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**Regional Integration and Industrial Location in a Landlocked
Spatial Economy**

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Abstract

Regional integration proposals often require agreements between countries that differ in geographic size, resource endowments, transportation assets, technologies, and product quality. In this asymmetric setting, questions arise about the potential for mutual gains and the distribution of benefits among industries and workers in each country. This paper examines how regional integration between a small landlocked country and a large neighboring country—with a unique port facility that both nations must use to export goods—affects the wage and location decisions of firms, the allocation of labor, the welfare of each country's workers and firms, and aggregate measures of economic welfare in each country and the region. A simulated spatial labor market model is used to explore the economic effects of various stages of regional integration. Beginning with autarky as a benchmark case, we consider two forms of regional integration partial mobility (mobile labor with geographically restricted firms); and full mobility (mobile labor and firms) with convergence of production technologies and product quality.

Keywords: regional integration, spatial, location, migration, labor

I. INTRODUCTION

Regional integration proposals often call for agreements between countries that differ greatly in geographic size, resource endowments, technologies, and transportation assets. Because of such differences, regional integration is usually contentious, especially for less dominant countries. Integration may allow economically or geographically disadvantaged countries to gain access to a larger product market, a larger labor pool, and better transportation facilities (ports, rail systems, airports, etc.). But regional integration also poses risks to smaller countries, including the possible out-migration of firms and workers and a loss of domestic market share. The risk inherent in such agreements likely depends on the degree of dissimilarity between potential bloc members and the extent of the proposed economic integration. In this environment, questions naturally arise about the potential for mutual gains and the distribution of benefits among industries and workers in each country.

Such questions often reflect political and economic self-interests, but they might be well founded. Previous studies show that asymmetries often contribute to an uneven distribution of the costs and benefits of regional integration (Edwards and Savastano 1989; Foroutan 1993; and Ben-David 1993). When such asymmetries are especially strong, regional blocs may fail to form if some countries expect the economic or political costs of integration to exceed their perceived gains. Some of the largest asymmetries involve demographic or geographic differences: population size, geographic area, amount of arable land, natural ports, etc. It therefore seems useful to study the potential effects of these “unnatural marriages” between dissimilar countries within a spatial setting that explicitly incorporates such features.

In this paper we use spatial methods to consider an extreme case where regional integration is proposed for two neighboring countries that differ in several key ways. Because the situation resembles that faced by India and its smaller neighbor, Nepal, we refer to the two countries in the model as I and N . Country I has a larger population (labor pool) and geographically dwarfs country N . Country I also enjoys direct export access to world markets through its own port. N also exports its products to the world, but because it is landlocked it must ship its output through country I to use I 's port. (It should be noted that the "port" as an export node fits nicely into the spatial framework, but it can be more generally viewed as a unique transportation asset of the larger country). Finally, relative to N , country I also initially enjoys a technological advantage in the form of higher labor productivity and produces a higher quality good that commands a higher export price. In sum, country I comes to regional integration holding all the economic cards.

Given these imbalances between I and N , what are the effects of various degrees of regional integration? In particular, can N 's firms or workers benefit from regional integration with a neighbor as dominant as country I ? Is partial integration preferable to a more complete form of regional integration? Does I , which already seems to have the upper hand, have anything further to gain from regional integration with its smaller neighbor? If regional integration occurs, how will the benefits or costs be distributed among firms and workers of each country? Such questions will be addressed within the spatial model developed here. Because our model is relatively simple and our simulations are specific, the results are only suggestive.

Why a spatial model? First, as noted, some of the most important asymmetries between potential members of regional blocs involve area, distance, and transportation assets--features that can easily be represented in spatial models. Second, spatial models readily capture product or labor market competition between economic rivals, providing a mechanism for the determination of market shares. This is a particularly attractive feature because some of the key questions about regional integration focus on the size of these market shares, before and after integration. Finally, spatial models lend themselves to analyses of mobility, and regional integration often allows or actively encourages increased mobility of workers and firms. In Section III, we develop a spatial model that displays these critical features, but first it is useful to briefly review some previous studies of regional integration.

II. EARLIER STUDIES

Traditionally, the overall welfare effect of regional integration is measured by the potential of the agreement to increase the region's volume of trade (Viner 1950). The welfare effects of regional integration, however, also should be measured by the specific impacts on wage income, employment, and the potential gain or loss of industries in a region. The debate over NAFTA demonstrated that the welfare implications of regional integration go well beyond the potential to generate a higher volume of regional trade. The effects of regional integration on industrial location and labor markets constitute important issues that often prove to be the greatest obstacles to integration and the most difficult ones to resolve. Such issues have been addressed in previous studies.

Many earlier papers ignored the role of distance, location, and transportation costs in determining the welfare effects of regional integration on member countries, but more recent welfare assessments of regional integration have adopted spatial methods. Specifically, the use of economic geography models by Krugman (1991) and others has bolstered interest in the role of space in trade. Krugman's model shows that demand linkages can generate manufacturing clusters. In subsequent studies, the model has been extended to address different issues of regional integration (e.g., Krugman and Venables 1995; Puga and Venables 1997; and Ludema and Wooton 1997). These studies mainly focus on regional integration, industrial location, and regional inequalities.

Other studies (Venables 1994; Baldwin and Venables 1995; and Puga 1999) measure the impact of regional integration on wage differentials and industrial structure. These studies show that integration can cause relative wages to diverge or converge, depending upon wage rigidity and labor mobility. Venables (1994), for example, argues that regional integration can cause industries to agglomerate in a few locations, causing divergence in the structure of the integrating economies and their income levels. Similarly, Baldwin and Venables (1995) argue that as trade barriers fall industry can be drawn to higher wage locations, thereby increasing interregional wage differences. They show that if wages are fixed regional integration will lead to a divergence of industrial structure. But if wages are flexible, they also show that integration will lead to a divergence of relative wages, up to a point, and convergence thereafter. Puga (1999) also justifies this argument in terms of labor mobility. He suggests that if labor is mobile, higher wages will draw workers to more industrialized regions, intensifying agglomeration and eliminating wage differentials. If workers are immobile, however,

interregional wage differences will persist. Krugman (1993) further argues that even if other non-land factors are mobile across countries, national boundaries can remain major barriers to labor flows.

Prior to Krugman's (1991) work, Hotelling's (1929) seminal paper served as the basis for much of the spatial pricing literature and provided a rationale for agglomeration that depends on market-share competition between sellers rather than trade linkages among producers or consumers. Hotelling's model also emphasizes the role of transportation (transaction) costs in determining equilibrium industrial locations. The basic idea of the model is that market-share competition between two mobile sellers of a homogeneous product leads to their agglomeration at the center of a bounded linear market. This agglomeration, however, can be inefficient, in that other site assignments might improve consumer welfare without harming producers.

Variants of the Hotelling model have been used to examine not just the equilibrium prices, wages, and locations of firms, but also the welfare effects of easing trade barriers. These studies range from analyses of price and location equilibria in a product market using price-location games, to analyses of the welfare effects of autarky versus free trade between two regions (Gronberg and Meyer 1982; Benson and Hartigan 1983; Fujita and Thisse 1986; Anderson and Neven 1991; Hatzipanayotou and Heffley 1991; Anderson and de Palma 1992; Anderson, de Palma, and Hong 1992; and Anderson, de Palma, and Nesterov 1995).

Most spatial pricing models focus on a product market with buyers and firms, and ignore labor market features that also could affect firms' location decisions. A spatial pricing model of the labor market can be used to analyze the effects of spatial

competition on wages, employment, and industrial location, but simplicity in such models often requires less complete treatment of product market competition. Relatively few studies have focused on labor markets using a spatial pricing model. Nakagome (1985, 1986, 1988, 1991) has done considerable work in this area. In his first study, Nakagome (1985) examines the existence of equilibrium wages as well as spatial unemployment under free and restricted labor mobility. His results suggest that spatial competition with fully mobile labor yields a lower equilibrium wage than a spatial monopsonist would offer, and full employment cannot be guaranteed. Similarly, incorporating both the product and labor markets, Nakagome (1988) examines the impact of spatial competition and technological innovation on wage rates. He finds that the greater the labor supply, the more likely the wage rate will fall as labor productivity increases. In his analysis, the supply of labor is assumed to be a linear function of the real wage net of commuting costs.

Most spatial pricing models assume a bounded market in which two competing firms have equal access to the product (or labor) market. In using such a framework to examine regional integration among dissimilar countries, however, it is useful to consider the situation where one country's producers have certain advantages over their rivals in the other country, in terms of market size or accessibility. We do this by positing a situation where there are two firms, one that is located in a smaller landlocked country and ships its exports to the world market via the larger country's port. Firms in the larger country have access to a larger labor pool as well as better access to the port. In this situation, regional integration that allows workers, and perhaps firms, to move from one country to the other could have interesting effects on wages, employment, output, profits,

the relative welfare of the two countries, and the overall welfare of the region. Section III describes such a model, which will then be used in Section IV to analyze the effects of various degrees of regional integration. Section V offers some final remarks.

III. THE MODEL

The model developed in this study will be used to analyze the impact of regional integration on the wage and location decisions of two export-oriented firms in a spatial economy that consists of two "linear" countries, I and N . Country I is relatively large, in geographic size and population, and has a port. Country N is a smaller landlocked economy with no direct access to ports other than via its larger neighbor. Firm i in country I and firm n in country N each must choose a profit-maximizing location and gross wage offer, subject to conditions that reflect various stages of economic integration. Each firm's ability to attract labor, and thereby produce goods for export, depends on its own location and wage offer and, under regional integration, the location and wage offer of the other firm. The primary notation is summarized below. Other notation will be introduced as needed.

Notation

x	distance from the port (at $x = 0$) located in country I
x_i	firm i 's chosen location
x_n	firm n 's chosen location
p_i	export price (at $x = 0$) of firm i 's product
p_n	export price (at $x = 0$) of firm n 's product
t	product transportation cost per mile to the port in country I
D	uniform residential density (workers per mile)
a_i	firm i 's fixed production coefficient (output per worker)

a_n	firm n 's fixed production coefficient (output per worker)
Q_i	output of firm i
Q_n	output of firm n
w_i	gross wage offer of firm i at location x_i
w_n	gross wage offer of firm n at location x_n
L_i	number of workers employed by firm i
L_n	number of workers employed by firm n
c	worker commuting cost per mile
π_i	profit of firm i
π_n	profit of firm n
NW_I	net wages to workers living in country I
NW_N	net wages to workers living in country N
NW	net wages to workers in the region ($= NW_I + NW_N$)
W_I	welfare in country I ($= NW_I + \pi_i$)
W_N	welfare in country N ($= NW_N + \pi_n$)
W	total welfare in the region ($= W_I + W_N$)

The two firms must locate along a closed line segment $[0, x_N]$. The line segment is divided into two parts $[0, x_I]$ and $[x_I, x_N]$ that represent the two countries, I and N , respectively. We assume that $x_I > (x_N - x_I)$ to reflect the imbalance in geographic size. Each firm exports its product to the world through country I 's port at $x = 0$. The two firms compete for workers who are distributed along the entire line segment at a uniform density of D workers per mile. It follows that each country's population is proportional to its geographic size or "length." Workers must always reside in their home country, but under various stages of regional integration they may be allowed to commute across the common border at x_I to supply labor services. For simplicity, both product transportation costs and worker commuting costs are assumed to be linear functions of distance. Figure

1 illustrates the spatial model with net wages (gross wage less commuting costs) declining with distance from each firm. The dashed portions of the net wage lines are relevant only when workers are allowed to commute across the common border at x_I . The x -axis measures the distance of each firm or worker from the port. Note that, in Figure 1, both firms have chosen interior locations, but corner solutions also can occur.

[FIGURE 1]

Regional Integration, Labor Mobility, and Labor Shares

The ultimate goal of integration is to allow not just free trade between member countries in a regional bloc, but also full mobility of inputs and firms between member countries. Under such conditions, we also might expect production technologies and output quality to converge over time as technical information spreads and competition reduces quality differences. Of course the actual degree of regional integration may vary. Depending on the degree of integration and the economic and geographic features of member countries, such pacts could significantly affect the decisions and performance of firms in the region. Our model focuses on firms' location and wage decisions, which in turn affect output levels, profits, and the net wages of workers in both countries.

Labor typically is the most important factor of production, particularly in capital-scarce developing economies. If a firm's technology is labor-intensive, the firm's output and profit depend largely on its ability to attract workers and the wage rate it must offer to do so. Consequently, the profit-seeking firm must select a location where it can capture a sufficiently large number of workers at a wage it can afford to pay. Both the

wage and location decisions will influence the amount of labor a firm can attract, but the wage-location decisions of other firms also will affect the outcome if there is active competition for labor.

Our model considers two firms that compete for workers, so we need to specify some mechanism to determine the share of labor from each residential site that chooses to work for each firm. For this purpose, we use a logistic function¹ to determine each firm's share of the workers who commute from any particular residential site $x \in [0, x_N]$. Since the total share of workers at any x is one, firm i 's share of the workers residing at x is denoted $s_i(x)$ and firm n 's share of the workers from x is denoted $s_n(x) = 1 - s_i(x)$. The share of workers residing at x that works for each firm is assumed to depend on the difference in net wages (gross wage less commuting costs) at x , defined as:

$$d(x) = w_i(x) - w_n(x) , \quad (1)$$

where $w_i(x) = (w_i - c|x_i - x|)$ and $w_n(x) = (w_n - c|x_n - x|)$ are the net wage functions of firm i and firm n , as depicted in Figure 1. With the logistic function, the share of workers from any particular residential site x that works for firm i is:

¹ While the logistic model is frequently used by researchers in marketing [Ben Akiva and Lerman 1986; and MaFadden 1986], Anderson and de Palma (1992) also have used a logistic function in location theory to model competition under product differentiation. Instead of the distinct (typically endogenous) market boundaries that characterize traditional models of spatial competition, the logistic specification allows the two firms' labor market areas to overlap. Rather than assuming that the firm offering the highest net wage at x attracts all workers from that site, the logistic function indicates that the firm offering a higher net wage attracts a higher proportion of workers. Some workers may still opt to work for the other firm. The approach has some appeal, but it also allows us to avoid some technical problems that crop up in a model where both prices (or wages) and locations are endogenous.

$$s_i(x) = 1/[k + mb^{d(x)}], \quad (2)$$

where k , m , and b are parameters that will be further restricted. Firm n attracts the residual share of workers from site x :

$$s_n(x) = 1 - \{1/[k + mb^{d(x)}]\}. \quad (3)$$

To ensure that $s_i(x)$ increases with the net wage difference, $d(x)$, and to ensure that $s_i(x) = s_n(x) = 0.5$ when $d(x) = 0$, the parameters k , m , and b must be restricted (see Appendix); we assume that $k \in (0, 2)$, $m = 2-k$; and $b \in (0, 1)$. Figure 2 shows a numerical example of this logistic function ($k = 1$, $m = 1$, $b = 0.1$), which gives firm i 's labor share, $s_i(x)$, for any net wage difference, $d(x)$, at location x . The function intersects the vertical axis at 0.5, indicating that if net wages at x are equal, that is $d(x) = 0$, each firm attracts half of the workers who reside at x .

[FIGURE 2]

The total amount of labor secured by each firm depends on the labor share functions, (2) and (3), which in turn depend on the wage difference, $d(x)$, at each location. As can be seen in Figure 1, the wage-location decisions of each firm, (w_i, x_i) and (w_n, x_n) , determine the spatial pattern of wage differentials and, hence, the allocation of labor to firms. The two profit-maximizing firms, i and n , are assumed to choose optimal wage-location combinations, subject to any restrictions that accompany various stages of regional integration. Assuming Nash behavior, each firm regards the wage-location decision of the other firm as given. The Nash equilibrium wage-location combinations provide no incentive for either firm to move or to further adjust its wage offer.

The two firms have potentially different technologies and different product qualities. The parameters a_i and a_n represent the production technologies of firms i and n . The model initially assumes that firm i is both more efficient ($a_i > a_n$) and produces higher quality output than firm n , as reflected in their export prices ($p_i > p_n$). Later these assumptions are relaxed to examine the effects of technological convergence and product homogeneity that might result from the improved information flows and greater competition that should accompany full regional integration.

Firm i

If regional integration allows mobility, more specifically commuting, of workers between countries, workers are more likely to work for the firm that offers higher net wages, regardless of the firm's home country. The amount of labor that firm i captures from a particular residential site x can be computed as the product of the firm's share of labor from that location, $s_i(x)$, and the uniform labor density, D . Under full labor mobility, the total labor (L_i) attracted by firm i from the entire region $[0, x_N]$ when it locates at some x_i ($< x_n$) is found by integrating the logistic labor share function, $s_i(x)$, over various segments of the linear labor market, and multiplying the results by D :

$$L_i = D \left[\int_0^{x_i} s_{i1}(x) dx + \int_{x_i}^{x_n} s_{i2}(x) dx + \int_{x_n}^{x_N} s_{i3}(x) dx \right] \quad (4)$$

where $s_{i1}(x)$, $s_{i2}(x)$, and $s_{i3}(x)$ represent the labor shares of firm i on the line segments $[0, x_i]$, $[x_i, x_n]$, and $[x_n, x_N]$, respectively. (Figure 1 illustrates this segmentation.) Since the net wages vary along different line segments, the workers' decisions to supply labor to a particular firm depend on the net wage differences $d_1(x)$, $d_2(x)$, and $d_3(x)$, as defined for (6) below, within the line segments $[0, x_i]$, $[x_i, x_n]$, and $[x_n, x_N]$, respectively. With its

fixed-coefficient production ($Q_i = a_i L_i$) and the assumption that each unit of output must be shipped to the port at a cost of tx_i to fetch the export price p_i , the profit function of firm i at location x_i can be written:

$$\pi_i = (p_i - tx_i)Q_i - w_i L_i = [(p_i - tx_i)a_i - w_i]L_i. \quad (5)$$

Using (2), with the restrictions noted earlier, and (4) in equation (5), the profit function of firm i can be restated:

$$\begin{aligned} \pi_i(x_i, w_i; x_n, w_n, p, t, c, b, k) = & [(p_i - tx_i)a_i - w_i] D \left\{ \int_0^{x_i} [k + (2-k)b^{d_1(x)}]^{-1} + \int_{x_i}^{x_n} [k + (2-k)b^{d_2(x)}]^{-1} \right. \\ & \left. + \int_{x_n}^{x_N} [k + (2-k)b^{d_3(x)}]^{-1} dx \right\} \end{aligned} \quad (6)$$

where the net wage differences are, for:

$$[0, x_i], \quad d(x) = d_1(x) \int \{ [w_i - c(x_i - x)] - [(w_n - c(x_n - x))] \};$$

$$[x_i, x_n], \quad d(x) = d_2(x) \int \{ [w_i - c(x - x_i)] - [(w_n - c(x_n - x))] \};$$

$$[x_n, x_N], \quad d(x) = d_3(x) \int \{ [w_i - c(x - x_i)] - [(w_n - c(x - x_n))] \}.$$

Firm i selects a profit-maximizing location-wage pair (x_i, w_i) , given firm n 's location and wage decisions (x_n, w_n) , the export price for its own product (p_i), its own technology (a_i), product transportation costs (t), worker commuting costs (c), and parameters (b, k) of the logistic labor share function. The firm's optimal location-wage pair jointly satisfies the conditions: $\partial \pi_i / \partial x_i = 0$ and $\partial \pi_i / \partial w_i = 0$. These conditions yield firm i 's Nash response functions.

Firm n

Similarly, with full labor mobility, the amount of labor available to firm n when it locates at x_n is determined by the number of workers it can attract from the entire region,

$[0, x_N]$. The model assumes that workers must supply labor to either firm i or firm n . The region's total population is Dx_N , so the labor attracted by firm n will be:

$$L_n = (Dx_N - L_i). \quad (7)$$

Thus, with $Q_n = a_n L_n$, firm n 's profit is

$$p_n = (p_n - t x_n) Q_n - w_n L_n = [(p_n - t x_n) a_n - w_n] (Dx_N - L_i) \quad (8)$$

where L_i is given by (4). Making the necessary substitutions, we get:

$$\begin{aligned} \pi_n(x_n, w_n; x_i, w_i, p_n, a_n, t, c, b, k) = & [(p_n - t x_n) a_n - w_n] D [x_N - \{\int_0^{x_i} k + (2 - k) b^{d1(x)}\}^{-1} dx \\ & + \int_{xi}^{xn} k + (2 - k) b^{d2(x)}\}^{-1} dx + \int_{xn}^{xN} k + (2 - k) b^{d3(x)}\}^{-1} dx] \quad (9) \end{aligned}$$

Firm n selects a profit-maximizing location-wage pair (x_n, w_n) , given firm i 's location and wage decisions (x_i, w_i) , the export price for its own product (p_n) , its own technology (a_n) , and other parameters of the model (t, c, b, k) . The firm's optimal location-wage pair satisfies the conditions: $\partial \pi_n / \partial x_n = 0$ and $\partial \pi_n / \partial w_n = 0$, which define firm n 's Nash response functions.

Equilibrium Locations and Wages

If regional integration allows full mobility of workers and firms across borders, the location and wage offer of each firm depend on the other firm's location and wage offer. This interdependency is adequately captured by Nash behavior: each firm's wage-location choices are conditional on the other firm's choices. The Nash equilibrium (*) locations and wage offers $\{x_i^*, w_i^*, x_n^*, w_n^*\}$ are found by simultaneously solving the two sets of first-order conditions $\{\partial \pi_i / \partial x_i = 0, \partial \pi_i / \partial w_i = 0, \partial \pi_n / \partial x_n = 0, \partial \pi_n / \partial w_n = 0\}$. Various degrees of regional integration may impose additional constraints (e.g., labor might be

allowed to commute across the border while firms might be constrained to a domestic location).

Even with simple technologies and inelastic individual labor supply, simultaneous solution of the four first-order conditions does not give simple reduced-form expressions for $\{x_i^*, w_i^*, x_n^*, w_n^*\}$. This, together with constraints imposed by incomplete regional integration and the possibility of corner solutions, means that simulation methods must be used to analyze the effects of parameter changes on the equilibrium behavior of firms and associated outcomes for the two countries and their residents.

We consider three main cases. *First*, an autarky case will be examined in which firms and workers in each country are not allowed cross the border at x_I . Each firm must operate in its home country and each worker must supply labor to the domestic firm. The model, however, assumes that this autarky restriction does not prevent firm n from shipping its product to the world through country I 's port at $x = 0$. In the *second case*, which represents an initial limited stage of integration, each country allows workers, but not firms, to commute across the border at x_I . *Finally*, the third case will allow full mobility of workers and firms across the border. This third stage of the analysis also will allow production technologies and product qualities (reflected in export prices) to converge due to full regional integration.

IV. STAGES OF INTEGRATION

Case 1: Autarky

Strict autarky limits the movement of factors and firms between countries. Such restrictions preclude competition for labor between firms in different countries and, under

autarky, the wage-location decisions of one firm in our model do not affect the other firm's wage-location decisions. Under these conditions, and with inelastic labor supply, each firm's location decision depends only on product transportation costs. To minimize such transportation costs, each firm optimally locates as close to the port as autarky permits: firm i locates at the port ($x_i^* = 0$) and fully eliminates product transportation costs; firm n locates at the common border ($x_n^* = x_I$) and ships its output across country I to the port.

Under autarky, workers are "captive" and must supply labor to their domestic firm. Complete exploitation is averted in this case by assuming that the (gross) wage in each country is parametric, but possibly different from the wage in the other country. This assumption is needed only for autarky, where the absence of competition for labor by profit-maximizing firms would drive wage offers to zero if workers have no reservation wage. In the simulations that follow, the parametric wages in the autarky case will be set at levels that enable comparisons with subsequent cases that allow for greater mobility of labor, and ultimately firms.

Figure 3 can be used to visualize the autarky case. The line segment $[0, x_I]$ represents the size of country I , while $[x_I, x_N]$ represents the size of country N . To reflect the imbalance in geographic size (and population) between the two countries, the simulations assume that $x_I > (x_N - x_I)$. In the autarky case, regardless of the parametric wage levels, firm i maximizes its profits by locating at the port ($x_i^* = 0$) and firm n maximizes its profit by locating at the common border ($x_n^* = x_I$). Within the context of the model, where workers have no reservation wage, autarky implies that each firm captures all the labor in its home country: $L_i^* = x_I D$ and $L_n^* = (x_N - x_I) D$, where D is the

uniform density of workers. The net wage line (gross wage less commuting costs) for each firm slopes downward to the right, with movement away from each firm's "corner" location.

[FIGURE 3]

Net Wages to Workers Under Autarky

As measures of worker well-being in country I and country N , we construct the expressions for net wages, NW_I and NW_N , respectively. A worker's net wage declines with commuting distance. Because, in the autarky case, firm i optimally locates at $x_i^* = 0$ and firm n optimally locates at $x_n^* = x_I$, the net welfare of workers in each country is computed as:

$$\begin{aligned} NW_I &= D \left[\int_0^{x_I} w_i - c(x_i - x) dx + \int_{x_I}^{x_I} w_i - c(x - x_i) dx \right] \\ &= D [w_i x_I - 0.5c x_I^2] \end{aligned} \quad (10)$$

and

$$\begin{aligned} NW_N &= D \left[\int_{x_I}^{x_N} w_n - c(x_n - x) dx + \int_{x_I}^{x_N} w_n - c(x - x_n) dx \right] \\ &= D [w_n(x_N - x_I) - 0.5c(x_N - x_I)^2] \end{aligned} \quad (11)$$

Again, the above expressions for NW_I and NW_N hold only if $x_i^* = 0$ and $x_n^* = x_I$.

The total net wages (NW) to workers in the region (i.e., both countries) is found by summing the net wages to workers in each country:

$$NW = NW_I + NW_N \quad (12)$$

Similarly, the total welfare (W) of the region is the summation of the two firms' profits and the total net wages of workers in both countries:

$$W = \pi_i + \pi_n + NW \quad (13)$$

Autarky Simulation

Table 1 summarizes a numerical example for the autarky case. Parameter values are somewhat arbitrary but yield a feasible baseline solution. The parameter values in the autarky case are assigned so that results can be readily compared with subsequent labor mobility and full mobility cases under regional integration. In addition to firm i 's geographic advantages (better access to port and larger size) over firm n , firm i is relatively more productive than firm n (i.e., $a_i > a_n$). Similarly, the more efficient firm i also produces a higher quality product, as reflected in export prices ($p_i > p_n$). The inequalities will eventually be relaxed in the full mobility case, where long-run mobility of labor and firms causes a convergence of the firms' technologies and product qualities (export prices).

As noted earlier, the autarky case requires a special treatment of wages. With no reservation wage for labor, producers could potentially drive the endogenous wages of "captive workers" to zero in their quest for profits. To provide a more realistic basis for comparison with subsequent regional integration cases, this study pegs autarky wages to levels that emerge endogenously in the labor mobility case (Table 2), the first form of regional integration we consider.

[TABLE 1]

Case 2: Labor Mobility

The labor mobility case allows workers to commute across the common border, but each firm must remain in its home country: $x_i^* \in [0, x_I]$ and $x_n^* \in [x_I, x_N]$. Subject to the restriction, each firm must balance the transportation cost advantages of locating as near to the port as possible against the need to attract labor, which can now work for either firm by possibly commuting across the border at x_I . Consider the tradeoffs faced by each firm.

Firm i could still locate at the port ($x_i^* = 0$) and eliminate product transport costs, as it did under autarky. But, for any chosen w_i^* , a movement away from the port raises its net wage to workers at interior sites, who would have a shorter distance to commute. This allows firm i to compete more effectively for labor at interior sites in its own country as well as for labor in country N , which is now allowed to cross the border and work for firm i . Alternatively, firm i could attract more labor by simply raising w_i^* . Competition for the regional labor pool was absent under autarky because workers in each country had to work for their domestic firm. Now, with labor allowed to commute across the common border, firms may use both location and wage decisions to actively compete for labor. For profit-seeking firms, the revenue gains from attracting more labor through wage or plant location adjustments must be balanced against the additional wage bill and higher product transportation costs.

What about firm n 's new tradeoffs? Before, under autarky, firm n could comfortably locate as close to the port as permitted ($x_n^* = x_I$) and still be assured of employing all the workers from country N . With labor mobility, however, all workers in N have the option to commute across the common border to work for firm i . For any w_n^* it chooses,

moving away from the common border ($x_n^* > x_I$) may help firm n to retain domestic workers, but it will reduce its ability to attract workers from country I (who now have the option to commute into N) and will raise the cost of shipping its output to the port.

Depending on the relative size of these effects, firm n might optimally choose some $x_n^* > x_I$ or, if transport costs are sufficiently high, continue to "hug" the border ($x_n^* = x_I$), as it did under autarky. Figure 4 illustrates a labor mobility case where firm i has moved away from the port ($x_i^* > 0$) but firm n continues to locate at the common border ($x_n^* = x_I$). This is the outcome that occurs in our labor mobility simulation.

[FIGURE 4]

Net Wages to Workers Under Labor Mobility

Relaxing the constraints on where workers can supply their labor requires some changes in earlier expressions. Labor mobility allows workers to supply labor in either country, so the total net wages (gross wages less commuting costs) of workers living in one country is the sum of the net wages of those workers, whether they are employed by the domestic firm or the foreign firm. The net wages of country I residents who work for either firm i or firm n is denoted NW_I . Because each firm, in this case, is still restricted to its own country (i.e., $x_i^* \in [0, x_I]$ and $x_n^* \in [x_I, x_N]$), the expression for NW_I in the labor mobility case is:

$$\begin{aligned}
NW_I = D \bigg[& \int_0^{x_i} s_{i1}(x) [w_i - c(x_i - x)] + [1 - s_{i1}(x)] [w_n - c(x_n - x)] dx \\
& + \int_{x_i}^{x_I} s_{i2}(x) [w_i - c(x - x_i)] + [1 - s_{i2}(x)] [w_n - c(x_n - x)] dx \bigg] \quad (14)
\end{aligned}$$

Similarly, in the labor mobility case, the expression for the net wages of country N residents who work for either firm i or firm n is:

$$\begin{aligned}
NW_N = D \bigg[& \int_{x_I}^{x_n} s_{i2}(x) [w_i - c(x - x_i)] + [1 - s_{i2}(x)] [w_n - c(x_n - x)] dx \\
& + \int_{x_n}^{x_N} s_{i3}(x) [w_i - c(x - x_i)] \\
& + [1 - s_{i3}(x)] [w_n - c(x - x_n)] dx \bigg] \quad (15)
\end{aligned}$$

Labor Mobility Simulation

Table 2 gives results for the labor mobility simulation. The same parameter values used in the autarky case (Table 1) are repeated. Two differences have been introduced: first, with labor mobility, firms can now hire labor from both countries; second, wages (along with firm locations) are now determined endogenously by Nash-competition between firms i and n . Unlike the autarky case, where wages had to be exogenous to prevent the full exploitation of inelastically supplied labor, labor mobility forces the firms to actively compete for workers. This competition entails wage offers as well as adjustments in location, still subject to the restriction that each firm must remain in its home country. To compare the results of partial regional integration--mobility of labor but not firms--with autarky results, Table 2 also shows, in parentheses, the numerical change in each variable as the system moves from autarky to labor mobility.

[TABLE 2]

In the labor mobility case, firm i moves away from the port ($x_i^* > 0$) because it must now compete with firm n for labor from both countries. Notice that firm n 's share of the labor force grows with the switch from autarky to labor mobility. Workers can now commute across the common border, so some of the workers in country I , especially those near the border (x_I) are likely to receive higher net wages by working for firm n in country N rather than commuting back toward the port to work for firm i , their home country employer. This shift of workers from firm i to firm n would be even larger if firm i retained its port location to eliminate its product transportation costs. But firm i can control its loss of workers by moving away from the port and/or raising its wage offer (w_i^*). We see only the location adjustment here ($x_i^* = 0.36$) because wages in the autarky case were exogenously set equal to the endogenous wages in the current labor mobility case to avoid a degenerate outcome under autarky (zero wage offers) and to facilitate comparison of the two cases.

Although firm i moves inward to compete more effectively for labor, it is still nearer the port than firm n , which must remain in country N . This inherent geographic advantage keeps firm i 's product shipment costs below firm n 's and, coupled with its productivity and output price advantages, allows it to offer a higher gross wage ($w_i^* = 0.69$) than its competitor ($w_n^* = 0.46$). Firm i 's higher wages also reflect the fact that, under labor mobility, it must compete more actively for workers from both countries than it did under autarky. While we constructed a somewhat artificial autarky case with wages pegged at the same levels seen here, an actual move from labor mobility back to autarky

with endogenous wages would diminish spatial competition for labor and almost certainly reduce wages in both countries. Even when workers have positive reservation wages, autarky allows domestic firms to exercise their spatial monopsony power without having to worry about any external source of competition for labor. They might have to worry about losing some workers if wages are pushed below reservation levels, but they don't have to worry about workers commuting across the border to work for a foreign employer.

Despite its lack of a port, its smaller geographic size and population, and its technological and market disadvantages, country N reaps certain benefits from partial regional integration (i.e., labor mobility). We stacked the deck against wage gains to residents of N by setting autarky gross wages equal to the levels that emerge in the labor mobility case. As a result, total net wages to N 's residents are actually lower ($NW_N^* = 3.09$) than under autarky ($NW_N^* = 4.10$) because some residents of N now commute across the border to work for firm i . Firm n 's gain in profits (+25.28), however, more than offsets this net wage loss, resulting in an increase in total welfare (nets wages plus profits) in country N . With an appropriate redistribution from firm n to residents of N , both groups could benefit from this limited form of regional integration, despite the country's seemingly weak initial hand.

The larger and better-endowed country I could be the loser and the source of opposition to partial integration. Because it must now compete for labor, firm i 's output (proportional to L_i^*) and profit decline. Workers in country I benefit in the form of higher net wages (+13.28), but this gain is too small to offset firm i 's losses (-52.81), so

total welfare in country I falls (-39.53) relative to the autarky case. Since I 's welfare loss exceeds the N 's welfare gain (+16.48), welfare in the region falls (-23.02).

The regional welfare loss under labor mobility arises largely from the decrease in firm i 's profits, which enjoyed considerable monopsony power over its large labor pool in the autarky case. Labor mobility reduces this monopsony power and forces firm i to move from an "export-convenient" location (the port) to a more "worker-convenient" location nearer the center of its labor pool. This enhances firm i 's ability to compete for labor from both countries, but it also tends to reduce commuting costs and thereby increase net wages for workers, especially those in country I . Country N workers, some of whom now commute into country I , experience a slight reduction in net wages, but the output and profits of firm n rise considerably with the ability to draw workers from both countries (L_n^* increases from 10 under autarky to 32.43 when labor is mobile). Welfare in country N , the sum of firm n 's profit and net wages in country N , more than doubles, while welfare in country I falls due to the reduction in firm i 's monopsony power and profits. Introducing labor mobility in this model clearly alters the distribution of welfare between firms and their workers: in this case, labor's share of the region's total welfare increases from 0.133 to 0.221.

Case 3: Full Mobility

Full mobility allows firms as well as workers to cross the common border. Unlike the labor mobility case, firms i and n are no longer restricted to locate in their home countries. They can compete with each other for workers and locations in the region without constraints: each firm can locate anywhere on the line segment $[0, x_N]$. For

simplicity, however, we assume that firm i never locates further from the port than does firm n , or $x_i^* \leq x_n^*$. Removal of the border constraint for firms, which represents a second and more complete stage of regional integration, further affects workers' net wages, firms' profits, and overall welfare in each country and the region. In general, full mobility of firms and workers is expected to increase the region's welfare relative to the previous case where only workers are fully mobile. Figure 5 illustrates a possible outcome in the full mobility case.

[FIGURE 5]

Net Wages to Workers Under Full Mobility

If firm n continues to locate in country N , the computation of NW_I , the net wages to workers who live in country I , is similar to that in the labor mobility case. But, if firm n locates in I rather than its home country N , and is no closer to the port than firm i (that is, if $x_i^* \leq x_n^* \leq x_I$), the net wages to country I 's workers must be written as:

$$\begin{aligned}
 NW_I = D \bigg[& \int_0^{x_i} s_{i1}(x) [w_i - c(x_i - x)] + [1 - s_{i1}(x)] [w_n - c(x_n - x)] dx \\
 & + \int_{x_i}^{x_n} s_{i2}(x) [w_i - c(x - x_i)] + [1 - s_{i2}(x)] [w_n - c(x_n - x)] dx \\
 & + \int_{x_n}^{x_I} [s_{i3}(x) [w_i - c(x - x_i)] + [1 - s_{i3}(x)] [w_n - c(x - x_n)]] dx \bigg] \quad (16)
 \end{aligned}$$

Similarly, if $x_i^* \leq x_n^* \leq x_I$, the net wages to country N 's workers in the full mobility case are given by:

$$NW_N = D \left[\int_{x_I}^{x_N} s_{i3}(x) [w_i - c(x - x_i)] + [1 - s_{i3}(x)] [w_n - c(x - x_n)] dx \right] \quad (17)$$

If either firm chooses to still locate in country N , the expression for NW_N becomes more complex.

Full Mobility Simulation

Mobility, proximity, and interaction can reduce technological and market disparities. In this simulation, in addition to allowing workers to commute across the common border at x_I and allowing firms to locate anywhere in the region (subject to $x_I^* \leq x_n^*$), we also allow firms' production technologies and product qualities (reflected in export prices) to converge, that is: $a_i = a_n$ and $p_i = p_n$. Results in Table 3 show the effects of full regional integration, including technological and product quality convergence, on the firms' location choices and wage offers. Also shown are the effects on firms' labor shares and profits, and the net wages and total welfare (net wages plus profits) accruing to each country and the fully integrated region.

[TABLE 3]

Removing any technical or product quality differences between the two firms, and allowing both to locate anywhere within the region, places the two firms on an equal footing. Not surprisingly, this equivalence leads the two firms to cluster at the same location ($x_i^* = x_n^* = 0.25$) and to offer the same gross wage ($w_i^* = w_n^* = 1.51$).

The labor pool is split ($L_i^* = L_n^* = 50$) and profits are identical ($p_i^* = p_n^* = 43.43$). This relaxation of the firm location constraint favors firm n , which can now move closer to the port in Country I , reduce its product shipment costs, and increase its profits (+18.15) relative to the labor mobility case. Much of firm n 's gain comes at the expense of firm i , which loses workers (-17.57), despite offering a higher wage (+0.82), and experiences a reduction in profits (-66.25).

The earlier move from autarky to labor mobility benefited workers, especially in Country I . Retaining this ability of workers to commute across the border, but also allowing firms to locate anywhere in the region, further benefits workers in both countries. Net wages rise for workers in country I (+76.08) and country N (+4.98). The total increase in regional net wages (+81.05) exceeds the loss in regional profits, resulting in a regional welfare gain (+32.93) under full mobility. Some of the gains to labor in the full mobility case are also attributable to the increase in firm n 's productivity (a_n) and the increase in its product quality, as reflected in the export price (p_n) it receives for its output.

V. FINAL REMARKS

While we generally should expect the relaxation of location or economic constraints to increase regional welfare, the composition of these welfare gains is more surprising. One might expect that larger countries with clear initial advantages in geographic size, transportation assets, productivity, and product quality might dominate any regional integration with smaller countries that "bring little to the table." Indeed, many small countries probably see high risks in entering into lopsided regional agreements with

dominant neighbors. The present analysis has many limitations, but simulation results suggest that both limited and more complete forms of regional integration might benefit both workers and firms in smaller countries. These benefits are more likely to come at the expense of the larger country's firms, since workers in the larger country also appear to gain from the increased competition for their services. The strongest opposition to such agreements might actually come from firms in the larger, better-endowed country. Even if the partners are small and resource-poor, regional integration may still dissipate the monopsony power of firms in the larger country, allowing firms in the smaller country to compete for labor and other regional resources and to gain access to unique transportation assets and better technologies. These efficiencies help to explain the potential overall welfare gains of regional integration.

Ironically, given the adverse effects on firms in the dominant country, the key to more universal support for regional integration might lie in subsidies to dominant-country firms. Given the overall welfare gains, such transfers might be feasible and could leave all parties better off than before integration. Such transfers, of course, may seem unnecessary and unfair to all parties except the dominant-country firms, helping to explain why regional integration has not progressed in some areas. Small-country fears about unbalanced coalitions, though perhaps unfounded, combined with potential losses to large-country firms and political resistance to compensating for these losses may be sufficient to block many regional integration proposals.

This model is designed to explore the effects of regional integration in an asymmetric setting, where one country enjoys significant advantages over another potential bloc member. We have focused on the equilibrium locations and wage offers of

firms, ignoring potential impacts on local product markets and land markets.

Incorporating such markets, without excluding some present features of the model, is challenging and, a priori, we cannot exactly say how these additions might affect our results. We hope the model provides a useful vehicle for better understanding the obstacles to unbalanced regional integration.

APPENDIX

Logistic function parameter restrictions

To ensure the desired properties of the logistic function

$$s_i(x) = 1/[k + mb^{d(x)}],$$

the parameters are restricted as follows. Suppose the net wage differential at some residential site x miles from the port is zero, that is:

$$d(x) = w_i(x) - w_n(x) = 0.$$

Each firm should receive the same share of labor commuting from this site.

This implies that:

$$s_i(x) = 1/[k + mb^{d(x)}] = 1/(k + m) = 1/2.$$

Therefore, to ensure that shares are equal whenever $d(x) = 0$, we need to set: $k + m = 2$, or $m = 2 - k$. Substituting this restriction into the logistic function gives:

$$s_i(x) = 1/[k + (2-k)b^{d(x)}].$$

Differentiating with respect to the net wage differential, $d(x)$, gives:

$$\partial s_i(x) / \partial d(x) = [-b^{d(x)} (2-k)(\ln b)] / [b^{d(x)} (2-k) + k]^2$$

The denominator is strictly positive, so for $s_i(x)$ to be an increasing function of $d(x)$, the numerator also needs to be positive. Note that $\ln b$ is defined only if $b > 0$, and if $b > 0$, then $b^{d(x)} > 0$ for any value of $d(x)$, positive or negative. If we further restrict b to the open unit interval, $b \in (0,1)$, then $\ln b < 0$ and the numerator will be positive, as required, if $k < 2$. Recapping, we assume that: $b \in (0,1)$, $k \in (0,2)$, and $m = 2-k$.

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Figure 1: Spatial Layout

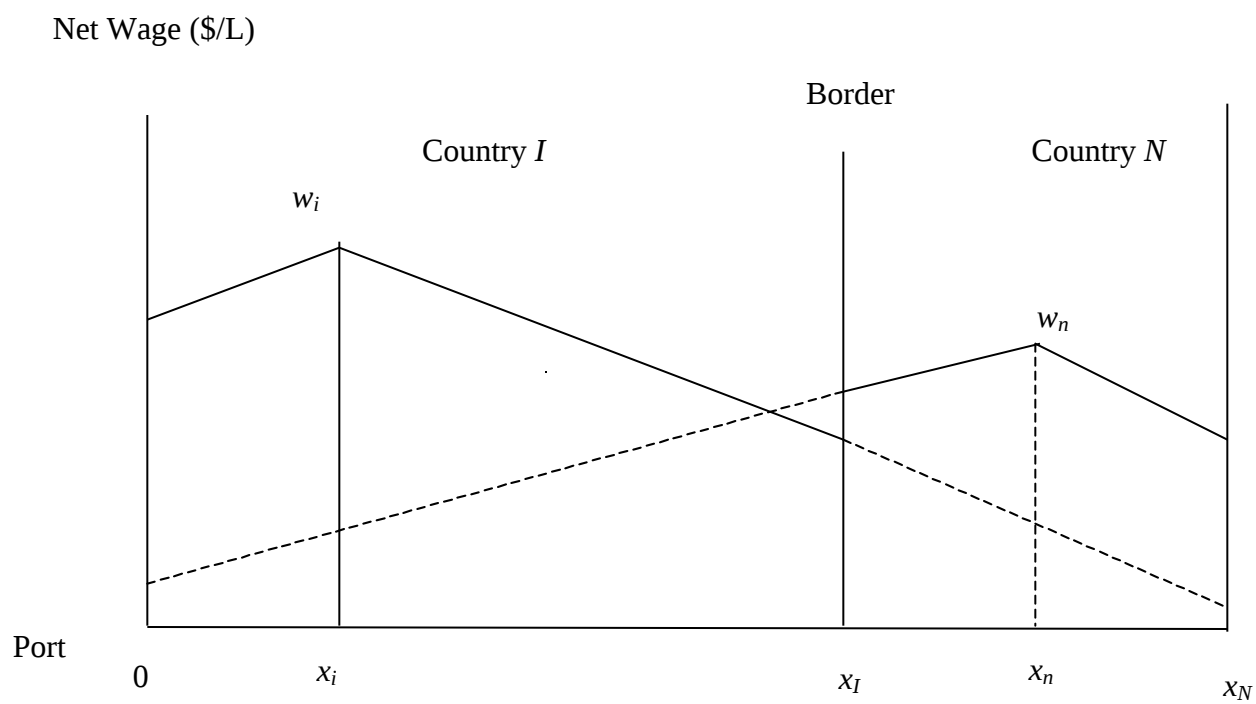


Figure 2: Logit Model

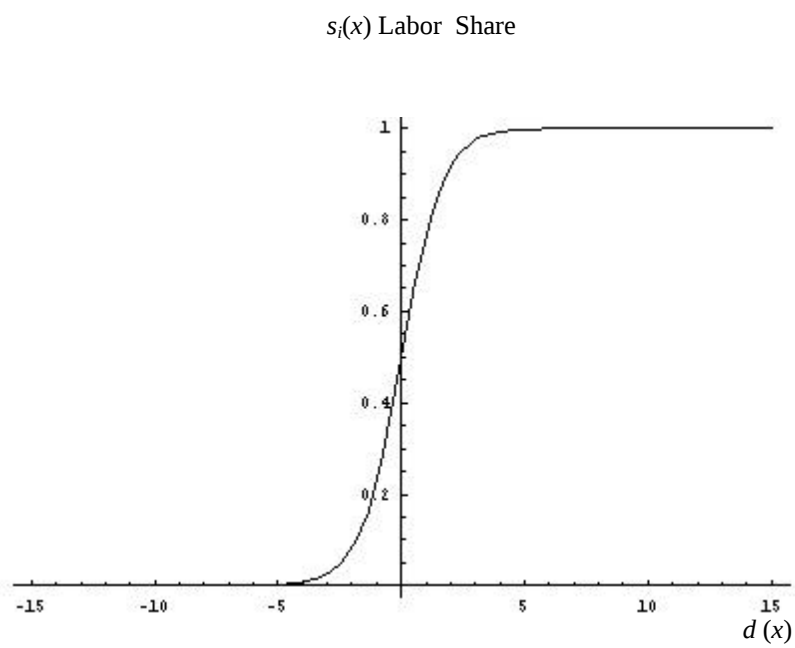


Figure 3: Autarky Case

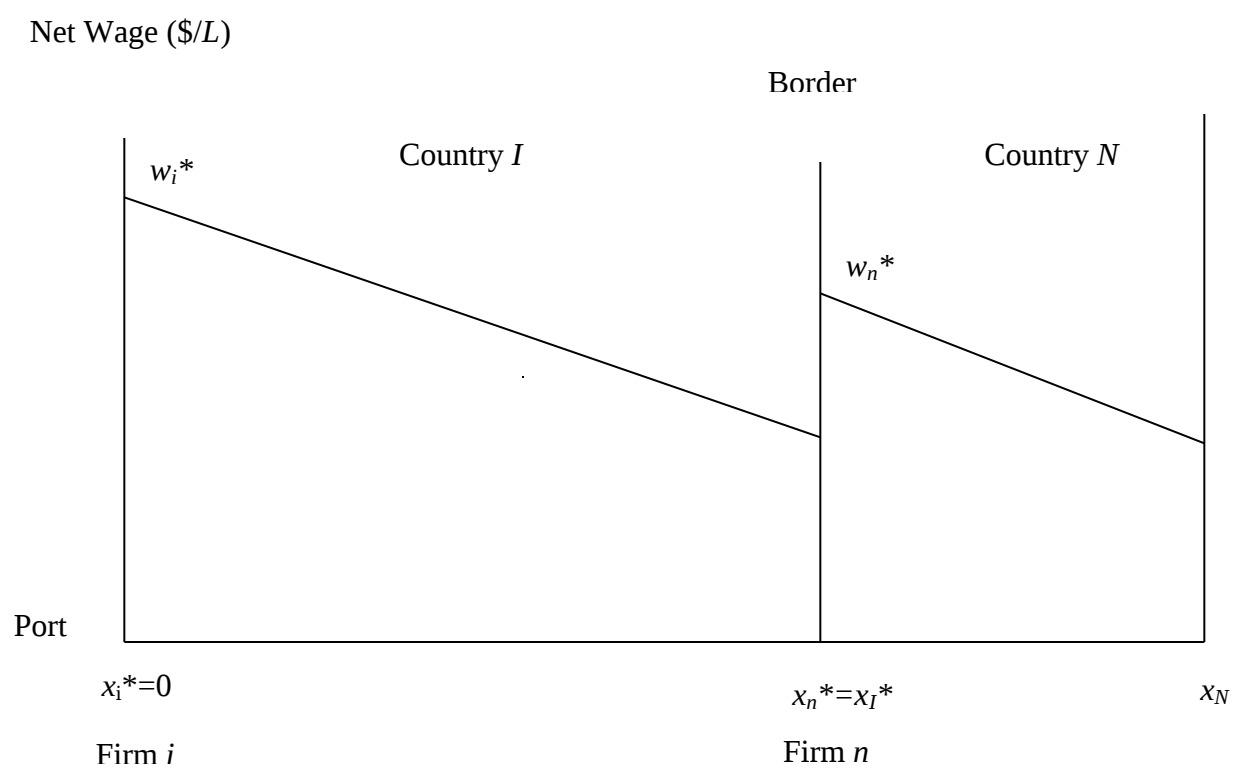


Figure 4: Labor Mobility Case

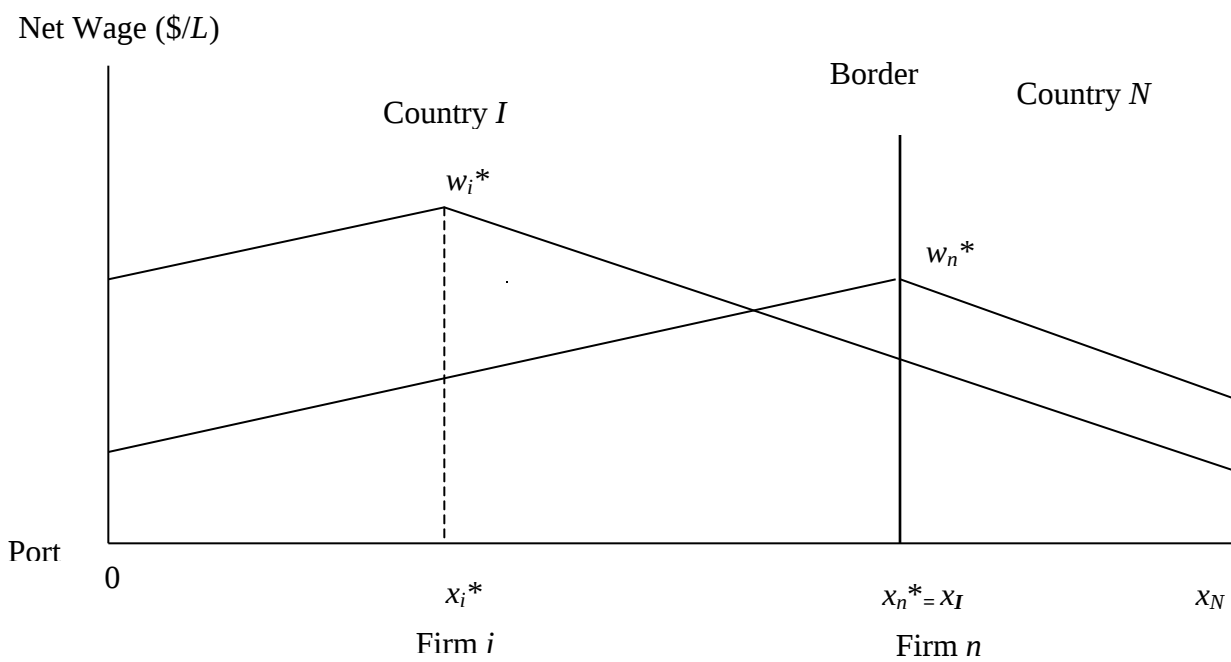


Figure 5: Full Mobility Case

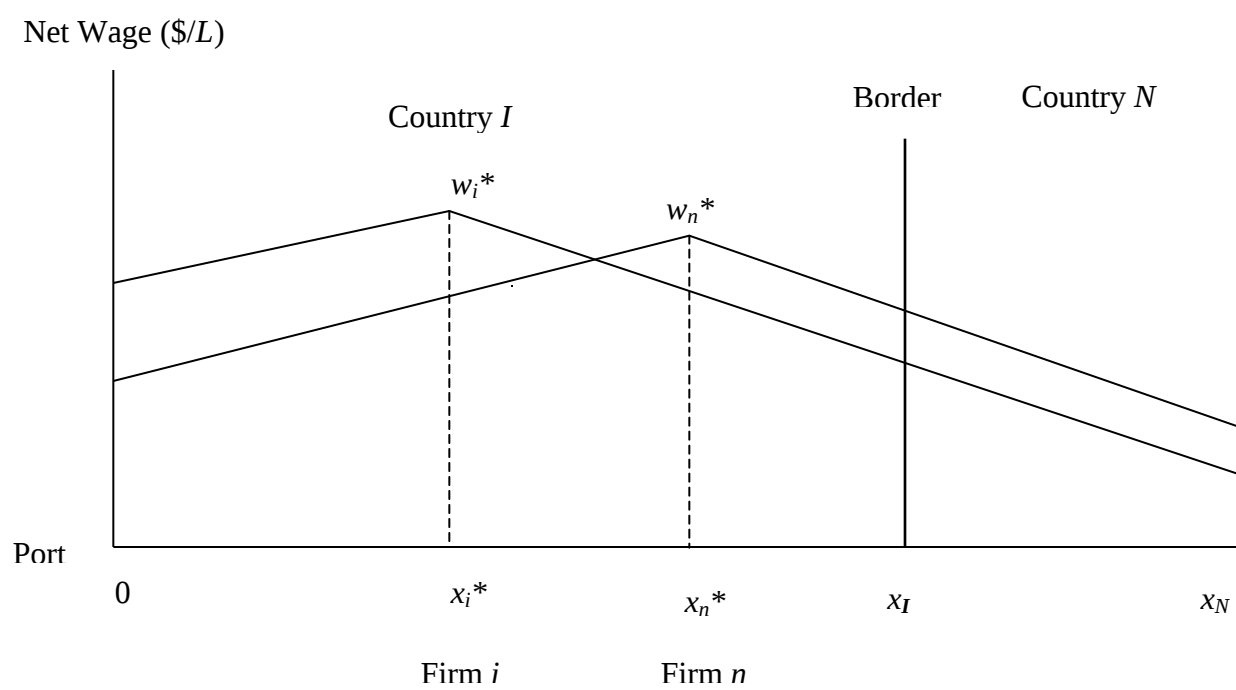


Table 1: Autarky Simulation Results
Parameters

output prices:	$p_i = 0.25, p_n = 0.20$
technologies:	$a_i = 10, a_n = 8$
spatial:	$x_I = 0.9, x_N = 1, D = 100, t = 0.05, c = 1$

Outcomes

firm i :	$x_i^* = 0.0$	$w_i^* = 0.69$	$L_i^* = 90$	$\pi_i^* = 162.49$
firm n :	$x_n^* = 0.9$	$w_n^* = 0.46$	$L_n^* = 10$	$\pi_n^* = 7.79$
country I :	$NW_I^* = 21.96$		$W_I = NW_I^* + \pi_i^* = 184.45$	
country N :	$NW_N^* = 4.10$		$W_N = NW_N^* + \pi_n^* = 11.89$	
region:	$NW^* = 26.06$		$W^* = 196.34$	

Note: Here, w_i^* and w_n^* are exogenous and set equal to the endogenous values in the subsequent labor mobility case.

Table 2: Labor Mobility Simulation Results

Parameters

output prices:	$p_i = 0.25, p_n = 0.20$
technologies:	$a_i = 10, a_n = 8$
spatial:	$x_I = 0.9, x_N = 1, D = 100, t = 0.05, c = 1$
logistic:	$k = 1, b = 0.1, m = 1$

Outcomes

firm i :	$x_i^* = 0.36$ (+0.36)	$w_i^* = 0.69$ (0)	$L_i^* = 67.57$ (-22.43)	$\pi_i^* = 109.68$ (-52.81)
firm n :	$x_n^* = 0.9$ (0)	$w_n^* = 0.46$ (0)	$L_n^* = 32.43$ (+22.43)	$\pi_n^* = 25.28$ (+17.49)
country I :	$NW_I^* = 35.24$ (+13.28)		$W_I = NW_I^* + \pi_i^* = 144.92$ (-39.53)	
country N :	$NW_N^* = 3.09$ (-1.01)		$W_N = NW_N^* + \pi_n^* = 28.37$ (+16.48)	
region:	$NW^* = 38.34$ (+12.28)		$W^* = 173.32$ (-23.02)	

Note: The endogenous values of w_i^* and w_n^* were used as parameters in the earlier autarky case. Numbers in parentheses below the outcome values show changes from the autarky case in Table 1.

Table 3: Full Mobility Simulation Results

Parameters

output prices:	$p_i = 0.25, \quad p_n = 0.25$
technologies:	$a_i = 10, \quad a_n = 10$
spatial:	$x_I = 0.9, \quad x_N = 1, \quad D = 100, \quad t = 0.05, \quad c = 1$
logistic:	$k = 1, \quad b = 0.1, \quad m = 1$

Outcomes

firm i :	$x_i^* = 0.25$ (-0.11)	$w_i^* = 1.51$ (+0.82)	$L_i^* = 50$ (-17.57)	$\pi_i^* = 43.43$ (-66.25)
firm n :	$x_n^* = 0.25$ (-0.65)	$w_n^* = 1.51$ (+1.05)	$L_n^* = 50$ (+17.57)	$\pi_n^* = 43.43$ (+18.15)
country I :	$NW_I^* = 111.32$ (+76.08)		$W_I = NW_I^* + \pi_i^* = 154.75$ (+9.83)	
country N :	$NW_N^* = 8.07$ (+4.98)		$W_N = NW_N^* + \pi_n^* = 51.50$ (+23.13)	
region:	$NW^* = 119.39$ (+81.05)		$W^* = 206.25$ (+32.93)	

Note: Numbers in parentheses below the outcome values show changes from the labor mobility case in Table 2.

