"MODERATE" MINIMUM WAGES ARE LIKELY TO BENEFIT WORKERS AFTER ALL: A GENERAL EQUILIBRIUM VIEW

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ABSTRACT

It is shown that long-held views on the links between minimum wages and human capital arising from on-the-job training are not in general valid in a general equilibrium context. Of the three propositions obtained from partial equilibrium models, namely that minimum wages cause (i) firms to reduce training, (ii) the fall of the average lifetime wage of workers that receive training, (iii) the decline of employment in industries that provide training, only the first hold while the other two are likely to be reversed. Moreover, it is also shown that capitalists are likely to carry more than the complete social cost of the minimum wage and that workers' welfares increase.

SÍNTESIS

Se muestra que los puntos de vista que se han sostenido durante mucho tiempo acerca de los vinculos entre el salario mínimo y el capital humano que se derivan de la capacitación no son, en general, válidos en un contexto de equilibrio general. De las tres propuestas obtenidas de modelos de equilibrio parcial, a saber, que los salarios mínimos hacen que i) las firmas reduzcan la capacitación, ii) los salarios promedios durante la vida útil de los trabajadores disminuyan y iii) el empleo en las industrias que proporcionan capacitación disminuya, la primera de ellas tiene validez en tanto que es posible que las dos restantes se reviertan. Aún más, se demuestra asimismo que es posible que los capitalistas absorban más que la totalidad del costo social del sueldo mínimo y que aumente el bienestar de los trabajadores.

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1. INTRODUCTION

The analysis of a minimum wage fixed above the wage rate for trainees but below the rate for unskilled workers not receiving on-the-job training (OJT)—a "moderate" minimum wage—has received prominent attention in the literature. Rosen (1972), Feldstein (1973), Welch (1978) and Hashimoto (1982) among others have used partial equilibrium analyses to study the effect of such minimum wages in the presence of implicit payment for non-firm specific OJT. Three major propositions arise from this literature concerning the effects of minimum wages: (1) firms reduce OJT for their workers; (2) the average lifetime wage of workers that receive OJT falls; (3) employment of the industries that provide OJT and are affected by the minimum wage (the "covered" sector) decline.[1]

Thus, according to this literature, a minimum wage not only generates aggregate income losses for a society as a whole due to its distortionary effects, but is also detrimental to workers themselves by reducing the level of training per worker, average lifetime wages and the number of workers receiving training. The objective of this study is to reconsider this analysis using a general equilibrium model of a small open economy. The major finding of the present analysis is that only the first of the above three results obtained in partial equilibrium holds in general equilibrium. Furthermore, results (2) and (3) are likely to be reversed in a general equilibrium framework. That is, lifetime average wages increase and, although training per worker decreases, more workers are likely to obtain training. Employment in the "covered" industry expands rather than contracts as the partial equilibrium models predicts. Finally, it is also shown that capitalists carry not only the complete social cost of the minimum wage, but are also forced to transfer part of their reduced income to the workers, which, in turn, increase their own welfare.

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[1] Hashimoto, (1982) however, obtains an ambiguous effect on employment in the covered sector if the per worker training costs are subject to externalities dependent on industry employment.

Considerable efforts have been devoted to modeling the general equilibrium implications of minimum wages considering a variety of possible channels by which they can have economy-wide effects. To our knowledge, no one has, however, focused on the OJT channels. The studies that have come closest to this have considered the human capital (i.e., formal education) implications of minimum wages. The effects of minimum wages on human capital and the structure of production of open economies have been in fact extensively analyzed in the international trade and development literature. The original works by Brecher (1974a and 1974b), extended by Batra and Seth (1977), Neary (1985) and others have studied economy-wide minimum wages in the context of general equilibrium models of open economies with fixed factor endowments. Studies by Kenan (1970) and Findlay and Kierzkowski (1983), on the other hand, have allowed for an endogenous determination of the composition of the labor force between skilled and unskilled workers in a general equilibrium framework. More recently, Djajíc (1985), Flug and Galor (1986), and Miyagiwa (1989) have combined these two strands of the literature to study the general equilibrium effects of economy-wide minimum wages (that affect unskilled workers) with an endogenous determination of the stock of human capital. That is, explicitly allowing for changes in the skill composition of the labor force. Their major findings were that the introduction of minimum wages reduces production of non-tradables, increases output of tradables and increases human capital from formal education.

The present model is directed to capture certain basic features of developing economies, namely the existence of a dual structure of production with a modern or formal sector comprised of medium and large size firms and a backward or informal sector comprised of a large number of low technology, small firms. The formal sector produces mostly tradable goods while the informal sector produces services and other non-tradables.[2] OJT is assumed to be provided only in the formal sector.[3] The latter is the key assumption of the analysis. The assumption that the informal sector produces only non-tradables provides analytical tractability but is not essential for the analysis. The results would not be essentially altered if a third sector, an informal sector producing tradables, is included in the analysis.

[2] In most developing countries the bulk of the import substitutes are manufactured goods produced by relatively large firms and most exports consist of raw commodities mostly produced in the modern farm sector (relatively large plantations, estate farms, etc.), large mines or other resource-based industries. Non-tradables, by contrast, consist of urban services and staple food items produced by small peasants. The latter are effectively non-traded either because of significant quality differences between domestically produced varieties and internationally traded ones or because they are protected via import quantitative restrictions rather than by tariffs.

[3] Informal sector activities are just too simple to generate OJT and any training attained in the formal sector is not useful to perform such simple tasks. See the World Development Report, 1990 for an analysis of the informal sector in developing countries.

The assumption that minimum wages are below the wage for unskilled workers not going through OJT precludes, in the absence of other distortions or market imperfections, the existence of open unemployment.[4] If this assumption does not hold, however, implicitly paid OJT would be non-existent and thus minimum wage changes would only affect unemployment. That is, in general small changes in minimum wages affect the level of unemployment or training but not both. The assumption that minimum wages are moderate has empirical support for countries that are less aggressive in setting minimum wages.[5] More importantly, two recent studies by Card (1991 and 1992) using a comprehensive microdata set combined with published States' data for the U.S., have shown that minimum wages do not have negative employment effects even though they significantly raise the wages of young workers. Thus, this evidence lends support to ignoring the unemployment consequences of minimum wages.

There is still another reason why the assumption of no unemployment makes sense in the context of the analysis. As indicated before, we do consider a low productivity informal sector where the level of employment is endogenously determined. The labor force employed in this sector is assumed in the model to use no physical capital and to receive no training. This implies that workers employed in the informal sector can be considered underemployed (or subemployed). One of the major concerns of the analysis is to study how this sector changes in response to the minimum wage. If the informal sector expands, the level of underemployment in the economy increases and vice versa. Thus, although we rule out open unemployment, we do consider changes in underemployment which is effectively equivalent. After all, the so-called open unemployment is more a statistical and reporting phenomenon than an actual economic issue. The majority of those declaring themselves unemployed in LDCs do in fact work, albeit in unregistered low productivity informal activities. Open unemployment is just an extreme case of underemployment.

The approach used in the main text is devoid of any technical or mathematical notations. The discussion in the text may for this reason appear at times imprecise. A technical appendix provides the complete underlying mathematical model for those readers interested in the rigorous foundations of the analysis.

The organization of the remainder of the paper is as follows: In Section II we discuss certain key issues regarding the role of minimum wages in the context

[4] This assumption is used in most studies of OJT. Hashimoto (1982) allows for employment effects of minimum wages due to changes in labor supply but there is no unemployment in his model. Studies considering formal (off-the-job) education, however, assume that minimum wages are binding for all unskilled workers (Djajíc, 1985; Flug and Galor, 1986; Miyagiwa, 1989).

[5] In fact, according to a recent World Bank study from a sample of 31 developing countries, legislated minimum wages were below the average wage for unskilled workers in more than 60% of the cases.

of on-the-job training. Section III shows the effects of minimum wages on training per worker and national income. The effects on the price of capital are discussed in Section IV, while the implications for the wage structure of the economy are reviewed in Section V. Section VI considers the impact of minimum wages on the structure of employment and production of the economy and Section VII concludes. A Technical Appendix provides the formal general equilibrium model as well as the comparative statics results which are the basis of the qualitative analysis in the text.

2. THE ROLE OF MINIMUM WAGES THAT ARE BINDING FOR TRAINEES

We consider a moderate minimum wage in the sense that it is binding only for workers undergoing training. The market wage rate for unskilled workers not being trained is assumed to be above the legal minimum wage. Trainees are willing to accept a wage below the market rate as a way to pay for the training that they receive. Workers (rather than firms) are willing to pay for the cost of training that is not firm specific. That is, after receiving training workers can find a job in another firm and receive a higher compensation as skilled workers.

In principle workers could pay for this type of training by either accepting a wage discount or by cash payment. Payment in cash is rarely observed, however, presumably due to high transaction costs involved and by the income tax disadvantages of explicit payment for training. Thus, we focus on implicit payment for training based on wage discounts.

3. TRAINING AND AGGREGATE INCOME

If workers pay for training via wage discounts, the direct effect of a minimum wage on OJT is immediately obvious. A binding minimum wage will put a limit on the ability of firms to retrieve its training cost via temporary wage reductions. Wages for trainees cannot go below the legal minimum wage and, therefore, the benefits of training workers for firms are reduced. This induces firms to reduce the amount of training per worker provided. This causes a social loss because a binding minimum wage induces a wedge between the marginal benefits of training (i.e., the value of future increases in productivity and wages of workers undergoing training) and the marginal cost of training. Indeed, the marginal benefits become larger than the marginal costs of training and the economy loses income by not being able to expand training. In other words, total income can expand by increasing training, but this is not possible because of the legal minimum wage.

Although a minimum wage causes a reduction of training per worker trained, this does not necessarily mean that the total level of training will decline by the same extent. (In the Technical Appendix it is shown, however, that the

total level of training necessarily declines). That is, a reduction in training per worker may be accompanied by an increase in employment in the formal or "covered" sector which is the only sector that provides training. This increased employment in the formal sector can lead to an increase in the number of people receiving training. It is thus possible that a reduction of training per worker be in part offset by an increase in the number of workers receiving training. Whether or not this happens depends on various general equilibrium aspects to be considered in the following sections.

4. RETURNS TO CAPITAL

In order to analyze the general equilibrium implications of minimum wage we need first to consider how the price of the other factor of production, capital, is being affected. A key aspect that defines the effect on the price of capital is the degree of capital intensity of the training activity vis-a-vis directly productive activities. The capital intensity of training activities refers to the process of production of training. This process involves labor in the form of instructors (which are skilled workers) and the stock of capital or machineries required for the trainee workers to practice on the job.

It seems reasonable to expect that the number of instructors is only a small proportion of the total number of skilled workers employed in directly productive activities. Also, the ratio instructor/trainees is likely to be considerably less than one. On the other hand, trainees probably use similar tools and capital equipment through their on-the-job training as production workers. Consider, for example, the case of a machine that is operated by one skilled worker. In this case the labor/capital ratio can be regarded as one. Training a machine operator requires that the trainee worker use the same machine under the supervision of an instructor. If the instructor devotes only a fraction of his/her time to assist one trainee, it follows that the instructor/capital ratio is less than the labor/capital ratio in production. Thus, it is reasonable to expect that the instructor/capital ratio in training activities is less than the labor/capital ratio in production of goods.

If the minimum wage reduces the total production of training, firms will release part of the resources that otherwise would have been used in training. These released resources become available for directly productive activities and, thus, the production structure of the economy changes. At the new equilibrium, the minimum wage induces not only a reduction in training activities but also an expansion of the level of directly productive activities. Or, equivalently, a reallocation of resources from training to production of goods.[6] Given that

[6] Given that productivity of workers declines as a consequence of receiving less training, the effect on output of this reallocation of resources is not necessarily positive. More on this later.

training activities are more capital-intensive than directly productive activities, this restructuring of the economy will cause a fall in the demand for capital. If the capital endowment is to be fully used in the long run, the price of capital needs to fall. Thus, the minimum wage causes a reduction in the return to capital, implying that the income burden of the minimum wage is at least in part shared by the owners of capital.

5. EFFECTS ON THE WAGE STRUCTURE OF THE ECONOMY

In equilibrium the present value of the lifetime wage income of workers that opt to undergo training must be equal to the lifetime present value of the wage income of those workers that remain unskilled. This is a long-run equilibrium condition. If, for example, the present value of skilled workers' income is less than that of the unskilled workers, fewer workers will be willing to undergo training which, in turn, reduces the supply of skilled workers and thus increases their wages. This process will continue until both income levels are equalized. Similarly, if the skilled worker's income is above the unskilled worker's income, more workers will demand training leading to a greater availability of skilled workers in the long run and, thus, to lower wages for skilled workers.

Since, as we discussed above, the price of capital declines, the wage rate for unskilled workers must necessarily increase. Or, to put it differently, the reduced training induced by the minimum wage increases the availability of resources (i.e., capital) in directly productive activities. This, in turn, raises the marginal value product of unskilled laborers which work in productive activities, leading to a rise in the wage rate for unskilled workers. Also, given the long-run equilibrium condition between skilled and unskilled workers' income, an increase in the unskilled wage rate necessarily implies that the average lifetime wage for skilled workers also increases. Note that the lifetime income of skilled workers is comprised of two wages, namely, their wage while on training (which is equal to the minimum wage if it is binding) and the wage as already skilled workers once they have completed their training. Clearly, the wage as trainees (i.e., the minimum wage) increases while the wage as skilled workers necessarily falls given that they have less skills. The fact that the average lifetime wage of skilled workers goes up means that their higher wage as trainees is not totally offset by their lower wage after finishing training.

6. THE STRUCTURE OF EMPLOYMENT AND PRODUCTION OF THE ECONOMY

The increase in the unskilled wage rate causes an unambiguous increase in the domestic price of non-tradables. Non-tradables are mostly services and other goods produced using a high component of labor. In particular, non-tradables produced by the informal sector are likely to have an even greater component of

unskilled labor and a negligible capital component. This implies that the higher wage rate will have a significant upward effect on the price of non-tradables (particularly those produced in the informal sector) while the reduced price of capital will have at best a minor downward effect. This implies that the price of non-tradable outputs produced in the informal sector is highly likely to increase.

At the same time we observed before that national income is reduced as a consequence of the minimum wage. Hence, if non-tradables are normal goods in consumption, their demand will shift downwards. Thus, the combined effect of higher prices for non-tradables and less aggregate national income will unambiguously cause a fall in the production of non-tradables due to a reduced domestic demand.

The fall in domestic production of non-tradables in the informal sector implies a greater availability of resources (particularly unskilled labor) for the rest of the economy, i.e., for production in the formal sector. If in the long run at least part of those resources are used in the formal sector, we have that such sector will expand production and employment. Thus, the effect of the minimum wage is to change the structure of production and employment leading to (i) a greater "formalization", and (ii) a greater "tradability" of the economy, i.e., the economy becomes more open, and more trade-oriented. In particular, in contrast with the predictions of partial equilibrium analysis, employment in the covered or formal sector increases as a consequence of the minimum wage. This leads to a counter intuitive implication: minimum wages cause a reduction in the extent of underemployment.

Although total employment in the formal sector expands, the effect of the minimum wage on the employment composition of the formal sector is in general ambiguous. The formal sector employs skilled and unskilled workers. Whether or not the increased total employment is translated into a greater number of skilled workers employed, i.e., whether or not the number of workers undergoing training increases, depends on at least three conflicting partial effects: (i) A minimum wage causes a reduction in the demand for capital in the formal sector because the training per worker declines. This, in turn, is translated into a temporary or incipient excess supply of capital. To be corrected a change in the composition of the employment in the formal sector is needed. Since skilled workers are more capital demanding than unskilled workers, one way of eliminating this excess supply of capital is by a shift in the composition of employment toward skilled workers. Thus, this effect would point to a higher proportion of skilled workers for a constant total employment; (ii) the level of employment in the formal sector does not, however, remain constant. As we already showed it necessarily increases. The increase in labor available in the formal sector increases the demand for capital creating a temporary excess demand. Since capital is fixed, to reestablish equilibrium it is necessary to reduce the demand for capital which occurs by decreasing skilled workers' employment

(remember that skilled workers are more capital-demanding than unskilled labor). Thus, the partial effect of increasing employment in the tradable sector is to reduce the level of skilled workers; (iii) the last effect is associated with the fall in the price of capital which also causes a temporary excess demand for capital. This effect also points to the reduction in skilled workers in order to restore capital market equilibrium. Thus, the net effect of minimum wages on the number of skilled workers is ambiguous. The number of skilled workers may increase if effect (i) is sufficiently strong vis-a-vis effects (ii) and (iii).

Needless to say, the welfare of workers increases despite that aggregate welfare falls. The reason for this is that the average wage rate increases. Aggregate welfare falls because income of capitalists declines. That is, capitalists carry not only the complete social cost of the minimum wage, but also must transfer part of their reduced income to the workers.

7. CONCLUSIONS

A stylized general equilibrium model for a small open economy has been developed to probe the robustness of widely accepted propositions regarding the effects of "moderate" minimum wages obtained using partial equilibrium analyses. Of the three major findings of the partial equilibrium studies, only the one suggesting that training per worker declines with minimum wages appears to remain valid. The other two results, namely, lifetime average wages and employment in the covered industry both decrease and do not in general attain equilibrium. Moreover, these latter results are reversed in the context of plausible assumptions. The effect of minimum wages on the number or proportion of skilled workers in the total labor force is in general ambiguous, and one cannot rule out the possibility that the reduction of training per worker could be accompanied by an increase in the number of workers that receive training.

Furthermore, although increases in binding minimum wages do impose a social loss, it has been shown that this loss is entirely absorbed by capitalists. The workers' welfare improves because of implicit transfers from capitalists to workers.

Another important result arising from the analysis suggests that a moderate minimum wage is likely to increase the degree of "formalization" of the economy. The formal sector becomes proportionally larger and absorbs a greater proportion of the labor force while the informal sector is diminished in size.

To the extent that employment in the informal sector reflects essentially low productivity jobs, a reduction of its importance in the economy is equivalent to a fall in disguised unemployment or underemployment. That is, contrary to

conventional wisdom a moderate minimum wage tends to decrease rather than increase underemployment.

The analysis of the present paper is naturally based on a highly stylized model. It appears, however, that most of the qualitative results are robust to generalizations of the assumptions made for the sake of tractability and focus. The results of this paper should not, of course, be considered an advocacy for minimum wages. They clearly indicate, however, that the commonly used argument against minimum wages, in the sense that minimum wages are bad for workers, is not robust in general equilibrium.

TECHNICAL APPENDIX

1. THE MODEL

We consider a perfectly competitive economy that produces two goods, a non-tradable, and a tradable one. Consistent with the assumption of perfect competition, it can be assumed that in each sector there is a representative firm exhibiting a constant return to scale production technology. Equilibrium is thus characterized by zero profit in each industry. It is assumed that the tradable sector provides training while the non-tradable sector is identified with the informal sector and thus does not provide any labor training. Training is sector specific but not firm specific. The non-tradable sector neither provides training nor uses skilled workers.

The formal or tradable sector uses three categories of workers, skilled or already trained workers, trainees and unskilled workers. If the marginal value product of unskilled workers is π, then the marginal value product of skilled workers is $(1 + T)\pi$, where T is an index of training per worker. It is assumed that trainees have the same marginal productivity as unskilled workers but since the firm is in the process of spending resources in their training, their net marginal value product is actually less than π.

The variable π is closely related to the variable profit function of the representative firm in the tradable or formal sector,

$$[(1 + T)L_1^T + L_1^{uT} + L_1^u]\,\pi(1, r) = \max_{K_1} \{F[(1 + T)L_1^T + L_1^{uT} + L_1^u, K_1] - rK_1\} \qquad (1)$$

where L_1^T, L_1^{uT} and L_1^u are the levels of skilled workers, trainees and unskilled workers used by the tradable sector, respectively, K_1 is the level of capital used in the production of the tradable good, $F(\cdot)$ is the constant returns to scale production function and r is the rental price of capital. We have normalized the price of the tradable output to one. The $\pi(\cdot)$ component of the profit function exhibits the usual properties of a profit function, increasing in the output price, decreasing in r, homogenous of degree one and convex in its arguments (Diewert, 1973). More generally one could generalize the representation of the profit function to allow for imperfect substitutability between efficiency normalized skilled and unskilled labor. In this case the variable profit function can be written as $h((1 + T)L_1, L_1^{uT}, L_1^u)\,\pi(1, r)$, where $h(\cdot)$ is an increasing and concave function of its arguments. It can be shown, however, that this increases the complexity of the algebra but does not change any of the qualitative results.

We assume that the working life of each worker lasts one period. Each worker that undergoes training must spend a proportion ϵ of his/her working life as a trainee and $1 - \epsilon$ as a skilled worker. If we define the total labor force that undergoes training or is already skilled as $\ell \equiv L_1^T + L_1^{uT}$ then in stationary equilibrium there will be $\epsilon\ell$ workers under training and $(1 - \epsilon)\ell$ already skilled workers.[7] The variable profit function (1) can therefore be written as $[(1 + (1 - \epsilon)T)\ell + L_1^u]\,\pi(1, r)$.

The workers' efficiency level T is achieved through OJT which the firm produces at a cost. For simplicity, we first assume that training requires only capital (see below for the implications of relaxing this by assuming that training activities require both capital and skilled workers as inputs). The representative firm must divert $\beta(T)$ units of capital to train one worker to reach a productivity $1 + T$ times the productivity of an unskilled worker. Since each unit of capital has a rental price of r, the total stationary training cost for the firm is,

$$c = \beta(T)\, r\epsilon\ell. \tag{2}$$

We assume that $\beta(T)$ is increasing and convex in T,[8]

Profits of the representative firm can be thus defined as,

$$G \equiv [(1 + (1 - \epsilon)T)\ell + L_1^u]\pi(1, r) - \beta(T)r\epsilon\ell - w_T(1 - \epsilon)\ell - w_{uT}\epsilon\ell - w_u L_1^u, \tag{3}$$

where w_T, w_{uT} and w_u are the wage rates for skilled, trainees and unskilled workers, respectively. In equilibrium $w_T = (1 + T)\,\pi(1, r)$ and $w_u = \pi(1, r)$. Moreover, the wage for trainees is equal to the unskilled wage less the wage discount that trainees are willing to offer in return for non-firm specific training, $\phi(T)$,

$$w_{uT} = w_u - \phi(T), \tag{4}$$

where $\phi(T)$ is increasing in T.

An explicit representation of $\phi(T)$ is obtained by analyzing the long run relative wage equilibrium. Assuming that workers are risk neutral, they will be willing to "buy" OJT as long as the expected income obtained by going through OJT over their working life is at least as great as the expected income of

[7] Similar assumptions were used by Findlay and Kierzkowski (1983) to analyze human capital attained through formal education.

[8] This convexity assumption is consistent with the idea that the natural ability of workers is a "fixed factor".

remaining unskilled. Moreover, as long as the expected income through OJT is greater than the expected income of remaining unskilled there will be excess demand for OJT thus increasing pressures on the wage discount factor and on the resources used by the firms (in this case capital) to provide OJT. Hence, in stationary equilibrium the expected lifetime income of a trained worker must be equal to that of an unskilled worker,

$$\varepsilon(w_u - \phi(T)) + (1 - \varepsilon)\, w_T = w_u. \tag{5}$$

For simplicity, we assume in (5) that the time discount rate is zero. A positive and fixed discount rate does not, however, affect any of the qualitative results. Using the expressions for w_T and w_u provided above we can solve (5) for $\phi(T)$,

$$\phi(T) = \frac{(1 - \varepsilon)}{\varepsilon} T\pi(1, r). \tag{6}$$

Thus, (6) implies that in equilibrium the total cost that workers pay for training, $\varepsilon\, \phi\, (T)$, should be equal to the increased wage earnings that they will obtain during the rest of their working life, $(1 - \varepsilon)\, T\, \pi$.

Competitive equilibrium implies zero profit for the representative firm. Thus, assuming $G = 0$ in (3) and using (6), (4) and the expressions for the wage rate for skilled and unskilled workers, we obtain

$$(1 - \varepsilon)\, T\pi(1, r) - \varepsilon\beta(T)r = 0. \tag{7}$$

Expression (7) simply indicates that in competitive equilibrium the total value for the firm of training a worker should be equal to the cost of the training per worker.

An important aspect following from (5) is that the average lifetime wage of workers that undergo OJT, $w_a \equiv \epsilon(w_u - \phi(T)) + (1 - \epsilon)w_T$, is equal to the wage rate of unskilled workers,

$$w_a = \pi(1, r). \tag{5'}$$

Thus, in stationary equilibrium any change in the wage rate for unskilled workers will have an identical effect on the average lifetime earnings of skilled workers.

If the minimum wage $\bar{w}$ is binding for the trainees we have that $w_{uT} = \bar{w}$. In this case equations (4) and (6) yield,

$$\pi(1, r)\left(1 - \frac{(1 - \epsilon)}{\epsilon} T\right) = \bar{w}. \tag{8}$$

Thus for a given r any increase of $\bar{w}$ will cause a reduction in training per worker.

Maximization of profits (G) of the representative firm with respect to T subject to the constraint $w_u - \phi(T) \geq \bar{w}$ yields,

$$(1 - \varepsilon)\,\pi(1, r) - \varepsilon\beta'(T)r = \frac{\lambda\phi'(T)}{\ell} \geq 0, \qquad (8')$$

where $\lambda \geq 0$ is the Lagrangean multiplier associated with the constraint and $\beta'(T)$and $\phi'(T)$ are the first derivatives of $\beta(\cdot)$ and $\phi(\cdot)$, respectively. The left-hand side of (8′) is strictly positive if the minimum wage is binding for trainees, i.e., if $w_u - \phi(T) = \pi(\cdot)(1 - \frac{1 - \varepsilon}{\varepsilon}T) = \bar{w}$. If it is not binding (i.e., if (8) becomes an inequality) then the left-hand side of (8′) becomes equal to zero. What (8′) indicates is that if $\bar{w}$ is binding for trainees, the marginal value of training is greater than its marginal cost.

Next we complete the model by explicitly considering the non-tradable or informal sector, the demand side of the economy, the economy's budget constraint (or current account balance) and the factor market clearing conditions. For simplicity and to emphasize the fact that the informal sector in developing countries is quite backward, we assume that production of non-tradables only requires unskilled workers and no capital. This underlines the fact that in most developing countries the informal sector uses very little capital.[9] Also we assume that the economy is small and open with respect to trade and that (natural) factor endowments are given. This implies that the domestic price of traded goods is exogenous.

Given that the informal or non-tradable sector only uses unskilled workers, by appropriately choosing the output units we can postulate that the price of non-tradables (p) is simply equal to the wage rate for unskilled workers (or, equivalently, that output of non-tradables is equal to employment in that sector),

$$p = w_u = \pi(1, r). \qquad (9)$$

Full employment implies the additional condition,

$$\ell + L_1^u + L_2 = 1, \qquad (10)$$

where L_2 is the employment level in the informal sector. The total labor force has been normalized to unity.

[9] Below we discuss how this and other simplifying assumptions used are likely to affect the results.

Equilibrium in the capital market requires that the total demand for capital equals its supply. Capital is used only in the formal sector for training and directly productive activities. Demand for capital to be used in training activities is directly derived from (2) using Shephard's lemma, $\beta(T)\varepsilon\ell$,. And demand for directly productive activities is equal to minus the derivative of the variable profit function with respect to r. Thus, the capital market equilibrium can be represented as,

$$\beta(T)\varepsilon\ell - [(1 + (1 - \varepsilon)T)\ell + L_1^u]\pi_2(1, r) = \bar{K}, \tag{11}$$

where $\bar{K}$ is the economy's capital endowment and $\pi_2(\cdot)$ is the first derivative of $\pi(\cdot)$ with respect to the price of capital.

The demand side of the economy comprises two equations, the budget constraint or current account equilibrium and the market clearing condition for non-tradables. The budget constraint for the economy can be represented as,

$$E(1, p; u) = rK + \pi(1, r) + [(1 - \varepsilon)T\pi(\cdot) - \varepsilon\beta(T)r]\ell, \tag{12}$$

where the left-hand-side of (12) is the aggregate expenditure function, and u is aggregate welfare. The first right-hand side term is the total income of capital, the second one is the total income of labor (remember that the average wage for labor is $\pi(\cdot)$ and that total labor endowment has been normalized to unity). The third right-hand term represents the net profits of training activities which in competitive equilibrium are zero by (8). In spite of this and for reasons to become apparent later we leave this term in (12).

The market clearing condition for non-tradables is,

$$E_2(1, p; u) = L_2 \tag{13}$$

where $E_2(\cdot)$ is the domestic demand for non-tradables represented by the first partial derivative of the expenditure function with respect to the price of non-tradables, p (Shephard's lemma). The right-hand-side of (13) is simply the supply of non-tradables.

Finally, the model is completed by the specification of the output equations,

$$y_1 = [(1 + (1 - \varepsilon)T)\ell + L_1^u]\,\pi_1(1, r), \tag{14}$$

where y_1 represents the level of production of tradable goods and $\pi_1(\cdot)$ is the first derivative of π with respect to the price of tradables (from Hotelling's

lemma). As indicated before, production of non-tradables is simply equal to the level of employment in such industry,

$$y_2 = L_2. \tag{15}$$

Thus, the general equilibrium model consists of the nine equations (7) to (15) that solve for the following nine endogenous variables: T, r, p, ℓ, L_1^u, L_2, u, y_1 and y_2. In fact, the system is block recursive which, of course, facilitates its solution. The zero profit condition and minimum wage equations (equations (7) and (8)) simultaneously solve for r and T. Once r is determined the price of non-tradables is obtained from (9). The two factor market clearing equations in conjunction with the economy's budget constraint and market clearing condition for non-tradables solve for the allocation of labor (ℓ, L_1^u, L_2) and social welfare for given levels of r, T and p as previously determined from (7) to (9). Finally, the last two equations yield the output levels.

2. EFFECTS OF INTRODUCING A MINIMUM WAGE

We first illustrate the difficulties of the partial equilibrium predictions by considering the simplest case: the introduction of a minimum wage that is only slightly higher than the original wage for trainees. This is, of course, a somewhat artificial experiment but is appropriate to illustrate the pure direct effects of minimum wages isolating them from indirect effects that occur through wealth and other changes induced by increases in already binding minimum wages.

In this case a change in T does not have any effect on r. This can be seen by differentiating (7) with respect to r and T noting that since initially the minimum wage is non-existent or non-binding, (8′) holds as an equality. Hence, since $\bar{w}$ only affects the zero profit condition (7) through its effects on T, it follows that r is not affected by the introduction of the minimum wage. The level of T, however, necessarily falls as can be seen by differentiating (8) with respect to T and $\bar{w}$ keeping r constant.

Since r remains constant it follows that the average lifetime wage of workers, $w_a = \pi(1, r)$, does not change either, thus contradicting the prediction of partial equilibrium that w_a falls. Also the price of non-tradables remains unchanged from (9) and the welfare effect is zero as can be checked from (12) noting that $(1 - \varepsilon)\pi - \varepsilon\beta'(T)r = 0$. Therefore, from (13) L_2 does not change either. This, in turn, implies that total employment in the formal sector is not affected by the introduction of the minimum wage.

Although total employment in the formal sector remains constant, its composition does not. From (11) it is clear that the fall in T necessarily decreases the demand for capital (noting that $\pi_2 < 0$, we have that

$\beta'(T)\varepsilon\ell - (1 - \varepsilon)\ell\pi_2$ is positive). This temporary or incipient excess supply of capital needs to be corrected by a change in the composition of the work force of the tradable sector. Since skilled workers are more capital demanding than unskilled workers (note from (11) that the effect of increasing ℓ by one unit is $-(1 + (1 - \varepsilon)T)\pi_2$ while increasing L_1^u by one unit causes capital demand to expand by only $-\pi_2$), equilibrium in the capital market can only be reestablished by an increase in ℓ and a decrease in L_1^u. That is, although training per worker T declines, the number of workers receiving training $\varepsilon\ell$ necessarily increases, again contradicting another prediction of the partial equilibrium analysis.

An important question is whether the labor force as a whole becomes more or less skilled as a consequence of the introduction of the minimum wage. Defining an index of total skills as $TS = \ell T$, by obtaining explicit expressions for $dT/d\bar{w}$ and $d\ell/d\bar{w}$ through differentiation of (8) and (11) using $dr = 0$, it can be shown that TS decreases (increases) if and only if the training cost function is less (more) than unit elastic in T. Since initially the minimum wage is not binding, the marginal cost of training is equal to the average cost. The average training cost is at its minimum. This, in turn, implies that the training cost function must be unit elastic. Hence, total skills are not affected by the introduction of the minimum wage.

The value of the previous discussion is to illustrate the potential for collapse of well accepted propositions based on partial equilibrium analysis. The important thing is that the analysis in this section is quite general, requiring only that the market clearing conditions and economy's budget constraint hold. The only essential assumption is that capital demand is more sensitive to changes in the level of employment of skilled than unskilled workers. This appears to be a very realistic and sensible assumption. The reader may verify that the above findings are not affected, in particular, by our assumptions that training activities require only capital as an input (or more generally, that training activities are more capital intensive than production activities) and that the non-tradable sector does not use capital.

3. COMPARATIVE STATICS OF INCREASING AN EXISTING MINIMUM WAGE

In the previous section we consider the case where a minimum wage that is slightly above the wage for trainees is introduced. In this section we generalize the previous analysis by considering changes in an originally binding minimum wage. Now minimum wage changes induce a number of indirect wealth, price and employment effects in addition to the direct impact considered in section III.

3.1 Effects on Training Levels and the Price of Capital

Differentiating the system of equations (7) and (8) with respect to T, r and $\bar{w}$ yields,

$$\frac{dT}{d\bar{w}} = -\frac{1}{|H|}[(1 - \varepsilon)T\pi_2 - \varepsilon\beta], \tag{16a}$$

$$\frac{dr}{d\bar{w}} = \frac{1}{|H|}[(1 - \varepsilon)\pi - \varepsilon\beta'(T)r], \tag{16b}$$

where $|H| = [(1 - \varepsilon)\pi - \varepsilon\beta'(T)r]\,[1 - \frac{(1 - \varepsilon)}{\varepsilon}T]\pi_2 + \frac{(1 - \varepsilon)}{\varepsilon}\pi[(1 - \varepsilon)T\pi_2 - \varepsilon\beta]$.

First we note that $|H|$ is negative in view of (8′) and by the fact that $1 - \frac{(1 - \varepsilon)T}{\varepsilon}$ is equal to $\bar{w}/\pi > 0$ from (8) (remember that $\pi_2 < 0$). This implies that (16a) and (16b) are both unambiguously negative if the minimum wage is binding. In particular (16b) is necessarily negative because if the minimum wage is binding the net marginal return of training is positive, i.e., the numerator is positive.

Thus, an increase of the minimum wage causes an unambiguous reduction of OJT and of the price of capital. The increased minimum wage reduces the wage discount that workers can offer in return for training. This, in turn, leads to a fall in profits in the tradable sector; that is, profits become temporarily negative. This induces some firms to exit with the consequent fall in the demand for capital. This excess supply of capital causes the rental price of capital to contract until equilibrium is reestablished. The reduction in the price of capital restores the zero profit condition if profits are decreasing in r. Thus a sufficient condition for r to fall is that profits be decreasing in r. In our model this condition is assured by the assumption that training activities only require capital as an input.

More generally, we can allow for skilled workers (i.e., instructors) as an additional input in the provision of training, i.e., we can define a training cost function per worker as $c(r, (1 + T)\pi(1, r); T)$. In this case profits are not necessarily decreasing in r. A sufficient but not necessary condition for this to happen is that the instructors/capital ratio in production of training be less than the labor/capital ratio in the production of tradables. In any case, if this assumption does not hold, the effect of $\bar{w}$ on both training and the price of capital would be ambiguous. Thus, relaxation of the capital intensity assumption would put in doubt even the first prediction (that T falls) of the partial equilibrium analysis. It seems reasonable to expect that the number of instructors is only a

small proportion of the total number of skilled workers employed in directly productive activities. Also, the ratio instructor/trainees is likely to be considerably less than one. On the other hand, trainees probably use similar tools and capital equipment through their on-the-job training and as production workers. Thus, the presumption that the instructor/capital ratio in training activities is less than the labor/capital ratio in production of tradables appears reasonable.[10]

3.2 Effects on Average (Lifetime) Wages

The induced reduction in the price of capital has important consequences. Since in the long-run the equilibrium (lifetime) average wage for the workers that obtain training must be equal to the average (lifetime) wage for those not acquiring training, $w_a = \pi(1, r)$, it immediately follows that the average lifetime wage of both types of workers must increase when the minimum wage increases! This of course follows from the fact that $\pi_2(\cdot) < 0$. The fact that capital is cheaper leads to a higher marginal value product of labor which causes the wage for unskilled workers to increase. The reduction in T induced by minimum wages points in the direction of a lower wage for already skilled workers but the reduction in r (increasing the marginal revenue for skilled workers as well) weakens this initial effect. In fact, the net effect of a minimum wage on the wage rate for already skilled workers ($w_T = (1 + T)\,\pi(1, r)$) is ambiguous. The increase in the wage rate for trainees, however, necessarily dominates a possible negative effect on the wage for already skilled workers, thus causing the average lifetime wage to increase. This result is exactly opposite to the conclusion reached from partial equilibrium analysis by Rosen (1972), Feldstein (1978), Hashimoto (1982) and others.

3.3 Welfare, Employment Structure and Output Effects

By totally differentiating (12) using (9), (10), (11) and (13) we can directly derive the welfare effects of minimum wages,

$$E(\cdot)\,\frac{du}{d\bar{w}} = [(1 - e)\pi - e\beta'(T)r]\,\ell\,\frac{dT}{d\bar{w}}, \tag{17}$$

[10] Consider, for example, the case of a machine that is operated by one skilled worker. In this case the labor/capital ratio can be regarded as one. Training a machine operator requires that the trainee worker use the same machine under the supervision of an instructor. If the instructor devotes only a fraction of his/her time to assist one trainee, it follows that the instructor/capital ratio is less than the labor/capital ratio in production.

which given $\frac{dT}{d\bar{w}} < 0$ and (8'), is unambiguously negative (we note that we have used equations (10), (11) and (13) to cancel several other terms that in equilibrium necessarily vanish). Thus aggregate welfare necessarily falls which is not, of course, surprising. The fact that the term in square brackets in the right-hand is positive reflects the distortion associated with insufficient provision of OJT.

The price of non-tradables unambiguously increases with minimum wages because the unskilled wage rate rises, (from (9) $\frac{dp}{d\bar{w}} = \pi_2(\cdot)\frac{dr}{d\bar{w}} > 0$). This fact in conjunction with the fall in welfare implies from (13) that employment in the informal or non-tradable sector must decline. This follows in view that the expenditure function is concave, implying that $E_{22} < 0$. The fall in welfare and the increase in the price of non-tradables implies a reduced domestic demand for non-tradables with the consequent fall in production.

The fall of employment in the non-tradable sector implies from (10) that total employment in the formal sector necessarily increases. Once again contradicting the available partial equilibrium results.

The mechanics of the adjustment in formal sector employment is very much in line with the Heckscher-Ohlin model. The fall in employment in the informal sector leads to temporary unemployment, inducing an incipient reduction in the wage for the unskilled workers. But this reduction, in turn, causes temporary non-zero profits in the formal sector.[11] This induces new (identical) firms into the tradable or formal sector and the wage rate for unskilled workers returns to its original levels thus reestablishing the zero profit condition. But the fact that new firms enter the tradable sector implies that employment in this sector rises. This process continues until all excess supply of labor is eliminated. As shown below, the entry of new firms increases the demand for capital which may compensate partially or even more than off-set the negative effect of lower OJT on the demand for capital.

Although total employment in the formal sector increases, the effects of a minimum wage on the employment composition in this sector is ambiguous. The net effect of minimum wages on the number of skilled workers (ℓ) is the product of three partial effects: (i) As discussed in section III, the decrease in training causes a fall in the demand for capital, which requires a change in the composition of the labor force toward ℓ when the total work force in the tradable sector is constant; (ii) the labor force in the tradable sector does not, however, remain constant and as we already showed it necessarily increases. The increase

[11] The decreased productivity associated with the fall in OJT is compensated by a fall in the wage rate of skilled workers as is shown below. Hence, zero profits still prevails.

in labor available in the tradable sector increases the demand for capital creating a temporary excess demand. Since capital is fixed, to reestablish equilibrium it is necessary to reduce the demand for capital which occurs by decreasing ℓ (remember that ℓ is more capital demanding that L_1^u). Thus, the partial effect of increasing employment in the tradable sector is to reduce the level of skilled workers; (iii) the last effect is associated with the fall in r which also causes a temporary excess demand for capital. This effect also points to the reduction in ℓ in order to restore capital market equilibrium. Thus, the net effect of minimum wages on the number of skilled workers is ambiguous. The number of skilled workers may increase if effect (i) is sufficiently strong vis-a-vis effects (ii) and (iii).

Needless to say, the welfare of workers increases despite that aggregate welfare falls. The reason for this is that the average wage rate increases. Aggregate welfare falls because income of capitalists declines. That is, capitalists carry not only the complete social cost of the minimum wage but also must transfer part of their reduced income to the workers.

Finally, it is worthwhile to discuss the sensitivity of the analysis to the assumption that the non-tradable or informal sector does not use capital. This assumption does not affect the results concerning the level of training, the price of capital and the lifetime average wage rate. It can, however, alter the conclusion that the price of non-tradables increases as well as the results concerning the employment effects of minimum wages. It can be shown that the effect of minimum wages on the price of non-tradables crucially depends on the relative capital intensities of production of non-tradables vis-a-vis production of tradables. If non-tradables are less capital intensive than tradables all the results discussed above hold. More generally, the key assumption is that industries that provide training are more capital intensive than industries that do not. This assumption is quite reasonable, particularly in the context of developing countries.

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