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Technical Change, Pecuniary Externality And The Market Failure

Hom M. Pant*

INTRODUCTION

Technical progress allows a price taking firm, no matter how small, to circumvent the restriction posed by its smallness in making effective factor prices it faces even if it is incapable of affecting market clearing prices, which others face. With the decisions to change technology falling entirely within the domain of each single firm whether the market outcome will still be efficient is an important question with far reaching implications. This issue is directly relevant to persons and institutions interested on regionnal problems and policies, particularly in regions where unemployment due to technological redundancy is quite high. We would like to know, for example, whether the so-called technological unemployment is an efficient outcome or is the result of the market failure. To my knowledge, the efficiency of market outcomes under changing technology has not been examined by previous authors.

Whether the market outcome of a firm-level technical change is efficient or not, if the technical change takes place in many firms, or in an industry, say because of nation or industry-wide policy reform simultaneously, then it will affect market-clearing prices producing a series of pecuniary externalities across the economy. Since Scitovsky (1954) these externalities have clearly been distinguished from the real or technological externalities and considered welfare benign. It is because the external benefits are believed to exactly offset the external costs of pecuniary changes (Shubik 1971, Anderson 1974, and Ng 1983). The pecuniary change is the mechanism through which the market is supposed to yield the most efficient outcome.

It has also been shown, nevertheless, that the pecuniary externality may cause the market to fail if there are imperfections in the market, such as incomeplete insurance market (Loong and Zeckhauser 1982), or the presence of monopolistic elements (Ng 1983) or agents holding inconsistent

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* Mr. Pant is Associated with the University of Tasmania, Australia.
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price information on potential product innovations (Makowsky and Ostroy 1995). Even when markets are complete and perfect, the pecuniary externality provides an incentive to the agents to behave strategically, such as collude or merge or extract some tribute, so that some of the external benefits of pecuniary changes can be internalised (Subik 1971 and Anderson 1974). As long as people respond to economic incentives, pecuniary externalities may form the basis for various lobbying activities and institutional change, which means that the pecuniary effects of technical change can not be dismissed *a priori*.

Is the outcome of a competitive and complete market socially efficient when a firm changes its production technology ? In other words, would a profit maximising firm guided by exogenously given market prices be able to fully appropriate its social contribution of technical progress ? If not, what can we do to correct it ? What determines whether there is any trikle-down effect of a firm-specific technical change ? What is the pattern of this effect ? Who benefits and who loses at the new equilibrium ? This is a list of interesting but yet unanswered questions.

This paper maily focuses on labour saving technical change and attempts to answer the above questions with a simple specific-factor model of a small open economy, which produces all traded goods and where no new product is being introduced. The purpose of modelling this type of a small open economy is to fix commodity prices and rule out coordinationa failure, so that the conditions for market efficiency as stated in Makowsky and Ostroy (1995) are satisfied.

In our model, each firm employs a specific-factor, called capital, and a composite of all mobile factors, called labour. The production function of a firm is defined on efficiency units of the two factors, while the firm, however, buys these factors in physical units from fully competitive factor markets. Firms convert physical units of the factors into their efficiency unit by a given rule and the efficiency units are then fed into a well-defined neo-classical production function to obtain output. A technological change has been been defined as a shift in the production function, which implies a change in the productivity of the efficiency units of the factors. A technical change has been defined as a change in the rule of converting physical units into efficiency units of the factors. If a firm requires less physical units of labour, say persons, to extract the same amount of efficiency units of labour then, other things remaining the same, the firm is said to have

acquired a labour saving technical progress. In this situation, the cost per unit of efficiency unit of labour falls even if the market clearing wage rate is unaffected by the technical change. Firms will make adjustments. The national output and the profit level of the firms will change. Following Makowsky and Ostroy (1995) we examine whether or not the firms following the price signal will be able to full appropriate the social contribution of thier technical change. A failure to do so implies a divergence between social and private benefits, which in turn can cause a market failure.

It is shown that whether the firm introducing a labour saving technical progress will be able to appropriate its social contribution fully, less than or more than fully depends on whether local wage elasticity of its labour demand is equal to, greater than or less than unity. A firm introducing a labour saving technological progress, however, would never be able to fully appropriate its social contribution. Therefore, even a complete and competitive market will fail to deliver an efficient outcome if the firm has a local wage elasticity of labour demand not equal to unity and the technical and technological progresses are not cost less. Furthermore, the firm will reduce or increase employment if its wage elasticity of labour demand is less or greater than unity as a result of the introduction of labour saving technical progress. This adjustment in employment is privately desirable, but it could be socially undesirable. A Tax or subsidy scheme to rule out the possibility of this kind of technological market failure has been provided.

Firms that have locally inelastic or elastic labour demand have an incentive to over introduce or under introduce labour saving technology. In the absence of corrective intervention, similar action can be expected on the part of many firms, which can culminate in sufficient level of unemployment i.e. excess demand to make the market adjust the market clearing wage rate. As the wage rate falls or rises, or all firms benefit or lose and the labour loses or benefits. Trickling-down of pecuniary effects of sector specific technical progress starts here. Moreover, a fall in the wage rate does not eliminate the incentives to introduce further technical changes. There is also an incentive to firms with elastic labour demand to subsidise the introduction of labour saving technology in firms with inelastic labour demand. Thus an economy may plunge into the cycle of unemploment and lower wages for ever.

Rest of the paper contains the market equilibrium under changing technique of production, the teachinical change and the appropriation problem, legislation of R and D, tax subsidy, and correction of the market failure, and finally the conclusion.

MARKET EQUILIBRIUM UNDER CHANGING TECHNIQUE OF PRODUCTION

In this section we describe a simplest general equilibrium model of an n-sector small open economy producing n-different tradable commodities. Each sector, representing the behaviour of a tiny, is assumed to be a price taker in all markets and strives to maximise profit subject to its production function, defined indirectly over labour and capital. The production decision is decentralised. There is one national consumer, who finally receives all income and consumes goods at constant prices to maximise utility. No new commodity is being introduced and therefore, there is no coordination problem as shown by Makowsky and Ostroy (1995). Under these conditions we can ignore the demand side since the income generating supply side is completely unaffected by it, and the social welfare depends on total income. It is also assumed that labour is mobile and capital is specific to each firm.

The Production Function Of A Firm

Each sector or firm produces a single commodity by employing labour and capital of given efficiency and the relation is defined by a concave production function:

$$X_j = F(L^*_j, K^*_j); \qquad j = 1, \ldots, n, \qquad (1)$$

Where L^*_j and K^*_j are labour and capital measured in their efficiency units and Xj is the unit of output produced in industry j. The function F is assumed to decribe the hard core technological relationship between factors, measured in efficiency units, and output. Any change in F relects the real technological breakthrough.

The efficiency units of factors and their prices are determined by :

$$L^*_j = L_j / A_{Lj}, \text{ and } K^*_j = K_j / A_{kj} \qquad (2)$$

$$W^*_j = A_{Lj} W_j, \text{ and } R^*_j = R_j A_{kj}, \qquad (3)$$

Where L_j and K_j are physical units of labour and capital employed in industry j whose prices are Wj, the wage rate and R_j, the rental rate

respectively. The rental rate R_j measures the profit rate per unit of capital in firm j and each firm faces the same market wage rate so we have $W_j = W$, for all j, The coefficiencents A_{Lj} and A_{kj} provide the current mapping between the efficiency units and the observed units of the factors and represent the current technique of production and management. Suppose both A_{Lj} and A_{kj} are unity, then it means the efficiency units, L^*_j and K^*_j, of the factors are equal to their physical units, L and K, respectively. A fall in the value of A_{Lj} indicates that to obtain a given level of efficiency units of labour we now need fewer persons than before or alternately, more efficiency units of labour now become available from a given stock of physical units of labour. Neutral technical progress occurs if changes in A_{Lj} and A_{Kj} are proportinate for each industry j and it is biased if they are not.

Given a markent clearing wage rate, W, efficiency wage rate, W^*, is determined by (3). Given the product price, P_j for each commodity j, a firm j solves the following maximisation problem:

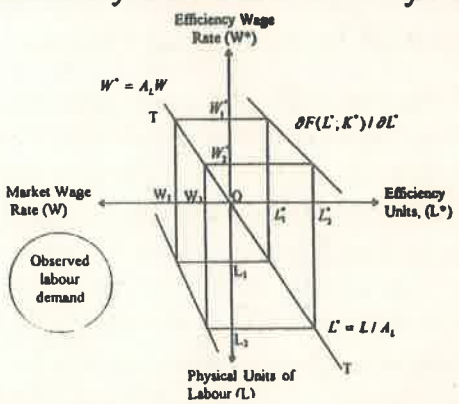
$$\underset{L^*_j}{\text{Max}} \quad P_jX_j - W^*L^*_j \qquad (4)$$

s.t. $X_j = F(L^*_j, K^*_j)$

by choosing efficiency units of labour, L^*_j.

Figure 1

Optimal Demand For Physical And Efficiency Units Of Labour



A solution to this problem satisfies the condition that

$$dF(L^*_j; K^*_j)/dL^*_j = W^*/P_j \qquad (5)$$

which can be expresses as

$$L^*j = L^*j(W^*;K^*j,Pj) \qquad (6)$$

The condition (5) states the obvious: to maximise profit, employment of efficiency units should be chosen so that its marginal product is equal to the efficiency wage rate. Once the optimal demand for efficiency unit of labour is determined, the demand for physical unit can easily be determined by (3) and (4). This process can be illustrated as in Figure 1.

The first quadrant in Figure 1 shows the marginal product curve of efficiency units of labour. Profit maximising behaviour on the part of the firm requires that efficiency units be so chosen that the marginal product equals the efficiency wage rate, the output price is normalised to unity, which is converted in the second quadrant into the market wage rate. The efficiency units of labour are translated into physical units in the fourth quadrant. Finally, the marginal product curve of, which is also the demand curve for, the physical units of labour is derived in the third quadrant.

To make the point clear, suppose that one person yields two efficiency units of labour per period, that is $A_L = 0.5$ If W_1 is the market wage rate then the efficiency wage rate, W^*_1, is equal to $0.5\ W_1$. The first quadrant of the figure shows that at this wage rate L^*_1 of efficiency units of labour maximizes the firm's profit. The fourth quadrant coverts this information into physical units of labour as $L_1 = 0.5\ L^*_1$. We have now got a point to trace the demand curve for physical unit of labour in the third quadrant. Other points can be obtained by similar arguments.

Technical Change And Technological Change

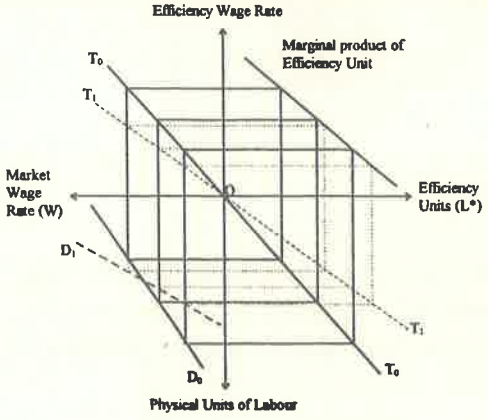
The slope of the line TOT that goes from the fourth to the second quadrant through the origin represents the technical coefficient A_L. A fall in the value of A_L makes the line flatter pulling towards the X-axis and an increase in the value of A_L makes the line steeper. A flatter line would mean that a person now yields more efficiency units of labour than before, whereas a steeper line would mean that the same person is now less efficient than before. Thus by rotating the line TOT around the origin, we can represent a particular type of labour productivity change, which we define as technical change. A pure technical change would leave the production function F unaffected, and the marginal product of efficiency units unchanged. Such a change, for example, can be brought about by

improved management practices, provision of recreational and training facilities, etc., but without changing the relationship between efficiency units and output. It only changes the relationship between the physical unit of a factor and its price of an efficiency unit proportionately. If the productivity efficiency of a physical unit of labour falls by 10 percent then, at a constant wage rate, the price of an efficiency unit of labour falls by 10 percent as well. The effect of a technical change on the demand for physical unit of labour is drawn in Figure 2.

Figure 2 is similar to Figure 1, except that the line T_0OT_0 representing the technique of production has rotated to a broken line. Labour has become more efficient, which is shown by the slope of the new line T_1OT_1. As a result, the demand curve for physical units of labour has rotated from D_0 to D_1 At a given market wage rate, efficiency wage rate has now fallen; demand for efficiency units has risen; and finally, the demand for physical units has, perhaps, changed. Above the point of intersection of the two demand curves D_0 and D_1 the demand for person has increased, but below the point of the new demand curve D_1, which can be explained as follows. Since a physical unit means more efficiency units now, say 4 units as against 2, and given the unchanged production technology F, the marginal product of the first physical unit is the total of the marginal products of all the first four efficiency units it produces. Therefore, the marginal product of first physical unit has gone up. Similarly the marginal product of the second physical unit also has gone up, but not by as much as the efficiency units, and so on. As we move on, the marginal products of physical units of labour start to fall rapidly, which is described by the tilt of the curve D_1.

Figure 2

Technical Change And Demand For Physical Units

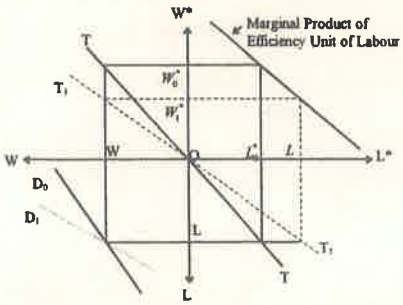


The point of intersection between the two demand curves D_0 and D_1 is determined by the wage elasticity of the demand for efficiency units. If the wage elasticity of demand for efficienty unit is unity, then a change in technique will not affect the demand for physical units at the going market wage rate.It is because, as productivity of the physical unit goes up, say by 10 percent the unit cost of efficiency unit falls by 10 percent as well. This will increase demand for efficiency units by 10 Percent so the demand for physical unit remains unchanged.

This point has been illustrated in Figure 3. At the going wage rate W, the demand for physical units has remained the same with the technique T_1OT_1 as with T_0OT_0. As an extension of this result we can say that, if the wage elasticity of the demand for efficiency unit is golobally unity, then no change in technique will bring a shift in the demand curve for physical units in the labour market. Alternately, if the wage elasticity of demand for efficiency unit is greater than unity over the relevant range, then the new demand curre for physical units will be flatter than the old one. Thus, the elasticity of demand for efficiency units plays a critical role in what follows.

Figure 3

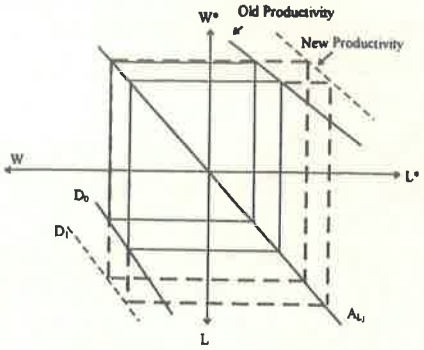
Wage Elasticity Of Demand For Efficiency Unit And Demand For Person



Now we consider change on production technology, that is a shift on the production function F. The effect of a labour productivity enhancing shift in the production function and its impact on the demand for person is illustrated in Figure 4.

Figure 4

Change In Technology And Demand For Persons

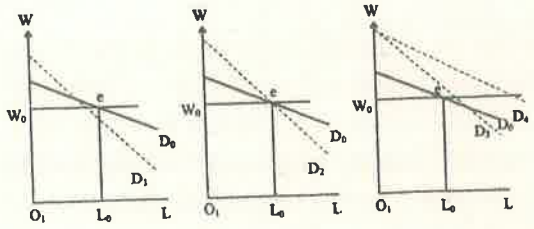


As shown in Figure 4, a shift is production function brings about a rightward shift on the marginal productivity of efficiency units of labour. Given the technique of extracting efficiency from a physical unit of labour, the effects on demand for person are traced by broken lines; the demand curve shifts out.

Figure 5 summarises the types of shifts on the demand-for-labour curve in the labour market discussed so far which were brought about by technical and technological changes in the firm.

Figure 5

Technical And Technological Change, Wage Elasticity And the Shifts On Labour Demand Curve



Do is the initial demad curve for physical units of labour. The market wage rate is given at Wo and the firm is currently employing L_0 persons. If a technical change takes place in the firm, then depending upon the local wage elasiticity of demand for the efficiency units, the shift on the demand curve for persons may take any of the situation shown in panel (a),(b) or (c). If the elasticity is less than unity, then the shift will be as shown in panel (a); the new demand curve will be like D_1, intersecting D_0 to the left of current equilibrium point e. If the elasticity is unity, then the new demand curve will be like D_2 as shown in panel (b), indicating no change in the demand for persons at the going wage rate. If the elasticity is greater than unity, then the new demand curve will be like D_3 as shown in panel (c), which indicates an increase in demand for physical unit at the going wage rate. Similarly, the new demand curve would be like D_4, definitely to the right of the point e throughout if it is caused by a labour saving technological progress. As far as the effect on demand for persons is concerned, D_3 and D_4 are similar. Therefore, in what follows we will consider three types of possible shifts of the demand curve for physical units of labour that is brought about by productivity changes under three different ranges of the wages elasticity : less than unity, unity and greater than unity.

Equilibrium In Labour Market: The Last Component Of General Equilibrium

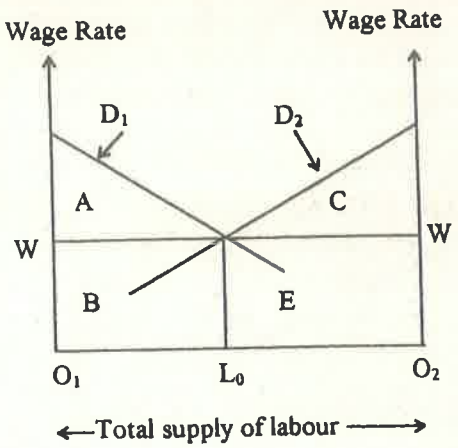
For the general equilibrium of the small open economy we now need to specify the resource constraint of the economy. For that matter we now require that the demand for physical units of labour by all firms add just up to the supply of labour. That is we require

$$\sum_j Lj = L. \qquad (7)$$

To illustrate the equilibrium and the comparative static graphically, let us aggregate the labour demand of all but one arbitary firm into one and call it as firm 2, and the arbitrarily chosen firm as firm 1. Given that the economy has got a fixed supply of labour and the flexible wage clears the labour market we can describe the essence of the general equilibrium of this economy as in Figure 6.

Figure 6

Equilibrium In The Labour Market



The small open economy described here has commodity prices determined exogenously by the world market; we shall hold them fixed throughout the analysis. We can choose the units so that commodity prices are alll unity. This normalisation lets us do our sums freely. The market clearing wages rate is W, firm 1 employs O_1L_0 units of labour, and all other firms together employ the rest, O_2L_0 units of labour. Marginal products of labour are equalised across the firms; This allocation of labour is efficient. Labour gets the area B+E, and sector-specific factors receive area A and C respectively. Total income of the society is given by the area A+B+C+E. Now we have got our tools ready for the comparative statics and the analysis of the appropriation problem. The main results are summarised in a series of propostions.

TECHNICAL CHANGE AND THE APPROPRIATION PROBLEM

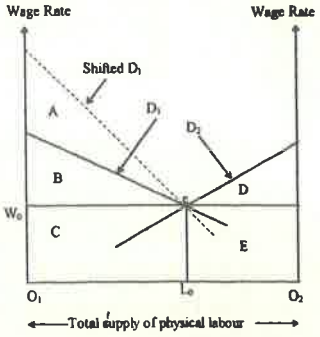
Propostion 1: *If a firm has wage elasticity of demand for efficiency units equal to unity locally, then this firm will just appropriate its social contribution of labour saving technical change. There will be no appropriation problem and the market will remain efficient.*

Proof: Assume that the conditions of the Proposition 1 hold – that is, the firm 1 has unitary elastic demand for efficiency units of labour at the going wage rate – and consider that there is a possibility of introducing a labour saving technical change. As discussed in previous section, if the firm

introduces this change then its demand curve for persons would shift, as shown by the dotted line in Figure 7. The shift will be such that the new demand curve will intersect the existing one at the point e so that there will be no change in the demand for labour at the going wage rate. The labour market equilibrium will be undisturbed, the wage rate will remain at W_0, and the allocation of labour would be given by L_0.

Figure 7

Technical Change And Appropriation In Firms With Unitary Elastic Labour Demand



The income of the society would be given by the area A+B+C+D+E, which currently is B+C+D+E. Hence the social contribution of the proposed technical change is given by the area A. Since firm 1 is currently appropriating the area B and would be appropriating the area (A+B) after the change. The private return of the proposed change is, therefore, given by the area A. Firm 1 will be able to fully appropriate its contribution to the society. If the proposed change is privately profitable, after taking into account the cost of the change, then it will be socially profitable as well. Hence the market will remain efficient.

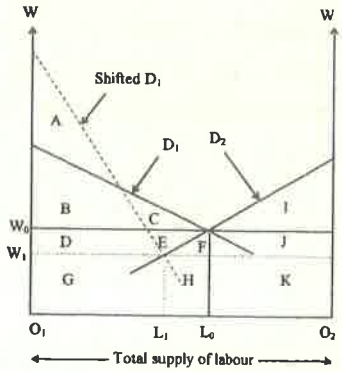
Propostion 2: *if a firm's local wage elasticity of demand for efficiency units is less than unity, then this firm will appropriate more than its social contribution of labour saving technical change. There will be an appropriation problem and the market will fail in delivering an efficient outcome. Such firms will over-introduce labour saving teachnical change than socially desirable.*

Proof: Assume that the conditons of Propostion 2 hold - that is, the local wage elasticity of firm 1's demand for efficiency units is less than

unity. Then as a result of labour saving technical change, its demand curve for physical units would shift as shown in Figure 8.

Figure 8

Appropriation Problem With Less Elastic Labour Demand



Since firm 1' s demand for physical units of labour will fall at the going wage rate, the equilibrium wage rate would be W_1 and the allocation of labour across firms would be given by L_1. Now let us examine the private and social contribution of this change.

Aggregate social output before the technical change in sector 1:

$Y_0 = [(B+C)+(D+E+F+G+H)]+[I+(J+K)]$

Aggregate social output after technical change in sector 1 would be :

$Y_1 = [(A+B+D) +G]+[(F+J+I)+(H+K)]$

Therefore the social contribution of the technical change,

$\Delta Y = Y_1 - Y_0 = [A-C-E)$

Profit of sector 1 before the technical change:

$\pi_0 = B+C$

Profit of sector 1 after change would be :

$\pi_1 = A+B+D$

Therefore, private benefit of the technical change $=\Delta\pi = A+D-C$

Excess appropriation by sector 1, which is the excess of private benefit of technical change to sector 1 over its social contribution, is given by:

$$\Delta\pi - \Delta Y = (A+D-C)-(A-C-E) = (D+E) > 0$$

Thus, sector 1 will be able to appropriate the area (D+E) in addition to its social contribution of the labour saving technical change. So all labour saving technical changes that cost more than its social benefit but less that private benefits to sector 1 will be privately profitable and will be introduced. Hence, in this case the market fails.

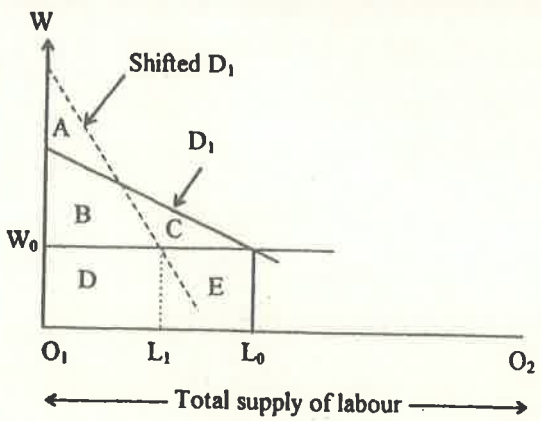
Since the area of excess appropriation is determined by the extent of the fall in the market clearing wage rate a question naturally follows: What if, the firm still appropriate more than its contribution and the market still fails ? The answer is in the following corollary.

Corollary 1: *In addition to the condition of Proposition 1, if the market wage rate is fixed exogenously, the firm will over-appropriate and the market will fail as a result of the introduction of labour saving technical progress in the firm.*

Proof: Let the wage rate be fixed at W_0. Consider a small firm as represented in Figure 9. Initially, the firm is in equilibrium at L_0 level of employment. Its contribution to social output is given by the area B+C+D+E. The specific factor has received the area B+C, and the area D+E is the wage bill.

Figure 9

Appropriation Problem In A Small Firm



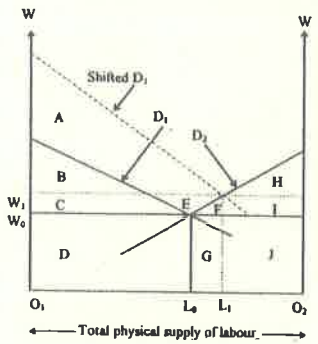
Suppose that as a result of the proposed change the firm's demand curve for physical units of labour shifts as shown by the broken line in Figure 9. The firm would find it profitable to reduce employment level down to the point L_1. As a result, L_0-L_1 persons will be unemployed. Since the output of the other firms would remain unchanged, the change in national output as a result of the introduction of the labour saving technical change in firm 1 is the same as the change in its own output, which is given by the area A-C-E. The change in the firm's profit is given by the area A-C. Since the area A-C exceeds the area A-C-E by the area E, the firm ends up appropriating more than its social contribution and thus, the market fails. A labour saving teachnical progress, if it occurs in firms with low wage elasticity of labour demand, can cause unemployment even if the economy has previously been in full employment. This result shows that in a world of ever changing technique of production, maintenance of full employment through the market process seems next to impossible.

Proposition 3: *If a firm's local wage elasticity of demand for efficiency units is greater than unity, then this firm will appropriate less than its socail contribution of labour saving technical change. There will be an appropriation problem and the market will fail in delivering an efficient outcome. Such firms will under-introduce labour saving technical change than it is socially desirable.*

Proof: This proposition covers the case left out by Propositions 1 and 2. The proof follows similar line of arguments. Assume that the firm 1 has at least, locally, elastic labour demand. As shown by the broken line in Figure 10, firm 1's demand for physical units of labour increases at the going wage rate as a result of the introduction of labour saving technical change.

Figure 10

Appropriation Problem In Firms With Elastic Demand For Labour



The wage rate rises to w_1 to clear the labour market, and firm 1 employs more person and other firms reduce their employment in the new equilibrium after the technical change. It is useful to recall that the shift in the labour demand curve of firm 1 is similar to the situation in which the firm had a labour saving technological progess. So the result that follows represents both cases.

Now, let us exmine the social contribution and private benefit of the change.

The national output before the technical change in sector 1 is given by:

$Y_0 = [(B+C)+D]+[(F+I+H)+(G+J)]$

The national output after the technical change in sector 1 would be:

$Y_1 = [(A+B)+(C+D+E+F+G)]+[H+(J+J)]$

Therefore, the social contribution of technical change is given by

$\Delta Y = Y_1 - Y_0 = A+E.$

Profit of sector 1 before the technical change is given by the area

$\pi_0 = B+C.$

Profit of sector 1 after change is given by the area

$\pi_1 = A+B.$

Therefore, private benefit to firm 1 of the labour saving technical change is given by

$\Delta\pi = A-C.$

Clearly, the excess appropriation by firm 1 in this case is negative, for

$\Delta\pi-\Delta Y = (A-C)-(A+E) = -(C+E) < 0.$

Thus, firm 1 fails to fully appropriate its social contribution of labour saving technical change. As a result some projects that are socially desirable but are privately costly will not be undertaken. The market fails.

Proposition 4: *Whether or not a labour saving technical change in a firm will produce pecuniary externality or trickle-down effects to other firms depends on whether or not the local elasticity of labour demand of the firm is unity.*

Proof: This proposition follows from Propositions 1,2 and 3.

Proposition 5: *There is an incentive to firms with elastic labour demand to subsidise the introduction of labour saving technical change in firms with very low elasticity of labour demand. Such a subsidisation may actually take place if the sizes of the firms are sufficiently large, even, if they behave competitively.*

Proof: It was shown in the proof of Proposition 1 that the market wage rate falls as a result of the introduction of labour saving technical progress in firms with inelastic labour demand. As a result of this fall, all other firms benefit. They increase their profit by the area (F+J) in Figure 8. Since firms with high elasticity of labour demand fail to fully appropriate their contribution to the national output and so under-invest in labour saving R and D of their own, they have an incentive to subsidise firm 1 up to F+J to introduce labour saving technical change in firm 1. If the change was not privately profitable to firm 1, it may now become profitable after the cross-subsidisation from other firms, which will further exacerbate the inefficiency of the market outcome.The only reason not to expect such cross-subsidisaton to take place is that the benefit of lower wage would be shared by sufficiently large number of firms suffering from the free rider problem. The presence of few big firms in the real world reduces the importance of this problem significantly.

LEGISLATION OF R AND D SUBSIDY AND CORRECTION OF THE MARKET FAILURE

In this section we will see how a carefully designed intervention improves the efficient functioning of the market.

Propostion 6: *For firms $j = 1, 2, ..., n$, let $Tj = (W_{0j}L_{0j} - W_{1j}L_{1j})$, where $W_{0j}L_{0j}$ and $W_{1j}L_{1j}$ are respectively the payroll of the firm j before and after the labour saving technical change is introduced in some arbitrary firm 1. Let $T_L = W_1L^1 - W_0L^0$, Where W_0 and W_1 are the market clearing wage rate before and after the change and L^0 and L_1 are respectively the economy-wide employment level before and after the change. Then the legislation of the tax $T = (T_1, T_2, ..., T_n, T_L)$ irrespective of whoever introduces the labour saving technical change improves market efficiency. It corrects the market failure with a small second order dead weight loss. Moreover, unless the economy has unemployment this R and D tax/subsidy leads to no collection of the tax or payment of the subsidy.*

Proof: We will first show that the R and D subsidy improves market efficiency, when a single firm introduces a labour saving teachnique. We consider both possibilities, the firm having the elasticity of labour demand

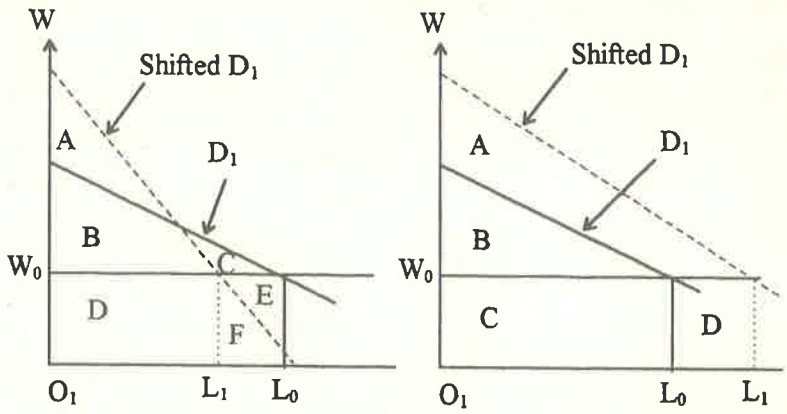
greater than unity or less than unity. For the first case, we recall Figure 9, and for the later we draw another one. Both cases are placed in Figure 11 in which the panel (a) repeats Figure 9 and the panel (b) represents the firm with local elasticity of labour demand greater than unity.

We know from Propositions 2 and 3 that in a free market solution the firm would over appropriate in (a) by the area E+F and under appropriate in (b) by the area D.

Since the employment in the firm falls in case (a) and rises in case (b) the payroll decliness in (a) and rises in (b). As a result, the firm is liable to an R and D tax equal to the area E+F in the case of (a), and a subsidy equal to the area D in the case of (b). The workers are entitled to a subsidy equal to the area E+F in a case of (a) and a tax equal to the area D in case of (b). Thus there is no funding problem in the scheme and since the tax exactly offsets the over or under appropriated amount, it corrects the malincentive as well. The Firm exactly receives what it contributes to the society, which is the area A-C-E-F in the case of (a) and the area A+D in the case of (b). Now we have to show that the firm actually chooses to employ L_0 amount of labour in case (a) and L_1 in case of (b) with the better technique of production in place.

Figure 11

Technical Change In A Small Firm And Correction Of The Market Failure



(a) (b)

In case (a) the firm has the following choices: employ L_1 and pay the R and D tax, employ L_0 and do not pay the tax, or choose in between the two. In case of (b) the choice is clear; it will employ L_1, which will be subsidised by the workers or by the society. Let us focus on case (a)

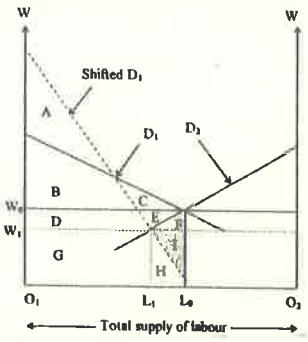
If the firm chooses to employ L_1 units of labour, its pay off from the technical change and the R and D tax would be the area A-C-E-F. If it chooses to continue to employ L_0 persons even after the technical change, then its payoff from the change would be the area A-C-E. It will be able to recoup the area F from the increased production. Clearly to employ L_0 dominates the strategy to employ L_1. Not only that to employ L_0 dominates any convex combination between the two. Hence the firm will employ L_0 and pay no R and D tax. Thus with this tax/subsidy scheme, no firms will reduce thier employment, and all socially profitable technical change will be implemented.

Now we will consider this scheme in general equilibrium. Assume that sufficiently many firms introduce labour saving technical change and the labour market feels the difference. The market clearing wage rate adjusts, but the direction of its change depends on whether the technical change increases the demand for labour at the going wage rate or reduces it. We will consider both cases, in turn.

First, let us consider the case of falling demand for labour, that firms with very small wage elasticity of labour demand introduce the change. We analyse the working of the scheme with Figure 12, which is basically Figure 8 with the area H in Figure 8 divided into two areas, I and H, in Figure 12.

Figure 12

Technical Change In Many Firms With Inelastic Labour Demand, Labour Market Equilibrium And The R and D Subsidy



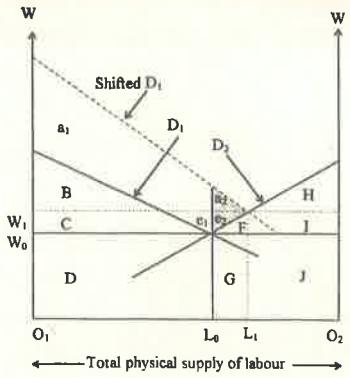
We know that the free market solution in this case is that the firm over appropriates by the area D+E, the employment in firm 1 falls to L_1, and the wage rate falls to W_1. Since the payroll declines after the change the firm is liable to an R and D tax, which is equal to the area D+E+F+I+H. Hence if the firm chooses to stay with the market solution its profit will increase by the area [A-(C+E+F+I+H)] from its initial value of (B+C). If, however, the firm chooses to employ the L_0 units, the it does not have to pay the tax and its profit will increase by [A-(C+E+F+I)]. Thus, by choosing to employ the original number of workers the firm can increase its profit by the area H, or recover the tax liability. Hence, the firm will choose to employ L_0. Since firm 1 is now ready to employ L_0, the wage rate will stay unchanged at W_0; there will be no effect on other firms whatsoever.

As the pecuniary externality is now eliminated the effect of technical change has been internalised. The firm appropriates just its contribution to the society, and the income of the rest of the society is unchanged. This is not the first best solution, however. There is some inefficiency left out here. It is the area (F+I), which represents the loss is social output of labour from being employed in less productive employment. The cost of being so will not be borne by the workers, though.

Finally, we consider the case in which firms with high wage elasticity of labour demand introduce the labour saving technical change. To analyse the effectiveness of the R and D Tax/subsidy scheme to reconsider Figure 10 again, which is basically reproduced in Figure 13.

Figure 13

Technical Change In Many Firms With Inelastic Labour Demand, Labour Market Equilibrium And The R&D Tax/Subsidy Scheme.



We know that in this case the market solution implies an under appropriation of the social contribution made by the firm. We want to see whether the R and D tax/subsidy scheme can correct this problem or not.

Note that the technical/technological progress introduced in firm 1 causes the market wage rate to rise; the payroll of the firm 2 will also rise at unchanged employment. Since the R and D tax/subsidy scheme provides subsidy to cover any rise in the wage bill at the market wages rate, there is no need to firm 2 to reduce its employment; whatever be the market wage rate. Since all extra wage earned will be taxed away, there is no incentive to the worker to move firms even if firm 1 wants to bid them away by offering them a higher wage rate. Hence the employment in firm I will remain at L_0, and the market wage rate will remain at W_0. Firm I will earn the area a_1+e_1+B+C, which is just equal to its socail contribution via technical change.

CONCLUSION

Market fails, as far as giving right incentives is concerned, when firms do change their technique or technology or production. The first theorem of welfare economics, which states that all Walrasian equilibria are Pareto efficient, needs another revision. The first revision was proposed by Makowsky and Ostroy (1995). They have shown that markets can not provide correct incentives as far as firms are engaged in product innovation. They suggested that private price information regarding new products held by different agents should be consistent in order that the Walrasian equilibrium with this possibility to be Pareto efficient. Here we have seen that if firms change production technique or technology, the Walrasian equilibrium may not necessarily be efficient. In order that the first theorem of welfare economics remains valid, the firms should not be allowed to change their production technology. They may, however, change their technique of production provided they maintain that the wage elasticity of labour demand always remains equal to unity.

In general, we have seen that firms with very inelastic demand for labour tend to over-do and firms with very elastic demand for labour tend to under-do labour saving technical progress compared to what would be the social optimum. It happens so because of the appropriation problem – that firms fail to appropriate their social contribution of the technical change correctly.

To avoid this deficiency of the market mechanism, we proposed a R and D tax/subsidy scheme. This scheme funds any increase in the payrolls of the firms arising out of labour saving technical progress and taxes away any saving made on the payroll by all firms, irrespective of whether the firm is responsible for the change or not. This scheme also does not let wage earners suffer or benefit from the pure technical change. The most interesting aspect of this scheme is that it restores the market efficiency and only needs to be legislated, neither there is any need for actual tax collection nor a need of the subsidy being paid out.

In the absence of such corrective policy, there is always a danger to economy of fall out of full employment, and plunge continually into the cycle of unemployment, and lower wages.

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