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Learning-by-Doing and Trade Policy in a Developing Economy

ROBERT E. MOORE

The process of industrialization has been successful in some prominent developing country cases, less successful in others, and completely absent in the most desperate cases. Many of the cases of successful industrialization have been associated with relatively open economies (at least eventually) and export success. This observation has contributed to the conjecture that an open trade orientation is a necessary ingredient to successful industrialization and rapid growth.

Another possibility that has been suggested is that an open trade policy should follow (not precede) industrialization, and that industrialization will not be possible, at least in some of the more extreme cases, if free trade precedes industrialization. The reply to this assertion correctly points out that industrialization that develops under protection from world competition will have difficulty ever being competitive on an international basis.

The purpose of this paper is to model, as simply and yet as realistically as possible, the dilemma faced by a developing country that is contemplating trade and industrial policy decisions in an environment where industrialization has not yet been successful. The underlying hypothesis of this model is that successful industrialization depends definitively on the productivity of labor available to the potential new industrial sector.

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Countries that have already experienced successful industrialization generally are known to have highly skilled and productive labor forces. Countries that have not yet experienced successful industrialization typically have mostly rural and relatively low skilled labor forces. The model presented in this paper suggests that in such countries workers, most of whom who are new to the industrial sector (and who have most likely just migrated from the rural sector), will not have the skills necessary to be productive in the industrial sector. That is, their value of marginal product will be so low as to make it impossible to pay a wage that supports a sustainable standard of living. Furthermore, since they cannot be profitably hired given their current skill set, in the absence of any policy intervention they will never have the opportunity to enhance their skills through learning-by-doing. This presents the interesting possibility of an industry that could be successful (under open international competition) if it had access to a labor force that had the productivity equal to the average lifetime productivity of the labor force in that country. Since, however, there is no way for a private-sector firm to recover from the initial "learning" period, short of a public policy intervention this industrial sector will not come into being. This explains the appeal of a more protective trade policy. Unfortunately, the protective trade policy, as will be demonstrated, overcompensates. That is, it results in too much investment going into the industrial sector with the result that it will not be internationally competitive. Furthermore, trade protection in the economy as modeled leads to higher lifetime earnings for those employed in the protected sector, but a limited number of these jobs. Therefore this model suggests that the combination of constraints modeled in conjunction with a protective trade policy may result in an outcome similar to that generated by a Harris-Todaro model.[1]

In the international trade theory literature the gains from trade have been well established in many models,[2] and the conventional wisdom is that high levels of protection are disadvantageous for any country and especially a developing country because they distort prices in such a way as to reduce economic output and hence welfare.[3] Many critics, nevertheless, remain disenchanted with liberal trade policies in general and especially for developing countries. It is charged that such policies are harmful to poorer and less powerful peoples in both the developing and the more developed countries.[4] Also, it is alleged that the mainstream trade and development literature (in which the liberal trade policies are shown to be optimal) "systematically excludes some important aspects of reality."[5] The concern is that the omitted aspects of reality are crucial to determining the appropriate policy choice. It is important, then, to examine the effects of trade liberalization and alternative policies in a developing country model that explicitly *includes* certain of those significant "aspects of reality" for developing countries and evaluates their impact on output and welfare.

This paper models a trading economy to incorporate certain "aspects of reality" for a developing country by including a trilogy of intertwined constraints. These are (1) a subsistence minimum wage, (2) a costly and time-consuming human capital accumulation process (learning-by-doing), and (3) the nonappropriability of that human capital by the firm. This model is based on the

premise that human capital is a key ingredient in the success of an (export or import-competing) industry. Raw labor simply may not be productive enough to hire in this industry at a wage that supports subsistence. This labor can, however, become more productive with work experience.

Section 1 describes the economy that is modeled in this paper and discusses differences between this economy and those modeled in the existing "distortions" literature including learning-by-doing, human capital, infant industry, and minimum wage trade models. Section 2 examines the socially optimal allocation of resources (labor and other inputs) in such an economy by solving the benevolent planner's problem. Characteristics of the planner's socially optimal allocation of resources can then be compared with the results from the market outcomes of the model investigated in section 3. Section 4 considers various policy options that may be available to modify the market outcomes such that the social optimum is obtained. The policies of some of the more successful countries are discussed in light of their impact in this model. Section 5 presents some observations and conclusions.

Background

The economy modeled has two sectors, the first can be stylized as a traditional/rural/agricultural sector and the second as a modern/urban/manufacturing sector. Each of the two sectors will use labor and a composite of nonlabor inputs. One may think of the composite input as capital. To keep the model as lean as possible and to focus on the driving characteristics of the results obtained from the model, valid less developed country (LDC) stylizations such as an informal sector, surplus labor, and chronic unemployment and underemployment are not included in this model.

The traditional sector produces a subsistence good that is designated as the numeraire good. The production process in this sector is simple and has no intertemporal dependence. On the other hand, the modern sector will produce a manufactured product using a structured and complex production process. Labor in this sector will be relatively unproductive in an initial "learning" phase, but will attain a higher level of productivity with experience in the sector. The simplest way to capture this intertemporal dependence is to model labor as having a two-period life. In any given time period both experienced and inexperienced labor may be present; therefore the labor force will consist of overlapping generations.

As labor in the modern sector must pass through the "learning" phase, with low productivity, to become more productive, the model incorporates a costly and time-consuming human capital accumulation process. Since there are assumed to be numerous competitive firms in each of the two sectors and the human capital is assumed to be sector specific (not firm specific), the model incorporates the nonappropriability of the human capital by the firms. The third constraint, a subsistence minimum wage, when binding and in the presence of the first two constraints, will have its impact by restricting the markets from optimally allocating labor.

It is important at this point to distinguish the economy modeled here from several well-known trade models in the "distortions" literature. Some of the outward characteristics of this economy appear similar to the infant industry case, particularly of the Hamilton-List variety. This paper differs in that the repository of human capital is assumed to be the individual worker (i.e., the worker is learning skills by doing them). Each new generation of labor must independently acquire the necessary human capital by its own experience. In the typical presentations of the Hamilton-List infant industry argument, knowledge accumulates to the industry or to the society in general, at least in the sense that once one worker has acquired new knowledge, all others can freely make use of it.[6] The case of this paper, in which human capital accrues to the individual worker and is not transferable, is arguably a more realistic and more crucial stylization for poorer LDCs and also has been curiously ignored in the trade and development literature.

Some attention in the literature has been given to the impact of human capital in general equilibrium trade models.[7] These models assume that two sectors utilize as factors of production both skilled and unskilled labor. Human capital accumulation occurs as an individual investment (education), not as a by-product of the production process. Imposition of a minimum wage will induce a greater tendency of individuals to invest in their human capital.

Richard Brecher models the independent, carefully isolated influences of an exogenous minimum wage in a trading economy.[8] He finds that the optimal policy involves a labor subsidy, but does not address how the subsidy is to be financed. In his model, productivity within a sector does not vary. This paper considers a somewhat different problem. Labor will have different productivities across time within the modern sector, but not over lifetimes between equally economically viable sectors.

Jagdish N. Bhagwati provides a generalized framework for the "distortions" literature in international trade.[9] This framework, however, is applicable to static trade models and is not particularly useful for characterizing models with distortions of an intertemporal nature.[10]

Social Optimum

In order to address the planner's problem, the model is now explicitly specified. Recall that there are to be two sectors, traditional/rural/agricultural (this sector will be referred to simply as traditional from here on) and modern/urban/manufacturing (which will henceforth be referred to simply as modern). The traditional sector produces the numeraire good X and the modern sector produces the good Y; and p is the relative world price of Y (in terms of X) and is taken as parametric according to the small-country assumption.

Each sector uses labor (L) and a composite of nonlabor inputs (K, henceforth called capital). Labor has a two-period life, and each generation is the same size as the previous. Hence exactly half of the labor force is old and half young in a given time period (these will be denoted n [for new] and o [for old] in the traditional sector and n [for new] and e [for experienced] in the modern sector). The economy has a fixed amount of capital to allocate in each time period.

The planner's problem is to allocate labor (and capital) between the two sectors at the beginning of each generation of labor in order to maximize the value of output (V), suggesting that the planner has a two-period planning horizon. With overlapping generations, however, the planning periods of each generation of labor are interlinked. The planner's problem may be solved for any number of finite periods. However, the necessary optimization conditions are the same for every period except the terminal one. Therefore, a two-period problem captures all the unique necessary conditions.[11] Thus the optimization objective is expressed simply as

$$V = pY_1 + \mu pY_2 + X_1 + \mu X_2 , \tag{1}$$

where the numerical subscript refers to the period of time from the planner's perspective and the μ is the periodic discount rate. Production in the first period is given by the production function

$$Y_1 = F^1(K_{Y1}, L_{eY1} + \phi L_{nY1}) , \tag{2}$$

where Y_1 is the output of the modern sector in the first period, F is the modern sector production function and the superscript references the time period, K_{Y1} is the amount of capital allocated to the modern sector in the first period, L_{eY1} is the amount of experienced labor, and L_{nY1} is the amount of new labor in the first period. The sum, $L_{eY1} + \phi L_{nY1}$, can be thought of as effective labor units, with ϕ restricted such that $0 < \phi < 1$; and ϕ is the parameter that captures the lower productivity of new workers to the sector. Similarly for the second period,

$$Y_2 = F^2(K_{Y2}, L_{eY2} + \phi L_{nY2}) . \tag{3}$$

For the traditional sector the output for the two periods can be expressed as

$$X_1 = G^1(K_{X1}, L_{oX1} + L_{nX1}) \tag{4}$$

and

$$X_2 = G^2(K_{X2}, L_{oX2} + L_{nX2}), \tag{5}$$

where G is a concave and continuous production function. Note that the following constraints simplify the problem:

$$L_{nY1} = L_{eY2} \tag{6}$$

$$L_{nX1} = L_{oX2} \tag{7}$$

$$\overline{L_{n1}} = \overline{L_{o2}} \tag{8}$$

These constraints simply recognize the same workers in the two different periods and in (8) that each generation is finite (where the overbar denotes a constant).[12]

$$\overline{L_{n1}} = L_{nX1} + L_{nY1} \tag{9}$$

$$\overline{L_{o2}} = L_{oX2} + L_{eY2} \tag{10}$$

$$\overline{L_{n2}} = L_{nX2} + L_{nY2} \tag{11}$$

The first of these constraints simply recognizes that the new generation of labor is finite and is fully employed in the two sectors. The second is essentially the same statement expressed for the second period of their generation. The third statement is the same expression as the first, but for the following generation of labor.

In the initial period of the planning problem there exists a given stock of old (second-period) workers, some of whom are "experienced" in the modern sector. Thus,

$$\overline{L_{o1}} = \overline{L_{oX1}} + \overline{L_{eY1}} \,. \tag{12}$$

Additional constraints related to labor can be derived from (6)–(12).

For capital, two constraints apply as follows:

$$\overline{K_1} = K_{Y1} + K_{X1} \tag{13}$$

$$\overline{K_2} = K_{Y2} + K_{X2} \tag{14}$$

These simply recognize that the total capital available in either period is fixed and fully employed in the two sectors.

Utilizing the constraints (6)–(14) and the production functions (2)–(5), the planner's objective can be rewritten as

$$\begin{aligned} V = {} & pF^1(K_{Y1}, \overline{L_{eY1}} + \phi L_{nY1}) + \mu pF^2(K_{Y2}, L_{nY1} + \phi L_{nY2}) \\ & + G^1(\overline{K_1} - K_{Y1}, \overline{L_{oX1}} + \overline{L_{n1}} - L_{nY1}) + \mu G^2(\overline{K_2} - K_{Y2}, \overline{L_{n1}} - L_{nY1} + \overline{L_{n2}} - L_{nY2}). \end{aligned} \tag{15}$$

As written, the objective reduces to a problem with four choice variables: K_{Y1}, K_{Y2}, L_{nY1}, and L_{nY2}. The respective necessary conditions for maximization of the objective, assuming an interior solution, are:

$$pF^1{}_K = G^1{}_K \tag{16}$$

$$pF^2{}_K = G^2{}_K \tag{17}$$

$$\phi pF^1{}_L + \mu pF^2{}_L = G^1{}_L + \mu G^2{}_L \tag{18}$$

$$\phi pF^2{}_L = G^2{}_L \,. \tag{19}$$

Equations (16) and (17) are the necessary conditions related to the allocation of capital and as can be seen, do not vary from one period to the next. Equation (18)

is the necessary condition for the allocation of a new generation of labor in any nonterminal period. If one extends the planning problem for more than two periods, the result is to provide analogous expressions of (16) and (18) for each period added. Equation (19) is the necessary condition for the allocation of a new generation of labor in the terminal period. The intertemporal dependency of labor is captured in (18) and this is the primary focus of what follows.

Market Results

In this section, first it is demonstrated that without a binding minimum wage in the model presented, the market allocation coincides with the social optimum. Second, it is demonstrated that with a binding minimum wage in this model, the market results deviate from the social optimum.

In the traditional (and numeraire) sector, where there is no learning-by-doing effect, the production function and profit maximization necessary conditions can be represented as follows:

$$X^t = G^t(L,K),\ w^t_x = G^t_L, \text{ and } r^t = G^t_K\,, \tag{20}$$

where the G_i's are the marginal products with respect to the factors. L and K are the inputs of labor and capital respectively, while w_x and r are the factor rewards, and t is the time period superscript.

The modern sector exhibits the learning-by-doing characteristic just described. In a case with no minimum wage, this sector would appear rather similar to the standard case, excepting that the experienced labor would command a relatively higher wage reflecting the rents to its accumulated human capital. That is, labor, whether experienced or not, is paid its value of marginal product. The production function for the modern sector can be represented as follows:

$$Y_t = F^t(L^*, K)\,, \tag{21}$$

where $L^* = (L_e + \phi L_n)$, $1 > \phi > 0$. The L^* can be thought of as effective labor units, and L_e and L_n are experienced and new labor respectively while ϕ captures the difference in productivity of L_n as compared to L_e.

Recall that p is the price of Y in terms of the numeraire good; r is the price of capital; and w_e and w_n are the respective prices of L_e and L_n. Then it follows that the necessary conditions for profit maximization in this sector can be written as

$$w^t_e = pF^t_L,\ w^t_n = \phi pF^t_L, \text{ and } r^t = pF^t_K, \tag{22}$$

where F is a concave and continuous production function and the F_i's are the marginal products with respect to the factors.

The learning-by-doing effect is captured by the intertemporal relationship

$$L_{eYt} = L_{nYt-1}\,. \tag{23}$$

This simply recognizes that labor must spend the first period as inexperienced (and lower productivity) workers in this sector in order to be experienced (and higher productivity) workers in the subsequent period. This condition does not affect employers in any way in the absence of a binding minimum wage.

Equilibrium in the labor market implies

$$w^1{}_n + \mu w^2{}_e = w^1{}_x + \mu w^2{}_x \,, \tag{24}$$

where μ is the periodic discount rate.[13] This condition requires that the present value of the lifetime earnings be equal in the two sectors. Note that by substituting from (20) and (22), that is, the necessary conditions for profit maximization, (24) can be rewritten as

$$\phi p F^1{}_L + \mu p F^2{}_L = G^1{}_L + \mu G^2{}_L \,, \tag{25}$$

which is identical to (18), the necessary condition for the socially optimal allocation of labor in a nonterminal period. Also from the necessary conditions for profit maximization (20) and (22), we can derive for capital

$$p F^t{}_K = r^t = G^t{}_K \,, \tag{26}$$

which by comparison to (16) and (17) confirms that the market also allocates capital in a socially efficient manner.[14]

The structure outlined in (20)–(26) captures the first two of the three constraints of concern: first, costly and time-consuming human capital accumulation, that is, learning-by-doing; and second, the nonappropriability of human capital by the firm. It has just been shown that with just these two elements built into the model there is no deviation from the first-best outcomes. Adding a binding, subsistence minimum wage to these two constraints results in the market imperfection. This is not to imply that this constraint is more important or powerful than the others. All three constraints must be present to cause the market distortion.

To be binding, the subsistence minimum wage, $\underline{w}$, must be greater than the value of marginal product of new labor in the modern sector, and therefore

$$\underline{w} > \phi p F^t{}_L = w^t{}_n \,. \tag{27}$$

A necessary condition for the existence of the traditional sector is that the return to labor in that sector is at least as great as the subsistence wage and hence

$$G^t{}_L = w^t{}_x \geq \underline{w} \,.^{15} \tag{28}$$

Equations (27) and (28) together imply:

$$w^t{}_x \geq \underline{w} > w^t{}_n \,. \tag{29}$$

Condition (29) establishes that the sector that produces Y (the modern sector) will not persist under free market pricing, because there is not a sustainable wage for inexperienced workers in this sector.[16] Yet, the modern sector is economically viable whenever (25) is satisfied. This condition states that the discounted sum of the value of marginal product of labor in the modern sector is equal to the discounted sum of the value of marginal product of labor in the traditional sector (for the two-period life of labor).

When the subsistence wage is higher than the value of marginal product of the inexperienced labor in the modern sector, a modern sector firm might like to hire labor for both periods, paying it above its value of marginal product in the first period and a discount-adjusted amount less than its value of marginal product in the second period. For example, the firm could pay wages

$$w^1_{n'} \geq \underline{w} > \phi p F^1_L$$

and

$$w^2_{e'} = pF^2_L - [(w^1_{n'} - \phi p F^1_L)/\mu] \,. \tag{30}$$

In this case the firm is effectively "investing" in the human capital of the new worker in order to receive a return on the investment. The investment is equal to $(w^1_{n'} - \phi p F^1_L)$ and the return on the investment is $(pF^2_L - w^2_{e'}) = (w^1_{n'} - \phi p F^1_L)/\mu$.

The problem with this wage scheme (30) is that existing competitors and potential entrants would hire away the experienced labor, bidding the wage up to w_c, their value of marginal product ($w_c = pF^2_L > w^2_{e'}$). Any firm that hires the labor during the learning period is never able to recoup its "investment" in labor from the initial period.[17] Thus the modern sector, though economically viable, is prevented from coming into existence owing to the subsistence minimum wage.

Policy Options

The appeal of a protective tariff policy in this model is that it can motivate production in the economically viable sector by artificially raising the value of marginal product of the inexperienced workers above the subsistence wage. Such a policy would have the domestic price of Y augmented by an import tariff large enough to make production using inexperienced workers feasible. Therefore,

$$p_d = p + \tau, \tag{31}$$

where p_d is the domestic price, p is the world price, and τ is the tariff with τ large enough such that

$$\phi p_d F^t_L = w^t_n \geq \underline{w}.\ ^{18} \tag{32}$$

The problem with the tariff policy is that too much production of Y (and too little of X) will result.[19] With this tariff policy in place, the equilibrium market allocation of labor, analogous to (25), is characterized by

$$\phi p dF^1{}_L + \mu p_d F^2{}_L = G^1{}_L + \mu G^2{}_L \,, \tag{33}$$

which using (31) can be rewritten as

$$\phi p F^1{}_L + \mu p F^2{}_L + \tau(\phi F^1{}_L + \mu F^2{}_L) = G^1{}_L + \mu G^2{}_L \,. \tag{34}$$

Note by comparison to (18) that this equilibrium condition differs from the condition for the socially optimal allocation of labor, and also from the market allocation when there is no binding minimum wage (25).

Without specifics related to production and domestic consumption preferences it is not possible to determine whether the *laissez-faire* free trade or a tariff policy is a preferable policy in this model with a subsistence minimum wage and learning-by-doing. There is, however, a general policy preferable to both. This policy is optimal in the sense that the first-best allocation of labor is recovered and is feasible in the sense that the intervention can be self-financing; that is, it does not require an exogenous source of funds as in Brecher,[20] for example.

In its simplest form, the general policy provides for free trade and a mechanism for the transfer of income from the latter period to the earlier period for workers in the learning-by-doing sector. Government may accomplish this with a subsidy, s, to inexperienced workers such that

$$s^t = \underline{w} - \phi p F^t{}_L \,; \tag{35}$$

and a tax, T, on experienced workers of

$$T^t = s^{t-1}/\mu \,. \tag{36}$$

As long as the sector targeted by this policy is economically viable and therefore satisfies (25) at world prices, then it can be shown that

$$T^t \leq p F^t{}_L - \underline{w} \,, \tag{37}$$

indicating that each generation can finance its own subsidy. With this tax and subsidy scheme in place employers simply pay workers their value of marginal product, and thus the market economy is optimally allocating labor. An effective method of implementation of this tax and subsidy scheme would simply be a progressive wage tax with a negative tax component.

Observations and Conclusions

Direct empirical support for the basic model presented will not be easy to obtain. One would want to test the extent of learning in the export industries of both very successful and less successful export regimes.[21]

It would also be interesting to investigate extensively the exporting successes of the East Asian newly industrializing countries (NICs). Gary S. Fields and Henry Wan report on the institutions involved in wage-setting in selected

countries of Asia and Latin America.[22] The reports on Singapore, Taiwan, Hong Kong, and South Korea shed some insight on how the export successes of these countries may be consistent with the model outlined here.

According to Fields and Wan, Korea and Singapore have both experienced periods of wage repression. Wage repression in this model amounts to a subsidy from experienced workers to inexperienced workers. A wage cap essentially allows employers to pay wages such as in (30) so long as the wage cap is no greater than w_e. The wage cap eliminates the interfirm competition for experienced workers that otherwise made the wages in (30) not feasible.

Wage repression in Singapore was direct and was exercised by the National Wages Council from 1972 to 1979. From 1979 to 1982 wages were allowed to increase, but the resulting economic recession forced a complete wage freeze again in 1985.

In Korea wage repression takes a more subtle form. The Korean government tries to inhibit wage increases by instructing the Bankers' Association of Korea to restrict credit for the firms that increase wages beyond government guidelines. This also serves to stifle interfirm competition for experienced workers.

All four of these countries have extensive social welfare systems for the working class that tend to lower the wage level necessary to sustain basic needs. In terms of this model, the effect of social welfare programs that provide for basic needs is to lower the subsistence minimum wage, making it possible to hire inexperienced and low-productivity workers. While the preceding observations are not conclusive, they do suggest that the governments in these countries may have acted is such a way, whether knowingly or not, so as to offset the problem of the low level of productivity of the inexperienced workers in export industries.

NOTES

1. John R. Harris and Michael P. Todaro, "Migration, Unemployment, and Development: A Two-Sector Analysis," *American Economic Review* 60 (March 1970).

2. See for example Paul A. Samuelson, "The Gains from International Trade Once Again," *Economic Journal* 72 (December 1962): 820–29; and Murray Kemp, "The Gains from International Trade," *Economic Journal* 72 (December 1962): 803–19.

3. Anne O. Krueger, "Trade Policies in Developing Countries," in *Handbook of International Economics*, vol. 1, ed. Ronald W. Jones and Peter B. Kenan (Amsterdam: North Holland, 1984), pp. 519–70.

4. Jaroslav Vanek, "Free International Trade and Investment: Curse or Blessing?" (Department of Economics, Cornell University, Working Paper #374, October 1986).

5. David Evans, "Alternative Perspectives on Trade and Development," in *Handbook of Development Economics*, vol. 2, ed. Hollis Chenery and T. N. Srinivasan (Amsterdam: North Holland, 1989), p. 1242.

6. For a good example and a clear presentation of this, see the model in chapter 7 of Pranab K. Bardhan's *Economic Growth, Development, and Foreign Trade* (New York: John Wiley, 1970). In the works of Simone Clemhout and Henry Y. Wan, Jr., "Learning-by-Doing and Infant Industry Protection," *Review of Economic Studies* 37 (January 1970): 33–56; and Gershon Fedor and Andrew Schmitz, "Learning-by-Doing and Infant Industry Protection: A Partial Equilibrium Approach," *Review of Economic Studies* 43 (February 1976): 175–78, the learning-by-doing is a one-time event in the history of the industry; hence the human capital essentially accrues to the society at large. The classic paper by Robert E. Baldwin, "The Case against Infant-Industry Tariff Protection," *Journal of Political Economy* 77 (May/June 1969): 295–305, which details the case against the protection of

infant industry, also has human capital accruing at the level of the industry. There is an article by Alwyn Young, "Learning by Doing and the Dynamic Effects of International Trade," *Quarterly Journal of Economics* 106 (May 1991): 369–405, that directly addresses learning-by-doing in a model of trade with endogenous, but bounded, growth. While Young's article has several unique and interesting aspects, its treatment of learning-by-doing is not carefully isolated. It treats the introduction of new goods as exogenous and then has knowledge related to the new good accruing to the industry. This brings up a small quibble over the use of the term "learning-by-doing." The use of the term here may suggest that there are many other papers not discussed here that are related. One can argue (and I do) that industries and societies do not "learn" in any meaningful sense. Industries or societies can be or, more accurately, can provide repositories for what is learned by individuals. This paper is dealing not with what happens when societies accumulate new knowledge, but rather the more basic issue of what happens when individuals learn.

7. Ronald Findlay and Henryk Kierzkowski, "International Trade and Human Capital: A Simple General Equilibrium Model," *Journal of Political Economy* 91 (December 1983); and Karnit Flug and Obed Galor, "Minimum Wage in a General Equilibrium Model of International Trade and Human Capital," *International Economic Review* 27 (February 1986).

8. Richard Brecher, "Optimal Commercial Policy for a Minimum-Wage Economy," *Journal of International Economics* 4 (May 1974): 139–49.

9. Jagdish N. Bhagwati, "The Generalized Theory of Distortions and Welfare," in *Trade, Balance of Payments, and Growth: Papers in International Economics in Honor of Charles P. Kindleberger*, ed. Jagdish N. Bhagwati, Ronald Jones, Robert A. Mundell, and Jaroslav Vanek (Amsterdam: North-Holland, 1971).

10. Nevertheless, casting the model of this paper in the Bhagwati "Theory of Distortions" framework as much as possible (and borrowing Bhagwati's notation), one can say that at world prices, $DRT_{AVE} = FRT = DRS$, but $DRT_E > FRT = DRS > DRT_I$ (where the subscripts AVE, E, and I refer to average, experienced, and inexperienced, respectively), resulting in no inexperienced workers being used in the modern sector and hence no experienced workers being "created" and an eventual corner solution with domestic production in the traditional sector only under a *laissez-faire* free trade policy. This "distortion" is not examined by Bhagwati.

11. Other specifications of the planner's problem are possible, for example, with infinite horizon or continuous time. These other specifications add complexity but no additional insights or different results for this case.

12. In the absence of an output price change it is clearly nonoptimal for a worker to switch sectors after one period. The worker going from the modern to the traditional sector loses the opportunity to use his sector-specific human capital. The worker going from the traditional to the modern sector also has no period in which to utilize the human capital during the second period. Allowing for output price changes large enough to result in the movement of old workers between sectors would only add additional nonunique necessary conditions.

13. The time superscripts 1 and 2 are used instead of t and $t + 1$ with no loss of generality and to ease comparison with results from section 2.

14. The labor market equilibrium in a terminal period ($w_n = w_x$) yields a condition equivalent to equation (19).

15. The case where $w_x = \underline{w}$ implies unemployment of labor (which one would suppose results in starvation and hence reduction of the labor force [in the long run]).

16. The absence or limited nature of the capital markets prevents inexperienced workers from borrowing against their future higher income. The assumption of limited functioning of the capital markets in also technically necessary, but this is a rather standard stylization for less developed countries. Indeed, even in the United States, only medical students are generally able to borrow against their future income (from nongovernment guaranteed sources).

17. It has been suggested that the institution of apprenticeships is in fact a binding multiperiod contract for just this situation and that during an apprenticeship the apprentice receives greater than his value of marginal product while he is relatively inexperienced, and less than his value of marginal product for a specified period once he is experienced. The institution of apprenticeships, however, does not seem to have adapted to industrial society.

18. Recall that F_L is generally not constant. For the production functions described, F_L will be declining with increases in p_d. It is possible in some cases that the combination of declining marginal productivity and limited domestic demand for the output will result in no tariff level satisfying (32).

19. There is also a welfare loss owing to the distortion of consumption prices.

20. Brecher, "Optimal Commercial Policy for a Minimum-Wage Economy."

21. Alice Amsden, "The Division of Labour Is Limited by the Rate of Growth of the Market: The Taiwan Machine Tool Industry in the 1970's," *Cambridge Journal of Economics* 9 (September 1985): 271–84, gives an interesting qualitative account of the importance of learning in the rapid growth of the machine tool industry in Taiwan.

22. Gary S. Fields and Henry Wan, Jr., "Wage-setting Institutions and Economic Growth," *World Development* 17 (September 1989): 1471–83.