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Abstract

In this paper I try to analyse the impact of environmental policies in the presence of eco-labelling on the wage level and production levels. For this I start with a general equilibrium framework where a country produces two traded goods using labour and capital, one of which pollutes when consumed. The pollution generated depends on the abatement technology used by the firms and also the scale of production and affects the health of workers and labour productivity. Since the consumers are adversely affected by the pollution generation, they are willing to pay a higher price for a cleaner variety of the dirty good. However, since the pollution is generated during production, they cannot judge the cleanliness of a good. Here the government steps in, monitors the pollution generation and issues an eco-labelling certificate regarding the quality. In this framework, analyse the impact of environmental standards on the wage levels and production. I find that a minimum standard adversely affects the wage rate, unless the productivity effect is very small. However, the eco-labelling process aides the labour market as it tempers the impact of the standard on wages.

Keywords: Eco-labelling, environmental standard, general equilibrium, product quality.

1. Introduction

Eco-labelling has become extremely popular in the developed countries and is slowly making its presence felt in less developed countries as well. It is a process which helps overcome the information problem associated with the generation of pollution during production, the steps taken for abatement and the gradation of products according to their cleanliness. Several studies have shown that consumers are increasingly becoming environment-conscious and are willing to pay a higher price for eco-friendly products. Forsyth et. al. (1990), Irland (1993), Nimon and Beghin (1999), discuss the impact of eco-labelling on price of products. Nimon and Beghin (1999), for example, observe that "eco-labeled apparel items command a price premium of about 30% relative to comparable conventional apparel items" in the US markets. Mattoo and Singh (1994) and Upton and Bass (1996) also observe that 80% of consumers in UK and Canadian markets are willing to pay more for environmental-friendly goods. Since the pollution is often generated during the production stage, they have no means of verifying the producers' claim regarding their level of cleanliness and a typical adverse selection problem arises. Unable to differentiate between clean and dirty varieties, the consumers do not pay the price premium to clean goods, making it unprofitable for firms to invest in abatement. Thus, the market for clean goods collapses. This is where a third, neutral party like the government or some other agency steps in. They verify the claims of the firms and issue a certificate regarding the pollution emitted during the production of the good. This certificate is usually valid for a specific period of time and the firm can use this "eco-label" on its products for that period. These 'eco-labelled' goods command a higher price in the market and thus, eco-labelling is becoming increasingly popular. However, this whole process is costly. Verification of pollution generation is an expensive process requiring a lot of monitoring and technology and hence, the certificate has to be obtained at a price by the firms from the agency. This often acts as a deterrent, specially for smaller firms and thus, governments often give subsidies and other incentives to promote clean products. Eco-labelling, government subsidies to promote it, taxes on dirty products, their impact on the environment and welfare in general have been widely discussed in literature. The impact of these policies on the labour market, have received relatively less attention.

There have been a few studies that have analysed how environmental regulation affects employment. The "double dividend hypothesis" which claims that environmental protection and social objectives like employment generation may go hand in hand has been hotly debated. The theoretical literature indicates that very restrictive conditions must be met for the recycling of environmental taxation to produce an increase in employment. In an empirical study, Morgenstern et al (2002) have examined the "jobs versus environment" debate at the industry level for four heavily polluting industries: pulp and paper mills, plastic manufactures, petroleum refiners and iron and steel mills of USA. They have shown that an increase in environmental spending does not cause a significant change in the employment. The relationship between environmental protection and sectoral unemployment has been addressed in a Harris-Todaro framework in many papers. In a closed model, Daitoh (2003) analyses the effect of an increase in the pollution tax rate on manufacturing employment and urban unemployment. He argues that while an increase in the pollution tax rate will lower the scale of production, reducing employment, it will also induce substitution between labour and the dirty input and that if the relative price-elasticity of relative demand for the manufactured good is sufficiently small then the substitution effect will dominate and manufacturing employment will rise. Chao et al (2000) find that in a closed economy with sectoral unemployment, an increase in the preservation of the raw materials lead to a rise in urban unemployment ratio. However, in a small open economy, an increase in environmental protection does not result in additional domestic unemployment. These papers talk of sectoral employment only and not aggregate employment in an open economy. This issue has been analysed by Sen and Acharyya (2007) and Wagner (2005) who have pointed out that while environmental regulation has an adverse effect on aggregate employment as production shifts to cleaner and more capital intensive technology, these is also a corresponding increase in abatement activities which generate employment and may offset the initial loss.

None of the above papers take into consideration the fact that environmental regulation may affect the health of the workers and hence, labour productivity and this can have a significant impact on employment. Only a few papers discuss the impact of environmental regulation on health and labour productivity. Chakraborty and Mitra (2005) observed that the health of the workers improved after environmental regulations were imposed in the lead-smelting sector in Calcutta, India. Williams III (2002) has analysed the case where an increase in environmental tax lowers pollution level and improves the health of workers. The reduction in pollution directly increases the utility of consumers. At the same time improved health increases the labour productivity by reducing the time-spent sick by a worker. This influences a person's labour-leisure decisions and affects labour supply. Sen and Acharyya (2012) showed that environmental standards may raise aggregate employment as the productivity effect makes labour relatively less costly and induces capital to be substituted with labour. Thus, demand for labour increases and though the direct impact of the productivity effect is negative, the increased production of labour intensive goods may result in increased employment. The paper, however, assumes that the labour productivity is affected only by the environmental-quality of the dirty good and the total output does not play a part. In other words, the scale effect on pollution is totally ignored. Also, wages are assumed to be rigid, and hence the impact of environmental standards on the wage levels has not been analysed.

In this paper I take into account the scale effect and that pollution depends the total output of the dirty good as well as the abatement technology used and try to analyse the impact of an environmental standard on the labour market, in particular, the wage rate of unskilled labour when the emissions affect health and labour productivity adversely. I show that the eco-labelling process actually aides the labour market as it tempers the adverse effect of the standard on wages.

2. The Model

In order to study the impact of environmental policies on wages, I adopt a general equilibrium framework where two traded goods are being produced (one clean and one dirty) in a small open economy. The two goods use two factors of production- unskilled labour (L) and capital (K). The clean good T can be considered to be a composite of all clean tradables that are produced in the country, while the dirty good Z which generates pollution when produced is a quality-differentiated good and can be produced in different qualities. The quality of Z is characterised by the amount of pollution generated during its production which in turn depends on abatement technology used. If Z is produced using a more sophisticated abatement technology such that less pollution is generated during production, then it is said to be a better or cleaner variety. The quality of Z is indexed by $A \in [0, \overline{A}]$ with $\overline{A}$ being the quality of the cleanest good that can be produced by the present state of technology. A higher *A* implies that lesser pollution is generated by Z. Thus, the technology available to the firm allows him to produce any quality between $[0, \overline{A}]$, and the quality chosen by the firm is endogenously determined. Such characterisation has been done previously by Arora and Gangopadhyay (1995), Bansal and Gangopadhyay (2003) and Sen and Acharyya (2012).

This paper deviates a slightly from these papers in that the above papers assume that A is observable to all while here I assume that consumers cannot verify environmental-quality unless the firms obtain an eco-labelling certificate from the government. Eco-labelling of dirty goods is assumed to be compulsory and the government charges a price M for this service.

As the country under consideration is assumed to be small and open, it cannot influence the world price of any of the two traded goods by varying its volume of trade. The prices of T and Z are thus, determined by the world markets. World price of T is taken to be P_T^* while that of Z is P_Z^*. Since the consumers are environment-conscious, they are willing to pay a higher amount for a cleaner variety.

$$P_Z^* = P_Z^*(A); \quad P_Z^{*\prime} > 0, P_Z^{*\prime\prime} = 0 \tag{1}$$

The two goods are produced with unskilled labour (L), and capital (K). Their production technologies are assumed to be Leontief or fixed coefficient technology. That is, one unit of T requires a_{LT}units of L and a_{KT} units of capital. In the same way, a particular variety of Z uses labour and capital in fixed proportions (a_{LZ} and a_{KZ}), but a cleaner variety of Z is more capital intensive[1]. That is,

$$a_{KZ} = a_{KZ}(A)\ ;\ a'_{KZ}(A) > 0 \tag{2}$$

So that, $$\frac{a_{KZ}(0)}{a_{LZ}} < \cdots < \frac{a_{KZ}(A)}{a_{LZ}} < \cdots < \frac{a_{KZ}(\bar{A})}{a_{LZ}}$$

It is further assumed that the dirty good is in general, more labour intensive than the clean good T, though cleaner varieties of Z are more capital intensive than the dirtier ones. This is

[1] See Figure 1.

reasonable enough as most of the dirty goods are manufacturing goods which are relatively more labour intensive than the other traded sectors, like the service sector (insurance, banking, information and technology, etc.) which requires huge capital investments. However, as I will show later, my analysis holds even if the intensity assumption is reversed.

For convenience we give below a table of all notations used in this paper.

Z	Environmental-quality differentiated traded good
T	Composite traded good
L	Unskilled Labour
K	Capital
w	Wage rate of unskilled labour
R	Rate of return to capital
P_T^*	International price of T
$P_Z^*(A)$	International price of Z
a_{ij}	Amount of *i*th input used for one unit production of *j*.
X_j	Output of the *j*th good
E	Pollution level
$\overline{K}$	Total capital in the economy
$\overline{L}$	Total labour in the economy
θ_{ij}	Share of the i^{th} input in the price of the j^{th} product.

λ_{ij}	Share of the i[th] input in the j[th] sector
η	Environmental-quality elasticity of capital in the production of Z
ζ	Environmental-quality elasticity of the price of Z
M	Ratio of averge fixed cost to price of Z
μ	Productivity effect
e_T	quality elasticity of pollution

The total pollution level in the country depends on the total output of the dirty good, and the abatement technology used. A cleaner variety of Z lowers the pollution level, while an increase in the scale of production raises it. That is,

$$e = e(A, X_Z)\ ; \qquad \frac{\partial e}{\partial A} < 0; \qquad \frac{\partial e}{\partial X_Z} > 0 \tag{3}$$

Thus, the *scale* and the *technique effects* are captured by X_Z and A respectively. The pollution in the country adversely affects the health of the workers and lowers their productivity. So, the labour coefficients are

$$a_{Lj} = a_{Lj}(e)\ ; \quad a'_{Lj}(e) > 0 \qquad j=T, Z \tag{4}$$

The *productivity effect* is assumed to be uniform on all workers and is defined as the proportional change in labour required to produce one unit of *j* due to one percent increase in the pollution level and is written as,

$$\mu = \frac{a'_{Lj}e}{a_{Lj}} > 0 \tag{5}$$

As the economy is perferctly competitive, and the country is small and open, the prices of the two goods are equal to their average costs. So,

$$P_Z^*(A) = a_{LZ}(e)w + a_{KZ}(A)r + M / X_Z \quad (6)$$

$$P_T^* = a_{LT}(e)w + a_{KT}r \quad (7)$$

Here, the firms producing dirty good has to bear a fixed cost *M*, which is the cost of eco labelling their products in addition to the variable costs of labour and capital. The environmental-quality is chosen by them so that the marginal benefit (profit) from one additional increment to quality equals the marginal cost of quality improvement. Or,

$$P_Z^{*'}(A) = a'_{LZ}(e)\frac{\partial e}{\partial A}w + a'_{KZ}(A)r \quad (8)$$

This, implies, that at the optimum environmental-quality A_0, the price line of Z is tangent to the average cost curve. (See Figure 2). The equation (8) yields the following relationship which holds only at the optimum[2].

$$\zeta = \mu e_T \theta_{LZ} + \eta \theta_{KZ} \quad (9)$$

Where $\zeta = P_Z^{*'}(A)A / P_Z^*(A)$

$e_T = \frac{\partial e}{\partial A}\frac{A}{e} < 0$ captures the technique effect

and $\eta = Aa'_{KZ}(A) / a_{KZ}(A)$

The total labour and capital in the economy, $\bar{L}$ and $\bar{K}$ are divided between the two sectors and their output depends on this stock of resources available in the economy.

$$\bar{L} = a_{LT}(e)X_T + a_{LZ}(e)X_Z \quad (10)$$

$$\bar{K} = a_{KT}X_T + a_{KZ}(A)X_Z \quad (11)$$

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[2] See Appendix A for derivations.

Thus, in equilibrium, the output produced in the economy is X_T^0 and X_Z^0 . (See Figure 3).

3. Imposition of a Minimum Environmental Standard

Since we have assumed that wages are flexible and the labour market is in full employment, any environmental policy will not affect the level of employment and their impact on the labour market will boil down to changes in wages. In this section I analyse the impact of an imposition of minimum environmental standards on the environmental pollution and wages.

Suppose the government decides to impose a minimum environmental standard A^* which is above the quality that was being originally produced in the economy. That is, the government now requires that firms generating pollution adopt better abatement technology than that they were adopting before. So, their average cost function does not change, but now environmental-quality is no longer a choice variable for the firms. They have to produce A^*. The average cost for A^* is naturally higher than that of A_0. Competitive forces again work towards maintaining the zero-profit condition (6) and so factor returns adjust. The marginal condition (8) is now no longer satisfied and at A^* [3]

$$\zeta < (\mu)(e_T)\theta_{LZ} + (\eta)\theta_{KZ} \qquad (12)$$

The change in wages and returns to capital depend on changes in environmental quality which necessitate greater capital investment in the Z sctor and withdrawal from the T sector, the changes in the total pollution levels which affect the labour productivity in both sectors and the change in output of Z which changes the average fixed cost. So, from equations (6) and (7) we can write (13) and (14) respectively.

[3] See Figure 2.

$$\theta_{LZ}\hat{w}+\theta_{KZ}\hat{r}=(\zeta-\eta\theta_{KZ})\hat{A}-(\mu)\theta_{LZ}\hat{e}-m\hat{X}_Z \quad (13)$$

$$\theta_{LT}\hat{w}+\theta_{KT}\hat{r}=-(\mu)\theta_{LT}\hat{e} \quad (14)$$

Where $\eta=\frac{a'_{KZ}(A)A}{a_{KZ}(A)}>0$ and $m=\frac{M}{P_Z^*(A)X_Z}$

The level of pollution changes due to both the scale and the technique effect.

$$\hat{e} = e_S\widehat{X_Z} + e_T\hat{A} \quad (15)$$

For simplicity we assume that one unit increase in production raises pollution levels by one unit. That is, $e_S = \frac{\partial e}{\partial X_Z}\frac{X_Z}{e} = 1$.

The environmental standard generates a change in the production pattern in the economy. As the Z sector has to produce cleaner goods, it requires more capital and draws it from the clean sector, T. So, even at original output level of Z, T sector contracts. At the same time, the shift towards a cleaner variety of the dirty good improves the labour productivity and increases the effective supply of labour. This will encourage an expansion of the labour-intensive Z sector and a further contraction of the T sector. However, the increase in the scale of production of the dirty good increases pollution and overall pollution may increase despite the imposition of minimum standards if the scale effect is strong enough to dominate the technique effect. However, in that case, labour productivity will fall, and there will be a decrease in the effective supply of labour. The overall change in output of Z and T due to environmental standards can be obtained from equations (10) and (11). [4]

$$\hat{X}_T=\frac{1}{\Delta_1}[\mu e_T\lambda_{KZ}-\eta\lambda_{KZ}(\mu+\lambda_{LZ})]\hat{A}<0 \quad (16)$$

[4] See Appendix B for derivations.

$$\hat{X}_Z = \frac{1}{\Delta_1}[\eta\lambda_{KZ}\lambda_{LT} - \mu e_T\lambda_{KT}]\hat{A} > 0 \quad (17)$$

Where $\Delta_1 = \mu\lambda_{KT} + (\lambda_{LZ}\lambda_{KT} - \lambda_{LT}\lambda_{KZ}) > 0$
as $\lambda_{LZ}\lambda_{KT} - \lambda_{LT}\lambda_{KZ} > 0,\ \mu > 0$

The equilibrium shifts from E_0 to E_1. So, the output of T decreases on two counts. One, the productivity effect increases effective supply of labour, causing output of capital intensive T to fall. This is captured by the first term in equation (16) and a movement from E_0 to E_2 in Figure 3. Second, capital is withdrawn by the Z sector for its own quality-improvement. This is captured by the coefficient of η, the second term in equation (16) and a movement from E_2 to E_1. In contrast, the productivity effect and the quality-improvement drive up the production of Z.

Lemma 1: *The level of pollution falls only if the technique effect is sufficiently strong.*

Proof: As a minimum standard is imposed, the abatement technology has to improve and the technique effect lowers pollution. However, as the production of the dirty good increases, the scale effect raises the pollution. So pollution can only fall is the technique effect is sufficiently strong. To be more precise, if

$$|e_T| > \eta\frac{\lambda_{KZ}\lambda_{LT}}{|\lambda|} \quad \text{as} \quad \hat{e} = [e_T|\lambda| + \eta\lambda_{KZ}\lambda_{LT}]\hat{A} \qquad ■$$

The change in the output levels and the reallocation of factors of production between the two sectors results in a change in wages and rate of returns.

Proposition 1: *For an environmental standard to lead to a rise in wages, the necessary condition is that the productivity effect must be very low.*

Proof: The change in the wages of unskilled labour can be written as

$$\hat{w} = \frac{1}{|\theta|}\left[\{\theta_{KT}(\zeta - \mu e_T\theta_{LZ} - \eta\theta_{KZ}) + \mu e_T\theta_{LT}\theta_{KZ}\}\hat{A} - \{\mu|\theta| - m\}\hat{X}_Z\right] \tag{18}$$

Where $|\theta| = \theta_{LZ}\theta_{KT} - \theta_{KZ}\theta_{LT} > 0$

Thus, $\hat{w} = \frac{1}{|\theta|}\left[\{\theta_{KT}(\zeta - \mu e_T\theta_{LZ} - \eta\theta_{KZ}) + \mu e_T\theta_{LT}\theta_{KZ}\} - (\mu|\theta| - m)\left\{\frac{1}{\Delta_1}[\eta\lambda_{KZ}\lambda_{LT} - \mu e_T\lambda_{KT}]\right\}\right]\hat{A}$

Now, $(\zeta - \mu e_T\theta_{LZ} - \eta\theta_{KZ}) < 0$ (as shown in (12)); And, $\mu e_T\theta_{LT}\theta_{KZ} < 0$

Also, $(\eta\lambda_{LT}\lambda_{KZ} - \mu e_T\lambda_{KT}) > 0$ as $\eta > 0, \mu > 0, e_T < 0$;

So, necessary condition for $\hat{w} > 0$ is that $(\mu|\theta| - m) < 0$

Or, $\mu < \frac{m}{|\theta|}$ ■

Thus, a minimum environmental standard lowers the wage rate unless the productivity effect is very low. Two major factors pushing down wages are as follows. One, the productivity effect raises the effective supply of labour and this pushes down wages. Second, the standard creates a distortion with the marginal cost of quality now becoming greater than the marginal benefit and competitive forces causing the wages to fall. The only factor in favour of wages is the fact that the standard causes production of dirty goods to increase, lowering the average fixed cost of the labour intensive good.

4. The Importance of Eco Labelling

The eco-labelling process which raises the average cost of production of the dirty good, actually softens the sting of the environmental standard on the wage rate. To demonstrate the role of the eco –labelling process, I lay out the structure without the eco-labelling. The price of the dirty good which equals the average cost is now,

$$P_Z^*(A) = a_{LZ}(e)w + a_{KZ}(A)r \tag{19}$$

Thus, when the standard raises the production of Z, this has no effect on the average cost. Earlier, average fixed cost would fall with increased output. So now, the wage adjustment is as follows:

$$\hat{w} = \frac{1}{|\theta|}\left[\{\theta_{KT}(\zeta - \mu e_T\theta_{LZ} - \eta\theta_{KZ}) + \mu e_T\theta_{LT}\theta_{KZ}\}\hat{A} - \{\mu|\theta|\}\hat{X}_Z\right] \tag{20}$$

Proposition 2: *In the absence of the eco-labelling process, an environmental standard lowers wage rate.*

Proof: In equation (20), $\hat{w} < 0$ as $\mu|\theta| > 0$. So, the wage rate now decreases on all counts and there is nothing to push it up. ■

Thus, though an environmental standard usually has an adverse impact on the wages, the eco-labelling process tempers the bite and may also turn the situation and raise wages when productivity effect is high.

5. Conclusion

In this paper I have studied the role of the eco-labelling process on the labour market, in particular, the wage rate. It has been shown that imposition of an environmental standard force firms to adopt a better abatement technology, but it also prompts them to raise their output. Thus, while pollution falls due to the technique effect, the scale effect raises it. Wage rate falls, unless the productivity effect is extremely small. Noteworthy is the fact that the eco-labelling process softens the impact of the standard on the wage rate and thus, should be seen as a boon for the labour market.

Appendix A

Equation (8) can be rewritten as

$$\frac{P_Z^{*'}(A)A}{P_Z^*(A)} = \left(\frac{a'_{LZ}(e)e}{a_{LZ}(e)}\right)\left(\frac{\partial e}{\partial A}\frac{A}{e}\right)\left(\frac{a_{LZ}w}{P_Z^*(A)}\right) + \left(\frac{a'_{KZ}(A)A}{a_{KZ}(A)}\right)\left(\frac{a_{KZ}r}{P_Z^*(A)}\right) \tag{A1}$$

Or, $\zeta = (\mu)(e_T)\theta_{LZ} + (\eta)\theta_{KZ}$

Where $\zeta = \frac{P_Z^{*'}(A)A}{P_Z^*(A)} > 0$; $\mu = \frac{a'_{LZ}(e)e}{a_{LZ}(e)} > 0$; $e_T = \frac{\partial e}{\partial A}\frac{A}{e} < 0$; $\eta = \frac{a'_{KZ}(A)A}{a_{KZ}(A)} > 0$

Appendix B

Differentiating equation (10),

$$\lambda_{LT}\hat{X}_T + \lambda_{LZ}\hat{X}_Z = -\mu(\lambda_{LT} + \lambda_{KT})\hat{e}$$

Substituting $\hat{e}$ from (12),

$$\lambda_{LT}\hat{X}_T + (\mu + \lambda_{LZ})\hat{X}_Z = -\mu e_T\hat{A} \tag{B1}$$

Differentiating equation (11),

$$\lambda_{KT}\hat{X}_T + \lambda_{KZ}\hat{X}_Z = -\eta\lambda_{KZ}\hat{A} \tag{B2}$$

The expressions for $\hat{X}_T$ and $\hat{X}_Z$ can be arrived at by solving (B1) and (B2).

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