TRADE AND WAGE INEQUALITY IN DEVELOPING COUNTRIES

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In this article we provide a theoretical analysis of the possible impact of trade and fragmentation on the skilled–unskilled wage gap in a small developing economy. In particular, we illustrate the possibility of a decline in the relative wage of the unskilled labor following an improvement in the terms of trade. (*JEL* F1, F11, F12)

I. INTRODUCTION

The impact of trade on the skilled–unskilled wage gap has attracted a lot of research interest in the developed world, primarily due to the observed pattern of increasing inequality over the past decade. The importance of two competing candidates, namely, trade and technology, responsible for such a phenomenon has been highlighted through numerous theoretical and empirical writings on this issue. Among them several papers have tried to demonstrate that more open trade regime in the developed countries (North) has led to the relative decline of the unskilled wage and/or employment via the standard Stolper-Samuelson effect. A representative sample of this growing literature is hard to construct. Interested readers may look at Berman et al. (1994), Leamer (1995), and Jones and Engerman (1996) for a general idea about the ongoing debate.

Although a huge body of literature has been developed looking for consequences of a liberated trade regime on the labor force in the North, the mirror image of the event, that is, the Southern experience, has been somewhat neglected. A standard theoretical presumption will be that the South, being an exporter of unskilled labor–intensive products to the North must experience a decline in the degree of wage inequality in a liberalized regime of international trade. The empirical literature on the consequences of liberal trade policies of the North on the Southern wage rate is not as extensive as its counterpart in the South. However, some systematic studies have been conducted for East Asia and Latin America and exhibit conflicting patterns. The most notable work in this area is due to Donald Robbins, who in a series of papers (Robbins 1994a; 1994b; 1995a; 1995b; 1996a; 1996b; Robbins and Zveglich 1995) has demonstrated that although inequality has been brought down to some extent in East Asia, Latin America in general has experienced an increasing wage gap between the skilled and the unskilled following a more open trade and investment regime. Wood (1997) eloquently summarizes the empirical findings and criticizes the conventional wisdom associated with the Stolper-Samuelson result, which predicts gradual eradication of wage disparity in the South.

At a theoretical level, hardly any attempt has been made to "model" the Southern response to a changed trade and investment environment other than the antiquated application of the two-by-two Stolper-Samuelson result. Except for an elegant piece by Feenstra and Hanson (1995), there has been a dearth of analyses that specifically incorporate the structural features of the developing countries, such as pattern of trade, characteristics of labor markets, structure of production, nature of capital mobility, and so on. In this entire debate on trade and wage inequality the two-by-two, Heckscher-Ohlin, or the Stolper-Samuelson arguments are always taken at their face values. The basic idea that commodity price movements have predictable consequences for factor-price movements can be utilized in a more complex description of reality and the

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celebrated Stolper-Samuelson–type arguments could be used to devise many interesting results. One purpose of this article is to pursue this line of argument. It is quite possible that the Southern example does not contradict the conventional wisdom, as has been claimed in Wood (1997), but it points toward a rather naive application of a standard theorem in contexts that do not properly specify the salient structural features of an economy.

Recently, several authors, such as Jones and Kierzkowski (1998), Deardorff (1998), Harris (1998), have analyzed the issue of fragmentation in world trade, whereby different countries increasingly specialize in different fragments of production activities. Sharp declines in transportation and communication costs make it possible for the production process to be fragmented and traded across the globe. This article builds up a simple model of fragmentation by which market opens for trading a specific intermediate good. It then goes one step further to discuss distributional consequences of commodity price movements with or without fragmentation.

This article proceeds as follows. Section II summarizes the standard empirical findings regarding trade and income inequality in the developing countries, that is, in Asia and Latin America. Section III describes the general equilibrium model with and without fragmentation. Section IV compares and contrasts the impact of trade and capital movement on the skilled–unskilled wage gap before and after fragmentation. Section V concludes.

II. EMPIRICAL EVIDENCE

There are two sets of empirical findings available so far, one on East and Southeast Asia and the other on Latin America. The major evidence, neatly summarized in Wood (1997), points toward a declining inequality in East Asia and a somewhat rising inequality in Latin America. The major problem with the empirical exercise as mentioned in Wood (1997) is that the data on relative wages contains gaps and deficiencies. Moreover, while finding the relationship between trade and wage gap only few analyses have attempted to control for the internal influences on the movement of relative wages. Nonetheless, as far as East Asia is concerned, most of the analyses show that increasing trade has led to an improvement in the earnings of workers with basic general education relative to those with specialized skills. Robbins (1994a) finds persistent compression of wage differentials by level of education in Malaysia from 1973 to 1989, particularly between university graduates and educated workers. This went on in the early 1990s with skilled and semiskilled blue-collar workers in manufacturing sector gaining relative to others. The share of employment in import sectors went up from 13% in 1984 to 16% in 1989 (Robbins 1994a, Table 22). Similar studies for other countries can be found in Robbins and Zveglich (1995). Feenstra and Hanson (1997) examine the rising wage inequality in Mexico and show that an increase in foreign direct investment is linked to a rise in relative demand for skilled labor.

Other studies by Robbins cover Argentina, Chile, Colombia, Costa Rica, and Uruguay. Table 1 (Table 3 from Wood 1997) summarizes the results for Latin American nations. In almost all the countries, the skill differentials in wages (by level of education) widened contrary to the conventional wisdom. Mexico is another example where the skilled–unskilled wage gap increased parallel to the radical liberalization of the trade regime. Robbins (1996b) corroborates the findings of the earlier study by Feenstra and Hanson (1995) that between 1987–93, controlling for changes in relative supply, the determining force was a shift in relative demand for the skilled workers. In Mexico the widening of the wage gap in 1984–90 coincided with the steep decline in the real minimum wage. Similarly, in Chile following the military overthrow of the Allende government, union power was contained and wage differentials were restored to the levels prevailing in the 1960s. The case in Argentina was similar. It is therefore difficult to rule out another competing explanation of the wage gap hypothesis, that is, curtailment of union power. But it is harder to explain the rise in wage inequality in Colombia, Costa Rica, Mexico, and Uruguay since mid-1980s.

It will be interesting to explain why cross-country differences have emerged in relative wage movement subsequent to greater openness in the trade and investment regimes. However, one has to find out the avenues through which favorable terms of trade movement in the South can lead to greater wage inequality. One of the major explanations pursued in Wood (1997) to contrast the Latin American case with the East Asian experience has been

TABLE 1
Effects of Increased Openness in Five Latin American Countries

Country and Years	Changes in Trade Regime	Skill Differentials in Wages	Relative Demand for Skill (Time series)
Argentina (Buenos Aires)			
1967–82	Barrier reduction with appreciation	Widened	Rising
1989–93	Barrier reduction with appreciation	Narrowed	Falling
Chile (Santiago)			
1974–79	Barrier reduction with devaluation	Widened	Rising
1984–92	Devaluation	Fluctuated	Rising
Colombia (seven cities) 1985–94	Devaluation to 1989, barrier reduction in 1990–92	Widened	Rising
Costa Rica 1985–93	Barrier reduction and devaluation	Widened except in 1988–90	Rising
Uruguay (Montevideo) 1990–95	Barrier reduction	Widened	Rising

Source: As reported in Wood (1997).

to suggest that late comers, competing in the export markets of Latin America, have depressed their unskilled wages and the benefit of greater openness was lost to a certain extent. But this argument, as Wood (1997) realizes, implies that wage inequality must have taken an opposite turn in those competing areas, such as China, South Asia, and Africa. Empirical evidence on these economies has not been reported so far.

Pattern of trade and comparative advantage are often much more complex than what the standard theory suggests. To measure an aggregate index of skill or capital content of exports to assert the relative factor abundance hypothesis in its starkest form may not help us identify the reason behind and pattern of factor price movements. One way of interpreting and quantifying the standard Heckscher-Ohlin proposition is to say that every country will produce goods consistent with its factor endowments. This is different from suggesting that a labor-abundant economy will export only labor-intensive goods. For example, India and China both are major exporters of primary products as well as software services. In fact, the software exports are the fastest-growing exports in India. India, with its vast land and unskilled population, continues to be a major agricultural nation. The impact of a price rise in software products in the world market, ceteris paribus, will lead to some sort of increasing inequality in the Indian economy if agricultural wage does not respond that much. This rising inequality will be consistent with the broader interpretation of pattern of trade based on factor intensities and factor endowments.

In a recent study, Bender and Li (2001, pp.10–11) examine two patterns of trade and comparative advantage for East Asian (Japan, Hong Kong, South Korea, Singapore, Indonesia, Malaysia, the Philippines, and Thailand) and Latin American (Argentina, Chile, Colombia, Peru, Mexico, Venezuela, Bolivia, and Ecuador) economies. In this context they analyze the change in export pattern of these countries over the period 1981–97. They showed that "the Latin American region seems to have experienced significant structural changes in export pattern in the 1990s and these structural changes were increasingly beneficial and promoted exports in dynamic sectors (products) in the world market." Moreover, they conclude that although the economies of both regions are now more comparative, they also have comparative advantage in most sectors and consequently a shift in comparative advantage hypothesis.

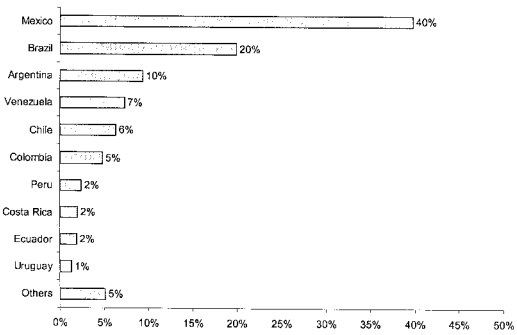
Historically, most Latin American countries have engaged in an import-substitution industrialization strategy as a response to the collapse of the international trading system during the Great Depression. During the 1930s and 1940s industrial growth was led by few industries (e.g., beverages, oil derivatives, nonmetallic minerals, and textiles). Since the early 1950s, a second phase of import substitution started with a focus on industries including paper and printing, chemicals and rubber, basic metals, and metal products. Currently the major exporters in the region (see Figure 1

TABLE 2
Capital-Intensive Exports from Top Ten Latin American Exporting Countries (by Product Group)

Product Group	1996 (US$ million)	1997 (US$ million)	1998 (US$ million)	1999 (US$ million)	2000 (US$ million)
Computer equipment	2,926	4,026	4,679	6,741	8,511
Medical equipment	94	178	234	243	253
Optical instruments	8	13	13	21	34
Medical instruments	679	893	1,004	1,151	1,552
Photographic equipment	128	171	248	298	403
Optical fibers	98	123	155	161	204
Telecommunication equipment	3,540	4,725	5,776	7,566	12,643
Electric power transmission equipment	1,453	1,757	2,091	2,388	2,876
Electric circuit equipment	2,718	3,072	3,415	3,869	5,504
Electrical distribution equipment	4,690	5,240	5,523	6,289	7,189

Source: Chakrabarti (2002).

FIGURE 1
Country Share of Exports (current US$) from Latin America (average: 1996–2000)



and Table 2) export goods that are highly capital-intensive, including computer equipment, medical equipment, optical instruments, medical instruments, photographic equipment, optical fiber, telecommunication equipment, electric power transmission equipment, electric circuit equipment, electric distribution equipment, as well as goods that have a relatively low capital content, for example, agricultural produce, spices, tobacco, wood, pulp, chemicals, footwear, and so on. (United Nations COMTRADE Database).[1]

Notable contributions that reflect on the intensity of capital use across Latin American industries in recent times include Isgut (2001), Moreira and Najberg (2000), and Ocampo and Villar (1995). The evidence consistently points to the fact that exporters in the region tend to be significantly more capital-intensive than nonexporters. On average, the differences in capital intensity between exporters and nonexporters are higher for the smaller plants (100% to 150% for plants with fewer than 30 employees and 46% to 69% for plants with 30–100 employees), but they are still significant for plants with more than 100 employees (between 32% and 42%). In all plant size categories, exporters hire more technicians and managers and invest in machinery or other type of physical capital than do nonexporters. Table 3 provides some recent representative estimates (in U.S. dollars) of capital per worker, investment per worker, and investment in machinery per worker for exporters as well as nonexporters for relatively small, medium, and large plants in the region.

It is interesting to note that Latin American countries, similar to India and China, import intermediate goods to be used along with skilled labor to produce the exportable good. Hence, rising wage inequality in many Latin American countries can be linked to a change in their export pattern. For a discussion on the theoretical aspect of such an interpretation, one may look at Jones et al. (1999). We now proceed to our theoretical formulation.

III. A THEORETICAL FRAMEWORK

We consider a scenario in which a small economy produces four goods, skilled export

1. Bender and Li (2001) measured the increased diversification of exports from Latin American economies by calculating their revealed comparative advantage and noted that such diversification was facilitated by the timely formation of NAFTA and MERCOSUL.

TABLE 3
Capital per Worker, Investment per Worker, and Investment in Machinery per Worker: Latin American Exporters versus Nonexporters (by Plant Size)

	All Plants		<30 Workers		30–100 Workers		>100 Workers	
	Exporters	Nonexporters	Exporters	Nonexporters	Exporters	Nonexporters	Exporters	Nonexporters
Capital per worker	429.9	224	180	89.3	205.2	140.5	462.3	330
Investment per worker	58.4	31.8	27.4	12	31.9	20.3	62.2	46.9
Investment in machinery per worker	42.9	21.4	17.4	7	22.2	13.1	45.9	32.3

Source: Isgut (2001).

good (X), an agricultural export good (Z), one importable good (Y), and an intermediate good (M), which is a nontraded intermediate input used in the skilled export good sector. There are four factors of production, skilled labor (S), unskilled labor (L), land (T), and capital (K). This pattern of production and trade captures the idea that an economy can export both skilled as well as unskilled products. Unskilled manufacturing sector represents the import-competing segment of this economy. Sector Y uses unskilled labor and capital. Sector M uses skilled labor and capital. Skilled exportable good uses skilled labor and an intermediate input, whereas agricultural product uses land and unskilled labor. Similar production structures have been discussed in Jones and Marjit (1993), Beladi and Marjit (1992), Marjit and Beladi (1996), and Marjit et al. (1997). According to this interpretation, sectors M and X constitute the Heckscher-Ohlin nugget with land and capital labor being two specific factors used in sectors Y and Z. The production functions exhibit constant returns to scale and diminishing marginal productivities. Markets are competitive. The following symbols are used in generating the equations used in the system.

$w_s =$ skilled wage

$w =$ unskilled wage

$r =$ return to capital

$R =$ rent on land

$P_i =$ price of the ith product, $i = x, m, y, z$.

X, M, Y, Z, L, K, and T have been defined before. a_{ij}'s are the usual input-output coefficients. Without loss of generality, we assume, $P_y = 1$ as the numeraire.

Competitive markets and equilibrium conditions imply

$$w_s a_{sx} + P_m a_{mx} = P_x, \tag{1}$$

$$w_s a_{sm} + r a_{km} = P_m, \tag{2}$$

$$w a_{ly} + r a_{ky} = 1, \tag{3}$$

$$w a_{lz} + R a_{tz} = P_z. \tag{4}$$

Full employment conditions imply

$$a_{sx} X = S - a_{sm} M, \tag{5}$$

$$a_{km} M + a_{ky} Y = K, \tag{6}$$

$$a_{ly} Y + a_{lz} Z = L, \tag{7}$$

$$a_{tz} Z = T. \tag{8}$$

The following equation equates demand for local intermediates and its supply:

$$a_{mx} X = M. \tag{9}$$

We have nine equations to solve for w_s, r, w, R, X, M, Y, Z, and P_m. If we substitute for P_m in equation (1), we have two specific-factor

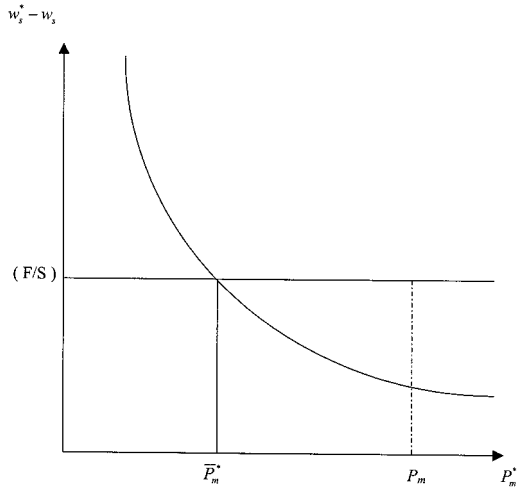
models superimposed on one another with S and T being two specific factors, whereas K and L are mobile to some extent.

To start with, the intermediate input M is produced within the country because the possibility of accessing the lower-priced intermediate from abroad is impeded by fixed costs of transportation and communication. For example, certain services can be used only via Internet facilities. Without the possibility of using the online facility, certain local resources need to be spent, which may be quite expensive. Satellite communications may entail fixed costs (F), and that will be the basic problem of accessing M from abroad. In particular, we assume

$$P_m^* < P_m, \tag{10}$$

where P_m^* is price of the foreign intermediate good. It is obvious that given P_x, a fall in P_m will raise w_s. Let w_s^* be the corresponding skilled wage when the price of the input is P_m^*. Also note that w_s^* and P_m^* are negatively related. If $(w_s^* - w_s)S < F$, skilled entrepreneurs do not have any incentive for using the foreign intermediate good. Figure 2 captures the incentive for fragmentation, that is, accessing the cheaper intermediate good from abroad. Note that for $P_m^* \in [\overline{P}_m^*, P_m]$ lower priced intermediate will not be used. It is assumed that the skilled labor sector as a whole decides on using the cheaper intermediate good and decides on incurring the fixed cost, and if $P_m^* < \overline{P}_m^*$, only then does import take place. It is straightforward to argue that a lower F and/or higher S will increase $\overline{P}_m^*$, the critical maximum price of the foreign intermediate for which the local users will go for foreign intermediate. Suppose a decline in F now makes it possible for the producers to pay P_m^*, and this is what we define as fragmentation in our framework.

FIGURE 2
Incentive for Fragmentation



However, lowering of P_m to P_m^* has intermediate impact on the factor prices. w_s must go up. The local product now has to face foreign competition and that, too, with a higher w_s. This implies r will fall and w will go up. This leads to the following proposition.

PROPOSITION 1. *Fragmentation will imply a decline (an increase) in* (w_s/w) *provided skilled export good* (x) *is less (more) capital intensive relative to the importable good* (y).

Proof. Simple algebraic manipulations yield, $(\hat{w}_s - \hat{w}) \gtreqless 0$ iff $\hat{P}_m[\theta_{ky}/\theta_{ly} - \theta_{kx}/\theta_{sx}] \gtreqless 0$, where $\theta_{kx} = \theta_{km}\theta_{mx}$, where θs are the unit cost shares of the factors and $\tilde{\theta}_{sx}$ denotes the direct θ_{sx} plus indirect $\theta_{sm}\theta_{mx}$ cost share for skilled labor in sector X, and the $\hat{}$ denotes the proportional change. Similarly, $\theta_{km}\theta_{mx}$ denotes the indirect cost share of capital in X (for more details, see the appendix).

If $\hat{P}_m < 0$ due to the possibility of fragmentation, (w_s/w) will go up if X is capital-intensive relative to Y. One interpretation of this result is that with a lower r following lower P_m both w_s and w gain. If the skilled labor sector uses capital more intensively than the unskilled labor manufacturing, it saves costs to a greater extent, and that leads to an increase in w_s/w. In the case of the unskilled labor sector, the measure of intensities is in terms of direct requirement of inputs, whereas for the skilled labor sector indirect input requirements play the crucial role via the intermediate input. Fragmentation must improve the unskilled wage via a fall in r, but the degree of inequality between the skilled and unskilled labor income may widen.

IV. TERMS OF TRADE AND THE WAGE GAP

This section explores the relationship between terms of trade, capital inflow, and the wage gap in two different setups, with

and without the possibility of fragmentation. In the previous section we dealt with a finite change, whereby a drop in F converted M into a traded input. Such a discrete change had predictable impact on the wage gap. Here we look at the impact on the relative wage of the unskilled labor allowing for treatment of M as a tradeable as well as a nontradeable.

PROPOSITION 2. *An increase in the price of Z, the agricultural product, ceteris paribus, will increase w, but may lead to a decline in w/w_s with a nontraded M. With fragmentation, an increase in the price of Z will leave w and w/w_s unchanged.*

Proof. The first part of the proof refers to the setup where there are three competitive price equations with (1), (3), and (4), along with (2) substituted into (1). A rise in P_z draws labor from Y into Z. It drives up w and reduces r. Given P_x, it must lead to a rise in w_s. It is straightforward to argue that if X is capital-intensive relative to Y, w/w_s may go down. Note that $\hat{w}_s = -\hat{r}\theta_{km}\theta_{mx}/(\theta_{sx} + \theta_{sm}\theta_{mx})$ and $\hat{w} = -\hat{r}\theta_{ky}/\theta_{ly}$. It is interesting to note that as $\hat{r} < 0$, $(\hat{w}_s - \hat{w}) > 0$ iff $\theta_{km}\theta_{mx}/\theta_{sx} > \theta_{ky}/\theta_{ly}$. Also note the similarity of this condition with the one in Proposition 1. This completes the proof of the first part of the proposition.

Now consider the case in which M can be bought and sold in the international market at a price P_m^*. We then have an extra competitive condition to be satisfied relating P_m^* to w_s and r. Given P_x and P_m^*, we now determine w_s and r directly from the commodity prices. It freezes w given $P_y = 1$, and the value for R, given P_z. Now an increase in P_z only increases R and does not affect w or w_s.

Two rather counterintuitive results have been discussed in Proposition 2. An increase in P_z, the price of a commodity that may heavily use unskilled labor, does not guarantee the relative improvement of unskilled labor wage. Without fragmentation, there is a possibility that w/w_s may go down. With fragmentation, this effect is neutralized. However, θ_{lz} never appears as a determining factor. When M is traded, labor is drawn into Z in response to an increase in P_z, but the skilled labor segment is left as is. Without fragmentation, resource flow into Z has factor-price implications. These results highlight that the so-called two-by-two outcomes are not robust to simple alterations and therefore should not be stressed as a reference point. We now have the following proposition.

PROPOSITION 3. *An increase in P_x, ceteris paribus, must reduce w/w_s when fragmentation is not allowed. With fragmentation a different outcome is possible.*

Proof. With a nontraded M, again we have a specific-factor structure. Suppose we freeze the amount of unskilled labor used in Z. Then a rise in P_x must increase w_s and reduce w, à la Jones (1971). However, as w drops, unskilled labor moves to agriculture, raising R. As P_z is given, w must drop in equilibrium.

With fragmentation, an increase in w_s reduces r as P_m^* is given. This in turn raises w. It is easy to check that $(\hat{w}_s - w) \gtreqless 0$ iff $\theta_{ky}\theta_{sm} \gtreqless \theta_{ly}\theta_{km}$. Because both P_m^* and price of Y are given, a change in w/w_s is directly related to the relative capital intensity in these sectors.

The last proposition will reflect on the effect of foreign capital inflow or liberalization of the capital market on w/w_s with or without fragmentation. Because we are analyzing the case of a small developing economy, it its reasonable to assume that it is a potential importer of capital. Capital inflow implies a decline in r to an exogenously given level $r^* < r$.

When M is nontraded, the impact of a fall in r on w/w_s is exactly the same as derived in the first part of the proof in Proposition 2. When fragmentation is allowed, a fall in r increases both w_s and w, given P_m^* and the price of Y. Then the outcome is the same as derived in the last proposition. Hence, we may write down Proposition 4 as follows.

PROPOSITION 4. *Without fragmentation, inflow of foreign capital will reduce w/w_s if the skilled export sector is capital-intensive relative to the unskilled importable sector (Y). With fragmentation, the outcome will be the same if the intermediate good sector is capital-intensive relative to the importable sector. Moreover, with fragmentation the skilled export sector is likely to shut down following the free inflow of capital.*

Proof. The first two parts of the proof have already been discussed. The last part suggests that as w_s rises with a fall in r given P_m^* the average cost of production in X rises. With P_x given, this must lead to zero production of X.

V. CONCLUDING REMARKS

The purpose of this article has been to provide a theoretical discussion on the possible impact of trade and fragmentation on the skilled–unskilled wage gap in a small developing economy. In particular we highlight the possibility of a decline in the relative wage of the unskilled labor following the improvement in the terms of trade. Available empirical evidence points toward such a possibility, although the standard two-by-two theoretical frameworks do not. A multisector model is developed to incorporate (1) diverse export pattern, (2) land as a crucial input, and (3) an intermediate good. Fragmentation allows the intermediate good to be traded, and this process by itself may alter the wage gap. One general outcome is that if a liberal trade regime reduces cost of capital, the gain of the unskilled relative to the skilled labor depends on the capital intensity of the unskilled manufacturing vis-à-vis the skilled segment of the economy. This is a testable hypothesis.

In all cases the absolute wage of the unskilled labor does improve, but the wage gap can move either way. Absolute and simultaneous increases in w and w_s is hardly the outcome in either a Heckscher-Ohlin or specific-factor structure with two goods and without technical progress, except in the specific-factor model, foreign capital inflow may increase both w and w_s. Such a result is a special case in our general structure. Implicit in the study is the issue of changing trade volume and pattern, which we have not focused on directly. A fall in r through capital movement leads to a vanishing X, and the entire skilled labor is absorbed in producing M. This will alter the trade pattern of the small economy. Instead of exporting X and importing M, it will now import X and export M. One could use our framework to address such related issues.

Future research in this area will extend the setup to incorporate specifics of the labor market in more detail to focus on the impact of fragmentation and will substantiate some of the theoretical results with empirical evidence. Some natural extensions of our model may include allowing unemployment, imposing the structure of an overlapping generations model, introducing diversification in household ownership of factors, incorporating domestic distortions, endogenizing product prices, and so forth. Because this is an emerging area of research with mixed evidence so far that does not have a proper theoretical background, one must build formal analytical models for rigorous empirical work. This article has been an attempt to fill such a gap.

APPENDIX

The impact of a decline in P_m on w/w_s. From the system of equations given in the text, we have

$$\text{(A1)} \qquad \hat{w}_s = -(\theta_{mx}/\theta_{sx})\hat{P}_m, \qquad \hat{r} = (\hat{P}_m - \theta_{sm}\hat{w}_s)/\theta_{km}$$

and

$$\text{(A2)} \qquad \hat{w} = -(\theta_{ky}/\theta_{ly})\hat{r} = -(\theta_{ky}/\theta_{ly}) \times [\hat{P}_m(1 + \theta_{sm}\theta_{mx}/\theta_{sx})/\theta_{km}],$$

$$\text{(A3)} \qquad (\hat{w}_s - \hat{w}) = \hat{P}_m[\{(\theta_{sx} + \theta_{sm}\theta_{mx})/\theta_{km}\} \times (\theta_{ky}/\theta_{ly}) - \theta_{mx}].$$

Because $\hat{P}_m < 0$ we have

$$\text{(A4)} \qquad (\hat{w}_s - \hat{w}) > 0, \quad \text{iff } \tilde{\theta}_{sx}\theta_{ky} < (\theta_{km}\theta_{mx})\theta_{ly},$$

where $\tilde{\theta}_{sx} = (\theta_{sx} + \theta_{sm}\theta_{mx})$.

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