A Theoretical Model on Trade and Environment in the Presence of FDI and Informal Sector

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Abstract

The paper examines the impact of foreign direct investment on the level of emission as well as tradable emission permit rate in a small open economy with four sectors. The model of Copeland and Taylor (2004) has been extended by incorporating an informal sector that produces non-traded input for the formal manufacturing sector for a small open economy. Foreign capital is used solely by the foreign enclave. In this framework with exogenous tradable emission permit rate FDI causes a reduction in the level of pollution. However, when tradable emission permit rate becomes endogenous the model shows that FDI causes a fall in the level of pollution along with a decline in emission permit rate. This result has strong implications regarding environmental governance in developing countries.

Keywords: *Informal sector, Environmental pollution, Foreign capital, Tradable emission permit*
JEL Classification: *F11, F18, O17*

1. Introduction

The implication of the relationship between trade and environment in the context of developing countries has gained considerable attention among the researchers from the beginning of 1990s. Since early 1990s most of the developing countries have matched themselves with the era of globalization by liberalizing their own economy along with privatization of different sectors. Multinational companies (MNCs) have entered developing countries through Foreign Direct Investment (FDI) which has resulted in drastic change in those economies. This evolving scenario of the world economy necessitates further exploration of the inter-linkages between trade and environment in terms of both theoretical as well as empirical frameworks. The issue of trade and environment at the empirical level is related to the inverted–U Environmental Kuznets Curve (EKC).[1] One common argument behind the inverted U-shape of EKC is international trade that can be best explained in terms of scale, technique and composition effects. At the initial phase of development, wide scale economic activities generate huge amount of wastes in the economy and it leads to more pollution. This is the scale effect. Then, further development reduces the share of dirty goods in total GDP of the economy. It is the composition effect which is considered in terms of less pollution in the economy and hence has a positive impact on country's environmental emission. However, this positive impact of composition effect is directly linked with the

[1] The EKC is explained in terms of a parabolic relationship between per capita GDP (independent variable), a proxy of level of economic activity and level of pollutant (dependent variable) of a country. The pollutant may be in the form of Carbon dioxide (CO_2) emission or Sulphur dioxide (SO_2) emission.

technological effect. With expansion of international trade the economy becomes more open to the outside world. It leads to transfer of technology to the economy (may be through FDI) from developed countries in the form of '*environmentally sound technology*' (EST). Adoption of EST in production method is referred to as technological effect which helps the economy to have a positive composition effect. In the initial phases of development usually the scale effect dominates over the combined impact of technological and composition effects but afterwards we have reverse situation. It explains the inverted U-shape of EKC. In the context of EKC there is one more aspect related to international trade and environment that is the 'displacement hypothesis' (DH), also known as the 'industrial flight hypothesis' (IFH). The reason behind DH or IFH is the 'Pollution Haven Hypothesis' (PHH). Given the fact that in most of the developing countries environmental regulations are much relaxed, these countries act as pollution haven for attracting pollution–intensive products and eventually become specialized in environmentally 'dirty' products whereas richer countries are specialized in environmentally 'clean' products. As a result of this there is an industrial flight/ migration of the pollution–intensive industries from developed to developing countries implying DH or IFH. However, the empirical literature shows that there is still a debate on the issue related to migration of dirty industries to developing countries and transfer of EST through FDI contradicts this traditional linkage of PHH with FDI. Hence, the issue of PHH should be discussed in connection with FDI in developing countries. One can refer to the works of Copeland and Taylor (1994, 1995), Suri and Chapman (1998), Cole and Sanders (1985), Stern et al. (1996) etc. in this context.

Regarding theoretical models related to trade and environment one can consider the paper by Chichilinsky (1994) as the starting point. It is followed by works of Copeland and Taylor (1994, 1995, 1997 and 2000) that are summarized in terms of a unifying structure in an another paper by Copeland and Taylor (2004) and this paper can be considered as a seminal contribution in the context of the literature on trade and environment.

Apart from these core papers related to trade and environment at the theoretical level, there exist quite a large number of papers in the context of trade models for small open economies. One of the main characteristics of developing economies is the existence of informal sector which causes the rising part of the EKC very much stretched in those countries. Therefore, the issue of informal sector has been considered widely in general equilibrium trade models.[2] It is argued that as a result of globalization, FDI in developing countries causes polarization in such economies in the form of expansion of service/formal manufacturing sector on one hand and informal sector on the other. So the significance of the informal sector in case of FDI has already gathered sufficient attention by various authors and specifically in the context of general equilibrium trade models the works of Chandra and Khan (1993), Gupta (1997), Gupta and Basu (2004) deserve special attention. The issue becomes more interesting when the study is focused on the impact of FDI on environmental pollution in the presence of informal sector. The works of Chaudhuri and Gupta (2003), Chaudhuri (2006), Chaudhuri and Mukhopadhyay (2006, 2013) have addressed this issue in the context of small open economy multi-sectoral general equilibrium trade models with an informal sector as the source of pollution. However, in all these works only the demand side of pollution has been considered as per Copeland and Taylor (2004) specifications. If we go through the work of Copeland and Taylor (2004), we find that it includes both the demand side and supply side of pollution. Again, Copeland and Taylor (2004) have not considered in their framework the existence of informal sector. Incorporation of the informal sector in an otherwise Copeland and Taylor

[2] One can refer to the works of Chandra and Khan (1993), Gupta (1997), Chaudhuri (2000), Marjit (2003), Gupta and Basu (2004), Marjit and Kar (2004), Marjit and Kar (2011) etc.

(2004) framework makes our model not only a value addition to the literature but also makes it very much relevant from the point of view of policy analysis in a developing economy. In the literature the impact of FDI is usually considered on the output of the informal sector and hence on environmental pollution when tradable emission permit rate (can also be treated as emission tax rate) is considered exogenous. The motivation behind the present study has been generated from the fact that the impact of FDI on informal sector and environment is to be studied in the presence of endogenous tradable emission permit rate to address the issue of environmental governance for a developing country. Such an issue is really missing in the literature and herein lies the significance of the present exercise.

Our model attempts to find out the conditions under which presence of informal sector causes changes in tradable emission permit rate along with the level of actual pollution in the economy. The paper has been organized in the following manner. Section 2 deals with the basic model examining the impact of FDI on environmental pollution in the presence of informal sector. Impact of FDI on environmental pollution and endogenous tradable emission permit rate in the presence of informal sector has been considered in terms of the extended model in section 3 of the paper. Finally, the concluding remarks are made in section 4.

2. The Basic Model

We consider a small open economy with four sectors – the rural agricultural sector (A), the intermediate good producing informal manufacturing sector (I), the formal manufacturing sector (M) and the foreign enclave (F). Output levels of all the sectors, except informal manufacturing sector, are traded in the world market. All the sectors use labour as an input. Regarding the other input, we have different specifications for the four sectors. Agricultural sector uses sector specific factor land (T). The informal manufacturing sector and the formal manufacturing sector use domestic capital, K, which is perfectly mobile between these two sectors. Foreign capital (K_F) is used only by the foreign enclave. The informal sector produces a non-traded intermediary that is used by the formal manufacturing sector on the basis of a fixed input-output requirement (a_{IM}). Labour is assumed to be perfectly mobile among all the four sectors although formal manufacturing sector and foreign enclave face an imperfect labour market. It is assumed that labour in these two sectors earns a contractual, exogenously given wage, $\overline{W}$, while agricultural and informal sectors have market determined competitive and flexible wage rate W with $\overline{W} > W$. Due to the small open economy assumption, the final commodity prices are given internationally. The price of the non-traded intermediary produced by the informal manufacturing sector is determined domestically.

We need the following symbols to describe the equational structure of the model:

X_j – production in the j th sector, $j = A, I, M, F$

P_j – world price for the product of j th sector, $j = A, M, F$

P_I – price for the non-traded intermediate informal manufacturing sector product determined endogenously

a_{ij} – quantity of the i th input required for the production of one unit of output of the j th sector, $i = L, T, K, K_F$ and $j = A, I, M, F$

a_{IM} – amount of informal intermediary output required to produce one unit of commodity of formal manufacturing sector
L – labour endowment of the economy in physical unit
T – stock of agricultural capital of the economy
K – domestic capital stock of the economy
K_F – foreign capital inflow to the economy
Z – actual level of pollution in the economy
W – competitive wage rate
$\overline{W}$ – fixed wage rate
R – return to agricultural capital
r – return to domestic capital
r_F – return to foreign capital
$q(Z)$– efficiency of each worker
θ_{ij} – distributive share of the ith input in the jth sector, $i = L,T,K,K_F$ and $j = A,I,M,F$
λ_{ij} –proportion of the ith input employed in the jth sector, $i = L,T,K,K_F$ and $j = A,I,M,F$
$\varepsilon_Z = \dfrac{q'(Z)\cdot Z}{q(Z)}$ – elasticity of efficiency of workers with respect to level of pollution
α – constant emission coefficient for sector I
$\beta\left(\dfrac{P_M}{\tau}\right)$ – emission coefficient for sector M
σ_j – elasticity of substitution between the inputs in the jth sector, $j = A,I,M,F$
τ – tradable emission permit rate
^ – percentage change

We assume that the production functions in each sector exhibit constant return to scale and diminishing return to inputs. Also, markets are competitive and resources are fully employed. The equational structure of the model can be explained as follows:

The competitive equilibrium conditions are given by the following four equations:

$$Wa_{LA} + Ra_{TA} = 1 \tag{1}$$
$$Wa_{LI} + ra_{KI} = P_I \tag{2}$$
$$\overline{W}a_{LM} + ra_{KM} + P_I a_{IM} = P_M \tag{3}$$
$$\overline{W}a_{LF} + r_F a_{KF} = P_F \tag{4}$$

The product of sector A is regarded as numeraire and hence, its price has been set equal to unity. The entire output of the informal sector, X_I, is used only for producing the effective output (or net output) generated from the manufacturing sector, X_M, so that the supply of X_I is determined by its total demand by formal manufacturing sector. In Equation (3), all the three input-output coefficients are assumed to be fixed.[3] The demand-supply equality condition for the informal sector is given by

$$a_{IM} X_M = X_I \tag{5}$$

[3] This is just a simplifying assumption. See the works of Gupta and Basu (2004), Basu(Chowdhury) and Gupta (2010) for more details.

Factor market equilibrium conditions are given by the following four equations

$$a_{TA}X_A = T \tag{6}$$
$$a_{KI}X_I + a_{KM}X_M = K \tag{7}$$
$$a_{KF}X_F = K_F \tag{8}$$
$$a_{LA}X_A + a_{LI}X_I + a_{LM}X_M + a_{LF}X_F = L \cdot q(Z);\ q'(Z) < 0 \tag{9}$$

Here we have considered total endowment of effective labour. Environmental pollution has a negative impact on human health, thus adversely affecting the worker's productivity. So, we can say that productivity of labour declines with increasing level of pollution and total amount of effective labour falls although physical labour endowment remains unchanged. Hence, it is assumed that the productivity of a representative worker, q, is inversely related to the level of pollution, Z, in the economy with $q'(Z) < 0$. Although pollution is generated both by the informal and formal manufacturing sectors, a tradable emission permit rate τ has to be paid only by the formal manufacturing sector for emission of pollutants. One can also refer to it as emission tax rate or as the price for pollution. Total supply of pollution in the economy is given by

$$Z = \alpha X_I + \beta\left(\frac{P_M}{\tau}\right)X_M \tag{10}$$

Initially we assume that the tradable emission permit rate, τ, to be exogenously given though in the extended model we shall determine endogenously the tradable emission permit rate. Given this assumption, in this model we have ten equations with ten unknowns – W, R, r, r_F, P_I, X_A, X_I, X_M, X_F and Z. The parameters of the system are P_M, P_F, T, K, K_F, τ and L. This system is indecomposable where factor prices cannot be determined independently of factor endowments.[4]

The working of the model can be explained in the following manner. From Equation (3) we find that, given $\overline{W}$ and P_M with all the three input-output coefficients fixed, r is a decreasing function of P_I. Similarly, in Equation (2), we can write W as an increasing function of P_I. Again, from Equation (1), for $P_A = 1$, R can also be expressed as a decreasing function of P_I.

[4] We are now in a position to focus on Copeland and Taylor (2004) type of justification to treat the output of the manufacturing sector as effective output. If we denote X_M as the potential output of the manufacturing sector and Z_M as the level of pollution generated from the product of this sector, we can write following Copeland and Taylor (2004)

$$\tilde{X}_M = Z_M^{\delta}\left[F_M(K_M, L_M, X_I)\right]^{1-\delta} \quad 0 < \delta < 1 \tag{11}$$

Here we assume abatement occurs. Then for $Z_M < X_M = F(K_M, L_M, X_I)$, we can write equation (11). One can interpret equation (11) as a production function for sector M (Cobb-Douglas type) with two inputs Z_M and a composite input $F(\cdot)$ with effective output $\tilde{X}_M$. Alternatively one can treat it as a production function where the level of technology, Ω, can be expressed as a positive function of the level of pollution i.e. $\Omega = \Omega(Z_M)$, $\Omega' > 0$. As the level of pollution increases higher level of technology is adopted for pollution abatement. More specifically one can consider $\Omega = Z_M^{\delta}$. Thus pollution is treated here as an input though in equation (10) it is treated as an outcome of output.

From Equation (4), we know r_F as $\overline{W}$ is given. Thus, it can be concluded that all the factor prices except r_F can be expressed in terms of P_I. Therefore, we have

$$R = R(P_I) \;\; ; \;\; W = W(P_I) \;\; \text{and} \;\; r = r(P_I) \;\; \text{where} \;\; \frac{\partial R}{\partial P_I} < 0 \;\; ; \;\; \frac{\partial W}{\partial P_I} > 0 \;\; \text{and} \;\; \frac{\partial r}{\partial P_I} < 0$$

Hence, all the variable input-output ratios are functions of P_I.

Using the above specifications and Equation (5), Equation (7) can be rewritten as

$$\left[a_{KI}(P_I) + \frac{a_{KM}}{a_{IM}}\right] X_I = K \tag{7.1}$$

Equation (7.1) is the locus of X_I and P_I such that the domestic capital market is in equilibrium. It is shown in Figure 1 and it is negatively sloped.

An increase in P_I increases the level of W and decreases the level of r so that wage-rental ratio rises. That in turn causes a decline in unit labour requirement (a_{LI}) and rise in unit capital requirement (a_{KI}) in sector I.[5] Although domestic capital is demanded by both types of manufacturing sectors, it is used at a fixed proportion by formal manufacturing sector. Hence, in order to maintain balance in domestic capital market the output level of sector I (X_I) must fall generating a negatively sloped KK curve.

Again, using the specifications mentioned earlier along with Equations (5), (6), (7) and (8) and after some algebraic manipulation, we have from Equation (9)

$$\left[a_{LI}(P_I) + \frac{a_{LM}}{a_{IM}}\right] X_I = L \cdot q(Z) - \left[\frac{a_{LA}(P_I)}{a_{TA}(P_I)} \cdot T + \frac{a_{LF}(P_I)}{a_{KF}(P_I)} \cdot K_F\right] \tag{9.1}$$

Equation (9.1) is depicted as positively sloped LL curve in Figure 1. This curve provides the locus of X_I and P_I such that the market of effective labour clears. Earlier we have found that a rise in P_I reduces a_{LI}. Hence, in order to maintain balance in labour market X_I must go up generating a positively sloped LL curve. The intersection between KK and LL curves gives the equilibrium level of X_I and P_I. Once P_I is known, all the factor prices, input-output ratios and hence output levels can be solved for. This completes the working of the model.

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[5] It is assumed that informal manufacturing sector is labour-intensive industry.

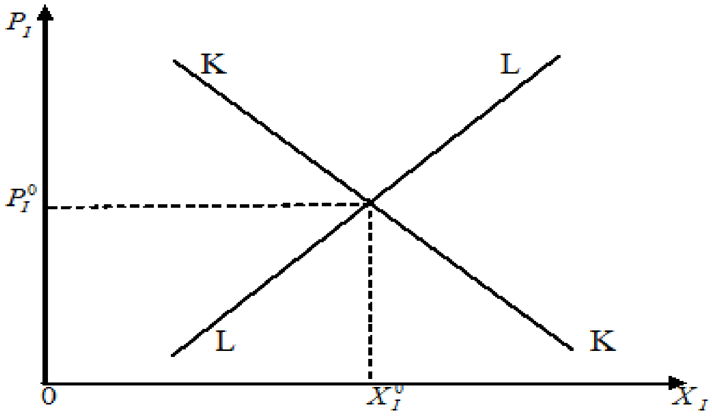

Figure 1

In this model, if we consider FDI, captured in terms of an increase in the inflow of foreign capital (K_F), production of foreign enclave increases. It requires more labour in that sector. Since labour endowment has not changed, all the other sectors contract to release the excess amount of labour required for the expansion of foreign enclave. For the informal manufacturing sector, at existing market price, lower production creates excess demand and that in turn raises price level. This has been shown in Figure 2 by left-ward shift of LL curve. Position of KK curve is same as domestic capital endowment has not changed.

Totally differentiating Equation (7.1) and after some algebraic manipulations, we have

$$\hat{X}_I + A.\hat{P}_I = 0 \tag{7.2}$$

where $A = \left[\lambda_{KI}\theta_{LI}\sigma_I\left(\dfrac{\theta_{KM}+\theta_{IM}}{\theta_{LI}\theta_{KM}}\right)\right] > 0$

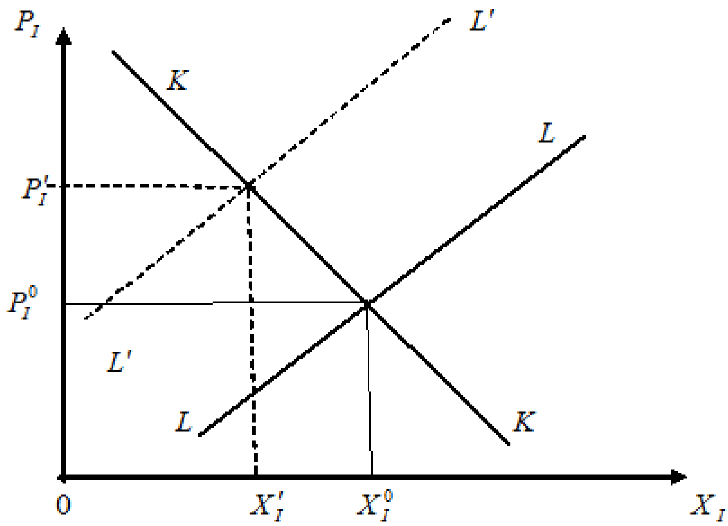

Figure 2

Totally differentiating equation (10) and with the assumption of fixed rate of tradable emission rate ($\hat{\tau}=0$), we get

$$\hat{Z} = \hat{X}_I \tag{10.1}$$

Now, totally differentiating Equation (9.1), using Equation (10.1) and after some algebraic manipulations we have

$$\left(\lambda_{LI}+\lambda_{LM}-\varepsilon_Z\right)\hat{X}_I - B\cdot\hat{P}_I = -\frac{\lambda_{LF}}{\lambda_{KF}}\hat{K}_F \tag{9.2}$$

where $B=\left[\frac{1}{\theta_{LI}\theta_{KM}\theta_{TA}}\left\{\lambda_{LA}\sigma_A\left(\theta_{KM}+\theta_{KI}\theta_{IM}\right)+\lambda_{LI}\sigma_I\theta_{KI}\theta_{TA}\left(\theta_{KM}+\theta_{IM}\right)\right\}\right]>0$

From Equations (7.2) and (9.2) we get

$$\hat{X}_I = \frac{1}{\Delta}\left[A\cdot\frac{\lambda_{LF}}{\lambda_{KF}}\cdot\hat{K}_F\right]$$

$$\hat{P}_I = -\frac{1}{\Delta}\left[\frac{\lambda_{LF}}{\lambda_{KF}}\cdot\hat{K}_F\right]$$

Since $\Delta = -B - A\left(\lambda_{LI}+\lambda_{LM}-\varepsilon_Z\right)<0$ [if $\left(\lambda_{LI}+\lambda_{LM}\right)>\varepsilon_Z$], we have $\frac{\hat{X}_I}{\hat{K}_F}<0$ and $\frac{\hat{P}_I}{\hat{K}_F}>0$.

A reduction in the output level of the informal manufacturing sector reduces the output level of the formal manufacturing sector as a result of FDI. This is because the linkage coefficient between these two sectors is fixed. Hence, for given tradable emission permit rate and so for given emission coefficient the emission in the economy falls that causes a decline in the level of environmental pollution also.

The above results lead to the following proposition:

Proposition 1: *In the presence of exogenous tradable emission permit rate, FDI in the foreign enclave of a small open economy raises the price level of informal intermediary sector and reduces the level of production of both informal intermediary and the formal manufacturing sector. Hence FDI causes the level of environmental pollution in the economy to decrease.*

3. The Extended Model: Endogenous Tradable Emission Permit Rate

We have extended our analysis by treating tradable emission permit rate endogenously. We retain all the equations of the model (from Equation (1) to Equation (9)). We just rewrite Equation (10) (using Equation (5)) in the form of Equation (12) and treat it as the demand function for environmental pollution (Z) given by

$$Z = f\left(\frac{P_M}{\tau}\right)X_M \tag{12}$$

where $f(\frac{P_M}{\tau}) = \alpha a_{IM} + \beta(\frac{P_M}{\tau})$ and $f^{/} > 0$

Here the tradable emission permit rate τ has been treated as the price of emission. The combination of Z and τ that satisfies the above relationship is depicted as DD curve in Figure 3. A rise in τ makes pollution more expensive and hence emission intensity falls. So the level of pollution decreases. Hence we refer to it as the demand for pollution and draw the DD curve as a negatively sloped demand curve[6]. The slope of the demand curve as obtained from Equation (12) is given below

$$\left.\frac{d\tau}{dZ}\right|_{DD} = -\left[\frac{\tau^2}{f'\left(\frac{P_M}{\tau}\right)\cdot P_M \cdot X_M}\right] < 0 \tag{13}$$

We now focus on the supply side of the model. It can be obtained on the basis of utility maximizing behaviour of a representative consumer. Consumption depends upon consumers' income as well as on consumers' preference for environmental quality. Assuming Y as the income of a representative consumer and assuming that there are N identical consumers, the national income of the economy measured in terms of domestic prices[7] is given by $G = N \cdot Y$. It is to be noted that national income measured at domestic prices in the presence of full repatriation of foreign capital income is given by

$$G = X_A + P_M X_M + P_F X_F - r_F K_F \tag{14}$$

As each consumer is assumed to be identical we consider the representative consumer who maximizes his/her utility derived from the consumption of X_A , X_M and X_F for a given level of pollution. We assume the consumption bundle as C and the entire income of the consumer is spent on consumption of C. We also assume that pollution has negative externality to the consumer so that the marginal impact of pollution on representative individual's utility is negative. To simplify matters we assume that the utility function of the representative consumer to be quasi-linear.[8] Hence, the indirect utility function for the representative consumer can be represented in terms of the following specification

$$V = V\left(\frac{Y}{P}, Z\right) = \frac{Y}{P} + h(z) \tag{15}$$

P is the (average) price index in Equation (15).

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[6] If we follow Copeland and Taylor (2004) and treat pollution as an input (as shown in footnote 4) then an increase in tradable emission permit rate implies producers of formal manufacturing sector face a higher input cost so that X_M contracts. So it is due to both reduction in emission coefficient and also reduction in the level of manufacturing output the level of pollution falls as a result of an increase in tradable emission permit rate.

[7] The earning from pollution permit is used by the pollution control board on behalf of government to combat pollution by undertaking various clean projects as a part of common property resource (for example aforestation or planting of trees by the side of roads). This model has been formed on the basis of the fact that ownership rights are well-defined in the form of private property. Hence, the earning from selling pollution permits is not added to national income as a transfer to various classes of the society. We have followed the specification in this regard as shown by Copeland and Taylor (2004).

[8] This is standard assumption where we assume that marginal utility from consumption is independent of marginal disutility from pollution. Here $C = \frac{Y}{P}$ so that replacement of $\frac{Y}{P}$ by C gives us the direct utility function.

Given the fact that
V_Z = level of marginal (indirect) utility with respect to environmental pollution and
V_Y = level of marginal (indirect) utility with respect to income
we have $V_Z = h'(z) < 0$, $V_{ZZ} = h''(z) < 0$; $V_Y > 0$, $V_{YY} = 0$. From the first-order-condition of maximising (indirect) utility with respect to pollution level, we have the following condition:

$$\tau = G_Z = -N\frac{V_Z}{V_Y} \tag{16}$$

$G_Z = \dfrac{\partial G}{\partial Z}$ = marginal abatement cost where G is the national income measured in terms of domestic prices

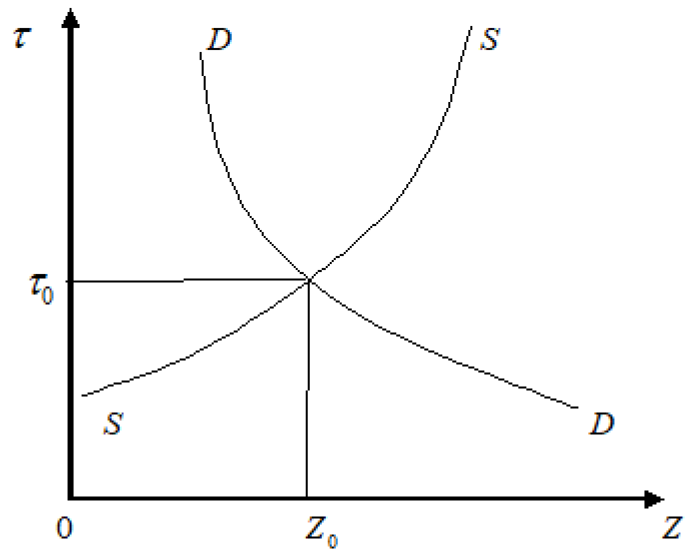

Figure 3

Equation (16) actually implies the supply function of environmental pollution as tradable emission permit rate is equal to the sum of individual consumer's marginal damage. As the level of pollution increases in the economy, marginal damage or disutility of the consumers also increases. To control pollution and hence to reduce disutility, the government must adopt abatement measures so that tradable emission permit rate (τ) increases and we have a positively sloped supply curve.[9] The combination of Z and τ such that Equation (16) is satisfied is shown by SS locus in Figure 3. The slope of the supply curve as obtained from Equation (16) is given by

[9] It is just like price = marginal cost which represents supply function. Here instead of price we have the price of pollution, i.e. the tradable emission permit rate, and instead of marginal cost we have marginal abatement cost.

$$\left.\frac{d\tau}{dZ}\right|_{SS} = -\frac{N \cdot V_{ZZ}}{V_Y} > 0$$
(17)

It implies higher is the level of pollution higher is the marginal abatement cost and hence higher is the price of pollution. The point of intersection between the demand and supply curve of pollution provides the equilibrium level of emission permit rate and corresponding pollution prevailing in the economy, as shown in Figure 3. This model shows that in a general equilibrium framework how the optimal environmental tax rate and the optimal pollution level can be determined endogenously. This is a new contribution in the literature.[10]

As a result of FDI, we find that it is only the demand curve for pollution will shift to the left-ward direction. [11] However, the SS curve remains unaffected as it is independent of K_F .

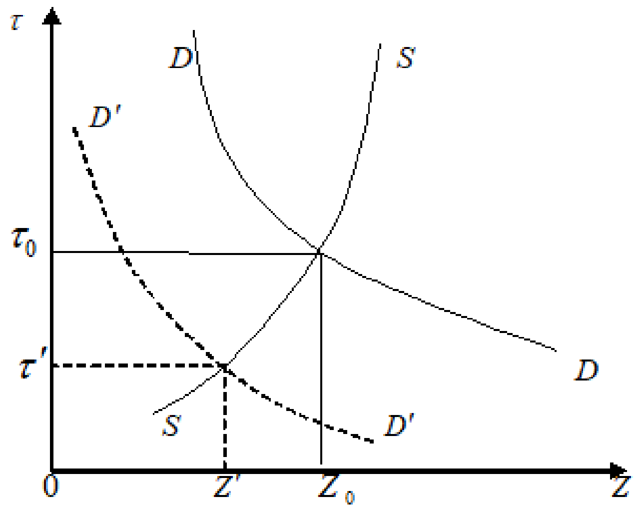

Figure 4

Finally, at the new equilibrium, both tradable emission permit rate and pollution level decrease. This result has strong implications for the policy makers in the sense that FDI reduces the emission level in an economy. If we assume that the technology that enters the economy due to FDI is EST then it is expected that the producers will take advantage of this technology and the demand for pollution will decrease. This will lead to reduction in the price of pollution in the form of emission tax rate and eventually level of pollution will also fall in the economy. The result can be summarised in the following proposition:

Proposition 2: *FDI in the foreign enclave of a small open economy in the presence of informal sector reduces the level of environmental pollution in the economy along with a fall in tradable emission permit rate.*

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[10] In what sense it is a new contribution is already explained earlier.

[11] One can check proposition 1 for a justification behind this. There we find for a given τ an increase in K_F reduces Z which implies a left-ward shift of DD locus to $D'D'$.

4. Concluding Remarks

The existing works on informal sector and environmental pollution in the context of a small open economy have considered only the demand side of pollution. Copeland and Taylor (2004) have first taken into account both the demand and the supply sides of pollution in this regard. The present work is an extension of Copeland and Taylor (2004) in the presence of informal non-traded intermediate goods sector and we have examined the impact of FDI in terms of inflow of foreign capital to the foreign enclave in an otherwise Copeland-Taylor (2004) type model. In terms of a four-sector general equilibrium model we have shown that with an exogenous tradable emission permit rate FDI expands the size of the foreign enclave but reduces the size of both formal and informal manufacturing sectors and hence reduces the level of environmental pollution in the economy. Here, we have achieved this result by considering only the demand side of pollution as per Copeland-Taylor (2004) terminology. We have then extended the model by introducing endogenous tradable emission permit rate and have focused on, following Copeland and Taylor (2004), both the demand and supply sides of pollution. However, our model simply differs from Copeland and Taylor (2004) as it incorporates FDI, informal sector and a different type of supply of pollution analysis. This model has strong implications from the point of view of environmental governance on part of environmental regulatory authorities in a developing economy. In a developing economy it is the informal sector which mainly pollutes the environment (as they cannot be regulated) and it is one of the main reasons for wide stretch of the rising part of EKC in these countries. Here we have shown that FDI reduces the tradable emission permit rate and at the same time improves environmental quality by reducing pollution in the presence of informal sector in a developing economy. This may appear paradoxical but such a situation may arise when we have technology transfer indicating transfer of EST. It leads to a situation of better environmental ambience and hence reduction in the price of pollution in terms of a lower tradable emission permit rate. Our finding contradicts Pollution Haven Hypothesis and it actually in accordance with Pollution Halo Hypothesis that says FDI plays significant role in reducing environmental emission in developing countries even with lenient environmental policies in terms of lower tradable emission permit rate.

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Appendix

Differentiating Equation (12) with respect to K_F gives

$$\frac{dZ}{dK_F} + U \cdot \frac{d\tau}{dK_F} = D \tag{12.1}$$

where $U = \left[f'\left(\frac{P_M}{\tau}\right) \cdot \frac{P_M}{\tau^2} \cdot X_M \right] > 0$

and $D = \left[f\left(\frac{P_M}{\tau}\right) \cdot \frac{dX_M}{dK_F} \right] < 0$

By differentiating Equation (16) with respect to K_F, we have

$$-E\frac{dZ}{dK_F}+\frac{d\tau}{dK_F}=J \tag{16.1}$$

where $E=\left[-\frac{N\cdot V_{ZZ}}{V_Y}\right]>0$

$$J=H\frac{G}{K_F}\left[\gamma_1\frac{\hat{X}_A}{\hat{K}_F}+\gamma_2\frac{\hat{X}_M}{\hat{K}_F}+\gamma_3(1-\theta_{KF})\right]=0$$

as $H=\left[\frac{V_Z\cdot V_{YY}}{V_Y^2}\right]=0$ since $V_{YY}=0$; $\gamma_1=\frac{X_A}{G}$, $\gamma_2=\frac{P_M X_M}{G}$, $\gamma_3=\frac{P_F X_F}{G}$

Solving Equations (12.1) and (16.1), we get

$$\frac{dZ}{dK_F}=\frac{1}{\Delta}D<0$$

$$\frac{d\tau}{dK_F}=\frac{1}{\Delta}E\cdot D<0$$

where $\Delta=(1+U\cdot E)>0$