisphere, (e)astern hemisphere**

<table>
<thead>
<tr>
<th>Observations</th>
<th>ES(pw)</th>
<th>ES(pe)</th>
<th>ES(we)</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Firms</td>
<td>0.623</td>
<td>0.816</td>
<td>1.91</td>
<td>4,605</td>
</tr>
<tr>
<td></td>
<td>(.0599)</td>
<td>(.049)</td>
<td>(.172)</td>
<td></td>
</tr>
<tr>
<td>Firms in</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Value Added Industries</td>
<td>0.788</td>
<td>1.12</td>
<td>2.09</td>
<td>2,492</td>
</tr>
<tr>
<td></td>
<td>(.085)</td>
<td>(.066)</td>
<td>(.222)</td>
<td></td>
</tr>
<tr>
<td>Low Value Added Industries</td>
<td>0.421</td>
<td>0.588</td>
<td>1.63</td>
<td>1,794</td>
</tr>
<tr>
<td></td>
<td>(.095)</td>
<td>(.789)</td>
<td>(.288)</td>
<td></td>
</tr>
</tbody>
</table>

**Export Intensity (p)arent, (f)actor access, (m)arket access**

<table>
<thead>
<tr>
<th>Observations</th>
<th>ES(pf)</th>
<th>ES(pm)</th>
<th>ES(fm)</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Firms</td>
<td>0.574</td>
<td>0.972</td>
<td>1.43</td>
<td>3,030</td>
</tr>
<tr>
<td></td>
<td>(.104)</td>
<td>(.069)</td>
<td>(.292)</td>
<td></td>
</tr>
<tr>
<td>Firms in</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Value Added Industries</td>
<td>0.764</td>
<td>1.07</td>
<td>1.21</td>
<td>1,663</td>
</tr>
<tr>
<td></td>
<td>(.141)</td>
<td>(.091)</td>
<td>(.344)</td>
<td></td>
</tr>
<tr>
<td>Low Value Added Industries</td>
<td>0.429</td>
<td>0.854</td>
<td>1.5</td>
<td>1,118</td>
</tr>
<tr>
<td></td>
<td>(.163)</td>
<td>(.116)</td>
<td>(.501)</td>
<td></td>
</tr>
</tbody>
</table>
Table 2.4: ELASTICITIES OF SUBSTITUTION
AFFILIATES DIVIDED BY DEVELOPMENT AND GEOGRAPHY
(1486 Observations)

Development (h,l) Restriction

Cross-Partial Elasticities of Substitution

<table>
<thead>
<tr>
<th></th>
<th>ph</th>
<th>pl</th>
<th>hx</th>
<th>hl</th>
<th>lx</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.328</td>
<td>0.7641</td>
<td>.0141</td>
<td>.7954</td>
<td>.756</td>
<td></td>
</tr>
<tr>
<td>(0.09)</td>
<td>(0.23)</td>
<td>(0.32)</td>
<td>(0.17)</td>
<td>(1.62)</td>
<td></td>
</tr>
</tbody>
</table>

Price Elasticities of Substitution

<table>
<thead>
<tr>
<th></th>
<th>ph</th>
<th>pl</th>
<th>hw</th>
<th>hehl</th>
<th>lwle</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.069</td>
<td>0.036</td>
<td>0.179</td>
<td>0.085</td>
<td>0.078</td>
<td></td>
</tr>
<tr>
<td>hp</td>
<td>lp</td>
<td>hehw</td>
<td>lh</td>
<td>lelw</td>
<td></td>
</tr>
<tr>
<td>0.243</td>
<td>0.565</td>
<td>0.037</td>
<td>0.383</td>
<td>0.146</td>
<td></td>
</tr>
</tbody>
</table>

Geography (w,e) Restriction

Cross-Partial Elasticities of Substitution

<table>
<thead>
<tr>
<th></th>
<th>pw</th>
<th>pe</th>
<th>wx</th>
<th>we</th>
<th>ex</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.435</td>
<td>0.894</td>
<td>-0.437</td>
<td>1.65</td>
<td>0.610</td>
<td></td>
</tr>
<tr>
<td>(0.06)</td>
<td>(0.08)</td>
<td>(0.37)</td>
<td>(0.52)</td>
<td>(0.34)</td>
<td></td>
</tr>
</tbody>
</table>

Price Elasticities of Substitution

<table>
<thead>
<tr>
<th></th>
<th>pw</th>
<th>pe</th>
<th>whwl</th>
<th>we</th>
<th>chel</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.040</td>
<td>0.182</td>
<td>-0.002</td>
<td>0.350</td>
<td>0.030</td>
<td></td>
</tr>
<tr>
<td>wp</td>
<td>ep</td>
<td>whwh</td>
<td>ew</td>
<td>eleh</td>
<td></td>
</tr>
<tr>
<td>0.434</td>
<td>0.695</td>
<td>-0.002</td>
<td>0.122</td>
<td>0.322</td>
<td></td>
</tr>
</tbody>
</table>

Unrestricted

Cross-Partial Elasticities of Substitution

<table>
<thead>
<tr>
<th></th>
<th>phw</th>
<th>phe</th>
<th>plw</th>
<th>ple</th>
<th>hx</th>
<th>wx</th>
<th>ex</th>
<th>lx</th>
<th>hwle</th>
<th>helw</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.373</td>
<td>0.551</td>
<td>0.433</td>
<td>0.494</td>
<td>1.17</td>
<td>-0.673</td>
<td>1.08</td>
<td>4.11</td>
<td>4.6</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>(0.10)</td>
<td>(0.07)</td>
<td>(0.12)</td>
<td>(0.25)</td>
<td>(0.33)</td>
<td>(0.94)</td>
<td>(0.53)</td>
<td>(1.37)</td>
<td>(1.32)</td>
<td>(0.43)</td>
<td></td>
</tr>
</tbody>
</table>

Price Elasticities of Substitution

<table>
<thead>
<tr>
<th></th>
<th>phw</th>
<th>phe</th>
<th>plw</th>
<th>phe</th>
<th>ple</th>
<th>hwhe</th>
<th>whwl</th>
<th>chel</th>
<th>lwle</th>
<th>lwle</th>
<th>helw</th>
<th>helw</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.013</td>
<td>0.099</td>
<td>0.014</td>
<td>0.008</td>
<td>0.210</td>
<td>-0.021</td>
<td>0.018</td>
<td>0.067</td>
<td>0.075</td>
<td>0.066</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hwp</td>
<td>hew</td>
<td>lwp</td>
<td>lep</td>
<td>hehw</td>
<td>whwl</td>
<td>chel</td>
<td>lwle</td>
<td>lwle</td>
<td>helw</td>
<td>helw</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.274</td>
<td>0.406</td>
<td>0.319</td>
<td>0.364</td>
<td>0.042</td>
<td>-0.024</td>
<td>0.193</td>
<td>0.130</td>
<td>0.166</td>
<td>0.374</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Number of Affiliate Observations

<table>
<thead>
<tr>
<th></th>
<th>total</th>
<th>hw</th>
<th>he</th>
<th>lw</th>
<th>le</th>
</tr>
</thead>
<tbody>
<tr>
<td>66,301</td>
<td>8,349</td>
<td>35,956</td>
<td>12,966</td>
<td>9,030</td>
<td></td>
</tr>
</tbody>
</table>

Note: Tables report Allen cross-Partial elasticities of substitution derived from translog cost functions and the associated price elasticities. Firm fixed effects are included. Confidence (half) intervals are reported in parentheses. The own elasticities (which are not reported here) are all negative.
Table 2.5: ELASTICITIES OF SUBSTITUTION
AFFILIATES DIVIDED BY DEVELOPMENT AND EXPORT INTENSITY
(1377 Observations)

Development (h,l) Restriction

Cross-Partial Elasticities of Substitution

<table>
<thead>
<tr>
<th></th>
<th>ph</th>
<th>pl</th>
<th>hx</th>
<th>hl</th>
<th>lx</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.797</td>
<td>0.58</td>
<td>1.56</td>
<td>2.52</td>
<td>3.24</td>
</tr>
<tr>
<td></td>
<td>(0.09)</td>
<td>(0.18)</td>
<td>(0.51)</td>
<td>(0.27)</td>
<td>(2.55)</td>
</tr>
</tbody>
</table>

Price Elasticities of Substitution

<table>
<thead>
<tr>
<th></th>
<th>ph</th>
<th>pl</th>
<th>hfhm</th>
<th>hl</th>
<th>lfhm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.163</td>
<td>0.026</td>
<td>0.215</td>
<td>0.113</td>
<td>0.091</td>
</tr>
<tr>
<td>hp</td>
<td>0.598</td>
<td>0.435</td>
<td>0.105</td>
<td>0.517</td>
<td>0.055</td>
</tr>
</tbody>
</table>

Export Intensity (f,m) Restriction

Cross-Partial Elasticities of Substitution

<table>
<thead>
<tr>
<th></th>
<th>pf</th>
<th>pm</th>
<th>fx</th>
<th>fm</th>
<th>mx</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.916</td>
<td>0.793</td>
<td>2.81</td>
<td>1.63</td>
<td>2.65</td>
</tr>
<tr>
<td></td>
<td>(0.11)</td>
<td>(0.06)</td>
<td>(1.75)</td>
<td>(0.17)</td>
<td>(0.66)</td>
</tr>
</tbody>
</table>

Price Elasticities of Substitution

<table>
<thead>
<tr>
<th></th>
<th>pf</th>
<th>pm</th>
<th>fhfl</th>
<th>fm</th>
<th>mhml</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.077</td>
<td>0.132</td>
<td>0.048</td>
<td>0.271</td>
<td>0.074</td>
</tr>
<tr>
<td>fp</td>
<td>0.687</td>
<td>0.595</td>
<td>0.188</td>
<td>0.137</td>
<td>0.366</td>
</tr>
</tbody>
</table>

Unrestricted

Cross-Partial Elasticities of Substitution

<table>
<thead>
<tr>
<th></th>
<th>phf</th>
<th>phm</th>
<th>plf</th>
<th>plm</th>
<th>hx</th>
<th>fx</th>
<th>mx</th>
<th>lx</th>
<th>hfhm</th>
<th>hfhf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.877</td>
<td>0.710</td>
<td>0.860</td>
<td>0.427</td>
<td>1.510</td>
<td>2.13</td>
<td>2.39</td>
<td>3.12</td>
<td>3.20</td>
<td>2.35</td>
</tr>
<tr>
<td></td>
<td>(0.14)</td>
<td>(0.11)</td>
<td>(0.25)</td>
<td>(0.21)</td>
<td>(0.57)</td>
<td>(1.66)</td>
<td>(0.53)</td>
<td>(2.59)</td>
<td>(1.14)</td>
<td>(0.94)</td>
</tr>
</tbody>
</table>

Price Elasticities of Substitution

<table>
<thead>
<tr>
<th></th>
<th>phf</th>
<th>phm</th>
<th>plf</th>
<th>plm</th>
<th>hfhm</th>
<th>fhfl</th>
<th>mhnl</th>
<th>lfhm</th>
<th>lfhf</th>
<th>hfhf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.059</td>
<td>0.098</td>
<td>0.015</td>
<td>0.012</td>
<td>0.208</td>
<td>0.036</td>
<td>0.067</td>
<td>0.087</td>
<td>0.090</td>
<td>0.040</td>
</tr>
<tr>
<td>hfp</td>
<td>0.665</td>
<td>0.532</td>
<td>0.645</td>
<td>0.320</td>
<td>0.101</td>
<td>0.143</td>
<td>0.330</td>
<td>0.053</td>
<td>0.214</td>
<td>0.157</td>
</tr>
</tbody>
</table>

Number of Affiliate Observations

<table>
<thead>
<tr>
<th></th>
<th>total</th>
<th>h'</th>
<th>hm</th>
<th>lF</th>
<th>lm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>66,301</td>
<td>22,521</td>
<td>21,774</td>
<td>13,135</td>
<td>8,861</td>
</tr>
</tbody>
</table>

Note: Tables report Allen cross-partial elasticities of substitution derived from translog cost functions and the associated price elasticities. Firm fixed effects are included. Confidence (half) intervals are reported in parentheses. The own elasticities (which are not reported here) are all negative.
Chapter 3

The Labor Demands of U.S. Multinationals: Part II

3.1. Introduction

Reductions in the costs of international trade have reportedly set off an exodus of low skill, labor-intensive manufacturing to developing countries in a trend known as outsourcing. The removal of trade barriers, declining transport costs, and advances in communications technology have made it possible to decompose or fragment production into component stages, locate these production stages in separate countries, and then trade the resulting intermediate goods across borders. The trend suggests a diminishing demand for unskilled workers in industrialized countries as multinational firms substitute toward workers in developing countries. This form of globalization is popularly called the "great sucking sound", but is it an empirically accurate description of the American economy or a rhetorical scare tactic?

Outsourcing is an important but largely neglected issue in the current debate over the impact of trade on relative wages and the location of manufacturing employment across countries. The stylized facts that the majority of international trade is controlled by multinational enterprises (Rugman, 1988) and similarly that over half of total trade is in intermediate goods (Markusen, 1989) motivate a close empirical examination of multinational corporations. These firms' foreign affiliates may have access to the proprietary technologies, financing and markets of their U.S. parent and consequently may serve as alternative suppliers of either the same set of final products or different complementary components of the same final good. And these possibilities raise the question of whether employees of multinationals in
industrialized countries are "in competition" with workers in developing countries: do fluctuations in relative wages lead to a relocation of production to developing countries that would otherwise be located in the North? Should the multinationals' employees in industrialized countries fear their firms' search for ever-cheaper assembly sites? And what does the evidence on outsourcing over the last decade imply about these firms' expected response to NAFTA?

At first glance, the relative aggregate employment growth of U.S.-parented multinationals across their foreign affiliates between 1983 and 1992 appears to support concerns that outsourcing is the result of a wage competition that workers in industrialized countries have lost: employment of U.S.-parented multinationals increased by 11% in developing countries, decreased by 3.5% in other industrialized countries, and decreased by 12.5% in the United States, all in the context of both a high initial wage of industrialized countries relative to developing countries and a 20% increase in this relative wage over the ten year period.

However, the aggregate numbers entirely misrepresent firm-level realities. Only a third of the U.S.-parented multinational firms have production activities in developing countries; the rest are located exclusively in industrialized countries to be close to large product markets. And of the firms that have employees in developing countries, employment in their industrialized country affiliates actually increased 13% while parent employment declined only 3%. Though the global scale of production of the firms responds to changing production costs of affiliates (due, for example, to exchange rate fluctuations), the employment proportions between industrialized and developing country affiliates of the firms remain relatively fixed on average. Anecdotal descriptions of multinationals, as well as more formal evidence, suggest that these
fixed proportions reflect a vertical decomposition of production across borders.\textsuperscript{30} skill-intensive production stages are located in industrialized countries and assembly is located in developing countries to exploit international factor price and skill differences.

We examine a large firm-level panel dataset from the BEA that reports the production activities of U.S.-parented multinationals and their foreign affiliates from 1983 to 1992 and confirm this relationship of labor demands across the affiliates of the firms. We examine the relationship of production across affiliates as it is echoed in the firm's labor demands in each location. There is a significant cross-border relationship at the firm-level between relative wages and employment shares; however, the North-South relationship is one of complementarity rather than competition. Cross-wage elasticities of labor demand are positive and statistically significant among affiliates in industrialized countries and among affiliates in developing countries (i.e., North-North and South-South), indicating that workers within these sets of affiliates produce goods which are substitutes through trade; on the other hand, cross-wage elasticities of labor demand are negative between affiliates in industrialized and developing countries (i.e., North-South), indicating that workers in these two types of affiliates produce complementary inputs, as is the case with a geographical decomposition of parts production and assembly.\textsuperscript{31}

We estimate labor demand relationships separately for a number of industries within the manufacturing sector. There is evidence of North-South complementarity for the electronic

\textsuperscript{30}For example, Flamm (1984) examines the practice of vertically decomposing production of multinationals in the semi-conductor industry.

\textsuperscript{31}Markusen (1989) and Lopez-de-Silanes, Markusen and Rutherford (1994) model the theoretical implications for trade policy when trade is in complementary intermediate goods. They emphasize that complementarity reverses conventional results.
components, food products, plastic products, glass products, service industry machinery, apparel, photo equipment, and medical instruments industries and a high South-South wage elasticity for the first four of these industries. On the other hand, labor demands of affiliates in resource-intensive chemical industries do not appear to be linked internationally.

Moreover, multinationals that establish new affiliates in developing countries typically do so in the context of a global expansion of employment across the affiliates of the firm. The correlation between the magnitude of start-up employment and the change in employment in the firm's affiliates in industrialized countries is positive and small, approximately .15. This evidence runs contrary to the zero-sum claim that multinationals are "exporting" U.S. jobs to low wage countries.

In Section 3.2, we develop a structural model of a multinational firm's labor demands in its interconnected affiliates. The model motivates interpretation of the empirical evidence of North-South complementarity as an international decomposition of production processes that differ by skill requirement. In Section 3.3, we present statistics describing the firms' employment proportions and labor costs across affiliate locations. Section 3.4 discusses specification issues regarding estimation of multinational labor demands, while Section 3.5 presents econometric evidence of the cross-border relationship as well as tests supporting the robustness of the results. Section 3.6 revisits the model to draw policy implications from the empirical results, with an emphasis on the implied effect of North-South trade liberalizations such as NAFTA. Section 3.7 summarizes the findings from the firm-level analysis and proposes an application of the methodology to studies of the impact of international trade on U.S. labor
markets that examine outsourcing at arm’s length as well as the intra-firm trade of multinationals. A discussion of related literature is presented in the previous chapter, Section 2.2.

3.2. A Stylized Model of a Single Multinational Firm

Consider a firm producing manufactures in a number of countries. The firm chooses a geographical configuration of production and employment with respect to the location of product demand and the set of relative factor prices it faces. Labor demand in each affiliate is derived from the international trade in intermediate and final goods that link the firm’s production locations.

Multinational producers typically sell a differentiated product or range of products on a number of national product markets. Each firm is assumed to face the following downward-sloping demand curve for market i

\[ Q_i = C + Y_i - P_i \]

where \( Y_i \) is aggregate demand in location i, \( P_i \) is the price in the national market, and \( C \) is a constant. The firm’s market power is likely related to the importance of a proprietary non-rival asset in production, such as a unique and protected technology or a sophisticated marketing network and corresponding brand recognition.

Production requires three factors: skilled workers, unskilled workers, and a third, internationally mobile factor. This third factor, which is denoted \( Z \) in the model, might be interpreted as human capital exported from the parent in the form of managers (Rauch, 1991) or
physical capital or raw materials that are supplied from world markets.\footnote{32}

Labor markets are segmented by legal and cultural barriers to international migration. National labor markets are assumed to be competitive, and therefore the wage of unskilled workers in country $i$, $W_i$, is taken as given by each individual firm. The cost of skilled workers in country $i$, $(W_i / E_i)(1+m)$, is increasing in the base wage and decreasing in educational attainment, $E_i$. $m$ denotes the wage premium paid to skilled workers over the local wage of unskilled workers. The effect of formal education on the cost of skilled workers can be interpreted either as a direct increase in productivity from "school skills" or alternatively as a reduction in the costs of the firm's training workers in firm-specific technologies that corresponds with the trainees' level of formal education. In contrast to the segmentation of labor markets, internationally mobile capital $Z$ is hired at a global price $R$.

The firm's final product encompasses a vertical range of production stages, which we group into two activities denoted $B$ for basic production or parts and $A$ for assembly. The production of the $B$ stage is more sophisticated, requiring skilled workers $L_s$, internationally mobile capital $Z$, and possibly an unskilled support staff $L_u$; on the other hand, assembly requires only unskilled workers and $Z$. Denoting the quantity of final production as $Q$, we assume the following two-stage production technology:

$$Q = \min \{ A, B \}, \quad A = \min \{ L_u, Z \}, \quad B = \min \{ L_u, L_s, Z \}$$

The assumption of fixed proportions of $A$ and $B$, while extreme, is likely a realistic description

\footnote{The purpose of this unspecified third factor is to illustrate a class of supply factors that may be plausibly partialled-out with firm-year fixed effects.}
of the technological relationship between parts and assembly.\textsuperscript{33} The point, more generally, is that substitution between different vertical stages of production is low relative to the case where A and B are non-differentiated stages, i.e., the case where decomposition is infeasible and therefore there is only one composite stage of production.

If the component stages of production are decomposed across different countries, there is international trade in intermediate goods.\textsuperscript{34} The volume of exports of intermediate goods from location i to location j are denoted $X_{ij}$. The firm faces costs to shipping goods across borders. Following Dornbusch, Fischer and Samuelson (1977), we assume these trade costs to be of the "iceberg" variety: G goods shipped across borders results in $tG$ goods received, where $t < 1$. This "melting" of exports is meant to represent a variety of barriers to trade as well as freight charges.

The fixed proportions technology implies that the quantity of domestic production net of the quantity of exports of the local product is equal to the quantity of imports of the other intermediate product:

$$Q_i = L_i - \sum_{c \in C} X_{ic} = \sum_{c \in C} t X_{ci} \quad \forall \text{country } i \quad [3.1]$$

A firm that can feasibly decompose production across borders therefore maximizes the

\textsuperscript{33}While this assumption of low substitution between production stages in final production is crucial to the results, fixed proportions in the second tier, in factor requirements, is only a simplifying assumption.

\textsuperscript{34}Helpman and Krugman (1985) provides a general equilibrium trade model of multinational production in the factor proportions tradition. The model in Section 3.2, on the other hand, does not specifically model wage determination, though the wage of unskilled workers might be determined by productivity in a CRS (in labor) agricultural sector that is open to the world market, for example.
following global profit objective, which is the sum of revenues across its various locations of production net of production costs,

\[
\Pi = \sum_i \left( \left[ C + Y_i \right] \left[ Q_i \right] - \left[ Q_i \right]^2 - \left[ W_i + R \right] A_i - \left[ \frac{W_i(1+m)}{E_i} + R \right] B_i \right)
\]

subject to the production technology and the set of trade flow relationships in [eqn.1]. The optimal labor demand of firm \( f \) in each country responds to what might be called a relative product wage: the multinational’s reduced-form labor demand for a given affiliate location \( i \) is a weighted sum of labor cost \( (W) \) and aggregate demand \( (Y) \) conditions across its set of affiliate locations, as well as the cost of globally-hired factors \( (R) \).

\[
L_{i}^f = \alpha_i^f + \beta_0 W_i + \gamma Y_i + \sum_{c \neq i} \left[ \beta_{ic} W_c + \gamma_{ic} Y_c \right] + \delta R \tag{3.2}
\]

Restricted versions of these \( \beta \) weights are the focus of our empirical analysis. These cross-elasticities of labor demand\(^3\) depend on whether production is decomposed across affiliate locations into component stages of production, which in turn depends on relative costs of training, relative wages, and the costs of trade. We illustrate this relationship with a simple two-country example of a firm with production facilities in North and South, denoted by subscripts \( n \) and \( s \) respectively.

Under the assumed linear production technology, the location of production stages between the two locations depends on relative wages and relative skill levels of workers if trade barriers

\(^3\)The coefficients are elasticities if [eqn. 3.2] is log-linear in the variables.
are not prohibitive. Assembly is produced in the low wage location if there is trade and in both countries otherwise. It costs \((W_c / E_c)(1+m)+R\) to produce the skill-intensive parts in country c. Therefore, parts are produced in the North if \((t)(W_N / E_N) < (W_S / E_S)\) and in the South if \((t)(W_S / E_S) < (W_N / E_N)\). These inequalities define regions in the space of these relative country characteristics that are illustrated in Figure 3.1. If North-South trade were completely liberalized (i.e., \(t=1\)), the inequalities would collapse to the dash lines.

The pattern of multinational production and the corresponding pattern of intra-firm trade is determined by the region in which the economies lie. There are four empirically relevant regions, which are numbered in Figure 3.2, while the remainder is shaded gray. In region I, all assembly is located in the South, though parts production is located in both the North and the South due to costs of trade that exceeds the relative production cost advantages of the North. There is technological diffusion in the sense that the firm’s skill-requiring technologies that it employs in the North are also used to produce parts in the South. In region II, excessive differences in educational attainment lead to complete specialization: all assembly has moved to the South but skill-intensive production has not. In region III, international differences in wages and education are overwhelmed by costs of trade. Production is horizontally rather than vertically decomposed, and multinationality is motivated solely by proximity to protected product markets.\(^{36}\) In region IV, the Northern-based firms have located some assembly in the South but maintain assembly in the North as well to avoid costs of re-exporting assembled parts. Therefore, firms facing relative wages and skills in regions I, II, and IV choose a vertical decomposition of

\(^{36}\)Region III applies to the large share (40%) of affiliates of U.S-parented multinationals located in Europe.
production and, consequently, there is complementarity in multinational labor demands.

\[ L_i^f = \alpha_i^f + \beta_0 W_i + \beta W_j + \gamma Y_i + \delta R \]  

[3.3]

Within regions I, II, and IV, the firm's labor demand [eq. 3.3] exhibits the following qualitative characteristics: labor demand in each location is (i) decreasing in the wage in that location, \( \beta_0 < 0 \); (ii) decreasing in \( W_j \), the wage of the other affiliate, \( \beta < 0 \); (iii) increasing in local aggregate demand, \( \gamma > 0 \); and (iv) decreasing in the costs of globally-hired factors, \( \delta < 0 \). On the other hand, if there is not a vertical decomposition of production, as would be the case in region III, then \( \beta \geq 0 \).

A *ceteris paribus* drop in Southern wages within regions I, II, or IV, due for example to a devaluation of the Southern currency, reduces the cost of Southern assembly without causing substitution from assembly workers in the North, and therefore results in an unambiguous increase in the demand for labor in the North. This is the case for wage changes indicated in Figure 3.3 by the arrows labeled C (for complementarity). On the other hand, wage changes that move the economies across these region boundaries typically lead to international labor substitution, as a stage of production is relocated from a country in which protection was previously effective. Wage innovations leading to labor substitution are indicated by arrows labeled S (for substitution) in Figure 3.3. Therefore, the effect of a decline in Southern wages depends both on the initial position in Figure 3.3 and the size of the innovation. In region III, wage changes do not have international effects because production in each affiliate is not linked by trade.

As mentioned in the Introduction, the empirical regularity documented in Section 3.5 is
North-South complementarity of labor demands. This indicates that the economies are within regions I, II, or IV and therefore that there is a vertical decomposition of production with specialization in the production of any intermediate goods that are traded. The reduced-form complementarity result does not indicate whether the firms produce the skill-intensive process in the South using Northern technologies: complementarity is consistent with regions II and IV, where the South does assembly only, as well as region I, where there is technological diffusion.

Labor demands are complementary between affiliates in the North and affiliates in the South, even between identically unskilled workers. This is because what matters for labor demand complementarity is not characteristics of workers (e.g., their skills) so much as the relationship between the production processes in which they are engaged, which may be complementary under a vertical decomposition. Scientists and skilled production workers are complements to unskilled assembly workers, but so are the unskilled support staff whose production activities cannot be decomposed from the skill-intensive production process, e.g., the janitors of the scientists.

The linear model is simple, but the corner solutions that it imposes are likely unrealistic. The model can be generalized to allow for multiple affiliates producing the same production stage and linked by intra-firm trade: convex costs of trade or costs of adjusting production capacity may limit substitution, and likely determine the magnitude of North-North and South-South labor substitution. Capacity constraints no doubt bound the high labor substitution observed between affiliates in developing countries that function as export platforms (see chapter 2). For firms in which there is not a vertical decomposition across affiliates, capacity constraints and trade costs limit substitution, in the limit driving the cross-wage elasticity of labor demand from large and
positive to zero; however, these frictions cannot explain the observed pattern of North-South complementarity. Fixed proportions of labor demands across borders despite variation in relative wages and variations in the firms’ global level of employment therefore imply a vertical decomposition of production.

The labor demand specification [eqn. 3.3] is tractably extended to the case of multiple affiliates (in both industrialized and developing countries) by constructing composite measures of wages to replace the single country wage measures of [eqn. 3.3].

\[
W_a = \left[ \sum_j ^f \omega_j \, W_j \right], \quad W_d = \left[ \sum_k \omega_k \, W_k \right]
\]

where \( j \) indexes other affiliates in countries at the same level of educational attainment as \( i \), and \( k \) indexes affiliates in countries at different levels of educational attainment. The \( \omega_c^f \) are firm-specific weights for each country \( c \) related to the firm’s production capacity in that location. In the econometrics below we use measures of the firm’s lagged employment in each country as weights on these "outside" wages. The general form of [eqn. 3.3] with multiple affiliates in developing and industrialized countries is therefore

\[
L_i^t = \alpha_i^t + \beta_o \, W_i + \beta_s \left[ \sum_j \omega_j^f \, W_j \right] + \beta_d \left[ \sum_k \omega_k^f \, W_k \right] + \gamma \, Y_i + \delta \, R \quad [3.4]
\]

Vertical decomposition along the lines of educational attainment implies that \( \beta_s > 0 \) and \( \beta_d < 0 \).

In Sections 3.3, 3.4, and 3.5 below, we examine the empirical evidence, and then in Section 3.6 we revisit this model to ask whether the multinational labor demand relationships
estimated between 1983 and 1992 have implications for North-South trade liberalizations such as NAFTA.

3.3. Description of the Panel Data

We base our empirical analysis on firm-level data from the Annual Survey of U.S. Direct Investment Abroad, which is administered on a mandatory basis and audited by the Bureau of Economic Analysis. The data set is a three-dimensional panel in which the production activities of each firm’s affiliates in up to ninety countries are tracked over a ten-year period ending in 1992, summing to approximately 60,000 firm-country-year observations. This firm-level panel has not been previously analyzed in econometric studies with the exception of Brainard and Riker (1995), though Lipsey, Kravis, and Roldan (1982) examines a cross-section in a study of the relative factor proportions of affiliates. We include all firms in manufacturing industries. In addition, we use aggregate private consumption from the World Tables as a measure of aggregate demand and measures of national average educational attainment from Barro and Lee (1993).

Table 3.1 reports the distribution of employment across affiliate locations. We group countries into the seven geographical regions and two educational attainment classifications (based on the 1985 Barro-Lee numbers) that define the rows and columns of the Table. In each cell we

---

Our operational definition of firms is based on both ownership and industry-of-sales criteria: it is a grouping of affiliates with a common U.S. parent who are classified (by sales) in the same three-digit ISI manufacturing industry. In doing so, we attempt to group production sites that are plausibly alternative supply sources either for the same differentiated final product or for intermediate goods that are components of the same final product. Our definition of the firm is constrained by the limitations of the data and no doubt imperfectly achieves this objective.

The data are geographically disaggregated at the country-level, and therefore throughout the paper the term locations refers to countries.
report aggregate affiliate employment in each set of countries in 1992, the share of the global
total affiliate employment, and the percentage growth of employment since 1983.\(^{39}\) Sixty-five
percent of affiliate employment (which does not include parent employment in the U.S.) was
located in countries with highly educated workers, primarily in Europe. One quarter of total
affiliate employment was in North America, where the 45% increase in employment in Mexico
corresponds with a 18% decrease in Canada over the sample period. Declines in Europe, South
America, and Africa were offset by job creation in the less educated countries of East Asia,
where affiliate employment has boomed from low initial levels.

Table 3.2 disaggregates the multinationals' global employment by three-digit industry
classifications. At 1.6 million workers, the motor vehicles industry is by far the largest, more
than twice the size of the rather large beverage, industrial chemical, electronic component and
office equipment industries. The first column of the Table reports the share of industry
employment in developing countries. Electronic components has one of the highest shares of
employment in developing countries with over 20% of global employment (which includes parent
employment in the United States), though this share has declined since 1983.

Table 3.3 reports the average dollar-denominated compensation per employee in affiliates
in each group of countries.\(^{40}\) Large differences across countries by level of educational
attainment are reported for North America and Northeast Asia. Though wage gaps between
China and Japan remain considerable, most affiliate employment remained in Japan and the NICs,
reflecting no doubt non-wage detractions to direct investment in China.

\(^{39}\)Countries with Low Educational Attainment are defined as countries whose national average in 1985
was less than six years according to the calculations of Barro and Lee.

\(^{40}\)Throughout Section 3.3, we refer to these constructed measures of labor costs as wages.
Figure 3.5 displays the evolution of average relative wages over the sample period. Relative wages of affiliates in other industrialized countries have risen considerably, reflecting the depreciation of the dollar since 1985. Average wages of affiliates in the developing world, on the other hand, have remained below four-tenths of parent wages. Wages in individual countries within the groupings have fluctuated considerably more than these averages.

In summary, though the vast majority of foreign affiliate employment is located in industrialized countries with developed product markets and rising relative wages, approximately a third of these firms simultaneously maintain affiliate production facilities (within the same three digit industry) in low wage, developing countries, suggesting a vertical decomposition of production to take advantage of wage and skill differences between the North and the South.

3.4. Specification Issues

Equation [3.4] is estimated by including affiliate dummy variables. This simple within estimator removes the influence of affiliate characteristics $\alpha_c^f$ that are fixed at the affiliate or any broader level (e.g., the firm or industry-level) but are not observed in the data.\footnote{We believe that within estimation goes part way toward controlling for physical plant that is firm-location-specific, approximately fixed over time, but not reported in the dataset.} In addition, we control for firm-year effects, in order to control for global demand innovations as well as the costs of globally-hired factors such as managers, internationally mobile capital or traded raw materials.

The fixed effects specification adds flexibility to the OLS estimation, in that it does not impose the restriction that the "level" term $\alpha_c^f$ is constant over all affiliates. An alternative form
of heterogeneity in the multinational labor demand relationship involves allowing the "slope" terms $\beta$ and $\gamma$ to vary across the sample (i.e., relaxing the pooling restrictions): along these lines, we estimate the model of labor demand separately for affiliates in countries with high and low educational attainment and for industry sub-pools of affiliates.

We estimate a log-linear version of [eqn. 3.4] and assume that the error term is not serially correlated:\textsuperscript{42}

$$\ln L_{it} = \beta_0 [\ln W_{it}] + \beta_s [\sum_j \omega^f_{j(t-1)} \ln W_{jt}] + \beta_d \left[ \sum_k \omega^f_{k(t-1)} \ln W_{kt} \right] + \gamma [\ln Y_{it}] + R_t + \epsilon_t \quad [3.5]$$

The compensation per employee measure, constructed at the affiliate level, may reflect the firm’s demand shocks and may lead to biased estimates of the coefficients in [eqn. 3.5]; therefore, we construct a country-year wage that is the average of compensation per employee paid by all other U.S. multinational manufacturing affiliates in the country in the year.\textsuperscript{43} The functional

\textsuperscript{42}We correct for heteroskedasticity in the error term. The error term may be predominately firm optimization error or omitted factors that are observed by the firm but not recorded in the survey. We assume that these unobservables are uncorrelated with wages and GDP of the affiliate locations, and are not serially correlated. Otherwise, there would be a simultaneity bias from using lagged employment as weights in the wage composites. The coefficients were also estimated with unweighted wage composites, and the qualitative results were robust. In addition, a Durbin-Watson test did not reject the null hypothesis of no serial correlation in the error terms.

\textsuperscript{43}An alternative approach would use a separately calculated measure of manufacturing wages in each country. However, international wage measures available from the Bureau of Labor Statistics do not cover many of the developing countries that are crucial to our analysis. The correlation between our constructed measures and BLS wages (for countries for which the data are available) is .9.
form used in aggregating the wage measures across affiliates is a geometric weighted average, with one-year-lagged firm employment shares as weights.

The wage composites separate countries by average educational attainment, with the cutoff at an average of six years of education. If we did not separate the measures of affiliate wages by average educational attainment of the workers, the larger, more numerous affiliates in industrialized countries would dominate the undivided measure, leading to the spurious finding that workers are substitutes among all affiliate locations, rather than only among affiliates in countries at the same level of educational attainment. We explicitly test this restriction. In addition, we separated the wage composite by geographic region as well as education to consider whether affiliate employment is more sensitive to innovations in labor costs of affiliates in neighboring countries than to costs in locations on different continents. We did not reject the null hypothesis that they are the same.

In addition, we control for the size of the local product markets by including measures of aggregate private consumption in the labor demand regression. Both wages and demand are measured in dollars and are deflated using a US PPI deflator (for intertemporal comparisons).

If trade costs were prohibitive, as would be the case with a high local content requirement, labor demand would be entirely local and would be the standard neo-classical function of the local product wage.\textsuperscript{44} This local model involves zero restrictions on the coefficients $\beta_s$ and $\beta_d$ that capture the effects of "outside" wage innovations. On the other hand, if multinational production were not vertically decomposed (i.e., if instead similar goods were manufactured in

\textsuperscript{44}This local model also applies in the absence of trade costs if products are customized for each product market and customization requires de-centralized production.
multiple countries and production were horizontally-integrated across borders), labor services in the various countries would be embodied in products that are substitutes and $\beta_s = \beta_d > 0$. These are the alternative hypotheses to our model's prediction of $\beta_s > 0$ and $\beta_d < 0$, i.e., the case of a vertical decomposition of production.

3.5. The Econometric Evidence

The results from fitting [eqn. 3.5] to the full sample of manufacturing firms are reported in Table 3.4, pooled separately for affiliates in industrialized and developing countries. The estimated coefficients indicate statistically significant North-South complementarity in labor demands. A ten percent decline in wages in industrialized countries decreases employment in alternative industrialized country affiliates by 1.54%, while the same decline in Southern affiliate wages results in an increase in employment in industrialized countries by 1.85%. Moreover, five percent growth in local aggregate demand increases employment in the country by 4.14%. Affiliate employment is more sensitive to local product markets for affiliates in industrialized countries, as indicated by estimates of $\gamma$. On the other hand, employment appears to be more "footloose" between affiliates located in developing countries: the elasticity of labor demand to wage changes in affiliates at the same level of educational attainment is greater for affiliates in developing countries. The standard errors reported in Table 3.4 are robust to heteroskedasticity that varies by country-year grouping.

The fundamental empirical result is that labor demand of U.S. multinationals is linked internationally at the firm-level, presumably through trade in intermediate and final goods, and this link results in complementarity rather than competition between employees in industrialized
countries and their low wage counterparts abroad. For the manufacturing pool overall, we reject the hypothesis that labor demands are local. Labor demand in a particular location is significantly related to composites of wages in other affiliate locations. When testing the null hypothesis of local labor demand against the alternative of global labor demand, the zero restrictions of the null are strongly rejected. Moreover, we reject the hypothesis that cross-wage elasticities are the same across affiliates irregardless of educational attainment in favor of the pattern of complements and substitutes implied by a vertical decomposition of production into stages that vary by skill intensity.

We estimate [eqn. 3.5] separately for a number of industries within the manufacturing sectors. The results are reported in Table 3.5. There is evidence of North-South complementarity for the electronic components, food products, plastic products, glass products, service industry machinery, apparel, photo equipment, and medical instruments industries and a high South-South wage elasticity for the first four of these industries. The motor vehicle and construction machinery industries do exhibit a significant cross-border relationship, though the pattern of complements and substitutes does not match the prediction of the model. A likely explanation of this result is that the groupings of countries used in the wage composites do not correspond to the groups of countries over which production is vertically decomposed for these industries. The industrial chemical, drug, soap and other chemical products industries do not show a significant cross-border relationship in labor demands. For this set of industries, we cannot reject the hypothesis that the labor demands of the multinationals are local. Local labor demands are typical of resource-intensive industries in which production requires more than technology and cheap labor and is therefore not "footloose".
We allowed for a separate coefficient on wage changes corresponding to affiliate start-ups (as distinct from wage innovations at pre-established affiliates) in case these innovations might correspond to shifts in the decomposition of production, to relocations of production stages from the North and thus labor substitution, modeled as crossing the regions in Figure 3.5. In fact, these start-up wages have the same qualitative effects (i.e., $\beta_r>0$, $\beta_d<0$), though they have a quantitatively larger effect than wage innovations at pre-established affiliates.

3.6. Policy Implications of the Results

What does North-South complementarity of labor demands imply for policy? The elasticity of labor demand to wage innovations reflects the effect of any change in marginal production costs, such as exchange rate fluctuations. Assuming the efficacy of exchange rate policy, the policy implication of North-South complementarity is that a devaluation by developing countries that are assembly locations will increase demand for complementary workers in the North. The centerpiece of policy evaluation, however, is trade liberalization.

An empirical examination of multinationals would ideally allow one to predict whether trade liberalizations such as NAFTA will lead to net job creation or loss in manufacturing multinationals. In fact, the issue is complicated, as illustrated in Figure 3.4. Within the regions in which there is North-South complementarity of labor demands, as observed in the data, the net effects of complete trade liberalization on MNE employment in the North is ambiguous.\(^45\) There could be a net job loss if the North loses any lingering assembly that had been protected

\(^{45}\)The net employment effect is ambiguous even in the partial equilibrium model of Section 3.2, which does not consider possibilities for reemployment in other sectors of the economies.
or a net job gain if the North can export the skill-intensive product from the North and avoid technological diffusion. *The crucial issue is whether the jobs of unskilled workers in the North prior to liberalization are inextricably bound to skilled production or can instead be geographically decomposed as distinct production processes.* If the multinational firms have already relocated all decomposable unskilled processes to developing countries, then trade liberalization does not lead to a "great sucking sound" and in fact has the opposite effect. However, the net employment effect of trade liberalization cannot be predicted solely from the relationship in labor demands exhibited in the BEA multinational employment data. More detailed data is necessary to make this policy prediction.

3.7. **Conclusions and Proposed Extensions**

The central result of the paper can be illustrated in the following description of multinationals in the electronic components industry. The labor demand in each affiliate is related to cost and demand conditions in other affiliates of the firm, and this relationship takes the form of a vertical decomposition of complementary intermediate stages of production between industrialized and developing countries. An exchange rate induced wage decline of 10% in a developing country with affiliate production leads to a 3.5% increase in employment in that country, a 6.3% decline in affiliate employment in other developing country affiliates that are alternative locations of assembly, and close to a 2% increase in employment in affiliates in industrialized countries, where the parts are produced for more efficient assembly abroad. Specialization in complementary intermediate stages of production between industrialized and developing countries implies that employees in industrialized countries need not fear the
multinationals' search for ever-cheaper assembly sites; rather, they benefit from an increase in labor demand in the North. The North-South relationship in labor demands is one of complementarity rather than competition. Though these results do not hold identically for all industries in the manufacturing sector, they are similar to the results from an all-manufacturing pooled estimation.

Our empirical analysis of the microeconomic relationship between trade and labor demands clearly benefits from the use of micro-level data, though such data are rarely available to researchers in international economics. The within specification accommodates some forms of heterogeneity in labor demands across firms and countries. Moreover, we can more plausibly isolate production activities and factor demands that are interrelated by looking at affiliates of the same firm (with sales classified in the same industry). On the other hand, multinational corporations are only a subset of the broader phenomenon known as outsourcing, which includes arm's-length trade in intermediate goods as well. Are the complementarity results applicable to this broader class?

The methodology of this paper is directly applicable to studies of the effect of trade on U.S. wages and employment. Revenga (1992), for example, regresses industry-level employment and wage measures on composite measures of import prices instrumented by trade share weighted exchange rates. However, a caveat to this approach is that the measure of import prices should be split between imports of substitute finals goods and imports of complementary intermediate goods. This split is not directly observed in the import price data, as the vertical decomposition of multinational production is not directly observed in the BEA panel data. Implementation of the split is again complicated, as it requires imposing priors on the relationship between
production in different countries. However, it is potentially of great importance, since the two forms of trade have opposite effects on domestic labor demand. If this distinction is not made, the effects of trade in substitutes and complements may offset each other, leading to the oft-reported result that international trade has no discernible effect on U.S. labor markets.

Grossman (1982) makes an important contribution along these very lines, though the estimated import demand functions do not specifically relate trade to factor markets. The separate effects of import prices from developed and developing countries on import flows are estimated. Grossman interprets low North-South substitutability of imports as specialization across countries in the production of final goods within the same broad product category. Our multinational labor demand estimates provide a firm-level counterpart to this result.
FIGURE 3.2
The pattern of multinational production and
the corresponding pattern of trade
FIGURE 3.3
Complements and Substitutes

(S) Substitution from North
(C) Complementary increase in Northern labor demand
(A) Ambiguous net effect
(D) No cross-border effect, no trade
FIGURE 3.4

The Net Effect of Trade Liberalization on Manufacturing Jobs in the North

\[ \frac{W_n}{W_s} \]

\[ \frac{E_n}{E_s} \]

- \( t = 1 \)

- Job losses in the North
- Job gains in the North
- Ambiguous net effect on jobs
Figure 3.5

Affiliate Wages Relative to Parent

Relative Wage

Year


— Industrialized — Developing
**TABLE 3.1**

EMPLOYMENT OF AFFILIATES BY GEOGRAPHICAL REGION AND NATIONAL AVERAGE LEVEL OF EDUCATIONAL ATTAINMENT

In each cell, we report
* The aggregate employment per group across the sample in 1992 OVER
* (The group’s share of the global affiliate employment in 1992)
* Percentage change in employment since 1983

<table>
<thead>
<tr>
<th>Countries</th>
<th>Countries</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>with High</td>
<td>with Low</td>
<td></td>
</tr>
<tr>
<td>Educational</td>
<td>Educational</td>
<td>Attainment</td>
</tr>
<tr>
<td></td>
<td>Attainment</td>
<td></td>
</tr>
<tr>
<td>North America</td>
<td>404,950</td>
<td>476,613</td>
</tr>
<tr>
<td></td>
<td>(.105)</td>
<td>(.123)</td>
</tr>
<tr>
<td></td>
<td>-17.9%</td>
<td>+44.6%</td>
</tr>
<tr>
<td>South America</td>
<td>60,098</td>
<td>424,235</td>
</tr>
<tr>
<td></td>
<td>(.016)</td>
<td>(.110)</td>
</tr>
<tr>
<td></td>
<td>-23.1%</td>
<td>-.67%</td>
</tr>
<tr>
<td>Europe</td>
<td>1,448,046</td>
<td>117,140</td>
</tr>
<tr>
<td></td>
<td>(.375)</td>
<td>(.030)</td>
</tr>
<tr>
<td></td>
<td>-12.8%</td>
<td>-3.5%</td>
</tr>
<tr>
<td>Northeast Asia</td>
<td>349,771</td>
<td>19,911</td>
</tr>
<tr>
<td></td>
<td>(.091)</td>
<td>(.005)</td>
</tr>
<tr>
<td></td>
<td>+7.4%</td>
<td>+1784%</td>
</tr>
<tr>
<td>Southeast Asia</td>
<td>229,601</td>
<td>196,790</td>
</tr>
<tr>
<td></td>
<td>(.059)</td>
<td>(.051)</td>
</tr>
<tr>
<td></td>
<td>-13.8%</td>
<td>+62.6%</td>
</tr>
<tr>
<td>Near East</td>
<td>5,977</td>
<td>64,017</td>
</tr>
<tr>
<td></td>
<td>(.002)</td>
<td>(.017)</td>
</tr>
<tr>
<td></td>
<td>+482.2%</td>
<td>-32.5%</td>
</tr>
<tr>
<td>Africa</td>
<td>0</td>
<td>64,663</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.017)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-44.6%</td>
</tr>
<tr>
<td>Total</td>
<td>2,498,443</td>
<td>1,363,369</td>
</tr>
<tr>
<td></td>
<td>(.647)</td>
<td>(.353)</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>Other Foods</td>
<td>.353</td>
<td>+.198</td>
</tr>
<tr>
<td>Glass</td>
<td>.236</td>
<td>+.137</td>
</tr>
<tr>
<td>Tobacco</td>
<td>.173</td>
<td>+.060</td>
</tr>
<tr>
<td>Apparel</td>
<td>.091</td>
<td>+.053</td>
</tr>
<tr>
<td>Lumber and Wood</td>
<td>.061</td>
<td>+.004</td>
</tr>
<tr>
<td>Grain</td>
<td>.078</td>
<td>-.013</td>
</tr>
<tr>
<td>Preserved Fruits</td>
<td>.096</td>
<td>-.033</td>
</tr>
<tr>
<td>Beverages</td>
<td>.086</td>
<td>-.050</td>
</tr>
<tr>
<td>Pulp and Paper</td>
<td>.023</td>
<td>-.039</td>
</tr>
<tr>
<td>Print</td>
<td>.008</td>
<td>-.015</td>
</tr>
<tr>
<td>Industrial Chemicals</td>
<td>.081</td>
<td>-.002</td>
</tr>
<tr>
<td>Drugs</td>
<td>.113</td>
<td>-.032</td>
</tr>
<tr>
<td>Soap</td>
<td>.139</td>
<td>+.044</td>
</tr>
<tr>
<td>Chemical Products</td>
<td>.102</td>
<td>+.015</td>
</tr>
<tr>
<td>Rubber</td>
<td>.164</td>
<td>-.023</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>Structural Metals</td>
<td>.073</td>
<td>+.020</td>
</tr>
<tr>
<td>Fabricated Metals</td>
<td>.098</td>
<td>+.034</td>
</tr>
<tr>
<td>Construction Machinery</td>
<td>.119</td>
<td>+.008</td>
</tr>
<tr>
<td>General Indust. Machinery</td>
<td>.046</td>
<td>-.013</td>
</tr>
<tr>
<td>Computers, Office Equip.</td>
<td>.092</td>
<td>+.070</td>
</tr>
<tr>
<td>Service Industry Machinery</td>
<td>.125</td>
<td>+.068</td>
</tr>
<tr>
<td>Electronic Components</td>
<td>.222</td>
<td>-.007</td>
</tr>
<tr>
<td>Electrical Machinery</td>
<td>.145</td>
<td>+.060</td>
</tr>
<tr>
<td>Motor Vehicles</td>
<td>.154</td>
<td>+.068</td>
</tr>
<tr>
<td>Scientific and Optical Equipment</td>
<td>.008</td>
<td>-.021</td>
</tr>
<tr>
<td>Medical Instruments</td>
<td>.074</td>
<td>-.020</td>
</tr>
<tr>
<td>Photo Equipment</td>
<td>.061</td>
<td>+.045</td>
</tr>
<tr>
<td>Plastics</td>
<td>.094</td>
<td>-.044</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Region</th>
<th>Countries with High Educational Attainment</th>
<th>Countries with Low Educational Attainment</th>
<th>Employment Weighted Mean Wage per Geographical Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>$32,328</td>
<td>$8,703</td>
<td>$19,583</td>
</tr>
<tr>
<td>South America</td>
<td>$12,819</td>
<td>$12,375</td>
<td>$12,431</td>
</tr>
<tr>
<td>Europe</td>
<td>$32,252</td>
<td>$27,104</td>
<td>$31,871</td>
</tr>
<tr>
<td>Northeast Asia</td>
<td>$32,252</td>
<td>$8,554</td>
<td>$31,018</td>
</tr>
<tr>
<td>Southeast Asia</td>
<td>$23,671</td>
<td>$11,666</td>
<td>$18,105</td>
</tr>
<tr>
<td>Near East</td>
<td>$23,415</td>
<td>$12,693</td>
<td>$13,822</td>
</tr>
<tr>
<td>Africa</td>
<td>$10,822</td>
<td>$10,822</td>
<td></td>
</tr>
<tr>
<td>Parent</td>
<td>$37,828</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
TABLE 3.4: THE LABOR DEMAND REGRESSION [eqn.5]
Pool of all affiliates in manufacturing industries
Affiliate (firm-country) fixed effects

REGRESSAND: EMPLOYMENT $L_{ct}^f$ (of firm f in country c in year t)

<table>
<thead>
<tr>
<th>Countries with High Educational Attainment</th>
<th>Countries with Low Educational Attainment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local wage</td>
<td>- .755 (.120)</td>
</tr>
<tr>
<td>Wage of other affiliates in industrialized countries</td>
<td>.154 (.057)</td>
</tr>
<tr>
<td>Wage of other affiliates in developing countries</td>
<td>- .185 (.049)</td>
</tr>
<tr>
<td>Local aggregate demand</td>
<td>.828 (.073)</td>
</tr>
<tr>
<td>Constant</td>
<td>.044 (.011)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Countries with High Educational Attainment</th>
<th>Countries with Low Educational Attainment</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R^2$</td>
<td>.462</td>
<td>.2099</td>
</tr>
<tr>
<td>Number of observations</td>
<td>9,174</td>
<td>3,677</td>
</tr>
</tbody>
</table>

F-Tests

<table>
<thead>
<tr>
<th></th>
<th>Countries with High Educational Attainment</th>
<th>Countries with Low Educational Attainment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prob [$\beta_s = \beta_d$]</td>
<td>.0002</td>
<td>.0045</td>
</tr>
<tr>
<td>Prob [affiliate (fc) dummies = 0]</td>
<td>.0000</td>
<td>.0000</td>
</tr>
</tbody>
</table>

The standard errors (reported in parentheses) are robust to country-year heteroskedasticity in the error terms.
### TABLE 3.5
Industry Level Labor Demand Regressions
(standard errors in parentheses)
The regressions are pooled separately for affiliate in industrialized and developing countries.

<table>
<thead>
<tr>
<th>Industries</th>
<th>country type</th>
<th>$\beta_0$</th>
<th>$\beta_1$</th>
<th>$\beta_d$</th>
<th>$\gamma$</th>
<th>obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electronic Components</td>
<td>Ind.</td>
<td>-.896</td>
<td>.362</td>
<td>-.224</td>
<td>.649</td>
<td>420</td>
</tr>
<tr>
<td></td>
<td>(.266)</td>
<td>(.163)</td>
<td>(.160)</td>
<td>(.039)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dev.</td>
<td>-.368</td>
<td>.629</td>
<td>-.187</td>
<td>.212</td>
<td>157</td>
</tr>
<tr>
<td></td>
<td>(.128)</td>
<td>(.161)</td>
<td>(.288)</td>
<td>(.064)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Food Products</td>
<td>Ind.</td>
<td>-.933</td>
<td>.472</td>
<td>-.295</td>
<td>.757</td>
<td>282</td>
</tr>
<tr>
<td></td>
<td>(.188)</td>
<td>(.342)</td>
<td>(.249)</td>
<td>(.064)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dev.</td>
<td>-.540</td>
<td>.982</td>
<td>-.637</td>
<td>.834</td>
<td>175</td>
</tr>
<tr>
<td></td>
<td>(.149)</td>
<td>(.219)</td>
<td>(.344)</td>
<td>(.130)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plastic Products</td>
<td>Ind.</td>
<td>-1.07</td>
<td>1.83</td>
<td>-1.30</td>
<td>.834</td>
<td>146</td>
</tr>
<tr>
<td></td>
<td>(.274)</td>
<td>(.741)</td>
<td>(.609)</td>
<td>(.069)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dev.</td>
<td>-.637</td>
<td>.863</td>
<td>-.459</td>
<td>.238</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>(.203)</td>
<td>(.304)</td>
<td>(.750)</td>
<td>(.128)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glass Products</td>
<td>Ind.</td>
<td>-.198</td>
<td>.404</td>
<td>-.905</td>
<td>.932</td>
<td>103</td>
</tr>
<tr>
<td></td>
<td>(.224)</td>
<td>(.400)</td>
<td>(.525)</td>
<td>(.114)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dev.</td>
<td>-.828</td>
<td>1.33</td>
<td>.206</td>
<td>.531</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>(.347)</td>
<td>(.395)</td>
<td>(.718)</td>
<td>(.128)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Service Industry Machinery</td>
<td>Ind.</td>
<td>-.779</td>
<td>.230</td>
<td>-.914</td>
<td>1.39</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td>(.349)</td>
<td>(.261)</td>
<td>(.427)</td>
<td>(.168)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dev.</td>
<td>-.485</td>
<td>1.85</td>
<td>-3.25</td>
<td>.914</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>(.569)</td>
<td>(1.54)</td>
<td>(1.99)</td>
<td>(.267)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apparel</td>
<td>Ind.</td>
<td>-.789</td>
<td>.948</td>
<td>-.379</td>
<td>.729</td>
<td>105</td>
</tr>
<tr>
<td></td>
<td>(.406)</td>
<td>(.698)</td>
<td>(.693)</td>
<td>(.130)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medical Instruments</td>
<td>Ind.</td>
<td>-1.50</td>
<td>1.46</td>
<td>-.750</td>
<td>.714</td>
<td>155</td>
</tr>
<tr>
<td></td>
<td>(.377)</td>
<td>(.548)</td>
<td>(.567)</td>
<td>(.112)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dev.</td>
<td>-.592</td>
<td>.060</td>
<td>-.023</td>
<td>.289</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>(.166)</td>
<td>(.240)</td>
<td>(.406)</td>
<td>(.085)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
TABLE 3.5 CONTINUED  
Industry Level Labor Demand Regressions  
(standard errors in parentheses)

<table>
<thead>
<tr>
<th>Industries</th>
<th>type</th>
<th>$\beta_u$</th>
<th>$\beta_s$</th>
<th>$\beta_d$</th>
<th>$\gamma$</th>
<th>obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photo Equipment</td>
<td>Ind.</td>
<td>-.208</td>
<td>.069</td>
<td>-.006</td>
<td>1.10</td>
<td>149</td>
</tr>
<tr>
<td></td>
<td>Dev.</td>
<td>-.030</td>
<td>.665</td>
<td>-.152</td>
<td>.286</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.800)</td>
<td>(.640)</td>
<td>(.594)</td>
<td>(.156)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.150)</td>
<td>(.320)</td>
<td>(.148)</td>
<td>(.173)</td>
<td></td>
</tr>
<tr>
<td>Motor Vehicles</td>
<td>Ind.</td>
<td>-.135</td>
<td>-.896</td>
<td>-.020</td>
<td>1.06</td>
<td>417</td>
</tr>
<tr>
<td></td>
<td>Dev.</td>
<td>-.841</td>
<td>.231</td>
<td>-.650</td>
<td>1.32</td>
<td>138</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.225)</td>
<td>(.345)</td>
<td>(.206)</td>
<td>(.053)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.182)</td>
<td>(.260)</td>
<td>(.459)</td>
<td>(.071)</td>
<td></td>
</tr>
<tr>
<td>Construction</td>
<td>Ind.</td>
<td>-.649</td>
<td>-.037</td>
<td>-.217</td>
<td>.836</td>
<td>327</td>
</tr>
<tr>
<td>Machinery</td>
<td>Dev.</td>
<td>-.253</td>
<td>-.064</td>
<td>.561</td>
<td>.487</td>
<td>158</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.243)</td>
<td>(.317)</td>
<td>(.238)</td>
<td>(.106)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.152)</td>
<td>(.249)</td>
<td>(.440)</td>
<td>(.063)</td>
<td></td>
</tr>
<tr>
<td>Industrial</td>
<td>Ind.</td>
<td>-.174</td>
<td>-.232</td>
<td>-.393</td>
<td>.866</td>
<td>888</td>
</tr>
<tr>
<td>Chemicals</td>
<td>Dev.</td>
<td>-.594</td>
<td>-.321</td>
<td>.597</td>
<td>.702</td>
<td>246</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.151)</td>
<td>(.271)</td>
<td>(.223)</td>
<td>(.038)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.135)</td>
<td>(.230)</td>
<td>(.403)</td>
<td>(.150)</td>
<td></td>
</tr>
<tr>
<td>Drugs</td>
<td>Ind.</td>
<td>-.775</td>
<td>.142</td>
<td>.038</td>
<td>.788</td>
<td>1091</td>
</tr>
<tr>
<td></td>
<td>Dev.</td>
<td>-.463</td>
<td>.122</td>
<td>-.020</td>
<td>.459</td>
<td>598</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.100)</td>
<td>(.189)</td>
<td>(.169)</td>
<td>(.025)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.110)</td>
<td>(.148)</td>
<td>(.106)</td>
<td>(.048)</td>
<td></td>
</tr>
<tr>
<td>Soap Products</td>
<td>Ind.</td>
<td>-.976</td>
<td>-.039</td>
<td>.005</td>
<td>.834</td>
<td>591</td>
</tr>
<tr>
<td></td>
<td>Dev.</td>
<td>-.396</td>
<td>.330</td>
<td>-.077</td>
<td>.472</td>
<td>377</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.095)</td>
<td>(.209)</td>
<td>(.199)</td>
<td>(.297)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.073)</td>
<td>(.163)</td>
<td>(.195)</td>
<td>(.062)</td>
<td></td>
</tr>
<tr>
<td>Chemical Products</td>
<td>Ind.</td>
<td>-.965</td>
<td>.006</td>
<td>.148</td>
<td>.640</td>
<td>459</td>
</tr>
<tr>
<td></td>
<td>Dev.</td>
<td>-.115</td>
<td>.170</td>
<td>.047</td>
<td>.377</td>
<td>147</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.240)</td>
<td>(.281)</td>
<td>(.205)</td>
<td>(.046)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.108)</td>
<td>(.120)</td>
<td>(.221)</td>
<td>(.110)</td>
<td></td>
</tr>
</tbody>
</table>
References


107