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EFFORT, WAGES AND THE INTERNATIONAL DIVISION OF LABOR

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ABSTRACT

This paper embeds variable effort into a traditional multi-sector model. Effort enters a production function like total-factor-productivity and on the assumption that effort doesn't 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. Among the implications of the model are:

- The capital savings from effort are greatest in the capital-intensive sectors which is where the high-effort high-wage contracts occur.
- Communities inhabited by industrious workers have high returns to capital and comparative advantage in capital-intensive goods.
- Capital accumulation in a closed economy causes reductions in effort. Capital accumulation in an open economy creates new high-wage high-effort jobs and higher effort levels.
- Price declines of labor intensive goods twist the wage-effort offer curve, lowering the compensation for low-effort work but increasing the reward for hard work.
- A deterioration in the terms of trade causes an economy-wide reduction in effort.
- A minimum wage does not cause unemployment. It forces effort in local services up high enough to support the higher wage. This acts like an increase in labor supply which increases the return on capital. A minimum wage by forcing greater effort increases GDP and reduces earnings inequality, but it makes workers worse off since they prefer the contracts offered by the free market.

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Effort, Wages and the International Division of Labor [1]

by

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In the United States, elevators wait for 10 seconds before the doors automatically close. In Hong Kong elevators wait for only 4 seconds.

This paper embeds variable effort into a traditional multi-sector model. Equipment is assumed to be operable at different speeds and for different numbers of hours during the day. Workers are assumed to prefer low-speed operations and fewer hours. The labor market thus offers a set of wage-effort contracts with higher wages offsetting the disutility of higher effort. It is also assumed that capital depreciation does not depend on the speed of operations or the number of hours of operation. High effort operations thus save capital costs. A competitive labor market passes the capital-cost savings on to those workers who are willing to exert high effort. These savings are greatest in the capital-intensive sector.

The most familiar setting in which the details of the model apply is the rental market for equipment for home improvements. Items like hammers and screwdrivers with a low rental cost are allowed to sit idle much of the time. Equipment like moving vans and floor sanders that are expensive to rent are ordinarily operated more-or-less constantly and as fast as we can get our helpers to move.

Formally, the models presented here assume 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. Production functions are written as $Q = e\,F(K,L)$ where Q is daily output, K is the stock of capital used in production, L is

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the number of workers, F(. ,.) is a production function exhibiting constant returns to scale and e is the level of effort, equal to the product of pace times hours worked. The effort variable looks like a factor-neutral technological multiplier also known as total factor productivity. The traditional approach treats total factor productivity as a mysterious gift from heaven. Here is it a choice variable of the economy.

Three different multi-sector equilibria are discussed. First there is a closed economy with all products made and sold at home. Second is a small open economy with prices of tradables fixed in the external marketplace and with a sufficiently diversified mix of home-produced tradables that local factor prices are set completely by external competitiveness conditions. Third is a small open economy with a concentrated mix of tradables and with factor prices that depend on the demand for nontradables.

From this framework are derived a variety of interesting implications.

- The capital savings from effort are greatest in the capital-intensive sectors which therefore offer 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 as in the efficiency wage literature.
- If capital is interpreted as human capital, 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.[3] This contrasts with the signaling model of education which, like the monitoring problems associated with efficiency wages, is based on the unobservability of worker characteristics by employers. The effort model is more like a model with heterogenous ability-to-learn.
- Communities inhabited by industrious workers who are willing to exert high effort for high wages have high returns to capital and correspondingly lower wages for any given effort level. These communities attract capital and have comparative advantage in capital-intensive goods. This explains why capital doesn't necessarily flow like Niagara Falls from North to South.

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[3] This effort effect should be present only for human capital that is "rented" at full market value, that is to say self-financed, not that which is provided gratis by another party such as a parent or a government.

- Capital accumulation that lowers the cost of capital increases the wage offered at every level of effort. Workers thus experience a wealth effect that allows them to select both higher wages and lower effort. A closed economy has a substitution effect also in favor of lower effort because prices fall for the capital-intensive goods which causes a like decline in the marginal compensation for effort. An open economy has a substitution effect in the opposite direction in favor of higher effort because it shifts its output mix in favor of more capital-intensive goods. Growth, with closedness, thus causes senescence. Growth, with openness, creates new high-wage high-effort jobs.
- Price declines of labor intensive goods twist the wage-effort offer curve, lowering the compensation for low-effort work but increasing the reward for hard work. Thus increased competition with the emerging third world adversely affects only the low-effort workers who find themselves having to work harder to maintain their living standards. High-effort workers are made better off by the increased marginal compensation for effort in high-wage high-effort jobs in the capital-intensive sector.
- A deterioration of the terms of trade of an economy with a specialized set of tradables causes a like decline in the return on capital. The consequent reduction in the demand for nontradables causes a reduction in the price of local services. Workers then opt for lower pay and lower effort in the local service sector. Workers also suffer wage reductions in the tradables sector and may reduce effort there as well. In words, a deterioration in the terms of trade causes an economic slowdown, literally.
- If workers differ in terms of their innate ability and if ability affects productivity in only the capital-intensive sector, then capital-poor economies have the able and the less able working together in the labor-intensive sector (apparel) and receiving the same compensation. Capital accumulation causes inequality by creating high-paying high-effort jobs that require high ability. If capital is abundant, it is possible to have an equilibrium in which less able workers are exerting great effort in the labor-intensive sector (apparel sweat shops) while the more able exert less effort and have higher pay in the capital-intensive sector.

- A minimum wage that is binding for local labor services does not cause unemployment. It forces effort in local services up high enough to support the higher wage. This increase in the effective labor supply causes the return on capital to be bid up which in turn causes a reduction in wages and an increase in effort in the high-wage high-effort jobs in the tradable sector that is not directly affected by the minimum wage. The greater effort in both the tradables sector and the local service sector means that output levels rise in both. Thus a minimum wage increases GDP and reduces earnings inequality, though it makes the representative worker worse off.
- Country-wide centralized bargaining may improve working conditions for the slothful, but if it is organized to maintain employment levels, the industrious are forced to accept jobs they regard to be inferior in terms of wages and effort.

Variable effort can help us understand a variety of empirical facts and puzzles . One is the rising income inequality in the liberalizing developing countries. A familiar implication of the simple two-good two-factor Heckscher-Ohlin model is that the abundant factor benefits from free trade but the scarce factor is hurt. This seems to suggest that the liberalizations that have swept the globe will have different effects on skilled and unskilled workers in the skill-scarce South than in the skill-abundant North. The HO theory apparently suggests that skilled workers will gain in the North but lose in the South. The facts are otherwise. While skilled workers in the North are receiving increased wage premia over their low-skilled counterparts, skilled workers in Chile, Costa Rica, Columbia, Mexico etc. are also gaining.(Robbins(1995)) How can this be? Is the Heckscher-Ohlin model fundamentally at fault? The simple 2 by 2 Heckscher-Ohlin model can't explain these facts, but a skillfully designed higher dimensional Heckscher-Ohlin model is compatible with just about anything. A three-factor multi-cone model will do the job. Another explanation is offered by a model with variable effort. A closed economy may opt for a completely low-effort solution with low wages and low compensation for human capital. Following opening, high-pay high-effort jobs may be created in either the labor-intensive or the capital-intensive sectors depending on

the supply of human capital. In both cases the impact of this is to raise the reward to effort and skills, and to lower the compensation for low-effort low-skilled jobs.

Another empirical anomaly is that, after controlling 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. Katz and Summers (1989) and Dickens et.al. (1989) and Copeland(1989), the last presenting a Ricardian model of international trade with efficiency wages. The theory of efficiency wages usually alludes to the difficulties in monitoring worker performance and the need to overpay workers who are infrequently monitored in order to assure the highest level of effort. The theory of effort here is very close in spirit to the theory of effort associated with the literature on efficiency wages. In both cases, high wages are compensation for effort. In the case of efficiency wages it is monitoring problems that give rise to high wages. Here it is strictly capital costs.

Endogenous effort eliminates the X in Leibenstein's X-efficiency, the mysteriously large differences in total factor productivity across countries. The model with variable effort answers Lucas'(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 basic model is introduced in the next section. Three different kinds of equilibria are discussed: A closed economy, a diversified small open economy with enough tradables that the demand for nontradables doesn't affect factor prices and a specialized open economy with nontradables that matter. Separate sections discuss capital accumulation, cultural attitudes toward work, changing prices of tradables, capital mobility, ability differences, minimum wages and collective bargaining. The concluding section discusses some data that compares 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. This conforms with the basic prediction of the model that wages should be high in capital-intensive sectors. Efficiency wage theories based on monitoring problems in principle can offer the same prediction, but they need to explain why the monitoring problems are so similar in the US, Germany and Japan that they

produce the same inter-industry wage differences. This brief reference to data is only a footnote in a long theoretical paper, and, of course, is only one very small step toward providing some empirical support for the theory presented here.

The argument in the text is entirely graphical and therefore limited and somewhat uncomfortable for those who prefer algebra. In addition, two-dimensional paper doesn't work well for depicting three-dimensional preferences and the graphical analysis is therefore based on the assumption that workers trade effort for consumption of only one good. A formal algebraic model is presented in an appendix and used to explore many of the results claimed in the body of the paper. The model allows workers to consume both nontradables and tradables. The algebraic model also allows substitutability between capital and labor, whereas the graphical treatment is entirely based on fixed input ratios.

2.0 Compensation for Effort in a Multi-Sector Model

This section presents a multi-sector model with endogenous effort levels. With s = speed of operations, h = daily hours of operation and e = effort, the production function is written as

$$Q = s\,h\,F(K,L) = e\,F(K,L) \tag{1}$$

where Q is the daily rate of output per unit of time, K is the (timeless) stock of capital used in production, L is the (timeless) stock of labor input and F(.,.) is a production function exhibiting constant-returns-to-scale. The effort variable e is the product of hours worked times pace of operations. "Pace" is not literally speed as measured by a clock-watch, but instead stands for human effort that increases equally the productivity of capital and labor time. For example, it might be attentiveness, which makes breakdowns of the equipment 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 that work is organized. A production function describing equipment sharing from multi-shift or weekend work could be written 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, multi-shift operations save capital costs and would certainly be adopted if workers didn't care. But worker preference for the first shift would require wage premia in the evening and graveyard shifts. The use of the multi-shift production function in place of (1) would alter the details of this paper but not the principle messages that come from the fact that the potential savings are greatest in the capital-intensive sector, which is where the high-effort high-wage jobs will occur.

We will make two additional assumptions about effort. First, capital doesn't care about the effort level; long hours of use at high speed doesn't wear out the equipment. Workers do care; they prefer low effort. Although workers may have attitudes regarding the relative undesirability of hours and pace, for our purposes all that matters is their willingness to trade effort (hours times pace) for goods. The second assumption is that

the effort level e is continuously and completely variable. A sewing machine can make 10 stitches a minute or a million stitches. It wouldn't be difficult to alter the theory below to restrict the values of hours and pace in some sectors. My 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 worked. Even if hours on the job is fixed by social convention at 40 hours per week, hours "actually worked" can still vary substantially, but of course not without limits.

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 Auerheimer 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 inter-temporal capital-usage questions. It is based on the opposite assumption that labor doesn't care about the intensity of work. Deardorff and Stafford(1976), on the other hand, provide a framework that would 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.

With the assumption that capital doesn't care about effort, a competitive labor market will award the marginal increase in output all to the workers willing to operate at the higher effort level. Entry of firms will allow a set of wage-effort contracts, all of which award the firms zero profits. The wage rate w(e) applicable to effort e is thus a solution to a zero profit inequality

$$e\ p\ F(K,L) \geq rK + w(e)L$$

where p is the price of the product, r is the capital rental rate per day, w(e) is the daily wage for workers operating at effort e. This can be inverted to solve for the wage offer:

$$w(e) \leq (pFe / L - rK / L) = (pfe - rk)$$

where pf is labor productivity for e = 1 workers and k is the capital/labor ratio. To facilitate the graphs and the algebra, the capital intensities are now assumed to be

technologically fixed. A simulation with Cobb-Douglas production functions is presented in the appendix.

Suppose initially that the economy has two sectors, a labor intensive sector (Apparel) and a capital intensive sector (Machinery). If both of these goods were consumed and if effort mattered, worker utility would have three arguments, and two-dimensional diagrams would not capture the whole story. To allow diagrammatic discussion, we need to assume that only apparel is consumed and that sectors make real wage offers in terms of the apparel good

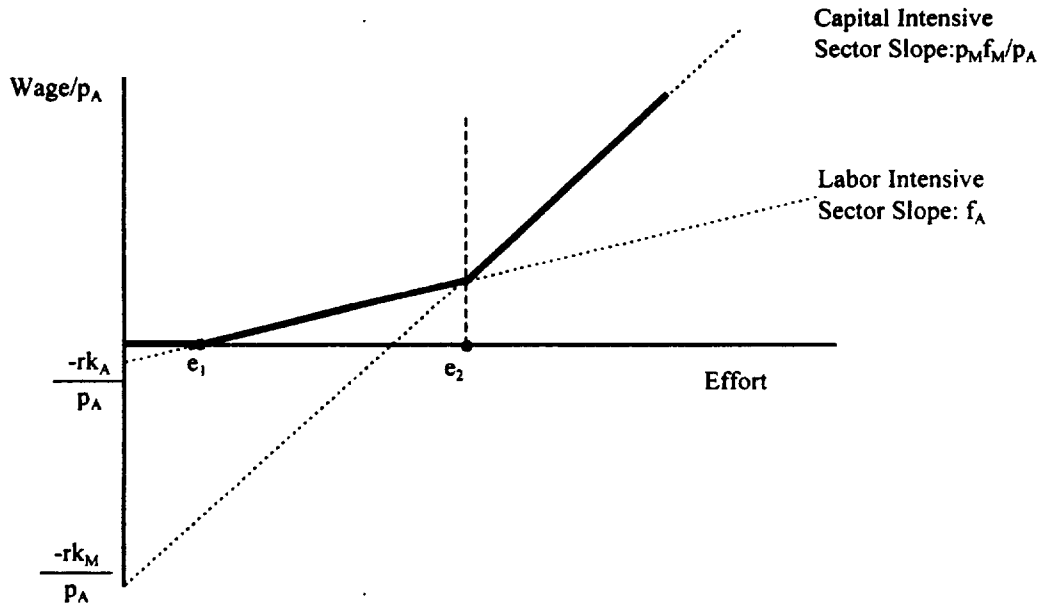
$$\frac{w(e)}{p_A} \leq (f_A\, e - \frac{r}{p_A} k_A)$$

$$\frac{w(e)}{p_A} \leq (\frac{p_M}{p_A} f_M\, e\ - \frac{r}{p_A} k_M)$$

These two non-negative profit inequalities are depicted by two straight lines in Figure 1.

Figure 1

Rising Compensation for Effort in a Two Sector Model



Both zero-profit lines have negative intercepts since at very low effort levels the value of output is not enough to cover the capital rental costs and these losses must be covered by charging workers to work. The intercepts of the zero-profit lines are proportional to the

capital intensities and thus more negative in the capital intensive sector. As the effort increases, workers can be awarded higher wages in both sectors because effort saves capital rental costs. The marginal capital savings from effort are greatest in the capital-intensive sector which has the zero-profit line with the higher slope. Labor contracts will lie along the upper envelope of these wage offers, which is the heavy piece-wise linear curve depicted in Figure 1. The low-effort contracts between e_1 and e_2 are offered in the labor-intensive sector. Contracts with effort levels above e_2 are offered in the capital-intensive sector.

A representative worker and a third sector (textiles) are added to the model in Figure 2. An indifference curve of a representative worker is shown tangent to the zero profit lines of the three sectors. Each point of tangency, depicted as a dark dot, selects a labor contract, a wage-effort combination. These three contracts are ordered from lower left to upper right in the figure. In words, the effort level increases with the capital-intensity of the sector and the wage rate increases by just enough to make the representative worker indifferent among the three contracts.

Figure 2

Equilibrium in a Three Sector Closed Economy

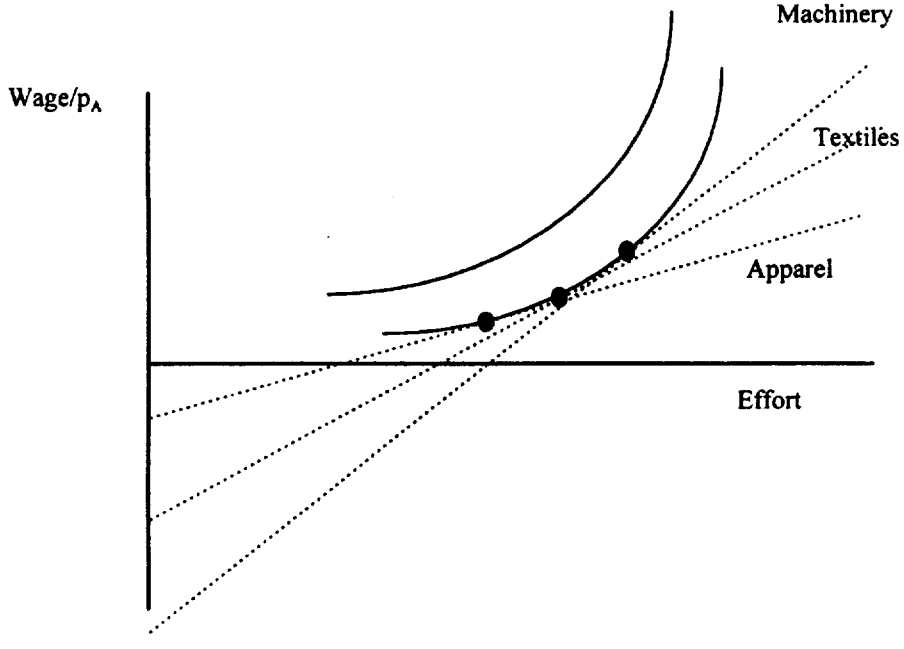


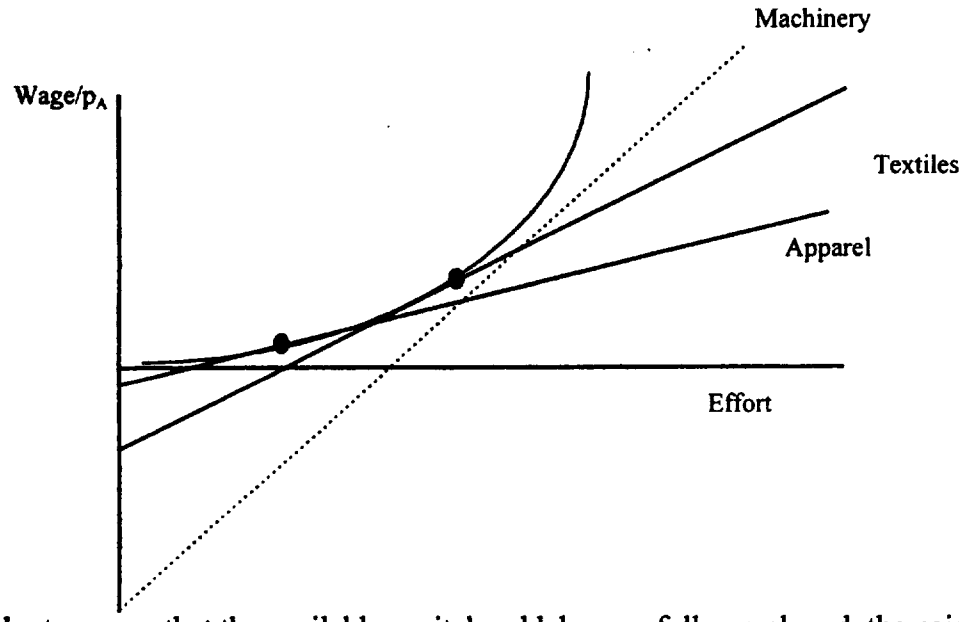
Figure 2 depicts one of a continuum of possible closed-economy equilibria, each one selecting wage-effort contracts along a different worker indifference curve. An economy that selected the other worker indifference curve in Figure 2 would have a higher cost of capital and lower relative prices for the capital-intensive goods, textiles and machinery. An algorithm for drawing the equilibrium is as follows. First place the apparel zero-profit line tangent to the worker indifference by varying the intercept of the line while the slope is held constant, which is fixed technologically. The intercept of the apparel zero-profit line selects the cost of capital, r/p_A, which positions the intercepts of the other two zero-profit lines. Then vary the slopes of these other two lines by changing the relative product prices until the lines are tangent to the same worker indifference curve. Among the equilibria differing in terms of the cost of capital, the one is selected that equates the supply of capital with the demand. More on this below when we discuss capital accumulation.

Specialized Production Set of a Small Open Economy

A small open economy has a much more limited set of possible equilibria because the prices of tradables are set in external marketplaces. This fixes the slopes of the zero-profit lines and allows only the intercepts to vary proportionately with capital costs. Given these fixed slopes, most countries will find themselves in specialized equilibria such as the one depicted in Figure 3

Figure 3

Equilibrium for Labor-Abundant, Small Open Economy



In order to assure that the available capital and labor are fully employed, the pair of products selected by the tangency conditions must have capital/labor ratios that capture the capital/labor supply ratio. Thus Figure 3 is labeled as an equilibrium for a labor-abundant country since it excludes the capital-intensive good. [1]

Nontraded Goods and Services

Next we may add to the model a nontraded service sector that is produced with labor only, $Q_N = e_N L_N$. The key results of the traditional Heckscher-Ohlin model apply also with nontradables and even with specialized subsets of produced tradables, provided there are enough zero profit conditions applicable to the produced tradables that factor prices are set by external competitiveness conditions. For example, with two tradables and one nontradable, it is enough that both tradables are produced at home. If, on the other hand, the number and diversity of tradables is to little to allow factor prices to be set

[1] The reader may verify that by varying the rental cost of capital it is possible to create two tangencies such as those depicted in Figure 3. Suppose that there is a utility curve is

by external competitiveness conditions, then the demand for nontradables affects the compensation of labor and capital.

The model with variable effort and nontraded services parallels the traditional HO model. It is possible that two tradables are produced as in Figure 3 in which case we can find the price of nontradables by rotating a line through the origin until it is tangent to the worker indifference curve. The slope of this line is the relative price of nontradables to apparel. This tangency will select a low effort-wage combination for the nontraded sector.

It is also possible for the economy to specialize on a "deficient" subset of tradables and for factor prices to depend on the demand for nontradables. An equilibrium with nontraded services and with one tradable made at home is depicted in Figure 4. Included are three zero-profit wage-effort lines, two applicable to the tradables sectors and the other to the nontradable. The nontradable line goes through the origin to reflect the assumption that the nontradable is made with labor only. This zero-profit line is tangent to the worker indifference curve at one point which selects the wage-effort contract that is offered in the nontraded sector. The machinery zero-profit line is also tangent to the worker indifference curve. It selects a contract with higher effort and higher wages than the nontradables sector. Also in the figure is the wage-effort offer line for the apparel sector, which is inferior in worker utility to the extant contracts in the machinery sector and the nontraded service sector. Thus this is an economy that specializes in one capital-intensive tradable and the nontradable.

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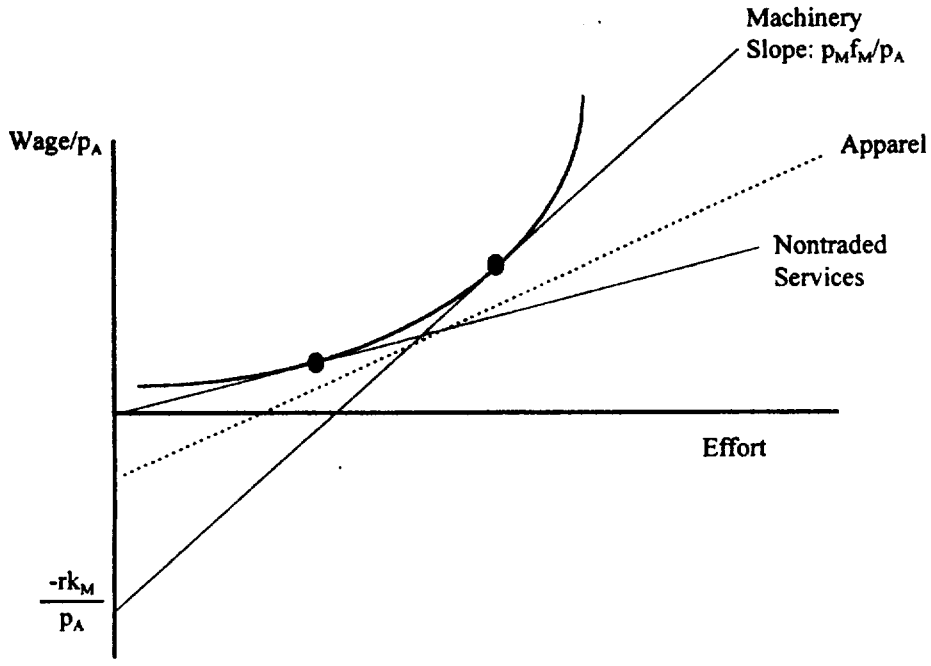
tangent to the apparel line but doesn't reach the textile line. Then lower the cost of capital to employ more capital. At some point, two tangencies will occur.

Figure 4

Equilibrium with Nontraded Labor Services
and one Tradable Intermediate Product



This figure is potentially misleading, however, since by expressing the worker indifference in terms of only two items, wages in apparel units and effort, the figure is implicitly based on the assumption that workers do not consume nontraded services. If they did consume nontradables, the indirect utility could be written as a function of two arguments: real earnings in terms of apparel, wage/p_A ,and the relative price of nontradables, p_N/p_A. To be completely correct it would then be necessary to include the price ratio p_N/p_A as an argument of the worker indifference in these figures, which renders the diagrams highly suspicious for any comparative statics exercises that allow this relative price to vary. Unfortunately, it is impossible with two dimensional figures to depict a model which is fundamentally three dimensional. Algebra, of course, will work, but is messy. I will use these diagrams to derive and to discuss results, thereby implicitly assuming that the worker trade-off between apparel consumption and effort is

not very sensitive to changes in the price of nontraded services relative to apparel, p_N/p_A. I am confident that I could write down a utility function that has this feature, but I am also confident that some of the results could be overturned if another utility function were selected. For intellectual backup, numerical examples of fully solved models are reported in the appendix.

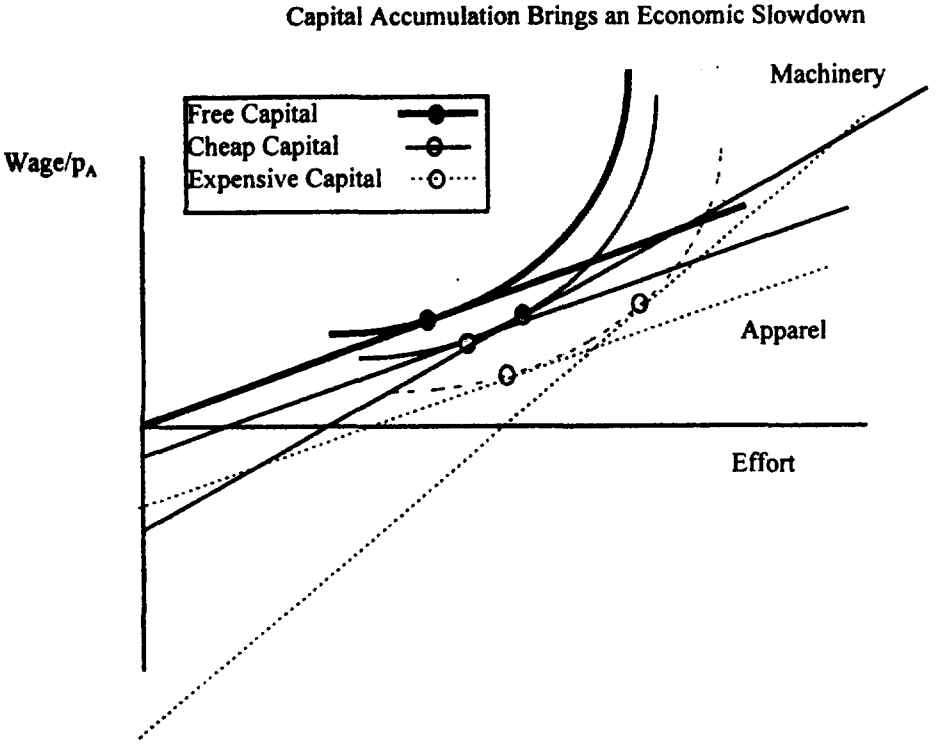
3.0 Capital Accumulation

We have now presented three different figures depicting first a closed economy equilibrium, second a small open economy with a pair of tradables, and third a small open economy with a single tradable. Capital accumulation has a very different effect in each of these circumstances. In a closed economy, the declining cost of capital induces a worker slowdown as workers use the improving economic circumstances to support lower effort work. In an open economy, capital accumulation creates new high-effort high-wage opportunities as the economy shifts its tradables mix toward more capital-intensive products. This offers a new reason why openness is essential to sustained growth. The traditional limit to growth in a closed economy is that capital deepening comes with diminishing marginal productivity of capital which chokes off the growth. A traditional Heckscher-Ohlin model allows a super-sensitive shift in product mix toward the more capital-intensive sectors which keeps the marginal productivity of capital constant (The Factor Price Equalization Theorem). Thus the traditional HO model implies that openness is compatible with sustained growth, closedness is not. Variable effort makes the argument in favor of openness all the stronger. Capital accumulation in a closed economy brings not only diminishing marginal productivity but also lower effort levels; but an open economy can speed up to take advantage of new opportunities.

First consider the closed economy. Three different equilibria are depicted in Figure 5 each selecting a different worker indifference curve.

Figure 5

Closed Economy Equilibria with Cheap and with Expensive Capital



Only the apparel and the machinery sector are depicted to reduce the clutter of the figure. Remember that the slope of the apparel zero-profit line is technologically fixed and its intercept therefore selects the cost of capital which declines as the intercept moves toward the origin. As this line moves upward with declining cost of capital, preferences are assumed to have workers spending part of their new wealth on higher wages and part on lower effort. The other sector has both a wealth and a substitution effect in favor of lower effort. The wealth effect comes from the upward movement of the intercept of the machinery zero-profit line. The substitution effect comes from the lowering of the slope of the zero-profit line.. The intercept of the machinery zero-profit line must move proportionately with the intercept of the apparel sector and the slope must be adjusted to create a tangency. The proportional upward movement of the intercept exceeds in absolute value the upward movement of the apparel intercept. In order to reestablish

tangency after such a large absolute movement upward of the line the slope of the machinery zero-profit line has to decline. In other words, the relative price of the capital-intensive good declines as capital becomes cheaper. The lower price in the capital-intensive sector means that the marginal compensation for effort declines, which encourages workers to slow down. Indeed, when capital is free, all the zero profit lines must go through the origin and must conform exactly. With free capital, all sectors have the same low-effort contract represented by the darkest dot in Figure 5. The equilibrium with the most expensive capital is depicted by unfilled dots. The intermediate equilibrium is depicted with gray-filled dots. These are arranged to show the economy slowing down as capital accumulates. The greatest slowdown occurs in the capital-intensive sector, which is depicted as maintaining approximately the initial level of wages.

Capital Accumulation in a Small Open Economy

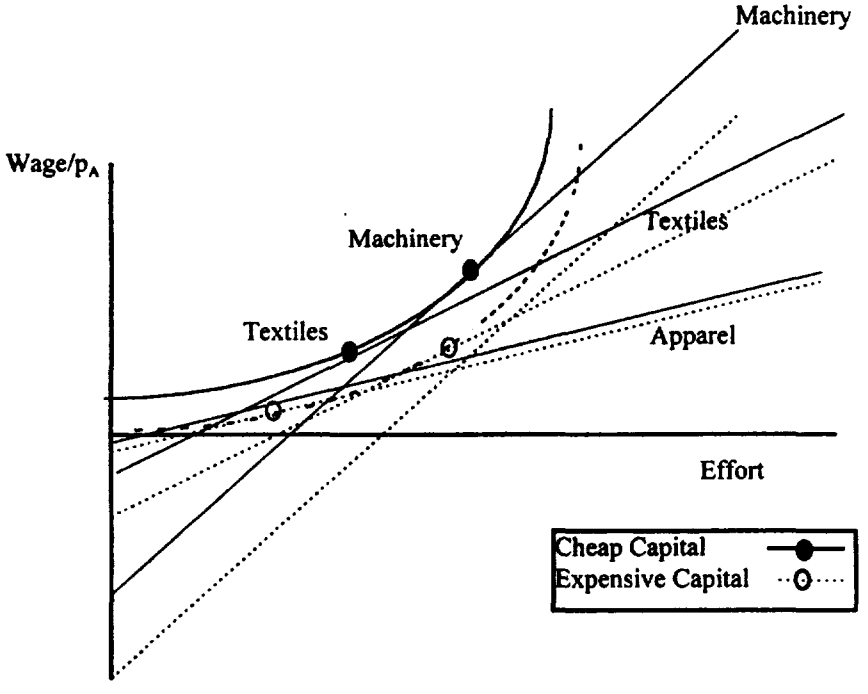
A small open economy with a diversified mix of tradables such as the one depicted in Figure 3 can absorb capital with no change in the compensation of factors. It simply shifts its output mix in favor of the more capital-intensive tradables. I have argued in my Graham lecture, Leamer (1995), that the Factor Price *Equalization* theorem is misleadingly named. It would be better to call it the Factor Price *Insensitivity* Theorem, meaning that factor prices don't change with changes in factor supplies; equivalently the demand for factors is infinitely elastic. Factor Price *Equality* across countries requires also 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 FPI since capital accumulation affects the output mix but not the labor contracts. We do not have Factor Price Equality even if countries may have the same technologies and the same product mix. The wage-effort contracts and the cost of capital depend on worker preferences..

Factor Price Insensitivity cannot apply for all changes in factor supplies. If capital accumulation is great enough the economy will specialize production on the nontradable and the relatively capital-intensive tradable, thus making the equilibrium look like Figure 4. Further capital accumulation then drives down the cost of capital which shifts upward

the tradables zero-profit line. Workers in the tradables sector spend their increased income partly to reduce effort and partly to raise wages. The improvement in working conditions in tradables has to be matched in the nontradables sector which improvement necessitates higher prices for nontradables. The slowing down of the economy continues to occur until a new more capital-intensive tradable emerges. The emergence of a new tradable is depicted in Figure 6 which is formed from Figure 3 by shifting the three zero profit lines upward but keeping the slopes unchanged.

Figure 6

Capital Accumulation in a Small Open Economy:
Shift in Product Mix And Greater Opportunity



The absolute shift is greatest in the capital-intensive sector which thus changes the production mix in Figure 3 from apparel/textiles to textiles/machinery. The wealth effect in the textiles sector allows workers to opt for lower effort as well as higher wages. But there is also a substitution effect in favor of higher effort associated with the emergence of a new high-wage high-effort job in the capital intensive sector, machinery. The old low-effort low-wage jobs in apparel disappear because they cannot compete with either the improved situation in textiles or the new opportunities in machinery. As work

conditions improve in the tradables sector, there must be a rising price for nontradables in order to support like improvements there. In summary, the effect of capital accumulation on effort in the open economy depicted in Figure 5 is very different from the effect in a closed economy depicted in Figure 6. **A closed economy slows down with capital accumulation. An open economy may speed up.**

4.0 Industriousness and the Compensation for Labor and Capital

Next we consider the effect of economic "culture", the willingness to work hard. "Is this the difference between Asia and Latin America?", I ask rhetorically. Are there countries in Eastern Europe with relatively large shares of their labor forces willing to exert high effort? Are there other countries with most workers accustomed to the comfortable low-effort Communist method of production? What difference will this make? The answer is that willingness to exert high effort saves capital costs, encourages capital inflows and creates comparative advantage in capital-intensive manufactures.

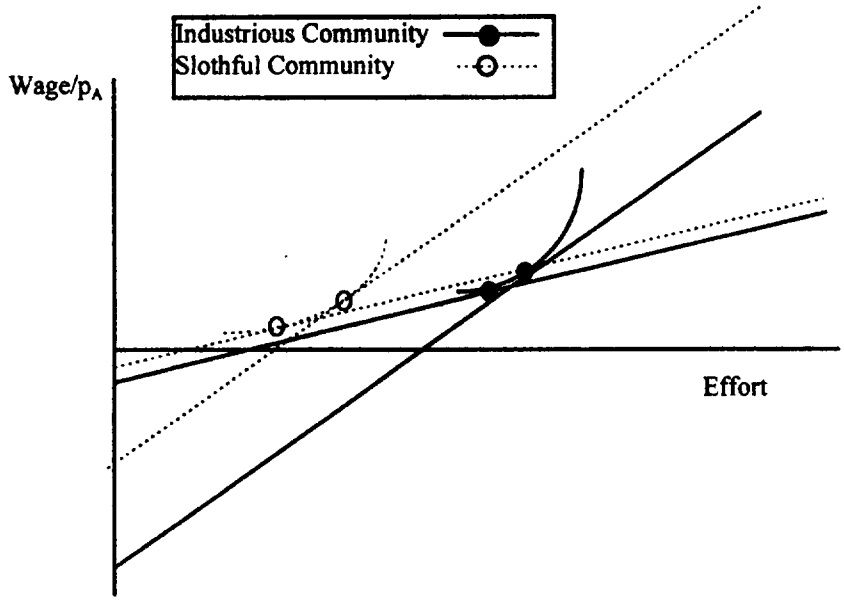
Contrast two communities that have identical supplies of capital and labor, one with workers willing to do high effort operations and another with workers who prefer to take it easy. If Figure 3 represents the equilibrium for a slothful community, then the industrious community can be modeled by a shift in the indifference curve in favor of higher rates of effort. This shift of preferences would leave the low-effort low-wage contracts in Figure 3 completely unfilled and these released workers seeking the high-effort jobs in the capital-intensive sector would increase the rental rate of capital, which shifts the zero profit lines downward, producing the new equilibrium in Figure 7. In the equilibrium applicable to the industrious community, workers opt for higher effort in both sectors. Wages in the industrious community may either exceed or fall short of wages in the equivalent sector in the slothful community. The increased cost of capital is a force for wage reduction, but the preference for effort is a force for wage increases..

In summary, the slothful community, other things equal, has a lower return to capital, and correspondingly, a wage-effort offer curve that provides higher wages at every level of effort relative to wages. But if the preference for sloth is

great enough, the slothful community can have lower wages and lower effort in both sectors compared with the industrious community.

Figure 7

Effect of a Shift in Favor of Industriousness:
Higher Cost of Capital, Higher Wages, Higher Effort



5.0 Exogenous rise in the relative price of tradables.

In the Heckscher-Ohlin model and in this model as well, a change in the external product markets is signaled to local labor markets by changes in relative price of tradables. The effect of changes in the prices of tradables differs substantially depending on whether the country produces a diversified set of tradables as in Figure 3 or a concentrated set as in Figure 4. In the diversified case, it is a decline in the relative price of the labor-intensive good that causes difficulties for labor. In the specialized case, it is a decline in the terms of trade, the relative price of the exportable to the importable. These may be the same relative price change or opposite ones, depending on which is the exported good.

Decline in Relative Price of the Labor-intensive Tradable in Diversified Economies

The traditional Stolper-Samuelson Theorem applicable to a country producing a pair of tradables with a pair of factors indicates that a rise in the relative price of the

capital-intensive good reduces the reduces the real wage in terms of either good. If effort level is variable, a modified Stolper-Samuelson applies. The wage-effort offer curve twists, with lower wages offered at low levels of effort but higher wages at high effort levels. Initially, as in Figure 8, the rise in the price of the capital intensive good makes the wage offer curve steeper because each increment in effort which generates the same increase in physical output produces relatively more revenue at the higher price. This has the effect of raising the compensation for only the high effort job. Although the initial impact is confined to the high-wage high-effort jobs, the effect spills over to the labor-intensive sector when workers attempt to move to the higher paying jobs in the capital-intensive sectors. The higher demand for capital that comes from the attempt to transfer workers to the capital-intensive sector increases the capital return.[2] This shifts the compensation curves proportionately downward as depicted in Figure 9. The new wage-effort offer curve is twisted, providing lower wages in the low-wage low-effort jobs but higher wages for the jobs with the highest effort. Workers in the labor-intensive sector experience a decline in wealth to which they may respond partly with reduced wages and partly with greater effort.. Workers in the capital intensive sector experience a like wealth effect but also a substitution effect since the marginal compensation for effort increases. These workers may end up with higher wages as well as higher effort. **To express this differently, the effects of Asian competition that raises the relative price of US capital-intensive tradables are:**

1) An increase in the compensation for capital.

2) A reduction in worker utility.

- **Harder work for less pay in the labor-intensive sector.**
- **Harder work but possibly higher pay in the capital-intensive sector.**

[2] Incidentally, I am being casual throughout about the effect of price changes of capital goods on the rental rate of capital. These figures make the most sense if the price of the capital good is fixed, but one could imagine tinkering with the interest rate to maintain the rental cost of capital in the face of changes in the price of the capital good.

Figure 8

Initial Effect of an Increase in the Price of Capital-intensive Tradables: Increase in Wage Offers in the Capital-Intensive Sector

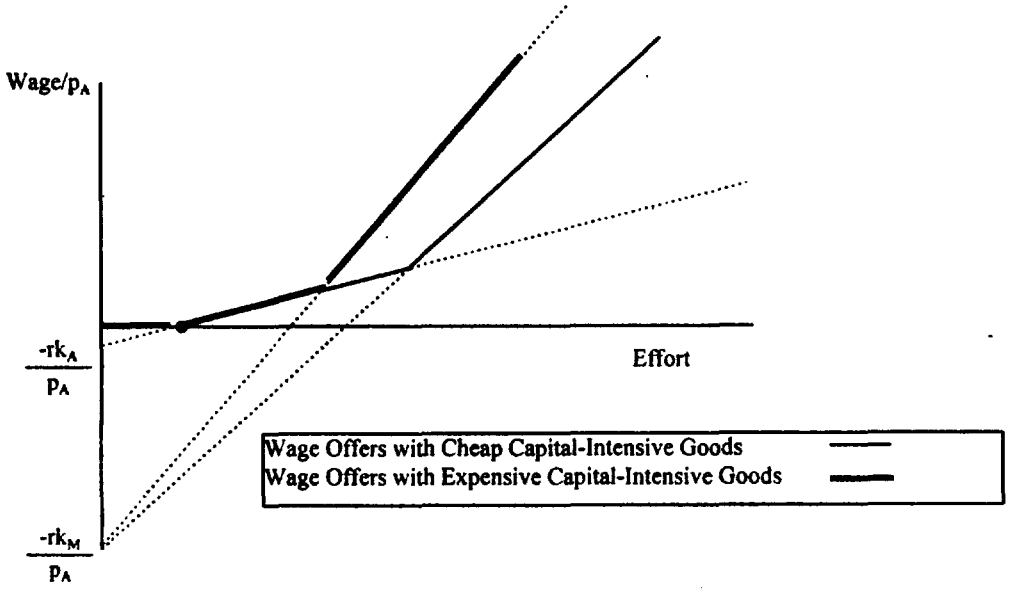
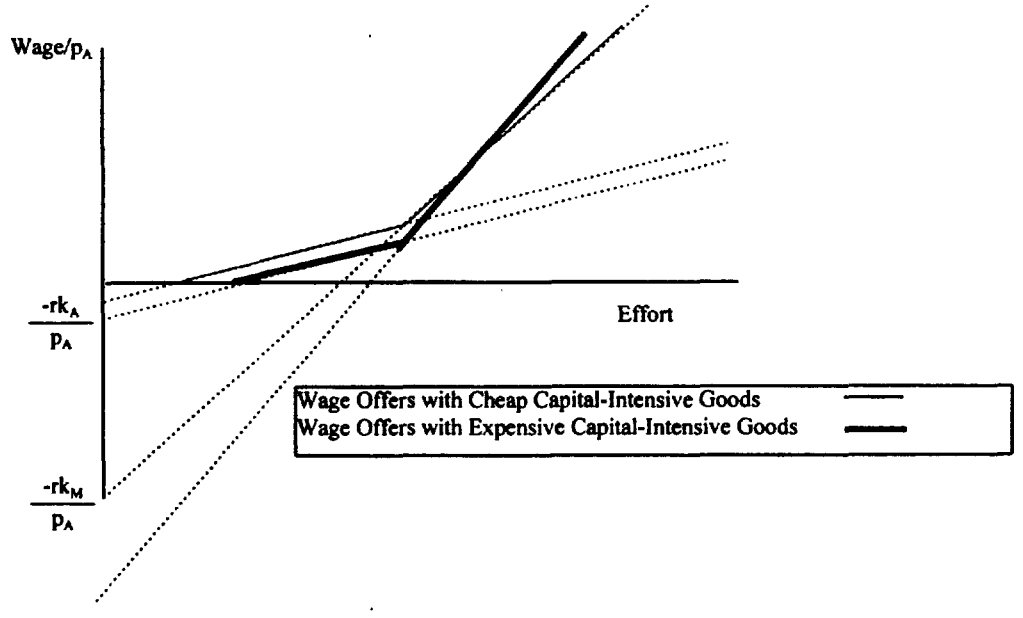


Figure 9

Secondary Effect of an Increase in the Relative Price of the Capital-Intensive Good: Increase in Return to Capital



The foregoing discussion has taken the mix of tradables fixed, but a declining price of labor-intensive tradables can induce a country to upgrade its production mix in favor of capital-intensive tradables. The labor-intensive apparel sector can be put out of business altogether and workers can move to move demanding jobs in more capital-intensive sectors. The higher effort is more than compensated with higher wages, and workers can be better off in the sense of being on a higher indifference curve. **Asian competition quickens the pace in the US.**

Decline in the price of exportable in specialized economies

Specialized open economies have a different reaction to external price changes. With the assumption of a representative worker, a deterioration in the terms of trade forces greater dispersion in labor contracts with the low-wage, low-effort jobs in the local service sector experiencing both wage and effort reductions but the high-wage, high-effort jobs experiencing increases in effort levels.

The effect of a decline in the relative price of the exportable good for a specialized economy is depicted in Figure 10 and Figure 11. A price decline for the exportable rotates downward the zero profit line, causing a deterioration in the wage-effort offers in that sector and thus making the representative worker prefer employment in nontradables. To maintain full employment of capital, the capital-intensive sector has to be put back in business. A potential new equilibrium depicted in Figure 10 can be established by moving the flatter tradables zero profit line up to reestablish the tangency between the original worker-indifference curve and the tradables zero-profit line. This can be done by making an appropriate reduction in the return to capital. Because this new zero-profit line is flatter, the new wage-effort contract in the tradables sector has both lower effort and lower wages, the combination leaving the representative worker completely indifferent to the change. However, in order for this to be an equilibrium, the demand for nontradables needs to be exactly the same as before since, with fixed input intensities in both sectors, the supply of nontradables is fixed. In fact, the demand for nontradables must fall for two reasons. Capital earnings have fallen because of the decline in the rate of return. Labor earnings have also declined, since the reduced compensation for effort in the tradables sector encourages workers to take more leisure and lower wages.

The excess supply of nontradables that must be a feature of the equilibrium depicted in Figure 10 must be equilibrated by a reduction in the price of nontradables and therefore a downward rotation of the nontradables zero profit line. A new equilibrium is depicted in Figure 11. Compared with Figure 10, this has a lower price for nontradables and a higher return on capital. The lower price for nontradables and the increased earnings of capital work to equilibrate the market for nontradables. The labor contract in the nontradables sector has lower effort and lower wages, the former reducing the supply of nontradables and thus working to equilibrate the market but the latter reducing the demand and working in the opposite direction. The labor contract in the tradables sector, compared with Figure 10 also has lower wages which works to reduce the demand for nontradables.

Based on this discussion we conclude (tentatively):

A deterioration in the terms of trade causes

1) An ambiguous change in the cost of capital
   - Cheaper capital is needed to keep the exportables sector externally competitive. (Figure 10)
   - More expensive capital (in the exportables sector) is needed to keep the nontraded sector competitive in the face of reduction in demand.(Figure 11)
2) A deterioration in worker utility
   - Lower wages and lower effort in the nontradables sector
   - Lower wages and either lower or higher effort in the tradables sector
3) A reduction in the price of nontradables

Figure 10

Initial Effect of Decline in the Terms of Trade
Reduction in Return to Capital

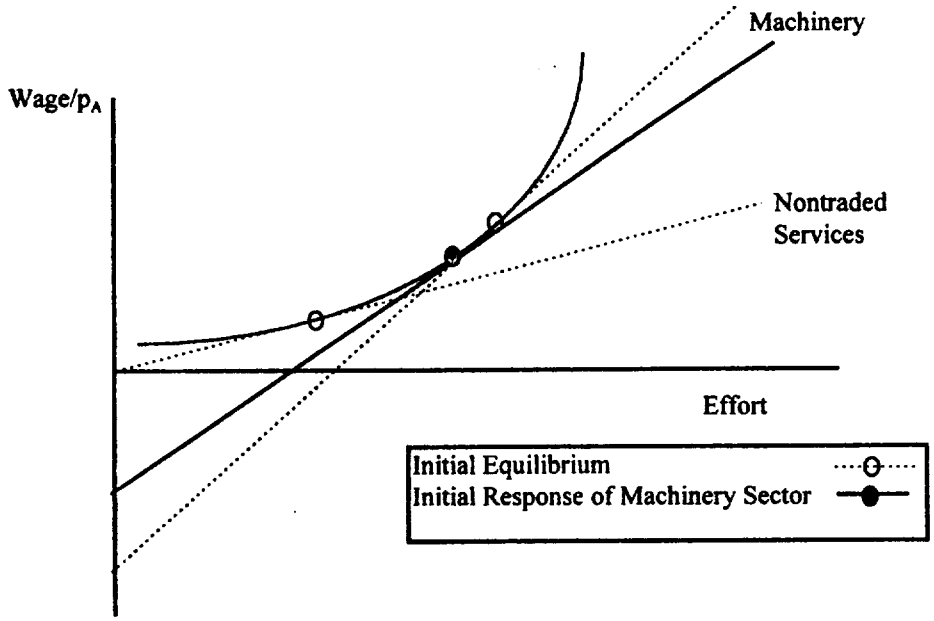
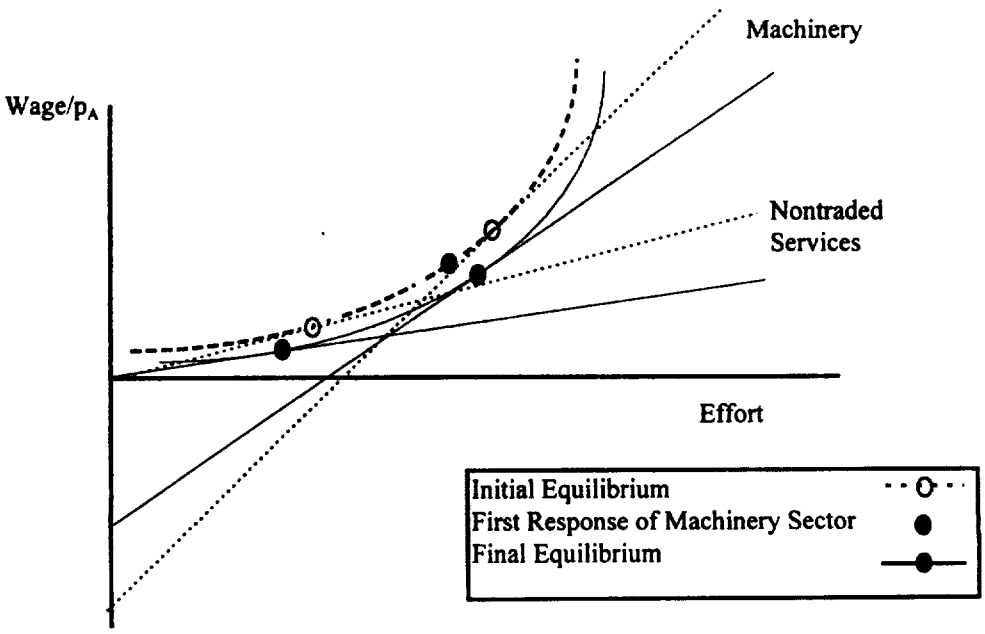


Figure 11

Secondary Effect of Decline in Terms of Trade
Decline in the Price of Nontradables



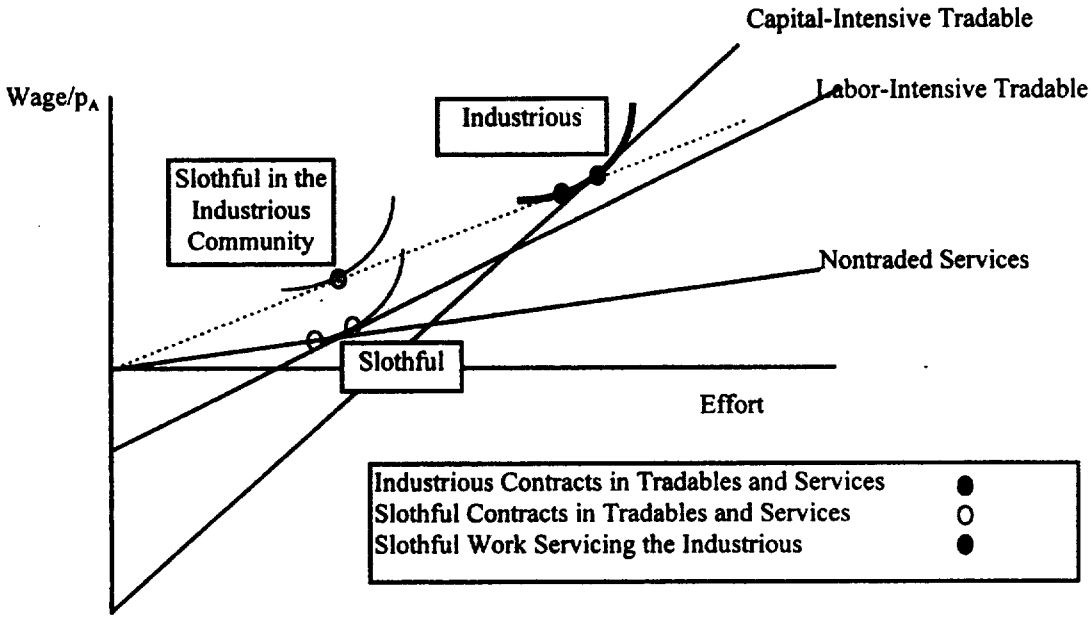
6.0 Capital mobility and Heterogenous Workers

The equilibria depicted in Figure 7 suggest that differences in industriousness among countries with similar capital/labor ratios can create a global equilibrium in which capital has an incentive to flow from the slothful to the industrious countries and for labor possibly to flow in the opposite direction. This labor flow toward the low-effort countries doesn't seem compatible with the facts. One reason is that wages don't depend only on community preferences; the supply of capital also matters. Another reason is that although the offer curve is superior in the low-effort communities, the extant contracts may not be appealing to industrious workers. If preferences are extreme like the ones depicted in Figure 7 then it is possible that the labor contracts offered in the slothful community are too low-key to be attractive to the industrious workers, in which case industrious workers who prefer the wage-effort *tradeoff* in the slothful community cannot find actual job opportunities to their liking, and they choose to stay at home.

Regardless of worker interest in migration, capital certainly has an incentive to migrate toward the industrious communities until rates of return are equalized and the wage-offer curve conforms in all countries. **With capital mobility, the global equilibrium is thus entirely determined by the community preferences toward effort.** Figure 12 depicts a global equilibrium with two tradables and a nontradable service sector.

Figure 12

Equilibria with Capital Mobility



The wage-effort offer curve in tradables in this figure is the same for all countries since both product prices and the cost of capital are equated by international arbitrage. In the figure are indifference curves representing an industrious community and a slothful community. The industrious community has high wages and high effort, produces the capital intensive tradable and has high prices for nontraded services. The slothful community has low wages and low effort, produces the labor-intensive tradable, and has cheap local services. **With internationally mobile capital, sloth creates comparative advantage in labor-intensive goods; industriousness creates comparative advantage in capital-intensive goods.**

Worker Heterogeneity

This same figure can be used to discuss worker heterogeneity inside a single community in which the cost of capital must be equated for both slothful and industrious workers. In such a community the slothful and industrious residents will opt for different contracts in different sectors. The key question that must be answered is: "What is the price of nontradables that prevails?" If it is the high price that would apply to

communities composed only of industrious workers, then the industrious work in both capital-intensive tradables and local services, and all the slothful work in the service sector. If the price of nontradables is the low price applicable to completely slothful communities, then the industrious work only in the capital-intensive tradable sector, and the slothful work partly in local services and partly in labor-intensive tradables. If the price of nontradables lies between these two extremes, then there is a completely bifurcated equilibrium with the industrious employed in the capital-intensive tradables sector and the slothful employed in local services.

The choice among these equilibria depends on the relative supply of industrious versus slothful. If there are many industrious and only a few slothful, then some of the industrious will be employed also in the local services which as a consequence will charge the high price that would apply if the community had no slothful workers at all. The slothful, in that case, benefit since they take good jobs in the high-priced service sector and command high wages. The wealth effect that they experience makes them want to choose low levels of effort compared with the contracts in the fully slothful community, but there is also a substitution effect in favor of higher effort, since the price of nontradables is greater in the industrious community than the slothful one. If the percentage of slothful workers is larger, they will drive down the price of local services and drive the industrious workers out of the sector. If the percentage of slothful is great enough, they will produce both local services and also the labor-intensive tradables. Then the lowest price of local services applies, the same value that is selected by communities inhabited only by the slothful. In these communities, the industrious opt for the high-wage high-effort contracts in the capital-intensive exportables sector.

The industrious indifference curve in Figure 12 suggests that the industrious workers don't care which of these equilibria applies. This comes from the inappropriate assumption that worker utility depends only on the consumption of labor-intensive importables and not at all from local services. Here again we are in a bind that two-dimensional diagrams cannot handle well a problem that is fundamentally three dimensional. But if we were to make the plausible assumption that the price of nontradables affects mostly the level of utility and not much the trade-off between

apparel consumption and effort, then it is easy to incorporate the effect of declining price of nontradables on the welfare of the industrious - it makes them better off. The conclusion is:

It's better to be different.

- **The slothful prefer communities with mostly industrious because they get paid well to supply local services.**
- **The industrious prefer communities with mostly slothful because it makes local services cheap.**

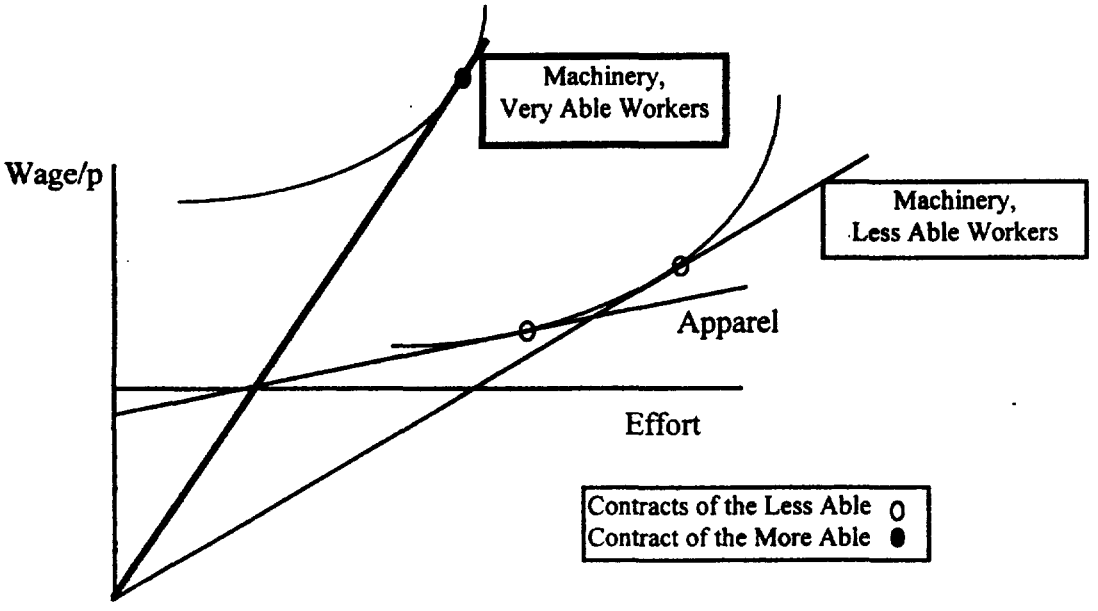
7.0 Ability Differences

The foregoing discussion of worker heterogeneity has the slothful workers finding low-effort jobs in the labor-intensive sectors. Workers in labor-intensive sectors such as apparel will find it a great surprise that they have the low-effort jobs. Most of them have the distinct impression that they are working longer hours and at 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. Figure 13 depicts an equilibrium with two kinds of workers who have the same attitudes toward work but differ in terms of their ability. The "able" workers operate the equipment in the capital intensive sector much more efficiently than do the "less able" workers. The compensation for effort for the able worker in the capital-intensive sector is consequently greater and the line of wage-effort contracts 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.

Figure 13

Differential Compensation for the Able and the Less Able
When Capital is Cheap

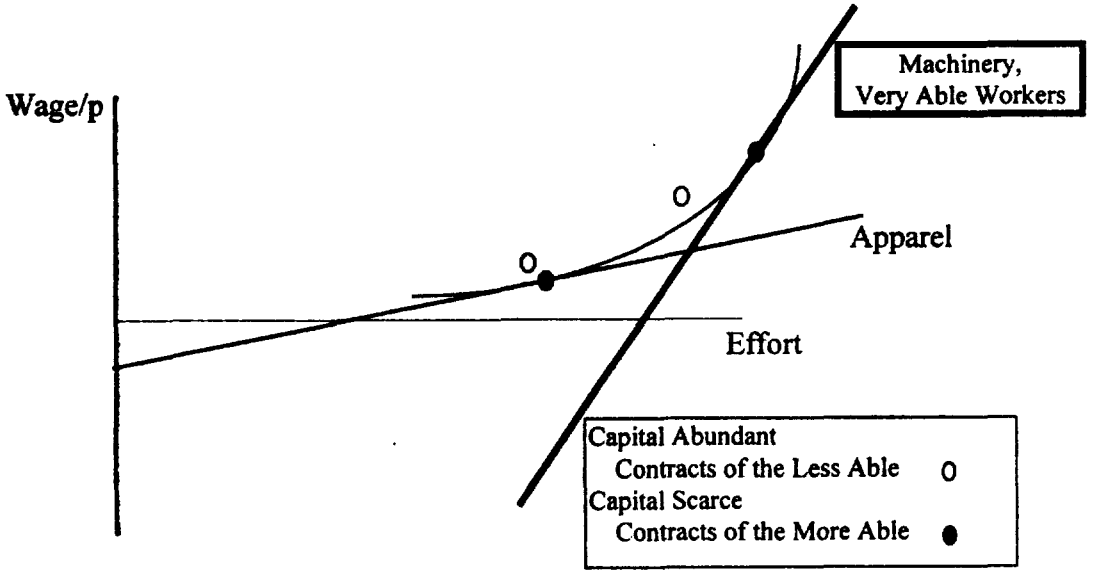


It is left as an exercise to determine what is the effect of changes in attitudes toward effort, changes in the price of tradables and capital mobility in a model with ability differences. I can tell you that the messages are not much changed. This model does allow one new kind of result regarding the relative compensation of the able and less able. If capital is very expensive, then the able and the less able receive exactly the same compensation. 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).

An equilibrium with expensive capital is depicted in Figure *. Here the able take jobs in both the capital-intensive sector and the labor-intensive sector, and the less able work along side the able in the labor-intensive sector doing the same work and receiving the same pay. Thus there is no difference in the utility levels of the able and the less able. The only difference is that the less able don't work in the capital intensive sector. Note that the empty dots represent the contracts of the less able taken from Figure ** that applies when capital is cheap. Note that the less able gain relatively little from the capital accumulation.

Figure 14

No Compensation for Ability when Capital is Dear



8.0 Minimum Wage:

Most economists hear minimum wages and salivate "unemployment" because Pavlov has trained them with a simple partial equilibrium model.[1] A very different conclusion applies if effort is variable since a minimum wage could generate just enough extra worker effort to compensate for the increased wage level, thereby keeping everyone employed. That is exactly what happens in the general equilibrium model presented here, but there is one additional effect. The increased effort is like an increase in labor supply, which increases the demand for capital and raises its return. This in turn 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 equally distributed, higher in the low-wage low-effort jobs and lower in the high-wage high-effort jobs.

Figure 15 depicts an equilibrium for a specialized small open economy with nontraded services produced with labor inputs only. Also in this figure is a line depicting the minimum wage which is assumed to be binding in the local service sector. An initial response to this minimum wage would be simply an increase in effort in local service to cover the higher wages. This contract is selected to provide the minimum wage and also to make workers indifferent between this new contract and the old ones. Although this is a higher effort contract, the increase is not enough to offset the increase in the wage, and the only way to maintain zero profits in the sector is by increasing the price of nontradables, thus rotating upward the nontradables zero profit line. Figure 15 cannot depict the equilibrium because of excess supply of nontradables. The higher price chokes off some demand and the higher level of effort means that the output of nontradables has increased. (The number of workers is fixed.) The downward pressure on nontradables prices can be accommodated only by increasing the return to capital, as depicted in Figure 16 which is the final equilibrium with a minimum wage high-effort job in nontradables and lower wages and higher effort in the tradables sector.

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[1] 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 there is no change in employment levels in either the local service sector or the tradables sector.

Figure 15

Initial Effect of Minimum Wage:
Higher Price, Higher Effort and More Output of Nontradables

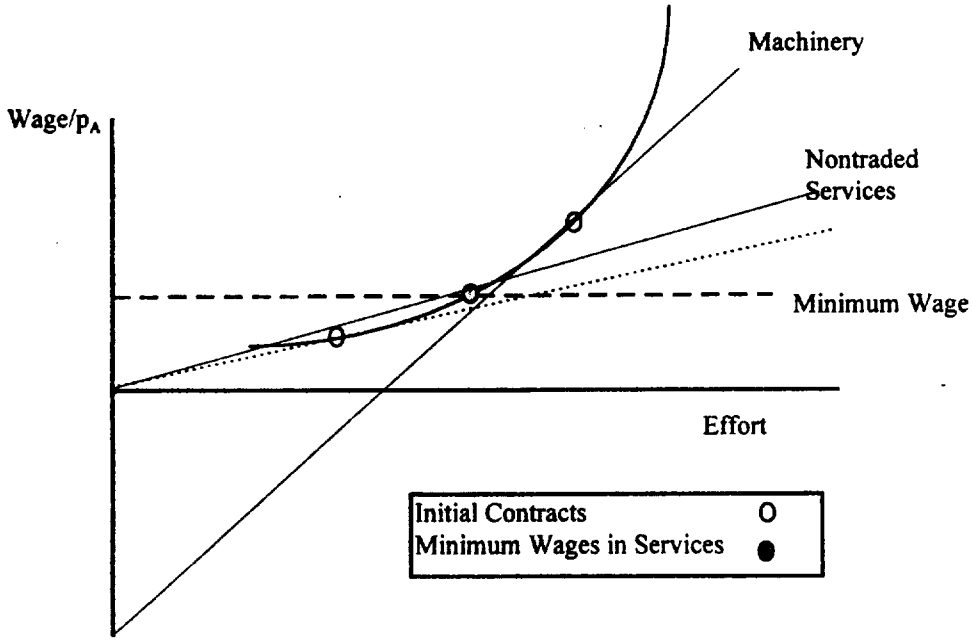

Figure 16

Lower Price for Nontradables and
Higher Return to Capital are Needed
to Equilibrate the Market for Nontraded Services

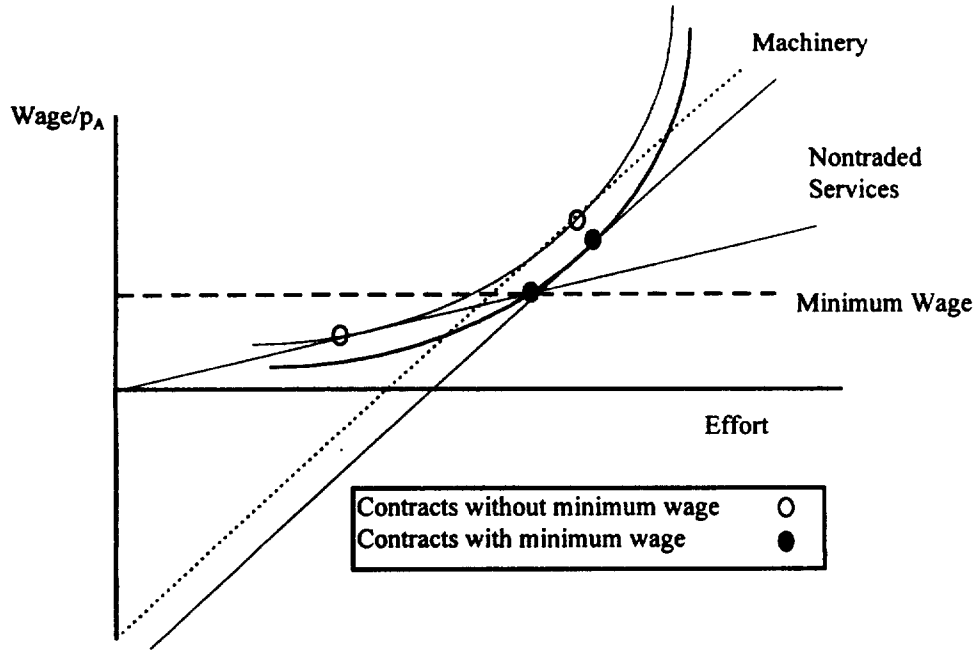

Figure 16 is easily amended to allow for a second tradable. If the initial minimum wage is binding in the labor-intensive tradables sector, then the higher costs put this labor-intensive sector out of business altogether and the economy's capital is redeployed in the capital-intensive tradables sector. Some of the released workers can find jobs in the capital-intensive sector, but the difference in capital/labor ratios means that there must be workers who cannot find tools for capital-intensive work and are forced to seek employment in nontradables. These released workers create an additional downward force on the price of nontradables, reinforcing the rise in the cost of capital illustrated in Figure 16. Even if the minimum wage is not binding in the labor-intensive tradables sector, the rising cost of capital illustrated in this figure can put it out of business.

From Figure 16 we conclude that a minimum wage

1. Raises the return to capital .
2. Makes the representative worker worse off, but reduces earnings inequality from above as well as from below.
   a) Raises wages but also effort in the local service sector
   b) Raises effort and lowers wages in tradables
3. Increases GDP, in fact increases output of both local services and tradables.
   a) Can eliminate the low-wage low-effort jobs in labor-intensive tradables
4. Has ambiguous effects of the price of the directly affected local service sector.
   a) Price increases for local services are needed to cover that portion of costs not eliminated by increased effort.
   b) Price reductions are necessary to sell the increased output that is generated from the increased effort.

9.0 Economy-wide collective bargaining

A collective bargaining agreement stipulates both the wage level and the conditions of work which in this paper is the level of effort. Economy-wide collective bargaining would eliminate all diversity of contracts and would require all workers to have the same effort and wage. A common contract in a small open economy may be compatible with the existence of only a single tradables sector. Figure 17 depicts a line of contracts that are compatible with two tradables sectors. Contracts above the line support only the capital-intensive sector. Contracts below the line support only the labor-intensive sector. Given the 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, this wage-effort combination varies toward and away from the origin. Given the rate of return to capital, the effort e and wage rate w(e) that can support both products are solutions to the zero profit conditions

$$w(e) + rk_i = p_i\ q_i\ e, \qquad i = A, B$$

These can be solved for the wage rate as a function of the effort by eliminating the rental rate r:[2]

$$(\frac{1}{k_A} - \frac{1}{k_T})w(e) = \left(\frac{p_A\ q_A}{k_A} - \frac{p_T\ q_T}{k_T}\right)e$$

which is a line through the origin depicted in Figure 17[3]. Contracts on this line are compatible with both sectors operating, given a suitable cost of capital. Contracts above this line are compatible with the existence of only the capital-intensive sector. Contracts below this line are compatible with the existence of only the labor-intensive tradables sector. If wages are very high compared with effort, then neither sector is viable, a possibility which is also illustrated.

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[2] $r = (p_A\ q_A\ s - w(s)) / k_A = (p_T\ q_T\ s - w(s)) / k_T$

[3] The fact that the slope is positive comes from the following inequalities

$$k_T > k_A$$

$$pq / k = r + w / k$$

$$p_T q_T / k_T < p_A q_A / k_A$$

Given the assumptions that all the capital is deployed in tradables and that the capital/labor ratios are fixed, the employment level in tradables is a weighted average of the extremes that come when all the capital is devoted to one sector or the other:

$$L_T = K\frac{K_A(L_A / K_A) + K_M(L_M / K_M)}{K_A + K_M}$$

Thus if the capital-intensive sector goes out of business, the employment level in tradables rises. If the labor-intensive sector goes out of business, then the employment level in tradables falls. In this latter case, the nontradables must be prepared to absorb workers, but that cannot occur for two reasons. First the collective bargaining contract in nontradables can be supported only with higher prices for nontradables, and therefore less demand. Second, the existing workforce in nontradables is compelled by the contract to exert greater effort and therefore produce more. Therefore contracts in Figure 17 that have only the machinery sector operating also have unemployment.

Figure 18 includes the line of contracts that supports both sectors and also indifference curves for the slothful and for the industrious and the corresponding free-market labor contracts. These indifference curves intersect at a point indicated by a dark circle which is the unanimously supported collective bargaining contract with the highest return on capital. Contracts to the northwest of this point provide greater utility to both the slothful and the industrious, but only by reducing the return to capital and causing unemployment. Unfortunately for the industrious depicted in Figure 18 all contracts that keep both sector operating make the industrious worse off. Also depicted in this figure is the contract that applies if the union is dominated by the slothful. Here the industrious are definitely worse off.

Thus, economy-wide collective bargaining makes the industrious worse off. Either they suffer some degree of unemployment or they are forced to accept low-wage low-effort contracts that are more suited to the slothful.

Figure 17

Viability of Contracts in Small Open Economy

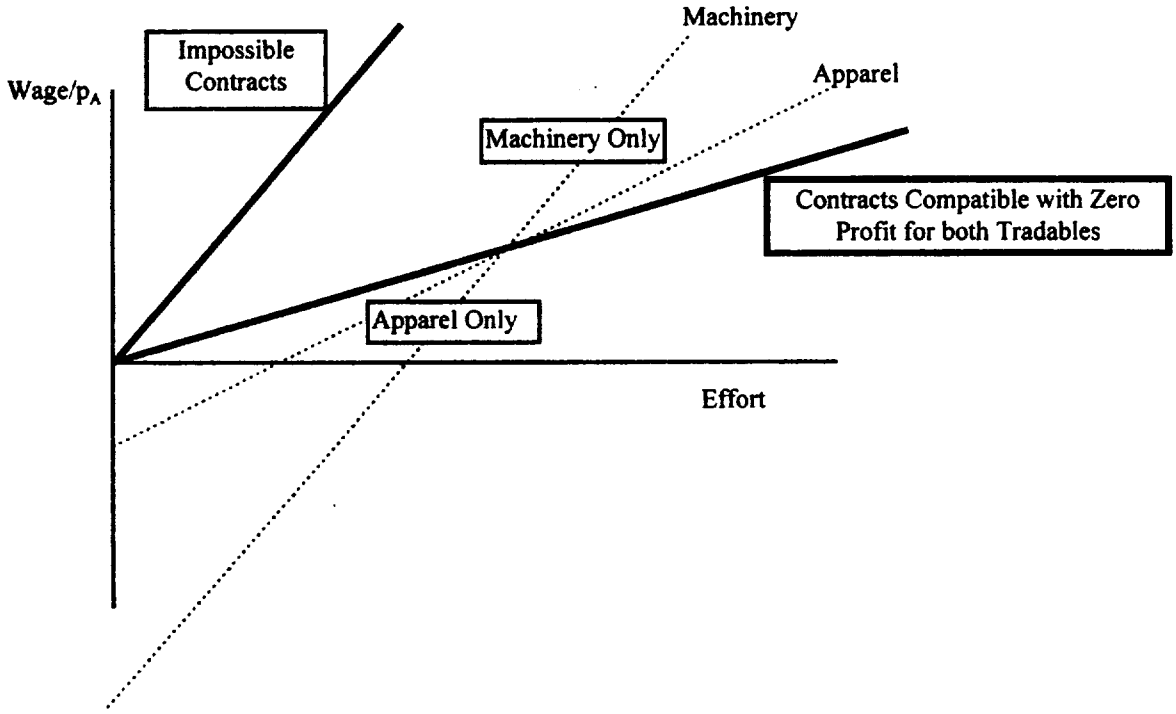
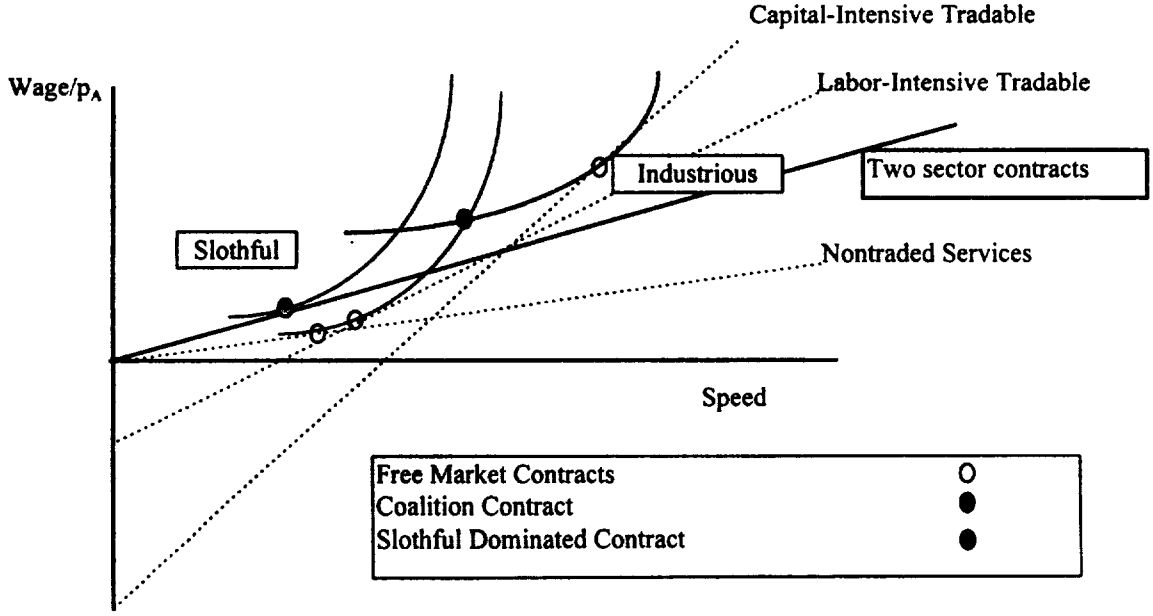


Figure 18

Collective Bargaining Equilibria



9.0 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 the increasing income inequality in the liberalized low-wage developing countries.

Table 1 shows 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 occur in the capital-intensive sectors where they effort saves the most capital costs. This relationship between wages and physical capital intensity might also be interpreted as suggesting complementarity between human capital and physical capital. However, after controlling 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. Katz and Summers (1989) and Dickens et.al. (1989). The theory of efficiency wages alludes to the difficulties in observing worker performance and the need to overpay workers who are infrequently monitored in 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 Table 2 shows that the sectoral distribution of wages in Germany and Japan are almost identical with the US. The similarity of the industrial pattern of wages across these countries and others is taken as that it is capital costs that matter, not monitoring.

Another set of empirical facts that is explained by the theory of effort is the total factor productivity differences among countries that tend to apply across all sectors. For example, Dollar and Wolff(1993, p.157) report that Korean labor productivity in 1986 relative to the US varied from a low of 21% in food products to a high of 67% in petroleum and 58% in iron and steel.[1] Figures 5, 6 and 7 all illustrate equilibria for two countries with total factor productivity differences across all sectors. Dollar(1991) found that productivity in Korea achieved two-thirds of the German level by 1978. Two thirds

[1]. These numbers admittedly are not total factor productivity figures and do not account for differences in capital per worker.

of the convergence over the 1966-1978 period came from capital deepening, one-third from convergence of total factor productivity. (Increases in effort?) Capital deepening was dominant in the heavy industries and TFP convergence in the light industries. An interpretation of these findings is that the pace of operations is largely fixed in capital intensive sectors but more subject to variability in the labor-intensive sectors.

Another empirical puzzle answered by the theory of effort is: "Why doesn't capital flow to the low-wage countries?" Lucas(1988) has stimulated a cottage industry producing models with increasing returns to scale to answer his question: The theory of effort described here offers one simple answer. The low-wage countries have 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.

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. But Robbins(1995) cites a number of studies of liberalizations in Chile, Argentina, Colombia and Cost Rica that 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. The theory of effort that is discussed here has an interesting explanation for these facts. Prior to liberalization, the labor markets could not compensate much for effort, and the wage levels and effort of work didn't differ much across workers. After liberalization, the wage-effort profile steepens, and those worker with ambition and industriousness can receive substantial increases in compensation.

Table 1: Capital per worker and earnings per worker by industrial sector, USA, 1990

1990 US Data from INDSTAT3, Unido Database 1996			
		Investment	Earnings
Sector		per worker	per worker
322	WEARING APPAREL,EXCEPT FOOTWEAR(322)	582	13408
324	FOOTWEAR,EXCEPT RUBBER OR PLASTIC(324)	746	14776
323	LEATHER PRODUCTS(323)	1458	17917
321	TEXTILES(321)	3269	18251
332	FURNITURE,EXCEPT METAL(332)	1416	18630
331	WOOD PRODUCTS,EXCEPT FURNITURE(331)	2717	19862
390	OTHER MANUFACTURED PRODUCTS(390)	1951	19919
361	POTTERY,CHINA,EARTHENWARE(361)	2895	21842
311	FOOD PRODUCTS(311)	5769	21928
356	PLASTIC PRODUCTS(356)	5090	22269
381	FABRICATED METAL PRODUCTS(381)	2914	24580
342	PRINTING AND PUBLISHING(342)	3778	25234
369	OTHER NON-METALLIC MINERAL PROD.(369)	4945	25687
355	RUBBER PRODUCTS(355)	5122	26146
362	GLASS AND PRODUCTS(362)	6525	27092
383	MACHINERY ELECTRIC(383)	6061	28397
372	NON-FERROUS METALS(372)	7814	29919
382	MACHINERY,EXCEPT ELECTRICAL(382)	4322	29976
341	PAPER AND PRODUCTS(341)	17966	30644
313	BEVERAGES(313)	8540	30949
354	MISC. PETROLEUM AND COAL PRODUCTS(354)	8500	32000
352	OTHER CHEMICALS(352)	9299	32371
385	PROFESSIONAL & SCIENTIFIC EQUIPM.(385)	4468	33204
371	IRON AND STEEL(371)	8571	33680
384	TRANSPORT EQUIPMENT(384)	6003	35084
314	TOBACCO(314)	6829	37073
351	INDUSTRIAL CHEMICALS(351)	27388	38010
353	PETROLEUM REFINERIES(353)	53056	44444
300	TOTAL MANUFACTURING(300)	5804	26911

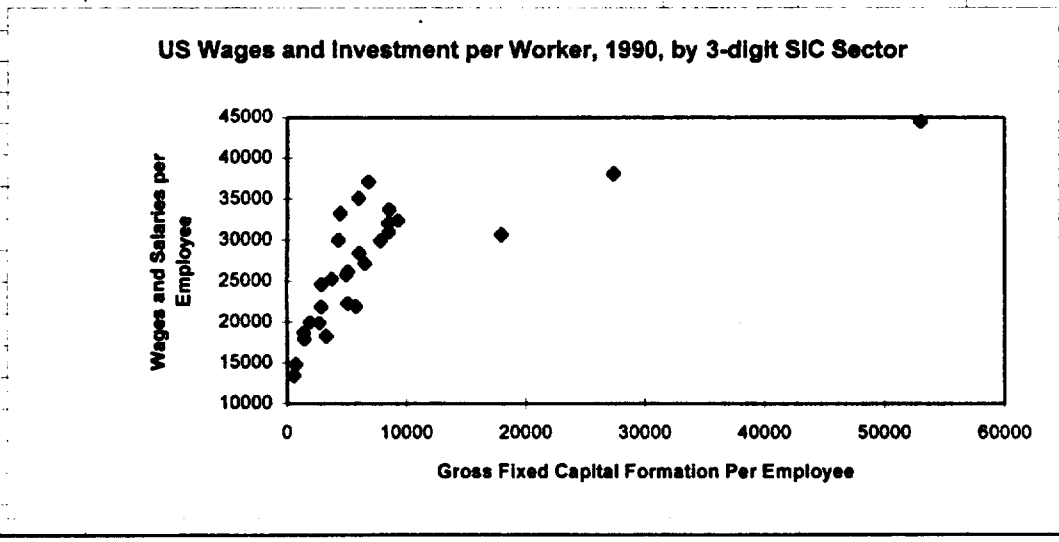
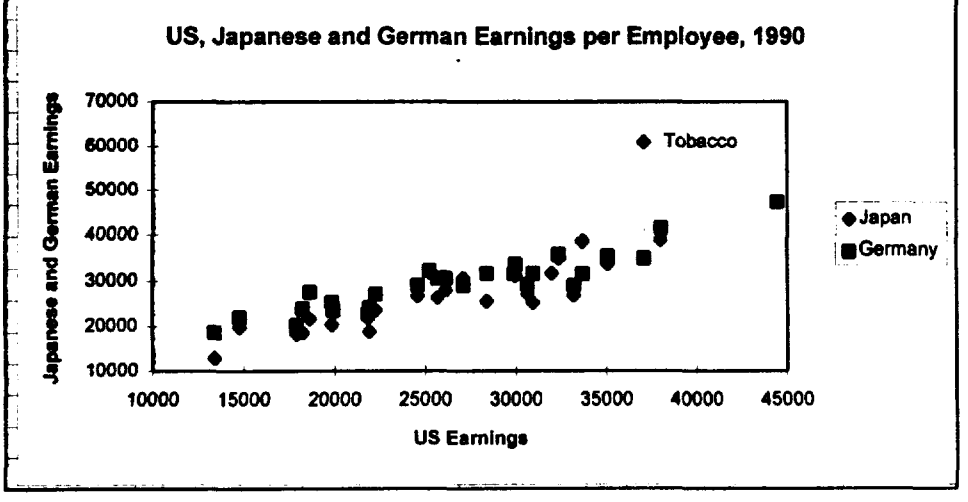


Table 2 1990 Earnings per Worker by Industrial Sector: USA, Japan and West Germany

1990 Data from INDSTAT3, Unido Database 1996						
	USA	Japan	West German	Japan:	German:	Japan:
	Earnings	Earnings	Earnings	US	US	US
Sector	per worker	per Worker	per Worker			
322	13408	12921	18683	0.96	1.39	0.69
324	14776	19704	21928	1.33	1.48	0.90
323	17917	18208	20239	1.02	1.13	0.90
321	18251	18639	23849	1.02	1.31	0.78
332	18630	21583	27542	1.16	1.48	0.78
331	19862	20287	25332	1.02	1.28	0.80
390	19919	22697	23508	1.14	1.18	0.97
361	21842	21721	22733	0.99	1.04	0.96
311	21928	18790	24102	0.86	1.10	0.78
356	22269	23522	27038	1.06	1.21	0.87
381	24580	26632	29000	1.08	1.18	0.92
342	25234	31775	32268	1.26	1.28	0.98
369	25687	26249	30533	1.02	1.19	0.86
355	26146	27990	30592	1.07	1.17	0.91
362	27092	30586	28948	1.13	1.07	1.06
383	28397	25457	31603	0.90	1.11	0.81
372	29919	32118	31565	1.07	1.06	1.02
382	29976	31124	33550	1.04	1.12	0.93
341	30644	27169	29200	0.89	0.95	0.93
313	30949	25106	31583	0.81	1.02	0.79
354	32000	31655		0.99		
352	32371	34968	35836	1.08	1.11	0.98
385	33204	26795	28901	0.81	0.87	0.93
371	33680	38579	31436	1.15	0.93	1.23
384	35084	33722	35359	0.96	1.01	0.95
314	37073	60800	34976	1.64	0.94	1.74
351	38010	38931	41470	1.02	1.09	0.94
353	44444	47359	47333	1.07	1.06	1.00
300	26911	26367	31236	0.98	1.16	0.84



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Appendix: Numerical Examples

Most international trade economists over the age of 40 were tormented in graduate school with figures like "Meade" diagrams that seemed incomprehensible unless manipulated on a daily basis. In order to pass the qualifying exams, international economists had no choice but to master a highly complex form of Diagramese, and they learned to speak this language with a passion unmatched in any other subdiscipline of economics. Today, however, in international economics and other subdisciplines, the languages of choice are Algebra and Numbers, and many economists no longer master Diagramese. If you haven't learned the language, the figures in the body of this paper are probably pretty incomprehensible and the conclusions may remain doubtful. To treat the incomprehension and the doubt, I provide in this appendix an explicit algebraic model and use it to explore the claims made in the body of the text. In addition, workers are allowed to consume more than one good, which is a limitation of the Diagramese used in the body of this paper.

This model has two consumables, one that is produced and sold only at home, and the other that is imported. There is also one exportable good that is used only to pay for imports. The nontraded consumable is produced with labor only and all the country's capital stock is deployed in the exportable sector.

Utility Function

Worker utility comes from consuming the nontraded good N and the imported consumable C. The utility function has built into it a maximum effort e_{MAX} and a minimum effort needed to support subsistence consumption levels I_{MIN}.

$$U = (\theta^{-\theta}(1-\theta)^{-(1-\theta)}C^{\theta}N^{1-\theta} - I_{MIN})(e_{MAX} - e)^{\delta}$$

The normalization in front of the Cobb-Douglas goods utility function makes the indirect utility function a bit simpler to write down. The parameter θ measures preference for the importable; the parameter δ measures distaste for high effort.

Expenditure Shares

Maximization of utility U for any given level of income w is accomplished by setting expenditure shares equal to the exponents in the utility function

$$p_C C / w = \theta \quad p_N N / w = 1 - \theta$$

The indirect utility function is then

$$U = (wP^{-1} - I_{MIN})(e_{MAX} - e)^{\delta}$$

where P is the price index

$$P = p_C^{\theta} p_N^{1-\theta}$$

The Nontradables Sector N

The nontraded good is assumed to be produced with labor only

$$N = e_N L_N ,$$

and the corresponding wage rate is proportional to the effort level e

$$w_N = p_N e_N$$

Workers in this sector accordingly choose their effort levels to maximize the indirect utility

$$U_N = (e_N p_N P^{-1} - I_{MIN})(e_{MAX} - e_N)^{\delta}$$

The solution to this maximization problem is

$$e_N = \frac{e_{MAX} + (I_{MIN} / p_N P^{-1})\delta}{(1+\delta)} \qquad \text{(A1)}$$

In words, the pace of work in the nontraded service sector is a weighted average of the maximum effort and the minimum effort needed to support subsistence consumption

$$e_{MIN} = I_{MIN} P / p_N = I_{MIN} \left(\frac{p_C}{p_N} \right)^{\theta} .$$

Exportables Sector X

The exportable product X is assumed to be made with capital K and labor L_X according to a Cobb-Douglas production function

$$X = e_X K^{\beta} L_X^{1-\beta}$$

Firms in this sector are assumed to rent capital at the rate r and to pay workers who operate at effort e_x the wage rate w_X. Firms that hire effort-e_X workers maximize profit $p_X X - r K - w_X L_X$ by setting the factor costs equal to their marginal productivities

$$\beta p_X e_X (K / L_X)^{\beta-1} = r$$

$$(1-\beta) p_X e_X (K / L_X)^{\beta} = w_X$$

Dividing the first equation by the second produces

$$\left(\frac{\beta}{1-\beta}\right) K^{-1} L_X = r / w$$

which can be solved for the cost-minimizing labor-capital ratio

$$\left(\frac{L_X}{K}\right) = \left(\frac{r}{w_X}\right)\left(\frac{1-\beta}{\beta}\right). \qquad \text{(A2)}$$

The wages of effort e_X workers will be bid up or down by these firms to eliminate profit in the sector, $w_X = p_X X / L_X - r K / L_X$. Using the optimal capital/labor ratio (A2), this zero profit condition can be written as

$$w_X = p_X e_X \left(\frac{\beta w_X}{(1-\beta) r}\right)^{\beta} - r\left(\frac{\beta w_X}{(1-\beta) r}\right)$$

which can be solved for the wage w_X as a function of the effort e_X.

$$w_X = (1-\beta)\left(\frac{\beta}{r}\right)^{\beta/(1-\beta)} (p_X e_X)^{1/(1-\beta)} \qquad \text{(A3)}$$

It should be noted that in figures in the body of the paper the set of wage-effort contracts is a straight line with a negative intercept, meaning that at very low effort workers do not produce enough to cover the capital charges. With substitutability of capital for labor, this can be avoided by allocating to the low effort workers relatively little capital, which is exactly what (A2) implies.. Thus the set of contracts (A3) goes through the origin. The exponent of eX in (A3) is equal to one plus the ratio of the capital share β to the labor share $(1-\beta)$. Thus, as should be expected, the sensitivity of wages to effort increases with the capital intensity of the sector.

Workers facing the set of contracts (A3) select the wage-effort pair that maximizes utility

$$U_X = (w_X P^{-1} - I_{MIN})(e_{MAX} - e_X)^{\delta} = (g\, e_X{}^{\gamma} - I_{MIN})(e_{MAX} - e_X)^{\delta}$$

where

$$\gamma = 1/(1-\beta)$$

$$g = (1-\beta)\left(\frac{\beta}{r}\right)^{\beta/(1-\beta)} p_X{}^{1/(1-\beta)} P^{-1}$$

The optimal effort e_X is found by maximizing this utility level. The first order condition is

$$e_X{}^{\gamma} g(\delta+\gamma) - e_X{}^{\gamma-1}\gamma\, g\, e_{MAX} - \delta\, I_{MIN} = 0 \qquad \text{(A4)}$$

Worker Indifference

Another condition for equilibrium is that workers are indifferent between the two jobs.

$$U_N = U_X \qquad \text{(A5)}$$

Market Clearing for Nontradables

Finally, we need to assure that the goods markets are in equilibrium. The produced nontraded goods must equal the demand, and imports must be paid for with exports. With the Cobb-Douglas utility function, assumed to apply to both workers and capital, expenditures on nontraded goods are equal to a fixed share of GDP: $(1-\theta)$ GDP = $(1-\theta)$ $(rK + w_N (L-L_X) + w_X L_X)$. The equilibrium condition equating the value of production of nontradables with the expenditures on nontradables is therefore

$$p_N e_N (L-L_X) = (1-\theta)(rK + w_N (L-L_X) + w_X L_X) \qquad \text{(A6)}$$

The other condition, trade balance, is automatically satisfied if (A6) is satisfied. The equation (A6) can be rewritten using $p_N e_N = w_N$ as

$$\theta (rK + w_N (L-L_X) + w_X L_X) = (rK + w_N (L-L_X) + w_X L_X) - p_N e_N (L-L_X)$$
$$= rK + w_X L_X$$

On the left of this condition is the expenditures on importables; on the right is the value of the output of the exportable computed in terms of the costs of its inputs.

Solutions

This gives us six equations and six unknowns: r, w_X, e_X, e_N, L_X, p_N. This model is impossible to solve analytically, but not difficult to solve numerically. Table 1 has several different solutions. The base case reported in the first column has relatively high effort and high wages in the exportables sector, and 26% of labor allocated to nontradables.

The second column in Table 1 shows the effect of a doubling of the supply of capital. Not surprisingly, the rental rate of capital falls and the wage rate in the exportable sector rises. The wage rate also increases in the nontradables sector, even though this sector uses no capital. This rise in wages in the nontraded sector is supported by a large increase in the price of nontradables that is needed to choke off the increased demand. The increase in wealth of workers is used to purchase lower effort in both sectors, especially in the nontraded sector. This makes for greater dispersion of wage levels. Thus capital accumulation causes income inequality, but keep in mind that workers are completely indifferent between the two jobs.

The third column shows what can happen if the worker disutility from effort diminishes. This causes an increase in effort in both sectors, more in the nontradables sector than the exportables sector. This rise in effort causes both the return to capital and the wage levels rise. Wages rise more in the nontradables sector and thus there is greater income equality. [1]

The fourth column shows the effect of an increase in the labor force. Like an increase in willingness to work, this causes an increase in the rate of return to capital. Otherwise the effect of an increase in the labor force is very different from the effects of greater diligence. The increase in the labor force causes wages to fall in both sectors, and this fall in income forces workers to opt for greater effort in order to maintain their consumption levels.

The fifth column indicates the effect of an improvement in the terms-of-trade, namely a doubling of the price of the exportable good. This induces a similar increase in

[1] Be alert that the change in the utility reported in the column corresponding to "more diligence" is comparing apples to oranges.

the return to capital and to wages, and some reduction in effort in both sectors. The price of tradables rises one-for-one with the price of the exportable, which is a feature of this Cobb-Douglas economy.

The sixth column shows the effect of a minimum wage that increases wages by 10% in the nontraded sector. With the minimum wage binding in the nontraded sector, the first-order condition (A1) that selects the level of effort in the nontraded sector is no longer applicable. In place of (A1) we use the condition that workers earn the minimum wage in the nontraded sector:

$$w_{MIN} = p_N e_N \qquad (A1^*)$$

The results are exactly what the diagrams have indicated. The minimum wage forces effort up in the nontraded sector, which generates more output and consequently lower prices. The 3% drop in the price of nontradables is offset by a 13% increase in effort in order to justify the 10% increase in wages. Offsetting the 13% increase in effort is a 4% reduction of the workforce, thus increasing output of nontradables by 9%. The transfer of workers into tradables increases the tradables workforce by 11%. Competition for tools for these new workers drives up the cost of capital by 6%. Wages fall in exportables, but the effort increases a bit to soften the effect on consumption. Output in both sectors increases; capital is better off, income of workers is more equal, but workers are 4% worse off.

The last two columns of Table 1 show the effects of a shift of demand in favor of nontradables, first because of preferences and second because of an external deficit. In both cases the price of nontradables (the real exchange rate) increases. Wages rise with the increased demand for workers in the nontradables sector and effort declines a bit. The compensation for capital declines and the share of the workforce allocated to tradeables also declines.

The effect of capital accumulation in Table 1 is a lowering of effort in both sectors. What is happening is that capital accumulation is raising wages and workers spend their new wealth partly for a more leisurely life style. This need not be the case. Table 2 is designed to show that as capital accumulates, a country will shift to a more capital intensive mix of exportables and workers may opt for higher effort jobs, not lower

effort ones. It is assumed that there are now two different exportables, the original one and another a more capital intensive product ($\beta = .6$, $p_X = .95$). The base case with the original product is repeated in column one. The second column indicates what happens if the economy switches to the second exportable. Although wages rise in the export sector, effort rises so much that workers are worse off. For that reason, the equilibrium selects the first product. The last two columns show that this ordering is reversed if there is more capital. Compared with the base case, capital accumulation makes workers 23.5% better off if the economy sticks with the less capital-intensive exportable, but 25.0% better off if the economy switches.

The effect of capital accumulation with multiple exportables is therefore shown in the last column of Table 2, not the penultimate column. As the exportables mix becomes more capital intensive, wages and effort both rise in the exportables sector. Wages rise in the nontraded sector, but not by as much, and effort actually falls. Thus capital accumulation leads to income inequality, or rather greater diversity of worker contracts. The wage gap widens between the rich and poor, but the diligence gap rises as well. In addition, capital abundant countries have relatively large export sectors but the relatively high prices for nontradables keeps the value share of nontradables constant.