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# Effort, Wages, and the International Division of Labor

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This paper embeds variable effort into a traditional two-sector Heckscher-Ohlin model of international competition. Effort enters a production function as total factor productivity, and on the assumption that effort does not affect capital depreciation, the capital cost savings from high-effort operations are passed on to workers. The labor market thus offers a set of contracts with higher wages compensating for higher effort. This has implications for growth, openness, minimum wages, collective bargaining, public support of education, efficiency of state enterprises, the distribution of wealth, childbearing, and much more.

In the United States, elevators wait for 10 seconds before the doors automatically close. In Hong Kong elevators wait for only four seconds.

## I. Introduction

This paper is built on the idea that equipment is operable at different speeds and for different numbers of hours during the day. Employers and workers are assumed to have opposite attitudes toward speed and hours. Rapid pace and long operating hours reduce capital costs by allowing employers to spread the fixed cost of capital over a larger labor input, but workers are assumed to prefer low-

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speed operations and fewer hours. A competitive labor market thus offers a set of wage-effort contracts with higher daily wages offsetting the disutility of higher effort. The capital cost savings from rapid pace and long hours are greatest in capital-intensive operations, where the high-wage, high-effort contracts occur.

The most familiar setting in which these ideas apply is do-it-yourself home improvements. Items such as hammers and screwdrivers with a low rental cost are allowed to sit idle much of the time. Equipment such as moving vans and floor sanders that are expensive to rent are ordinarily operated more or less constantly and as fast as one can get one's helpers to move.

Formally, the models presented here are based on the assumption that the daily output of a machine is proportional to the "effort" of the operator, defined as the product of the number of hours of operation times the speed of the equipment times the level of attentiveness. Production functions are written as  $q = eF(K, L)$ , where  $q$  is daily output,  $K$  is the stock of capital used in production,  $L$  is the number of workers,  $F(\cdot, \cdot)$  is a function exhibiting constant returns to scale, and  $e$  is the level of effort. The effort variable is like a factor-neutral technological multiplier, also known as total factor productivity. Traditional growth accounting treats total factor productivity as an unexplained residual attributable to technology. Here it is a choice variable of the economy.

Most of the discussion of the role of effort in this paper is placed in the context of a two-good, two-factor model with fixed input coefficients, fixed capital stock and labor force, variable effort levels, and homogeneous workers who prefer high wages and low effort. This very simple framework has a surprising number of interesting implications.

1. The capital savings from effort are greatest in the capital-intensive sector, which therefore offers the highest wages for the highest effort. This helps to explain the wage premium in capital-intensive sectors without resorting to assumptions regarding monitoring costs used in the efficiency wage literature.

2. Communities inhabited by industrious workers who are willing to exert high effort have high returns to capital. This helps to explain why capital does not flow as Niagara Falls, from north to south. These industrious communities do not necessarily have the highest wages since it is possible that the increased competition for the limited capital drives up the capital rental costs so much that wages net of capital costs are relatively low.

3. Communities inhabited by industrious workers have comparative advantage in the *labor*-intensive goods, not the capital-intensive goods. This surprising implication comes from the assumption that there is a maximum effort level. In all communities, the moving vans

and floor sanders are operated at close to the maximum level of effort. The genuinely industrious communities keep the screwdrivers and hammers going as well. Industriousness thus has offsetting effects on comparative advantage. It raises the return to capital and encourages capital formation, which creates comparative advantage in the capital-intensive products. But industriousness also has a relatively great impact on effort in the labor-intensive sector. These offsetting forces help to explain the limited amount of north-south trade.

4. There is a dramatic difference between capital accumulation in an open economy and capital accumulation in a closed economy. In a small open economy facing fixed external prices, capital accumulation may leave the product mix unchanged or it may cause a shift toward a more capital-intensive mix of tradables. If the product mix is unchanged, capital accumulation alters the output levels but not the rental rate of capital, wages, or effort levels. If the product mix shifts, capital accumulation lowers the return to capital but creates new high-effort, high-wage jobs in the newly emerging capital-intensive sector. The induced increase in effort is a source of growth. Capital accumulation in a closed economy, on the other hand, comes with a decline in the relative price of the capital-intensive good, a decline in the rental rate of capital, and a consequent reduction in effort levels in both sectors. Thus capital accumulation in a closed economy brings senescence, whereas capital accumulation in an open economy may leave the effort levels unchanged or may create new high-wage, high-effort jobs in newly emerging sectors. This helps to explain the difference between the growth rates in Asia and Latin America.

5. Price declines of labor-intensive goods twist the wage-effort offer curve, lowering the compensation for low-effort jobs but increasing the reward for hard work. The increased demand for the high-effort jobs in the capital-intensive sector causes a rise in the rental rate of capital, the same as the familiar Stolper-Samuelson response of the capital rental rate. In the new equilibrium, wages are lower and effort levels higher in both sectors. Apparent inequality, measured as the ratio of the wages in the two sectors, increases, though the representative worker is still indifferent between the two jobs. This helps to understand the effect of increased competition from labor-abundant third-world countries, and it conforms very well with some features of the rise in inequality in the United States in the last several decades, namely the stagnation of wages, the increase in the interindustry dispersion of wages, and the rise in hours worked.

6. A minimum wage does not cause unemployment. It forces effort in the low-wage, low-effort contracts up enough to support the higher wage. This increase in the effective labor supply increases the demand for capital and causes the rental rate of capital to be bid

up. This causes a reduction in wages and an increase in effort in the high-wage, high-effort jobs not directly affected by the minimum wage. The greater effort in both sectors means that output levels rise in both. Thus a minimum wage benefits capital and hurts labor. It increases gross domestic product and reduces earnings inequality, though it makes the representative worker worse off. By forcing effort levels to more closely conform, the minimum wage creates comparative advantage in the *labor*-intensive sector, exactly the opposite of what might have been expected.

7. Countrywide centralized bargaining that fixes a common wage-effort contract in both sectors, unlike a minimum wage, can make workers better off. By collectively withholding effort, workers exert monopoly power over capital and force a reduction in the rental rate. In the model discussed here, the optimal collective bargaining contract has workers exerting an effort level as though capital were free. Although wages in both sectors are lower, the decrease in effort makes workers better off. By forcing a common effort level, centralized bargaining creates comparative advantage in the *labor*-intensive sector in comparison with countries in which the effort is greater in the capital-intensive sector.

8. The distribution of wealth affects the societal effort level. The greatest effort occurs when wealth is extremely concentrated, with a small capitalist class choosing leisure and everyone else choosing to work. Effort levels are lower in an egalitarian society in which the capital is equally owned. This may offer some insight into the difference between Asia, where natural resources are scarce, and Latin America, where natural resources are abundant. But inheritance patterns also matter.

9. If capital is gifted and is not transferable, then workers regard the capital as free and select a correspondingly low level of effort. The effort reduction associated with nontransferable capital gifts is most pronounced in the capital-intensive sector, where the gap between the social cost of capital and the private cost of capital is greatest. This creates a comparative advantage in the *labor*-intensive product. One important nontransferable capital gift is human capital. Communities that provide free education with no mechanism to enforce high effort levels (such as nagging from one's parents) thus experience low returns on their educational investments and have a comparative advantage in sectors that require little human capital. The absence of organized capital markets may also limit the transferability of capital inheritance and allow expensive equipment to be operated by low-effort workers. Putting expensive capital in the hands of those willing to exert high effort may be an important consequence of the emergence of organized capital markets in developing countries. A third group of recipients of nontransferable capi-

tal grants includes the state enterprises in Latin America, Asia, and Eastern Europe as well as public utilities generally. The Averch-Johnson (1962) effect is operative and state-subsidized operations choose inappropriately high capital/labor ratios, but in addition and maybe more important, these enterprises choose low-effort labor contracts. This helps to explain the rising income inequality following economic privatization: New high-wage, high-effort jobs emerge.

10. If capital is interpreted as human capital and if education is self-financed, a message of the model is that those who choose more education also choose higher effort. Thus part of the apparent return to human capital is really compensation for willingness to exert effort. This contrasts with the signaling model of education, which, like the theory of efficiency wages, is based on the unobservability of worker characteristics by employers. The effort model is more like a model with heterogeneous ability to learn.

11. If it takes special talent to operate the equipment in the capital-intensive sector, there is a talent premium when capital is sufficiently abundant but no premium when capital is scarce. The ability premium in capital-abundant countries helps to explain the puzzling immigration of high-skilled workers into the skill-abundant United States.

12. An important feature of home production is that most of the capital is idle most of the time. The hammer and the spinning wheel sit idle when the spade is being used. Spinning skills sit idle when the hammer is swung. Home workers must be charged implicitly or explicitly for the rental cost of the capital even when it is idle. The factory system produces a great reduction in capital costs by allowing the operation of this underutilized human and physical capital for many more hours during the day. Indeed, the principal efficiencies from the division of labor may come from putting idle capital to work, a point that Adam Smith overlooked.<sup>1</sup>

<sup>1</sup> Adam Smith (1776) identifies some reasons why the division of labor is efficient, but he misses this one, which may well be the most important. Smith sees economies of division of labor coming from (1) learning by doing, (2) elimination of task transitions, and (3) induced innovation. According to Smith (bk., chap. 1), "This great increase of the quantity of work which, in consequence of the division of labour, the same number of people are capable of performing, is owing to three different circumstances; first to the increase of dexterity in every particular workman; secondly, to the saving of the time which is commonly lost in passing from one species of work to another; and lastly, to the invention of a great number of machines which facilitate and abridge labour, and enable one man to do the work of many." The observations of the workplace that suggested to Smith learning by doing and induced innovation could just be a simple consequence of the fact that both human and physical capital are cheaper if they are not idle. Ghiselin (1978, p. 234) also argues that Smith overlooked the capital cost savings from the division of labor: "Turning to *The Wealth of Nations* itself, we find that it contains an exceedingly simpleminded discussion . . . [Smith] gives only three advantages to the division of

13. Childbearing and other predictable work interruptions cause idle human capital, which, unlike machinery, cannot be used by anyone else. The economic incentive to allocate capital to high-“effort” workers helps to explain why women have often received less education and training than men.

The repeated use of the word “help” in the preceding list of implications reminds the reader that a theory gives insight but is not a complete description of reality. Obviously different assumptions will lead to different conclusions. Some of the more surprising implications come from my assumption that there is a maximum effort level. Furthermore, I have not allowed substitutability of capital and labor within a sector. I have allowed workers and capital to move freely between sectors. I have assumed that production functions have constant returns to scale. I have assumed that all workers in a sector perform the same task and use the same amount of capital. And so on, and so on. None of these changes in assumptions alters the basic message that I want to convey here, which is that  $e$  ought to be about the third letter in our alphabet, after  $p$  and  $q$ .

One very important fact that  $e$  helps to explain is that there are large and persistent differences in wages across industries. This fact has given rise to a literature on “efficiency wages,” for example, Copeland (1989), Dickens et al. (1989), and Katz and Summers (1989), the first presenting a Ricardian model of international trade with efficiency wages. According to the efficiency wage literature, costly monitoring makes it profitable to pay a wage premium, monitor infrequently, and fire for shirking rather than monitor constantly. There are obvious parallels between the efficiency wage literature and the theory of effort discussed here, but there is one critical difference. The theory offered here necessarily has high wages in capital-intensive sectors. A theory of efficiency wages, such as in Copeland (1989), can use only labor as an input, in which case it misses the critical point of this article: work should be organized to put the most expensive capital in the hands of those willing and able to exert the greatest effort.

This paper suggests a name for the X in Leibenstein’s (1975) X-

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labor, none of them particularly profound. . . . Imagine, if you will, a man who tried to function as both a plumber and a carpenter. He would have to invest time in learning both trades, and money in purchasing the tools for both. Since he could not ply both trades simultaneously, the return on his investments in training and tools would be low.” There is a large literature interpreting Smith including the paper by Rosen (1983), which discusses indivisibilities: “it does not pay to purchase a hammer to drive a single nail. Only if a sufficiently small hammer were available to accomplish the task would it be advantageous to do so” (p. 43). Divisibility in some cases is a good thing, but not if it means cluttering the workbench with tools suited to narrow tasks, most of which are sitting idle.

efficiency, the mysteriously large differences in total factor productivity across firms and countries. High productivity can come both from high effort and from organizational forms that reduce the idleness of capital. The model with variable effort offers one answer to Lucas's (1990) question, Why doesn't capital flow from rich to poor countries? An answer is that the low-wage countries/regions have workers who prefer low-effort contracts and the rates of return to capital are accordingly low.

The elements of the model are formally described in Section II. The traditional comparative statics exercises are discussed in Section III, namely the Stolper-Samuelson effect of prices of goods on compensation of capital and labor, the factor price equalization (non)effect of factor supplies on compensation rates, and the Rybczynski effect of factor supply on output mixes. The responses to capital accumulation of closed and open economies are contrasted. In addition, Section III discusses the effect of attitudes toward work on outputs and compensation rates. Section IV describes the impact of two labor interventions: minimum wages and collective bargaining. Section V discusses alternative capital ownership assumptions and includes a discussion of the implications of nontransferable capital gifts. Section VI allows a variety of alterations of the model: international capital mobility and nontraded goods, heterogeneity in attitudes and ability, and more than two tradable products. Section VII interprets some important empirical regularities using the effort model: (1) a comparison of wages across sectors and across countries; as suggested by the theory, the capital-intensive sectors pay high wages in the United States, and also in Germany and Japan; (2) productivity differences across countries and the lack of capital flow from high-wage to low-wage countries; and (3) the rising inequality in the liberalizing low-wage economies.

## II. Two-Sector Model

This section presents a two-sector model with endogenous effort levels. The production function is written as

$$q = eF(K, L), \quad (1)$$

where  $q$  is the daily rate of output,  $K$  is the (timeless) stock of capital used in production,  $L$  is the number of workers sharing the capital  $K$ , and  $F(\cdot, \cdot)$  is a function homogeneous of degree one. The effort variable  $e$  can be thought to be the product of hours worked times "pace" of operations times "attentiveness," which stands for a variety of worker attributes that increase proportionately the productiv-



ity of capital and labor time. For example, attentiveness might make breakdowns less likely and downtime less frequent.

Of course (1) is not the only way that a production function might be written to embody savings that come from the way in which work is organized. A production function describing equipment sharing from multishift or weekend work is written by Betancourt, Clague, and Panagariya (1984) as  $q = \sum_i F(K, L_i)$ , where  $q$  is the daily rate of output,  $L_i$  is the distinct labor input used in shift  $i$ , and  $K$  is the common capital used in every shift. By using the equipment more than once, multishift operations save capital costs and would certainly be adopted if workers did not care. But worker preference for the first shift would require wage premia in the evening and graveyard shifts. The use of the multishift production function in place of (1) would alter the details of this paper but not the messages that come from the fact that the potential savings are greatest in the capital-intensive sector, which is where the high-wage, second-shift jobs will occur.<sup>2</sup>

Two additional assumptions are made about the technology of effort. First, capital does not care about the effort level; long hours of use at high speed do not wear out the equipment.<sup>3</sup> Second, the effort level  $e$  is continuously and completely variable. A sewing machine can make 10 stitches a minute or a million stitches. The first assumption is critical for what follows since it affects substantially the nature of the viable wage-effort contracts. The second assumption is not so important. It would not be difficult to alter the theory below to restrict the values of hours and pace in one or both sectors.<sup>4</sup>

<sup>2</sup> Betancourt et al. offer an analysis that is close in spirit to the one presented here, but they assume that one sector can and one cannot employ multishift operations. They therefore miss what I regard to be the fundamental idea of this paper: work should be organized to put the most expensive capital in the hands of those willing to exert the greatest effort.

<sup>3</sup> Parenthetically, it is worth noting that there is a substantial literature built on the assumption that capital does care—that increased capacity utilization causes increased depreciation. A recent working paper by Auernheimer and Rumbos (1996) includes many references, among them Calvo (1975) and Bischoff and Kokkelenberg (1987). In contrast to the emphasis in this paper on sectoral differences, this literature generally uses a one-sector model and focuses on intertemporal capital-use questions. It is based on the opposite assumption that labor does not care about the intensity of work. Deardorff and Stafford (1976), on the other hand, use a production function that is essentially the same as the one used here, but they allow both labor and capital to care. They write output proportional to hours of operation and explore the coordination problem between two inputs that have different preferences regarding hours of work.

<sup>4</sup> My uninformed preference would be to assume that the pace of operations in labor-intensive sectors is greatly variable (piece-rate pay) but the pace in capital-intensive sectors is technologically limited. In capital-intensive sectors, variability in effort may come mostly from variability in hours of operation, which of course cannot exceed 24 hours per day. On the other hand, even if hours on the job are fixed

*Production function.*—It is particularly convenient to assume fixed input technologies, in which case the allocation of labor and capital between the two sectors does not depend on prices, and any supply response to changes in prices can come only from changes in effort levels. A production function with variable effort and fixed input technologies takes the form

$$q = e \times \min\left(\frac{K}{A_K}, \frac{L}{A_L}\right),$$

where  $e$  is the effort level and  $K$  and  $L$  are capital and labor inputs.

*Factor allocation.*—The allocation of capital and labor is governed by the usual “Rybczynski” system, which equates factors used to produce the pair of outputs to available factor supplies. With  $x$  denoting the output levels corresponding to effort level  $e = 1$ , the Rybczynski equations are

$$\begin{bmatrix} A_{L1} & A_{L2} \\ A_{K1} & A_{K2} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} L \\ K \end{bmatrix}, \quad (2)$$

which can be inverted to solve for the activity levels  $x$ :

$$\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} A_{L1} & A_{L2} \\ A_{K1} & A_{K2} \end{bmatrix}^{-1} \begin{bmatrix} L \\ K \end{bmatrix}, \quad (3)$$

with corresponding sectoral inputs  $L_i = A_{Li}x_i$  and  $K_i = A_{Ki}x_i$  and outputs

$$q_i = e_i x_i. \quad (4)$$

In the ensuing discussion, it is important to keep in mind that the system (2) fixes the allocation of labor and capital between sectors. Moreover, it is assumed that the activity levels  $x$  implied by (3) are both positive or, equivalently, that the factor abundance ratio  $K/L$  lies between the capital intensities of the two sectors. This allows full employment of both inputs.

*Wage-effort contracts.*—With the assumption that capital does not care about effort, a competitive labor market will award any marginal increase in output from greater effort all to the workers willing to operate at the higher effort level. Expressed differently, it is as though workers rented the capital equipment and received the excess earnings as compensation for the effort they decide to exert. The wage rate  $w(e)$  applicable to effort  $e$  is thus a solution to a zero-

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by social convention at 40 hours per week, hours “actually worked” can still vary substantially, but of course not without limits.

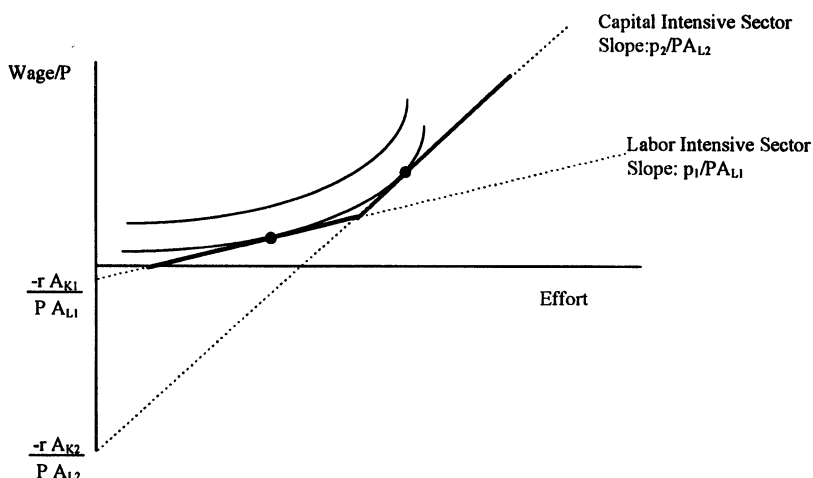


FIG. 1.—Equilibrium in a two-sector model

profit condition  $epF(K, L) = rK + w(e)L$ , where  $p$  is the price of the product,  $r$  is the capital rental rate per day, and  $w(e)$  is the daily wage for workers operating at effort  $e$ . With fixed input technologies, this zero-profit condition implies the set of wage-effort contracts in sector  $i$ :

$$\frac{w_i}{P} = \frac{p_i e_i - r A_{Ki}}{P A_{Li}}, \quad i = 1, 2, \quad (5)$$

where  $P$  is a price index and  $w/P$  is the real wage level. Two such wage-effort offer lines are depicted as dotted lines in figure 1.

Both zero-profit lines in figure 1 have negative intercepts since at very low effort levels the value of output is not enough to cover the capital rental costs. The intercepts are proportional to the capital intensities and thus more negative in the capital-intensive sector. As the effort increases, earnings net of capital costs increase. The capital-intensive sector has to have the steeper wage-effort line in order to offer contracts that can compete with the contracts in the labor-intensive sector. Labor contracts will lie along the upper envelope of these wage offers, which is the heavy piecewise-linear curve depicted in figure 1. The low-effort, low-wage contracts are offered in the labor-intensive sector. The high-effort, high-wage contracts are offered in the capital-intensive sector.

A necessary condition for both sectors to be operating is that the two wage-effort lines (5) intersect in the positive quadrant. If this intersection point were outside the positive quadrant, then one of

the sectors would offer contracts that are strictly inferior to the other. Given the assumption that sector 2 is capital intensive,  $A_{K2}/A_{L2} > A_{K1}/A_{L1}$ , this implies two inequalities:

$$\frac{A_{K2}}{p_2} > \frac{A_{K1}}{p_1}, \quad \frac{A_{L2}}{p_2} < \frac{A_{L1}}{p_1}. \quad (6)$$

*Utility function and the supply of effort.*—In much of what follows I shall assume that workers have identical attitudes toward the trade-off between work and goods. Figure 1 has two indifference curves of a representative worker, one of which is tangent to the wage-effort offer lines in both sectors. This represents an equilibrium with identical workers who are indifferent between the two prevailing contracts: high-wage, high-effort and low-wage, low-effort. It is necessary to have the representative worker indifferent between the best contract in each sector in order to have both sectors operating and the full-employment conditions (2) satisfied.

Worker willingness to trade effort for income is a key feature of this model. A convenient utility function is Cobb-Douglas (log-linear) with a maximum effort level  $e_{\max}$ .<sup>5</sup>

$$U = \theta^{-\theta} (1 - \theta)^{-(1-\theta)} c_1^\theta c_2^{1-\theta} (e_{\max} - e)^\delta,$$

where  $c_i$  stands for consumption of good  $i$ . The parameter  $\theta$  measures preference for the first good, and the parameter  $\delta$  measures distaste for high effort. Maximization of this utility function taking as given money wages leads to the usual consumption budget shares:

$$\begin{aligned} p_1 c_1 &= w\theta, \\ p_2 c_2 &= w(1 - \theta). \end{aligned}$$

Inserting these into the utility function, we obtain

$$U = \frac{w(e_{\max} - e)^\delta}{p_1^\theta p_2^{1-\theta}} = wP^{-1} (e_{\max} - e)^\delta,$$

where  $P$  is a price index,  $P = p_1^\theta p_2^{1-\theta}$ . Thus by first allocating income  $w$  optimally between the two goods, we can rewrite the worker utility in terms of real wages  $w/P$  and effort  $e$  and collapse a three-dimensional maximization problem into two dimensions suited to graphi-

<sup>5</sup> Although workers may have attitudes regarding the relative undesirability of hours and pace and attentiveness, for our purposes all that matters is their willingness to trade effort (hours times pace times attentiveness) for goods. Incidentally, the normalization in front of the Cobb-Douglas goods utility function makes the indirect utility function a bit simpler to write down.

cal displays such as figure 1. Maximizing this utility subject to one of the wage-effort lines (5) determines the effort level in sector  $i$ :

$$e_i = \frac{e_{\max} + \delta e_{\min,i}}{1 + \delta}, \quad (7)$$

where the break-even level of effort ( $w = 0$ ) is

$$e_{\min,i} = \frac{rA_{Ki}}{p_i}. \quad (8)$$

In words, the effort level is an average of the maximum possible effort and the break-even effort needed to have zero net earnings, weighted by the disutility of effort,  $\delta$ .

The wage level corresponding to effort level (7) is

$$\begin{aligned} w_i &= \frac{p_i e_i - rA_{Ki}}{A_{Li}} \\ &= \left[ p_i \frac{e_{\max} + (\delta rA_{Ki}/p_i)}{1 + \delta} - rA_{Ki} \right] / A_{Li} = \frac{p_i e_{\max} - rA_{Ki}}{(1 + \delta)A_{Li}}, \end{aligned} \quad (9)$$

with corresponding utility level

$$U_i = w_i P^{-1} (e_{\max} - e_i)^\delta = \frac{\delta^\delta (1 + \delta)^{-1-\delta} (e_{\max} - e_{\min,i})^{1+\delta} p_i}{PA_{Li}}.$$

If workers are identical, they must be indifferent between these two contracts, since otherwise they would all select one sector or the other and the factor market conditions (2) could not apply. Worker indifference requires

$$\frac{[e_{\max} - (rA_{K1}/p_1)]^{1+\delta} p_1}{A_{L1}} = \frac{[e_{\max} - (rA_{K2}/p_2)]^{1+\delta} p_2}{A_{L2}}. \quad (10)$$

Solving this for the rental rate of capital yields the ‘‘Stolper-Samuelson’’ equation:

$$r = e_{\max} p_2 \left[ 1 - \left( \frac{p_1 A_{L2}}{p_2 A_{L1}} \right)^{1/(1+\delta)} \right] / A_{K2} \left[ 1 - \frac{p_2 A_{K1}}{p_1 A_{K2}} \left( \frac{p_1 A_{L2}}{p_2 A_{L1}} \right)^{1/(1+\delta)} \right]. \quad (11)$$

The model consists of the factor allocation system (2), output determination (4), effort choice (7), wage levels (9), and the capital rental rate determination (11). Product prices are treated as exogenously determined in the external product market; in other words, this is a small open economy. Although workers are indifferent be-

tween the two contracts, there is apparent inequality since the wage rates are not the same. Using the wage rate (9) and the indifference condition (10), we can solve for the relative wages as

$$\frac{w_2}{w_1} = \frac{(p_2 e_{\max} - rA_{K2})/A_{L2}}{(p_1 e_{\max} - rA_{K1})/A_{L1}} = \left( \frac{A_{L1}/p_1}{A_{L2}/p_2} \right)^{\delta/(1+\delta)} \quad (12)$$

and relative effort levels

$$\frac{e_2}{e_1} = \frac{e_{\max} + (\delta r A_{K2}/p_2)}{e_{\max} + (\delta r A_{K1}/p_1)}. \quad (13)$$

To confirm the connection between the diagrams and the algebra, note that the inequalities (6) and the equations (12) and (13) imply that wages and effort levels are both higher in the capital-intensive sector.

### III. Comparative Statics

#### A. Change in Product Prices

A standard result in the two-sector model is Jones's (1965) amplification condition, which characterizes the (Stolper-Samuelson) response of factor prices to, for example, an increase in the price of the capital-intensive good:  $dw/w < 0 < dp_2/p_2 < dr/r$ . In words, in the standard model, an increase in the price of the capital-intensive good causes a reduction in wages and a more than proportionate increase in the rental rate of capital. This amplification result is not a foregone conclusion in a model with variable effort since potential wage reductions might be offset by increases in effort. As it turns out, with our choice of effort supply, the real rental rate of capital increases, and wages and effort levels worsen in both sectors. Thus the content of the Stolper-Samuelson theorem remains intact.

The supply response to a change in relative prices is not standard, however. In the standard model, a change in relative prices induces an output shift in favor of the sector that experiences the price increase, provided that production functions allow substitutability of labor for capital. Here, however, an increase in the relative price of the capital-intensive product produces a *positive* supply response in *both* sectors. With variable effort, the effective labor supply is not fixed and a rise in the price of the capital-intensive good and the consequent increase in the rental price of capital cause an increase in effort and therefore output in both sectors.

More surprising still, the relative output levels can shift in a direction opposite of the price change. When the cost of capital is already

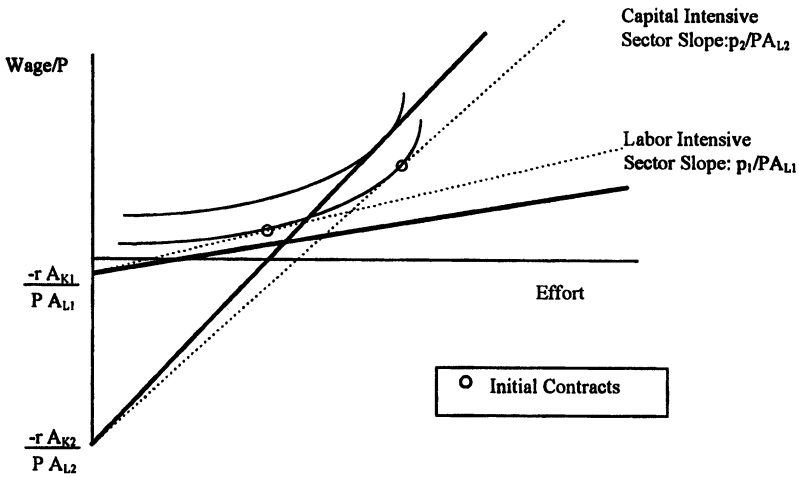


FIG. 2

high, the effort level in the capital-intensive sector is close to the maximum, and the effort response to a further increase in the price of the capital-intensive good is mostly in the labor-intensive sector.

Figure 2 depicts the initial effect of a simultaneous rise in  $p_2$  and fall in  $p_1$  that leave the overall price level  $P$  constant. What this does is rotate upward the wage-effort offer line in the capital-intensive sector and rotate downward the wage-effort offer line in the labor-intensive sector. These changes render the low-wage, low-effort contract in the labor-intensive sector unattractive to workers and cause income and substitution effects that have opposite effects for the two contracts. This cannot be an equilibrium because capital constraints do not allow all workers to operate in the capital-intensive sector and the excess demand for capital is rationed by increasing the capital rental rate. This rise in the rental rate of capital shifts both wage-effort offer lines downward, stopping only when indifference between the high-effort and low-effort jobs is reestablished.<sup>6</sup>

Both the initial rotation and the shift downward of the wage-effort offer line in the labor-intensive sector worsen the terms of the low-wage, low-effort contract, and it follows that the final equilibrium selects a lower worker indifference curve. The negative income effect, which shifts the contracts to a lower indifference level, causes

<sup>6</sup> The rising cost of capital at some point has to switch the preference in favor of the low-effort job since the cost of capital can be made so high that just to break even in the capital-intensive sector requires the maximum effort  $e_{\max}$ , in which case the low-effort job is surely preferred.

both lower wages and higher effort in both sectors, provided that both leisure and goods are “normal.” There is also a substitution effect that tends to drive the contracts in opposite directions: the low-wage, low-effort contract shifts in favor of lower effort and lower wages, and the high-wage, high-effort contracts shift in favor of higher wages and higher effort. Thus a rise in the relative price of the capital-intensive good makes workers worse off and increases income inequality, though of course workers are indifferent between the two contracts and there is no inequality in utility in the model.

The algebra that is needed to confirm these assertions is discussed next.

### 1. The Stolper-Samuelson/Jones Amplification Condition

The ideas that come from manipulating figure 2 can be confirmed with algebra, allowing an increase in  $p_2$  and holding  $p_1$  fixed. The first step is to verify the amplification result applicable to the capital rental rate, namely,  $0 < dp_2/p_2 < dr/r$ , by differentiating (11) to obtain

$$\begin{aligned}
 \frac{dr/r}{dp_2/p_2} &= \frac{\frac{1}{1+\delta} \left( \frac{p_2}{A_{L2}} \right)^{1/(1+\delta)}}{\left( \frac{p_2}{A_{L2}} \right)^{1/(1+\delta)} - \left( \frac{p_1}{A_{L1}} \right)^{1/(1+\delta)}} \\
 &\quad - \frac{\frac{-\delta}{1+\delta} \frac{A_{K2}}{p_2} \left( \frac{p_2}{A_{L2}} \right)^{1/(1+\delta)}}{\frac{A_{K2}}{p_2} \left( \frac{p_2}{A_{L2}} \right)^{1/(1+\delta)} - \frac{A_{K1}}{p_1} \left( \frac{p_1}{A_{L1}} \right)^{1/(1+\delta)}} \\
 &= \frac{1}{1+\delta} \left[ \frac{1}{1 - \left( \frac{p_1}{A_{L1}} \frac{A_{L2}}{p_2} \right)^{1/(1+\delta)}} \right. \\
 &\quad \left. + \frac{\delta}{1 - \frac{A_{K1}}{p_1} \frac{p_2}{A_{K2}} \left( \frac{p_1}{A_{L1}} \frac{A_{L2}}{p_2} \right)^{1/(1+\delta)}} \right] > 1,
 \end{aligned}$$



with the inequality following from the fact that both the denominators are less than one provided that the conditions (6) apply. From the rise in the capital rental rate relative to the price of either good, it follows from (9) that wages in both sectors fall. Furthermore, from (12), it follows that wages fall by a greater proportion in the labor-intensive sector and that wage inequality therefore increases.

## 2. Output Response

From the falling real wages and from (7) and (8), it follows that effort levels and therefore outputs in both sectors rise. Next we need to determine whether the effort level in the capital-intensive sector increases by a greater percentage than the effort level in the labor-intensive sector as one might expect. This turns out true for low values of the relative price of the capital-intensive good but not for high values. The best way to confirm this result is to note that the two effort levels are identical when the relative price is low and also when it is high. The effort levels both are equal to  $e_{\max}/(1 + \delta)$  when the price of the capital-intensive good is so low that the cost of capital is zero, that is, when the slopes of the wage-effort offer lines conform:  $p_1/A_{L1} = p_2/A_{L2}$ . The effort levels are also equal when the relative price of the capital-intensive good is high and capital is very dear, since then they both become  $e_{\max}$ .<sup>7</sup> Thus an increase in the relative price of the capital-intensive good above its minimum feasible value first drives the effort levels apart but then pulls them back together.

### *B. Change in Factor Supplies in a Small Open Economy: Rybczynski Effect and Factor Price Insensitivity*

A change in the factor supplies can be completely absorbed through changes in the activity levels  $x$  with no change in factor prices. The usual Rybczynski/Jones amplification applies; for example, an increase in labor force causes a reduction in the output of the capital-intensive sector and a more than proportional increase in the output of the labor-intensive sector:  $dx_2/x_2 < 0 < dL/L < dx_1/x_1$ .

Incidentally, I have argued in my Graham lecture (Leamer 1995) that the factor price *equalization* theorem is misleadingly named. It

<sup>7</sup> The inequalities (6) limit the range of price variability compatible with the production of both goods. The capital rental rates (11) corresponding to the extreme price ratios are zero and  $e_{\max}p_2/A_{K2}$ . The relative effort levels (13) at both these capital rental rates are equal.

would be better to call it the factor price *insensitivity* theorem, meaning that factor prices do not change with changes in factor supplies, or, equivalently, with prices of tradables held fixed, the demand for factors is infinitely elastic. Factor price *equality* across countries also requires identical technologies and identical mixes of tradables. Here we have factor price *insensitivity* but not factor price *equality*. Indeed, we have a new reason for factor price inequality. We have insensitivity since capital accumulation affects the output mix but not the labor contracts. We do not necessarily have factor price equality even if countries have the same technologies and the same product mix since the wage-effort contracts and the cost of capital depend on worker attitudes toward effort.

### C. Change in Factor Supplies in a Closed Economy

A small open economy has the product prices exogenously determined in the external marketplace. A closed economy has product prices adjusting to equilibrate supply and demand. On the assumption that both capital and labor earnings are spent on the goods in the same proportion, the condition for equilibrating supply and demand equates supply shares with demand shares:  $p_2 e_2 x_2 / p_1 e_1 x_1 = (1 - \theta) / \theta$ . Accumulation of capital gives rise to the shift of activity levels  $x$  in favor of the capital-intensive sector. To equilibrate demand with supply, this shift in favor of the capital-intensive sector must be offset by declines in relative price or relative effort.

The relevant range for the variation in activity levels is (proof available on request)

$$\frac{1 - \theta}{\theta} \frac{A_{K1}}{A_{K2}} < \frac{x_2}{x_1} < \frac{1 - \theta}{\theta} \frac{A_{L1}}{A_{L2}}.$$

When capital is so scarce that the activity ratio  $x_2/x_1$  is close to the lower bound in this interval, the equilibrium has the highest relative price of the capital-intensive good, the highest possible rental rate, both effort levels near the maximum, wages near zero, and extreme inequality ( $w_2/w_1$  high). (Does that sound like some closed economies that you know?) With capital accumulation comes a lower relative price of the capital-intensive good, lower rental costs, lower effort levels, higher wages, and more equality. When capital is so abundant that the activity ratio  $x_2/x_1$  is at the upper bound of the interval above, the rental rate drops to zero and effort in both sectors is set to the minimal level  $e_{\max}/(1 + \delta)$ . (The zero rental value can be expected to choke off further capital accumulation.)

In summary, closed economies and open economies experience dramatically different development paths. All small open economies with the same attitudes toward work look pretty much alike. They differ in terms of output mix but not rents, wages, or effort levels. Closed economies, however, are very different. There are poor closed economies with expensive capital, substantial wage inequality, and only high-effort jobs. There are wealthy communities that have cheap capital, high wages, and very low effort levels. Thus capital accumulation in a closed economy causes a decline in the rental rate of capital and an economic slowdown (literally), neither of which occurs in a small open economy facing fixed externally determined product prices.

*D. Increase in Industriousness/Reduction  
in Materialism*

A decrease in the disutility of effort (smaller  $\delta$ ) can be described emotively as a shift from humanism to materialism or, if you prefer, a shift from slothfulness to industriousness. Regardless of the words, industrious communities that have a smaller dislike of effort and a greater desire for goods have higher rental rates of capital, higher effort levels, and greater wage equality. These industrious communities do not necessarily have higher wages. Wages can be an inverted U-shaped function of industriousness. Increases of industriousness from very low levels necessarily increase wages; but for the more industrious communities, further increases in industriousness can drive up the rental rate of capital, and wages net of capital costs can fall.

A surprising feature of this model is that materialistic/industrious communities have comparative advantage in the *labor*-intensive good. Indeed the relative supply of the capital-intensive good compared with the labor-intensive good is a monotone *decreasing* function of industriousness. This is not so surprising if one realizes that in the most industrious communities, effort levels are nearly the same in both sectors and equal to the maximum  $e_{\max}$ . It is the less industrious communities that have unequal effort levels and, by implication, relatively more effort in the capital-intensive sector (proofs available on request).

#### **IV. Labor Market Interventions**

Two labor market institutions are discussed in this section: minimum wages and collective bargaining. A minimum wage that is binding for

the low-wage, low-effort contracts makes workers worse off because it forces the effort levels up and increases the demand for capital. Collective bargaining, on the other hand, limits the effort levels, reduces the demand for capital, and makes workers better off because the rental cost of their equipment falls.

### A. *Minimum Wages*

Most economists have been trained with a simple partial equilibrium model to associate minimum wages with unemployment.<sup>8</sup> One basic shortcoming of this thinking is that the labor contract is assumed to be one-dimensional, stipulating wages but nothing about working conditions. If the contract is multidimensional, a law that fixes a lower bound for one aspect of the contract is likely to be met by adjustments to other aspects of the contract. If effort is variable, a minimum wage could generate just enough extra worker effort to compensate for the increased wage level, thereby keeping everyone employed. That is an unsurprising implication of a model with variable effort, but the general equilibrium model presented here has an additional effect. The increased effort is like an increase in labor supply, which increases the demand for capital and raises its return, not just in the directly affected sector but in the capital-intensive sector also. It is therefore capital, not labor, that gains from the minimum wage. The increase in the capital rental rate forces down wages in the high-wage, high-effort capital-intensive sectors. Because of this increase in the cost of capital, the representative worker is made worse off by the minimum wage, but realized earnings are more equal: higher in the low-wage, low-effort jobs because of the minimum wage and lower in the high-wage, high-effort jobs because of the rise in the cost of capital.

The contracts applicable before and after the imposition of a minimum wage are illustrated in figure 3. The initial impact of the minimum wage is to drive out of existence the labor-intensive sector. Those unemployed workers seeking employment in the capital-intensive sector drive up the price of capital, thus lowering wages and forcing up effort in the high-wage, high-effort contracts. If the minimum wage is high enough, then both sectors have the same wage-effort contract.

<sup>8</sup> Card and Krueger (1995) have attracted the wrath of the profession for suggesting that they cannot find unemployment induced by a minimum wage. In the model presented here with fixed input intensities, there is no possibility of unemployment and indeed no change in employment levels in either sector. If input intensities were variable, there would be a shift of employment away from the low-wage, labor-intensive sector affected directly by the minimum wage.

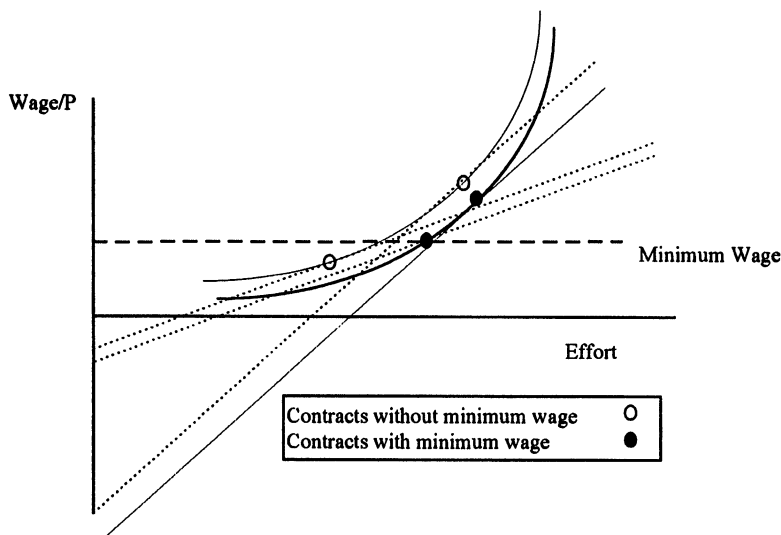


FIG. 3.—Effect of a minimum wage

### B. Collective Bargaining

A collective bargaining agreement stipulates both the wage level and the conditions of work, which in this paper are the level of effort. Economywide collective bargaining would eliminate all diversity of contracts and would require all workers to have the same effort and wage. Most potential common contracts do not allow both sectors to operate competitively and would therefore cause unemployment of one factor or the other. Given the rental cost of capital, the intersection of the two zero-profit lines identifies the only wage-effort combination that is compatible with production of both products. As the cost of capital shifts the zero-profit lines up and down, their intersection varies on a line through the origin. This sweeps out the set of full-employment collective bargaining contracts. As a function of the rate of return to capital, the effort  $e$  and wage rate  $w(e)$  that can support both products are solutions to the two zero-profit conditions  $w = (p_i e - r A_{Ki}) / A_{Li}$ . Solving out the rental rate  $r$  determines the line of common contracts:

$$w = e \left( \frac{p_1}{A_{K1}} - \frac{p_2}{A_{K2}} \right) \bigg/ \left( \frac{A_{L1}}{A_{K1}} - \frac{A_{L2}}{A_{K2}} \right),$$

which is depicted as the dark line in figure 4. Contracts on this line are compatible with the operation of both sectors, given a suitable cost of capital. Contracts above this line are compatible with the exis-

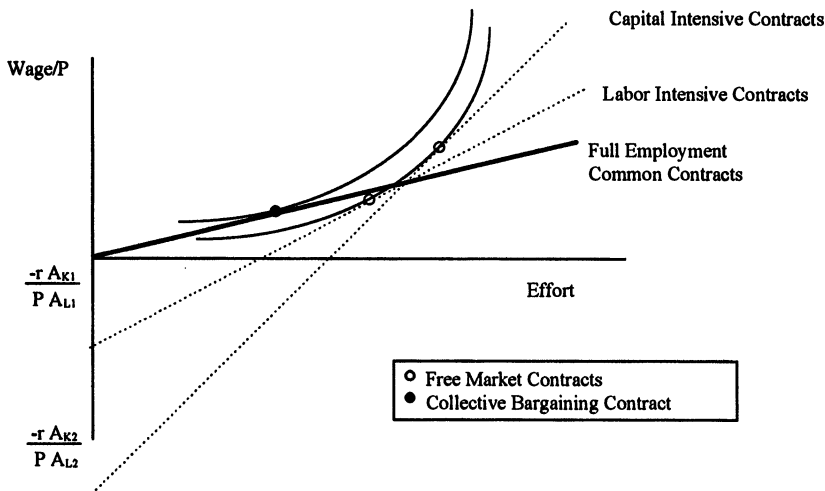


FIG. 4.—Collective bargaining

tence of only the capital-intensive sector. Contracts below this line are compatible with the existence of only the labor-intensive sector. If wages are very high compared with effort, then neither sector is viable.

The dark dot in figure 4 is the workers' optimal collective bargaining contract with full employment. The line of full-employment contracts is like a zero-profit line when capital is costless. Thus in choosing an effort level along the line of common contracts, workers behave as though capital were free, and they choose the minimal effort level  $e_{\max}/(1 + \delta)$ . With this very low common effort level comes lower wages in both sectors (proof available on request) but a higher utility level. Thus collective bargaining, unlike the minimum wage, makes workers better off. It comes with minimal effort levels and therefore lower output in both sectors. By forcing the effort levels to be the same in both sectors, collective bargaining creates comparative advantage in the *labor*-intensive sector.

V. Worker Earnings from Capital

Perhaps without your noticing, we have so far assumed that there are two kinds of humans: some who must work to live and others who receive the earnings from capital and do not work. This odd assumption can be rectified by explicitly allocating the capital earnings to individuals who can choose to work or not to work depending on their attitudes toward leisure and goods. In addition to the as-

sumptions regarding the ownership of capital, we need to be clear about who can use the capital. A feature of physical capital is that organized capital markets allow the separation of ownership and use. A worker who chooses leisure can rent his or her unused capital to other workers. Human capital is not marketable, however. If your parents decided to provide you an education, there is no way for you to transfer that education to me. This has important implications for the functioning of the economy. Both extreme assumptions regarding transferability will be explored in this section.

*A. Nonlabor Earnings with Transferable Capital:  
Specialization in Production*

If the country's capital stock is fully transferable, then earnings of worker  $j$  in sector  $i$  as a function of the effort level include the worker's share of capital rent:

$$w_{ij} = s_j r K + \frac{p_i e_i - r A_{Ki}}{A_{Li}} = r \left( s_j K - \frac{A_{Ki}}{A_{Li}} \right) + \frac{p_i e_i}{A_{Li}},$$

where  $s_j$  is the share of capital owned by worker  $j$ . The nonlabor earnings alter the basic equilibrium depicted in figure 1 by shifting upward the intercepts of both wage-effort lines by an amount equal to  $s_j r K$ . In addition, there is a third activity, leisure, which offers an earnings level of  $s_j r K$  and effort level zero. In order to find an equilibrium with nonlabor earnings, we need to vary the capital rental rate  $r$  and let the workers select among the three activities: leisure and work in one of the two sectors. An equilibrium balances the available capital supply with worker demands for the three activities. This equilibrium depends on attitudes toward effort as discussed above, but it also depends on the distribution of wealth. The preceding discussion is appropriate when there is a small set of capital owners who do not contribute to the labor supply either because they are too small in number to matter or because their earnings from capital are great enough to induce them to choose leisure.

This "capitalist" equilibrium contrasts with the egalitarian case now to be discussed in which all individuals are identical and share equally in the ownership of capital,  $s = 1/L$ . With an egalitarian distribution of capital, clearing the demand for capital requires workers to be indifferent between at least two of the activities. Except for special cases, the utility values of the three activities as a function of the capital rental rate do not cross at the same point, which means that only two of the activities are present in the equilibrium. If leisure is one of these two activities, then the economy produces only one of

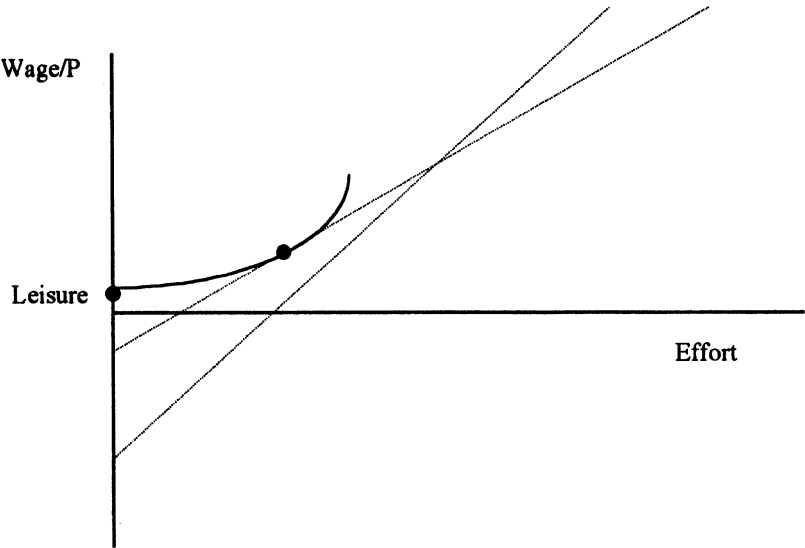


FIG. 5.—Equilibrium with leisure specialists: capital abundance too scarce to generate jobs for all.

the goods. This possibility is depicted in figure 5, which has workers indifferent between leisure and work in the labor-intensive sector. This could be an equilibrium if the per capita capital stock falls short of the capital intensity in the labor-intensive sector, in which case an appropriate number of individuals need to opt for leisure. This leaves the capital to worker ratio equal to the capital intensity in the labor-intensive sector.

In the traditional model with fixed input coefficients and fixed factor supplies, if the capital/labor supply ratio falls short of the capital intensity in both sectors, then labor is a redundant factor and commands a zero wage. But if the supply of workers is not perfectly inelastic, the wage rate need not go to zero. The model with leisure opportunities and nonlabor earnings has an upward-sloping labor supply curve. Thus with low levels of capital abundance, the economy specializes in the labor-intensive product and workers are indifferent between the two extant labor contracts: subsistence leisure or hard work at low pay.

When capital accumulates, the rental rate of capital declines, leisure disappears, and everyone works in one of the two sectors of the economy. When capital becomes even more abundant, leisure reemerges. Then only the capital-intensive sector operates, and the excess labor experiences high-paid leisure. The discussion in Sec-



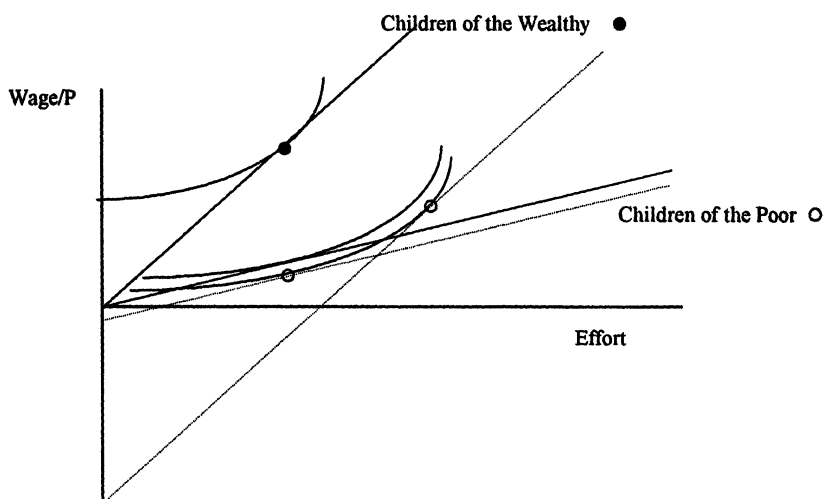


FIG. 6.—Effect of inheritance on earnings and effort

tion II of the two-sector model applies for moderately capital-abundant economies with enough capital to create jobs for all workers, but not so much that the economy can afford idle workers.

In case you have missed the central point: the distribution of wealth affects the supply of effort. There is a fat and lazy egalitarian society with relatively good working conditions but a low rate of return to capital and little incentive to accumulate further. This contrasts with a highly efficient capitalistic society with capital owned by a wealthy few, with a high rate of return to capital, and with demanding labor contracts enforced by an army of subsistence leisure specialists.

### *B. Nontransferable Capital Grants*

Next suppose that the capital is nontransferable either because organized capital markets do not exist or because human capital is literally embodied in workers. Since the capital is nontransferable and since the capital/labor intensity in each activity is fixed, we need to assume that some workers inherit from their (wealthy) parents enough nontransferable capital to support work in the capital-intensive sector, and others inherit only enough to support work in the labor-intensive sector.

Figure 6 depicts the contracts with and without capital charges.

When workers are not charged for the capital they use, the wage function in each sector is  $w_i = p_i e_i / A_{Li}$ . Given this wage function, the effort levels become  $e_i = e_{\max} / (1 + \delta)$ , the same relatively low level in both sectors. Thus inherited, nontransferable capital supports an equilibrium with low effort by everyone, but high wages in the capital-intensive sector for the children of the wealthy. The effort reduction of the wealthy is greater in the capital-intensive sector, and nontransferability creates comparative advantage in the labor-intensive sector, compared with similarly endowed economies in which capital is fully transferable and is all owned by a non-working capital class with numbers small compared with the workforce.

We have now considered three alternative assumptions regarding the ownership and transferability of capital. Most of this paper is built on the assumption that there is a small capitalist class that earns all the rents and chooses not to work. In the previous subsection, we discussed transferable physical capital that is equally owned by all workers. Finally, there is nontransferable human capital that is unequally owned by workers. The greatest levels of worker effort occur in the first case in which there is a small elite capitalist class and workers do not have any nonlabor earnings. If all the capital is owned equally by workers and if it is fully transferable, a capitalist class emerges when capital is sufficiently abundant. These capitalists are leisure specialists who use their capital earnings to support a relatively low standard of material well-being. The representative worker is indifferent between leisure specialization and working to increase material well-being. Finally, when workers inherit nontransferable capital, they do not have the option of choosing pure leisure because they have to do some work to survive; but because they do not "pay" for the capital, they choose the same low effort level in every activity. The effort reduction from inherited nontransferable capital is most pronounced in the capital-intensive sector, which is where the greatest effort would occur if the capital were rented at fair market value.

The first two of these ownership assumptions yield different but fully efficient outcomes. Nontransferability, however, causes inefficiencies because the grantees use their expensive capital with low levels of effort, whereas other workers would be willing to pay a premium to rent that expensive capital and exert high effort to pay back the rental costs. I repeat for emphasis: Nontransferable capital grants create economic waste by supporting a low-effort use of scarce capital. Public education in the absence of a work ethic is one example. State enterprises are another example. These state-owned or state-regulated enterprises suffer from the usual Averch-Johnson ef-

fect and choose excessively capital-intensive operations, but they also allow the capital to be used by low-effort workers.

## VI. Model Amendments

### A. *Nontraded Goods*

Next we can include some nontraded goods. In the traditional model of the small open economy with factor prices fully determined by global competitiveness conditions, it is straightforward to include nontraded goods in the model since the externally determined factor prices select the only price of nontradables compatible with zero profits. The same applies for the models with endogenous effort. The cost of capital is determined in the traded-goods sector as described by equation (11). This fixes the intercept of the wage-effort offer line for nontradables. The slope of this line of contracts in the nontradables sector can then be adjusted by varying the nontradables price to make the line tangent to the worker indifference curve that selected the two contracts in the tradables sector. This leaves unaffected the Stolper-Samuelson mapping of external product prices into the capital rental rate and the wage-effort contracts. The responsiveness of outputs to product price variability is, however, complicated by the fact that factor allocation system (2) applies to capital and labor net of what is used in nontradables.

### B. *Specialized Equilibrium*

Another kind of equilibrium has only one tradable and the rest of the factors allocated to the nontradables sector. For discussion we can assume that the nontradable uses only labor as an input: it is local services. Very labor abundant countries and countries with relatively little demand for local services absorb their workforce as best as they can by specializing completely in the labor-intensive tradable and deploying the residual labor force in local services. Very capital abundant countries and countries with high demand for local services do the opposite. They economize on labor by specializing completely in the capital-intensive tradable.<sup>9</sup>

<sup>9</sup> Specialized open economies have a reaction to external price changes different from that of diversified open economies. With Cobb-Douglas preferences, the price of the nontradable and the rental rate of capital are proportional to the price of the exportable. Thus a fall in the price of the exportable (a deterioration in the terms of trade) causes a proportional reduction in the rental rate on capital, the price of nontradables, and wages in both sectors but no change in effort levels. This coincidence of interests is a feature also of the usual specialized Heckscher-Ohlin model.

*C. Capital and Labor Mobility*

Another amendment to the model is free international capital mobility that fixes the capital rental rate. Then all countries with the same technologies offer the same set of wage-effort contracts in the tradables sectors. When they are faced with the same set of potential contracts, attitudes toward work completely determine comparative advantage. Communities with materialistic workers specialize their tradables production completely in the capital-intensive tradable and have high wages and exert high effort. Communities with humanistic workers specialize tradables production completely in the labor-intensive sector and have low wages and low effort levels. If the nontraded sector is labor intensive, then local services are relatively expensive in the high-wage materialistic communities.

Incidentally, the humanistic workers could benefit from moving to the materialistic communities, which offer attractive high-wage contracts in labor-intensive nontradables. Conversely, the industrious would prefer to move to the humanistic communities, where they can earn the same wages but can purchase cheap labor-intensive nontradables. Labor mobility in pursuit of the advantages of difference creates communities with mixed workforces, which are now analyzed.

*D. Heterogeneity in Attitudes toward Work*

Industrious communities have been shown to have high rental rates of capital, high effort levels, and high wages. This conclusion is altered somewhat if workers are heterogeneous. It remains true that communities with plentiful industrious workers have high rental rates of capital. But in these communities, workers of all types have higher effort and lower wages than in communities inhabited mostly by slothful workers. To make the argument, suppose that there are two types of workers, some who prefer the high-wage, high-effort contract and others who prefer the low-wage, low-effort contract. The empty circles in figure 7 then depict a potential equilibrium in which all the materialistic workers take jobs in the capital-intensive sector and all the humanistic workers take jobs in the labor-intensive sector. This is not likely to be an equilibrium because the number of jobs in each sector is completely fixed by the capital and labor allocation equations (3). If the number of jobs in the capital-intensive sector determined by (3) is smaller than the number of materialistic workers, then an equilibrium has to have materialistic workers willing to take jobs in the labor-intensive sector. This can be accomplished by raising the cost of capital, thus producing the contracts

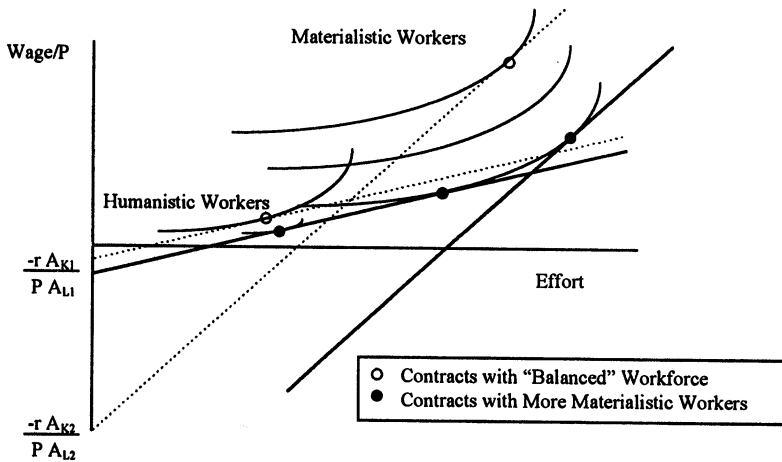


FIG. 7.—Heterogeneity in attitudes toward work

in the dark dots in figure 7. Here there are two kinds of operations in the labor-intensive sector. Some employ materialistic workers at high wages and high effort. Others employ humanistic workers at low wages and low effort. Alternatively, if humanistic workers are abundant, then the wage-effort lines shift the other way to induce indifference between the sectors by the humanistic. In this equilibrium, the capital rental costs are less, and all workers are better off. The message of this model is: don't work so hard, you are making us all worse off.

#### E. *Heterogeneity in Ability*

In figure 7 the humanistic workers take low-effort jobs in the labor-intensive sectors. This feature of the model will come as a great surprise to workers in labor-intensive sectors such as apparel. Most of them have the distinct impression that they are working longer hours and at a higher pace than almost anyone else in the economy. It is not difficult to adjust this model to produce an outcome more in line with the impressions of the apparel workers. Allow workers to differ in terms of ability instead of attitudes. Assume as in Leamer (1995, p. 11) that there are two kinds of workers. Both are equally productive in the labor-intensive sector, but some are especially productive in the capital-intensive sector. Inserting this new opportunity into our basic diagram produces figure 8. Because of the special ability, the compensation for effort for the more able worker in the capital-intensive sector is greater, and the line of wage-effort con-

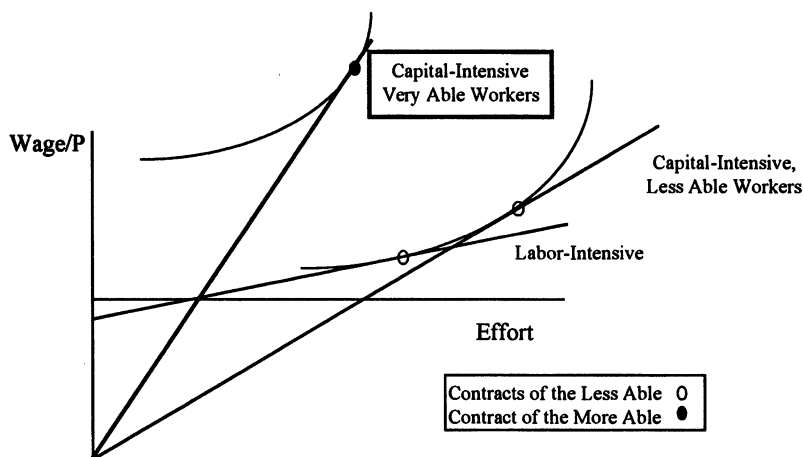


FIG. 8.—Differential compensation for the able and the less able when capital is cheap.

tracts steeper. What is depicted in the figure is an equilibrium in which the less able work hard in both the labor-intensive sector and the capital-intensive sector. The able take it easy in the capital-intensive sector but receive high wages anyway.

The equilibrium depicted in figure 8 does not have enough more able workers to fill all the jobs in the capital-intensive sector, and some less able workers are employed doing the same tasks but receiving lower wages commensurate with productivity. This applies when capital is abundant. If capital is very scarce, then there are too few available jobs in the capital-intensive sector to employ all the more able workers, and some of them have to find jobs in the labor-intensive sector. Thus capital accumulation creates opportunities for the able. Indeed, the less able gain little from the cheaper capital since they use inexpensive tools. See the same point in a model with fixed effort levels in Leamer (1995), but keep in mind that the opposite applies if ability matters in the labor-intensive sector (e.g., programming).

#### F. *More Products*

In the two-product, open-economy model that has so far been considered, capital accumulation affects the relative output levels but not the prevailing contracts. If there are more than two tradables, then capital accumulation can shift the product mix in favor of more capital-intensive sectors. In the usual Heckscher-Ohlin model (e.g., Leamer 1987), this shift in the “cone of diversification” comes with

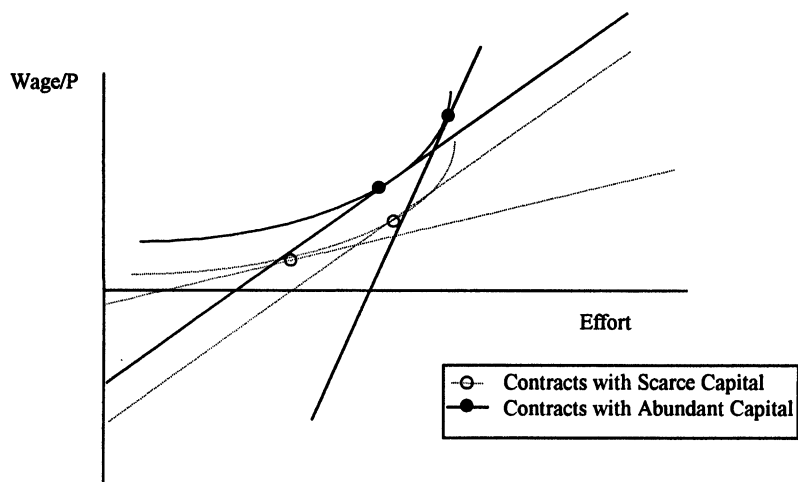


FIG. 9.—Product upgrading and economic acceleration from capital accumulation.

a decline in the rate of return to capital and an increase in the wage rate. The model with variable effort has an additional effect: the emergence of new high-wage, high-effort contracts in the new capital-intensive sector. This can mean that capital accumulation causes an economic acceleration, with greater effort and even higher wage rates. This is illustrated in figure 9, which has a capital-scarce equilibrium with a labor-intensive set of tradables and a capital-abundant equilibrium with a capital-intensive set of tradables. Although the decline in the cost of capital has raised wages and lowered effort for the contract in the moderately capital-intensive sector, the emergence of the new high-wage, high-effort contract in the very capital intensive sector has had the effect of speeding up the economy overall.

## VII. Empirical Evidence

This theory of effort helps to explain four sets of empirical facts: wage differences across industries, productivity differences across countries, the limited amount of capital flow to the low-wage developing countries, and (maybe) the increasing income inequality in the liberalized low-wage developing countries.

### A. Interindustry Wage Differences

Table 1 reports 1990 data on U.S. investment per worker and U.S., Japanese, and German earnings per worker.<sup>10</sup> These data are dis-

<sup>10</sup> Similar data for 1975 are reported in Leamer (1984, p. 29).

TABLE 1  
1990 DATA ON EARNINGS AND INVESTMENT PER WORKER

SECTOR	INVESTMENT PER WORKER: UNITED STATES	EARNINGS PER WORKER		
		United States	Japan	West Germany
322 Wearing apparel, except footwear	582	13,408	12,921	18,683
324 Footwear, except rubber or plastic	746	14,776	19,704	21,928
323 Leather products	1,458	17,917	18,208	20,239
321 Textiles	3,269	18,251	18,639	23,849
332 Furniture, except metal	1,416	18,630	21,583	27,542
331 Wood products, except furniture	2,717	19,862	20,287	25,332
390 Other manufactured products	1,951	19,919	22,697	23,508
361 Pottery, china, earthenware	2,895	21,842	21,721	22,733
311 Food products	5,769	21,928	18,790	24,102
356 Plastic products	5,090	22,269	23,522	27,038
381 Fabricated metal products	2,914	24,580	26,632	29,000
342 Printing and publishing	3,778	25,234	31,775	32,268
369 Other nonmetallic mineral products	4,945	25,687	26,249	30,533
355 Rubber products	5,122	26,146	27,990	30,592
362 Glass products	6,525	27,092	30,586	28,948
383 Machinery, electrical	6,061	28,397	25,457	31,603
372 Nonferrous metals	7,814	29,919	32,118	31,565
382 Machinery, except electrical	4,322	29,976	31,124	33,550
341 Paper products	17,966	30,644	27,169	29,200
313 Beverages	8,540	30,949	25,106	31,583
354 Miscellaneous petroleum and coal products	8,500	32,000	31,655	35,836
352 Other chemicals	9,299	32,371	34,968	28,901
385 Professional and scientific equipment	4,468	33,204	26,795	31,436
371 Iron and steel	8,571	33,680	38,579	35,359
384 Transport equipment	6,003	33,084	33,722	34,976
314 Tobacco	6,829	37,073	60,800	41,470
351 Industrial chemicals	27,388	38,010	38,931	47,333
353 Petroleum refineries	53,056	44,444	47,359	31,236
300 Total manufacturing	5,804	26,911	26,367	

SOURCE.—INDSTAT3, Unido data base (1996)



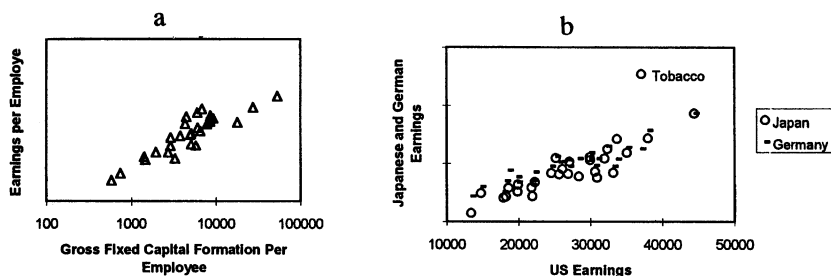


FIG. 10.—Data in table 1. *a*, U.S. wages and investment per employee. *b*, U.S., Japanese, and German earnings per employee.

played in figure 10. Panel *a* reveals the close relationship between wages and capital intensity in the United States, exactly what the theory of effort suggests: the high-wage, high-effort jobs are in the capital-intensive sectors, where effort saves the most capital costs. This relationship between wages and physical capital intensity also suggests complementarity between human capital and physical capital. However, after one controls for educational differences and working conditions, there remain very large differences in wages across firms and industries. This fact has given rise to a literature on “efficiency wages” (e.g., Dickens et al. 1989; Katz and Summers 1989). The theory of efficiency wages alludes to the difficulties in observing worker performance and the need to overpay workers who are infrequently monitored to encourage the highest level of effort. If monitoring costs were the key determinant of interindustry wage premia, one would expect the industrial distribution of wages to differ across countries with different cultural attitudes toward work. But panel *b* of figure 10 shows that the sectoral distributions of wages in Germany and Japan are almost identical with those of the United States. I take this as modestly supportive evidence that it is the need to put capital in the hands of high-effort workers per se, not monitoring problems, that causes the interindustry distribution of wages.

A companion paper by Leamer and Thornberg (in press) shows that in the United States there is not only a substantial correlation of wages with capital intensity but also a substantial correlation of hours with capital intensity. It is the capital-intensive sectors in which the long-hour, high-wage contracts occur, exactly what would be expected from this theory of effort.

Incidentally, not all the evidence points in favor of effort. Most of this paper uses the assumption of a representative worker, which implies that high wages are merely compensation for high effort. The efficiency wage literature, in contrast, has workers preferring

the high-wage jobs: that is what makes the contract work to ensure maximum effort with incomplete monitoring. As the efficiency wage literature suggests, Andrew Clark (1996) finds that British wage premia across sectors are correlated with satisfaction premia. What really matters, of course, is not what workers say, but what they do. I am assuming that workers can and do move between high-wage and low-wage jobs. The time frame in which this assumption applies may be a worker's lifetime.

### *B. Cross-Country Differences in Productivity*

Another empirical puzzle answered by the theory of effort is, Why doesn't capital flow to the low-wage countries? Lucas (1990) has stimulated a cottage industry, producing models with increasing returns to scale to answer this question. The theory of effort described here offers one simple answer. The low-wage countries have humanistic workers who prefer low-effort contracts, and the rates of return to capital are accordingly low. If there is a flow, capital seeks communities with workers who are willing to work hard. These communities can have high productivity and high wages.

The notion that effort is greatly variable across countries causes many eyebrows to rise, but Gregory Clark (1987a, 1987b, 1989) answers "effort" to his title question: "Why Isn't the Whole World Developed? Lessons from the Cotton Mills." He finds that "in 1910 one New England textile operative performed as much work as 1.5 British, 2.3 German and nearly 6 Greek, Japanese, Indian or Chinese workers. Input substitution, and differences in technology, management, and workers' training or inherent abilities do not explain this. Instead local culture seems to have determined worker performance" (1987b, p. 141). This efficiency came mostly from the number of machines each worker tended, varying from 0.46 in Greece to 2.97 in New England. Clark points out that if this were capital-deepening, then the ratio of output per machine should be higher where greater labor is used. In fact, the "low-wage countries were not getting greater utilization of their capital except through running longer hours" (p. 153).

Moreover, there is ample evidence of productivity differences across countries that may be partially explained by effort levels. For example, Dollar and Wolff (1993, p. 157) report that Korean labor productivity in 1986 relative to that of the United States varied from a low of 21 percent in food products to a high of 67 percent in petroleum and 58 percent in iron and steel.<sup>11</sup> Dollar (1991) found

<sup>11</sup> These numbers admittedly are not total factor productivity figures and do not account for differences in capital per worker.

that productivity in Korea achieved two-thirds of the German level by 1978. Two-thirds of the convergence over the 1966–78 period came from capital-deepening and one-third from convergence of total factor productivity, which may be partly technological and partly increases in effort. Capital-deepening was relatively important in the heavy industries and total factor productivity convergence relatively important in the light industries.

*C. Rising Inequality and Productivity Convergence in the Low-Wage Liberalizing Economies*

Finally, there is the increasing income inequality that has been shown to exist in the liberalizing developing countries. A simple Heckscher-Ohlin-Samuelson model with two factors suggests that economic integration of the developed and developing countries will drive down wages of the unskilled labor in the high-wage countries but drive up wages in the low-wage countries; in other words, income inequality will worsen in the high-wage countries but improve in the low-wage countries. Leamer (1998) finds Stolper-Samuelson increases in inequality in the United States in the 1970s. But Robbins (1995) cites a number of studies of liberalizations in Chile, Argentina, Colombia, and Costa Rica that also suggest that increasing trade is associated with increasing wage dispersion. Likewise, anecdotal evidence from Eastern Europe suggests that some workers are doing extremely well, but others have been much hurt by the collapse of Communism.

In the traditional two-good, two-factor model, it is the rise in the relative price of the labor-intensive sector following an economic liberalization that causes an increase in the real wage rate. This same Stolper-Samuelson force in favor of greater equality of incomes is operative in the model with effort. But the theory of effort has two other possible explanations for the rise in inequality in Eastern Europe and South America. (1) Prior to liberalization, the labor market institutions did not allow much compensation for effort. This is the collective bargaining solution. (2) Prior to privatization, the state-supported firms did not “feel” the cost of capital. Either the elimination of centralized wage setting or the full charging of firms for capital can steepen the wage-effort profile, and workers with ambition and industriousness can receive substantial increases in compensation.

## References

- Auernheimer, Leonardo, and Rumbos, Beatriz. “Variable Capital Utilization in a General Equilibrium, ‘Supply Side’ Model.” Working paper. College Station: Texas A&M Univ., 1996.

- Averch, Harvey, and Johnson, Leland L. "Behavior of the Firm under Regulatory Constraint." *A.E.R.* 52 (December 1962): 1052-69.
- Betancourt, Roger; Clague, Christopher K.; and Panagariya, Arvind. "Trade and Factor Prices in a Model of Capital Utilization." *Southern Econ. J.* 50 (January 1984): 734-42.
- Bischoff, Charles W., and Kockelenberg, Edward C. "Capacity Utilization and Depreciation-in-Use." *Appl. Econ.* 19 (August 1987): 995-1007.
- Calvo, Guillermo A. "Efficient and Optimal Utilization of Capital Services." *A.E.R.* 65 (March 1975): 181-86.
- Card, David E., and Krueger, Alan B. *Myth and Measurement: The New Economics of the Minimum Wage*. Princeton, N.J.: Princeton Univ. Press, 1995.
- Clark, Andrew E. "Job Satisfaction in Britain." *British J. Indus. Relations* 34 (June 1996): 189-217.
- Clark, Gregory. "Productivity Growth without Technical Change in European Agriculture before 1850." *J. Econ. Hist.* 47 (June 1987): 419-32. (a)
- . "Why Isn't the Whole World Developed? Lessons from the Cotton Mills." *J. Econ. Hist.* 47 (March 1987): 141-73. (b)
- . "Why Isn't the Whole World Developed? A Reply to Hanson." *J. Econ. Hist.* 49 (September 1989): 707-14.
- Copeland, Brian R. "Efficiency Wages in a Ricardian Model of International Trade." *J. Internat. Econ.* 27 (November 1989): 221-44.
- Deardorff, Alan V., and Stafford, Frank P. "Compensation of Cooperating Factors." *Econometrica* 44 (July 1976): 671-84.
- Dickens, William T.; Katz, Lawrence F.; Lang, Kevin; and Summers, Lawrence H. "Employee Crime and the Monitoring Puzzle." *J. Labor Econ.* 7 (July 1989): 331-47.
- Dollar, David. "Convergence of South Korean Productivity on West German Levels, 1966-78." *World Development* 19 (February-March 1991): 263-73.
- Dollar, David, and Wolff, Edward N. *Competitiveness, Convergence, and International Specialization*. Cambridge, Mass.: MIT Press, 1993.
- Ghiselin, Michael T. "The Economy of the Body." *A.E.R. Papers and Proc.* 68 (May 1978): 233-37.
- Jones, Ronald W. "The Structure of Simple General Equilibrium Models." *J.P.E.* 73 (December 1965): 557-72.
- Katz, Lawrence F., and Summers, Lawrence H. "Industry Rents: Evidence and Implications." *Brookings Papers Econ. Activity: Microeconomics* (1989), pp. 209-75.
- Leamer, Edward E. *Sources of International Comparative Advantage: Theory and Evidence*. Cambridge, Mass.: MIT Press, 1984.
- . "Paths of Development in the Three-Factor, *n*-Good General Equilibrium Model." *J.P.E.* 95 (October 1987): 961-99.
- . *The Heckscher-Ohlin Model in Theory and Practice*. Princeton Studies in International Finance, no. 77. Princeton, N.J.: Princeton Univ., Dept. Econ., February 1995.
- . "In Search of Stolper-Samuelson Effects on US Wages." In *Imports, Exports, and the American Worker*, edited by Susan M. Collins. Washington: Brookings Inst., 1998.
- Leamer, Edward E., and Thornberg, Christopher F. "Effort and Wages: A New Look at the Inter-industry Wage Differentials." In *The Impact of International Trade on Wages*, edited by Robert C. Feenstra (in press).
- Leibenstein, Harvey. "Aspects of the X-Efficiency Theory of the Firm." *Bell J. Econ.* 6 (Autumn 1975): 580-606.

- Lucas, Robert E., Jr. "Why Doesn't Capital Flow from Rich to Poor Countries?" *A.E.R. Papers and Proc.* 80 (May 1990): 92–96.
- Robbins, Donald J. "Trade Liberalization and Earning Dispersion—Evidence from Chile." Manuscript. Cambridge, Mass.: Harvard Inst. Internat. Development, May 1995.
- Rosen, Sherwin. "Specialization and Human Capital." *J. Labor Econ.* 1 (January 1983): 43–49.
- Smith, Adam. *An Inquiry into the Nature and Causes of the Wealth of Nations*. 1776. Reprint. World's Classics series. Oxford: Oxford Univ. Press, 1993.