Foreign direct investment, environmentally sound technology and informal sector

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Abstract: The paper examines the linkages between foreign direct investment, informal sector and transfer of environmentally sound technology (EST) in a developing economy in terms of a three-sector, full-employment general equilibrium model with an informal sector that produces a non-traded input for the formal final good producing sector. The same input is produced by another division of the formal sector, which generates less pollution than the informal sector since the former uses a different type of capital that embodies EST. The formal sector has to pay a penalty in the form of a production tax for using the output of the excessively polluting informal sector. In this scenario, the analysis finds that foreign capital inflow in the formal sector may accentuate pollution, even if it involves transfer of EST. Secondly, there might exist a positive relationship between pollution and national income in the economy both in the presence and absence of transfer of EST. These results can at least question the desirability of transfer of EST and also give theoretical explanations behind the existence of a positively sloped segment in the Environmental Kuznets Curve.

Keywords: Pollution, foreign capital, environmentally sound technology, informal sector, formal sector, Environmental Kuznets Curve, general equilibrium.

JEL Classification: F18, O17, O33, Q56.

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1. Introduction

The most exigent task ahead of all the economies perhaps is to strive for environmentally sustainable economic growth. The desperate pursuit for economic well-being, particularly in the last few decades after liberalization, has triggered colossal environmental deterioration. The trade and environment economists consider liberalization as a vector for perpetuating environmental damage. Their disapproval stems from the apprehensions that any gains from trade liberalization may be substantially outweighed by the damage it tends to inflict on the environment through pollution and loss of natural resources.

The role of foreign direct investment (FDI) in environmentally sustainable growth in the developing countries has drawn serious cognizance. It is asserted by the pessimists that the environmental quality of the developing countries is jeopardized due to their low environmental standards, fostering migration of 'dirty' industries to these countries (the industrial flight hypothesis). In addition, the developing countries may deliberately undervalue the environment in order to attract the multinational firms (the 'pollution haven' hypothesis) ending up in unwarranted environmental pollution in these countries. While there exist some empirical evidences that support the pollution haven hypothesis (Cagatay and Mihci, 2006; He, 2006; Merican et al., 2007), several studies have rejected the phenomenon (Dietzenbacher and Mukhopadhyay, 2007; Eskeland and Harrison, 2003; Rock, 2002). It is argued that factors like capital abundance, technology differences, and infrastructure are more important than environmental policy in determining trade and FDI patterns[1].

The optimists, on the other hand, highlight the environmental benefits that FDI tends to generate. Apart from promoting higher incomes, possibly leading to higher levels of

[1] For detailed discussion, see de Almeida et al (2008).

investment in pollution prevention and control facilities, it constitutes an important catalyst for the transfer of environmentally sound technologies (EST) to those countries. Environmentally sound technologies are those that "protect the environment, are less polluting, use all resources in a more sustainable manner, recycle more of their wastes and products, and handle residual wastes in a more acceptable manner than the technologies for which they were substitutes" (Agenda 21 of the Rio Declaration).

The possibilities of EST transfer associated with FDI have important role in stimulating the developing countries to attract FDI, despite the general contention among the trade and development theorists that the welfare effects of foreign capital inflow in the presence of tariff protection are, in general, discouraging for them.[2] However, successful transfer of EST depends on both regulatory instruments and market-based mechanisms. Strong environmental regulation and enforcement are the main incentives for firms to acquire and transfer new technologies, so that to make foreign investment conducive to the influx of EST, it is imperative to progressively develop and implement strong environmental regulation, nonetheless, allowing for flexibility in the enforcement of environmental standards and having positive disposition towards a plant's experimentation with alternative cost-effective solutions (Luken et al, 2008).

Moreover, various direct incentives such as the elimination or reduction of taxes on income or sales from investment, the deferment of taxes, tax holidays, and taxation graded according to the level of environmental improvement achieved, may be instrumental (Juma, 1994; Less and McMillan, 2005) in creating a favourable investment environment for EST transfer. Therefore, it is environmentally viable for countries to pull

[2] Brecher and Alejandro (1977) have analyzed the immiserizing effects of foreign capital inflow in a two- commodity, two-factor full-employment framework and showed that inflow of foreign capital, with full repatriation of its earnings, leads to a reduction in welfare if the import-competing sector is capital-intensive and is protected by a tariff. Khan (1982) has examined the Brecher-Alejandro (1977) proposition in a two-sector Harris-Todaro (1970) framework and reached the same conclusion as that of Brecher and Alejandro (1977). This proposition has been subsequently re-examined on the basis of two-sector and three-sector models in different directions (Grinols (1991), Chandra and Khan (1993), Gupta (1997), Beladi and Marjit (1992), Chaudhuri (2001).

FDI only if the costs that they have to bear in the form of incentives are outweighed by the environmental benefits from transfer of EST. However, empirical evidence on the role of FDI in transfer of cleaner technology is rather inadequate and inconclusive. Even if the MNCs from developed countries have important roles in terms of cleaner technologies, this does not hold for MNCs from developing countries (Zarsky, 1999).[3]

The environmental impact of FDI on host countries appears even more debatable in the developing countries due to the persistence of urban informal sector.[4] The presence of a large number of pollution sources in the form of informal sector units that lack knowledge, funds, technology and skills to treat their effluent, is likely to frustrate environmental instruments and policies.

Empirical evidences indicate that the urban informal sector units mostly produce intermediate inputs for the formal manufacturing sector on a subcontracting basis.[5] In a number of cases, the large industries give subcontract to production units that produce a component of the formal sector output, mostly involving environmentally "dirty" tasks and processes, on an informal basis[6]. Perrings, Bhargava and Gupta (1995) argue that

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[3] See also Dominguez (1998); Jenkins (1999); Jha and Teixeira (1994); López and Chidiak (1996) and Levy (1995) in this context.

[4] The informal sector implies that segment of the labour market where free entry exists (due to high labour turnover) and wages are significantly lower than in the formal sector. It consists of small scale unregistered units, engaged in the production and distribution of goods and services, with the primary objective of generating employment and income to their participants despite capital constraints. See Sethuraman (1981) in this context.

[5] See for example Joshi and Joshi (1976), Bose (1978), Papola (1981) and Romatet (1983). In India the trend of increasing ancillarisation and subcontracting has increased with the introduction of globalization package in recent years. For example, many of the large industries like the carpet weaving industries, the glass manufacturing industries, the bangles industries, leather bag and shoe manufacturing industries, garments industries etc. have been split up into very small units and been subcontracted to the informal sector.

[6] For example, in the city of Kolkata, leather-tanning process is handled by the informal sector. Similarly, for the garment industry the dyeing of garments are done by the informal sector participants on a subcontracting basis. Both tanning and dyeing pollute the environment.

such subcontracting is an economical way for formal sector firms to avoid investment in ESTs made obligatory by the regulatory authority. This is due to the fact that since the informal sector firms are difficult to identify and monitor, they remain outside the purview of environmental regulations and face fewer incentives to prevent pollution.[7] The interlinkage between FDI and pollution of developing countries may occur in two different ways: first, pollution increases due to subcontracting between the formal firms (including the foreign owned ones), and the polluting informal units; secondly, transfer of EST in firms where there is no such subcontracting has favourable effect on pollution.

However, there hardly exist any work that focus on the nexus between, FDI, informal sector and EST.[8] The main objective of the present paper is to examine the effects of an inflow of foreign capital on the level of domestic pollution and national income in a developing economy in the presence and absence of transfer of EST. A three sector full-employment general equilibrium model consisting of three sectors, a rural sector, an informal and a formal sector has been considered. The formal sector has two divisions, one producing a final manufacturing good and another producing a non-traded intermediate input for production in the final good sector. The intermediate input is also produced in the informal sector. Both the formal and informal intermediate input producing sectors pollute the environment. But while the formal sector has access to EST, the informal sector uses backward technology, so that the latter generates more pollution. The paper shows that under some reasonable conditions, an inflow of foreign capital in the formal sector involving greater adoption of EST may actually aggravate domestic pollution but increase national income, while foreign capital inflow in the informal sector without transfer of EST may reduce pollution despite having adverse effects on national income. These interesting results despite simplicity and abstract of the analytical framework can at least question the favourable environmental impact of FDI even if it involves transfer of EST and suggest a trade off between economic and

[7] For examples of ESTs in individual firms in Brazil, India, China and Zambia, see Perrings, Bhargava and Gupta (1995).

[8] Chaudhuri and Mukhopadhyay (2006, 2009) deal with the theoretical aspect of informal sector pollution and FDI, but the aspect of EST has not been considered in these.

environmental goals for attracting FDI. The analysis also explains theoretically that at the initials levels of (per capita) national income the Environmental Kuznets Curve (EKC) is indeed positively sloped that has been confirmed by a numerous empirical studies[9].

2. The Model

A small, open economy is considered to consist of two informal sectors and a formal sector, the latter comprising of two divisions. Thus, there are four sectors in total in the economy. Sector 1 is an informal sector that produces an agricultural commodity, X_1 by means of labour (L) and capital of type K. The informal sector 2 uses the same inputs to produce a non-traded intermediate input, X_2 for sector 3. Sector 3 is the formal sector division producing a final manufacturing commodity, X_3 using labour, capital of type N and the intermediate input, X_2. The other division of the formal sector (sector m) also produces the intermediate commodity, X_m with the help of labour and both types of capital. Thus the intermediate good is produced in both sectors 2 and m, and is entirely used up in sector 3. Labour is perfectly mobile between all the sectors. Capital of type 1 is mobile between the two informal sectors and the intermediate good producing formal sector division, while capital of type 2 is mobile between the two formal sector divisions. Sector 1 is assumed to be non-polluting[10], but the production of the intermediate input generates pollution; this implies that the two sectors (2 and m) producing it and sector 3

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[9] It may be noted that the Environmental Kuznets Curve refers to the relationship between various indicators of environmental degradation and income per capita. It hypothesizes that degradation and pollution increase in the early stages of economic growth, but the trend reverses beyond some level of income per capita, so that at high-income levels economic growth leads to environmental improvement. This implies an inverted-U-shaped pollution-income relationship. Despite considerable controversies, a number of empirical studies validate this hypothesis (See World Bank, 1992; Grossman and Krueger, 1995; Beckerman, 1992; Barrett and Grady, 2000, among others).

[10] This is a simplifying assumption. A typical agricultural goods producing sector also vitiates the environment through use of chemical fertilizers and pesticides. However, the amount of pollution generated by the rural sector is insignificant relative to that produced by the manufacturing sectors.

using it pollute the society. However, the production technology in sector m is less polluting than in sector 2.

The formal sector divisions face an imperfect, unionized labour market where workers receive a contractual wage, W^* while the wage rate in the informal sectors, W, is market determined and $W^* > W$. The aggregate stock of capital of type K consists of both domestic and foreign capital, which are perfect substitutes, while capital of type N is completely owned by foreign capitalists. It is assumed that the agricultural sector is more labour-intensive than both the intermediate good producing sectors. The price of the non-traded intermediate good, P_2 is endogenously determined[11,12], while the prices of the products of the other sectors, P_i, $i = 1, 3$ are exogenously given due to the small open economy assumption. Commodity 1 is chosen as the numeraire. It is assumed that the technologies of production are of the fixed-coefficient type[13].

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[11] A pertinent question is why the formal sector (division m) produces at least a part of the total requirement for the non-traded input especially when the informal sector (sector 2) has a cost advantage over the formal sector in production of the input. There could be two reasons. First, sector m produces the input in order to avoid complete dependence on the informal sector. Second, the production of the intermediate input generates environmental pollution. However, due to possession of an improved technology of production, the formal sector is able to produce the input in a less polluting manner vis-à-vis the informal sector. In order to put a brake on the practice on the part of the formal sector to arrange the production of the input in the informal sector through subcontracting, the pollution regulatory authority imposes a penalty on the formal sector in the form of a production tax for using the output of the informal sector. The higher the use of the output of the informal sector the greater the environmental pollution and the higher would be the rate of production tax imposed on the formal sector. Therefore, in order to reduce the burden of taxation, the formal sector (division m) might be producing some amount of the non-traded input.

[12] The price of the non-traded input must be the same across sectors. Even if the prices of the input produced in sector 2 and m differ initially, competitive forces would ultimately lead to the uniform price, P_2.

[13] This is basically a simplifying assumption. Let us discuss intuitively what happens if production technologies are of the variable coefficient type. Since the production structure is indecomposable, any changes in factor endowments (e.g. resulting from inflows of foreign capital) would change factor prices and hence the factor coefficients (a_{ji}s) which in turn would produce secondary changes in the output composition apart from the primary (direct) effects on the output composition. The primary effects usually dominate the secondary effects with or

The general equilibrium of the model is given as follows.

Given the assumption of perfectly competitive markets, the usual price-unit cost equality conditions relating to the sectors of the economy are given by the following equations, respectively.

$$Wa_{L1} + ra_{K1} = 1 \tag{1}$$

$$Wa_{L2} + ra_{K2} = P_2 \tag{2}$$

$$W^* a_{Lm} + ra_{Km} + Ra_{Nm} = P_2 \tag{3}$$

$$W^* a_{L3} + Ra_{N3} + P_2 a_{23} = P_3[1 - t(X_2)] \tag{4}$$

Here a_{Li} denotes the labour-output ratio in sector i, $i = 1, 2, m, 3$; a_{Ki} denotes the capital (of type K) -output ratio in sector i, $i = 1, 2, m$; a_{Ni} denotes the capital (of type N) -output ratio in sector i, $i = m, 3$; a_{23} is the amount of X_2 required to produce one unit of output in sector 3; r and R denote the returns to capital of type 1 and 2 respectively. It is reasonable to assume that sector 1 is less capital-intensive relative to sector 2 in both physical and value sense implying $|\theta| = (\theta_{L1}\theta_{K2} - \theta_{L2}\theta_{K1}) > 0$ and $|\lambda|_{LK}^{12} = (\lambda_{L1}\lambda_{K2} - \lambda_{L2}\lambda_{K1}) > 0$ where θ_{ji} is the distributive share of the *j* th input in the *i* th sector for $j = L, K, N$ and $i = 1, 2, 3, m$; for example, $\theta_{K2} = (\frac{ra_{K2}}{P_2})$ and λ_{ji} is the allocative

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without sufficient conditions. In the present case, where there are fixed-coefficient technologies, the secondary effects are absent. So, by relaxing the assumption of fixed-coefficient technologies no additional insights can be obtained. It would only complicate the algebra of the model, involving terms with elasticities of substitution between factors of production, S_{ji}^k s where S_{ji}^k is the elasticity of substitution between factors *j* and *i* in sector *k* (i.e. $S_{ji}^k = (W_j / a_{ji})(\partial a_{ji} / \partial W_j)$. Besides, our objective here is to show that there can be cases where foreign capital inflows accompanied by transfer of EST might be counterproductive and there might exist a positive relationship between the pollution level and national income. Our purposes are served if we can establish these results even in a simplified structure like the present one.

share of the jth input in the ith sector for $j = L, K, N$ and $i = 1, 2, 3, m$; for example, $\lambda_{N3} = (\frac{a_{N3}X_3}{N^*})$.

Since the sub-sector m within the formal sector produces the intermediate input in a less polluting manner, it is likely that the pollution regulatory authority (or simply the government) directs the formal sector (sector 3) to carry out the production of the input entirely in sector m. If sector 3 does not comply with the regulation and arranges for production of at least a part of its aggregate requirement of the input in the informal sector (sector 2) through a subcontracting system with the intention of cost reduction, the government imposes a penalty in the form of a production tax on the formal sector. As the production technologies and the production levels by the two sub-sectors of the formal sector are known to the regulatory authority, it can easily detect the amount of the intermediate input that the formal sector purchases from the informal sector which is also the level of production of the latter, X_2. So it is quite reasonable to assume that the production tax on the formal sector is a positive function of the amount of the non-traded input purchased from sector 2, X_2. So we have $t = t(X_2)$ with $t'(.) > 0$.

The pollution level in the economy, Z, is a positive function of the production levels of the intermediate input in sectors 2 and m. Therefore,

$$Z = \alpha X_2 + \beta(A(N^*))X_m;\ \alpha > \beta > 0;\ A' > 0;\ \beta' < 0. \qquad (5)$$

Here α and β are the proportions of pollution generated in producing one units of output in sectors 2 and m respectively. Since sector 2 uses relatively environmentally backward technology, it is assumed that $\alpha > \beta$. An inflow of N results in the residents of the host country coming into contact with foreign entrepreneurs possessing superior technical skills and know how, leading to technology transfer. Therefore the technology parameter, A in sector m is a positive function of the level of N so that $A' > 0$. Transfer of technology results in less emission of pollutants by sector m so that $\beta' < 0$.

Complete utilization of labour and capital of types 1 and 2 imply respectively

$$a_{L1}X_1 + a_{L2}X_2 + a_{Lm}X_m + a_{L3}X_3 = L^* \quad (6)$$

$$a_{K1}X_1 + a_{K2}X_2 + a_{Km}X_m = K^* \quad (7)$$

$$a_{Nm}X_m + a_{N3}X_3 = N^* \quad (8)$$

Here L^*, K^* and N^* denote the endowments of labour, capital of types K and N, respectively.

The supply of X_2 and X_m are circumscribed by their demand in producing X_3. Assuming $a_{23} = 1$, we may write

$$X_3 = X_2 + X_m \quad (9)$$

Using (9), equation (5) may alternatively be written as

$$Z = \alpha X_3 + (\beta(.) - \alpha)X_m \quad (5.1)$$

There are nine endogenous variables in the system, $W, r, R, P_2, Z, X_1, X_2, X_3$ and X_m that can be solved from the above nine equations. This is an indecomposable system where any change in factor endowment affects the factor prices and factor coefficients. Here, W, r and R are obtained from equations (1) – (3) as functions of P_2. Then X_1, X_2, X_m and X_3 are determined from equations (4) and (6) – (8) as functions of P_2. Finally, P_2 is solved from equation (9) and Z is obtained from (5) or (5.1).

The national income at domestic prices, *Y*, is expressed as follows:

$$Y = [WL^* + (W^* - W)(a_{L3}X_3 + a_{Lm}X_m)] + rK_D^* + t(X_2)P_3X_3 \quad (10)$$

Here $[WL^* + (W^* - W)(a_{L3}X_3 + a_{Lm}X_m)]$ is the aggregate wage income of the workers while rK_D^* is the rental income from domestic capital. Finally, $t(X_2)P_3X_3$ is the production tax revenue of the government, which is totally transferred to domestic

consumers in a lump-sum fashion. As capital of type N is entirely owned by foreign capitalists, the rental income earned from this type of capital is not included in the national income expression.

One may argue that the national income at domestic prices cannot appropriately measure social welfare since it does not explicitly contain any social cost due to pollution. While admitting this limitation, we can suggest two ways to address this problem. First, if instead of physical units we measure labour endowment in efficiency units where the efficiency of a representative worker, h, is inversely related to the level of pollution, Z in the economy, we can indirectly accommodate pollution in the economy's national income expression. Environmental pollution leads to health hazards, thus adversely affecting the worker's efficiency. This is because air pollution can lead to irritation, breathing problems and lung diseases; water pollution causes contaminated drinking water; improper waste disposal management involves significant human pathogens; all these contribute directly to reduce human performance. In that case the national income of the economy at domestic prices would be given by

$$Y^* = [Wh(Z(.))L^* + (W^* - W)(a_{L3}X_3 + a_{Lm}X_m)] + rK_D^* + t(X_2)P_3X_3 \qquad (10.1)$$

where $h(Z(.))$ with $h'(.) < 0$ is the efficiency of each worker in the economy. The Y^* function indirectly incorporates the cost due to pollution. This is because it contains the labour endowment in efficiency units, which is negatively related to the level of pollution. So, as pollution level rises the endowment of labour in efficiency unit falls leading to a decrease in aggregate wage income. It can be checked[14] that all qualitative results of the model hold under different sufficient conditions despite this modification. However, the direct way to measure social welfare in the presence of pollution would be to introduce the social welfare function, $S = S(Y, Z)$ with $(\partial S / \partial Y) > 0$ and $(\partial S / \partial Z) < 0$. Social welfare rises if national income rises while it falls if pollution rises. The net effect on social welfare would then be a matter of value judgment.

[14] Interested readers may check these results or can obtain proofs from the authors on request.

3. Comparative Statics

Conventional wisdom suggests that an inflow of capital (of type K) that is used by the informal sectors in a developing economy causes the polluting sectors to expand and thereby accentuates environmental pollution in the economy. On the contrary, foreign capital inflow (of type N) to the formal sector(s) involving transfer of EST has favourable impact on pollution. In this paper, we reanalyze the effects of foreign capital inflow, both with and without transfer of EST on the pollution and national income of the economy. Since the production structure that we have considered is an indecomposable one, factor prices depend on factor endowments. Hence, an increase (a decrease) in the endowment of the j th factor with $j = L, K, N$, lowers (raises) the price of this factor of production. More specifically, we assume that the returns to both types of capital decline as their supply increases following foreign capital inflows.

3.1. Effects of changes in K and N on P_2, factor prices and output composition

First, we find out the consequences of foreign capital inflows of either type on the price of the non-traded input, different factor prices and on the output composition of the economy. These effects would then determine the outcomes of the policies on environmental pollution and national income of the economy. Differentiating equations (1) – (9) and using the stability condition in the market for commodity 2, the following two propositions can now be established.[15]

Proposition 1: An inflow of foreign capital of type K unambiguously lowers the price of the intermediate good and raises the wage rate. It may increase the return to capital of type N if a_{Km} is sufficiently high. On the other hand, inflows of foreign capital of type N raise the price of the intermediate good and the return to capital of type K and lower the wage rate if a_{Km} is sufficiently high.

[15] The detailed derivations along with the sufficient conditions can be obtained from the authors on request.

Proposition 2: As a result of foreign capital inflow of type K the intermediate good producing formal sector expands, while the final good producing formal sector and the informal manufacturing sector (sector 2) contract if a_{Km} and/or a_{N3} is sufficiently high. The agricultural informal sector expands if additionally sector m is more capital (of type N) intensive vis-à-vis sector 3. On the other hand, an inflow of foreign capital of type N leads to an expansion of both the intermediate good producing sectors and the formal final good sector, but a contraction of the agricultural sector under the same set of sufficient conditions.

Let us now derive a few important relationships that would be helpful in explaining the propositions intuitively. Differentiating equations (1) and (2) we obtain respectively:

$$\hat{W} = -(\frac{\theta_{K1}}{\theta_{L1}})\hat{r} \tag{11}$$

$$\hat{P}_2 = \theta_{L2}[\frac{\theta_{K2}}{\theta_{L2}} - \frac{\theta_{K1}}{\theta_{L1}}]\hat{r} \tag{12}$$

Again, differentiating (3) and using (12) we obtain

$$\hat{R} = [\frac{(\theta_{K2}\theta_{L1} - \theta_{K1}\theta_{L2} - \theta_{Km}\theta_{L1})}{\theta_{Nm}\theta_{L1}}]\hat{r} \tag{13}$$

Finally, differentiating equation (4) and using (12) and (13) one finds

$$\hat{X}_2 = -(\frac{A_2}{A_1})\hat{P}_2 \tag{14}$$

$$\left.\begin{array}{l} \text{where: } A_1 = \dfrac{t'X_2}{1-t(X_2)} > 0 \text{ and } A_2 = \{(\dfrac{\theta_{N3}}{|\theta|})(\theta_{L1}\theta_{K2} - \theta_{K1}\theta_{L2} - \theta_{L1}\theta_{Km})\} + \theta_{23}; \\ \text{and, } |\theta| = \theta_{Nm}(\theta_{L1}\theta_{K2} - \theta_{K1}\theta_{L2}) > 0 \end{array}\right\} \tag{15}$$

Propositions 1 and 2 can be verbally explained as follows. As the production structure considered in this paper is indecomposable, factor prices and factor endowments are inversely related. An inflow of foreign capital of type K lowers its return, r, since the supply of this input rises given its demand. To satisfy the zero-profit condition in sector 1 (equation 1) it follows that the competitive wage rate in the informal sector, W, must rise. Due to changes in W and r, from the zero-profit condition of sector 2 (equation 2) it

follows that the price of the non-traded input, P_2, must also change. However, the direction of the change must depend upon the relative factor intensities of sectors 1 and 2. Our analysis (see equation 12) shows that P_2 must fall as sector 2 is more capital-intensive vis-à-vis sector 1. Since both r and P_2 fall, from the zero-profit condition of sector m (equation 3), we find that the effect on the return to capital of type N i.e. R is somewhat inconclusive. However, from equation (13) it is easy to verify that R rises if $\theta_{Km} \geq \theta_{K2}$ i.e. if $a_{Km} \geq a_{K2}$. The direction of change of the output of sector 2 i.e. X_2 should come out from the zero-profit condition of sector 3 (equation 4). From equations (14) and (15) we see that sector 2 contracts i.e. X_2 falls iff $A_2 < 0$ i.e. if a_{N3} and/or a_{Km} is adequately high.[16] Sector 2 releases labour and capital of type K to the other sectors. As a result, sector m definitely expands; sector 1 also expands if sector 3 is more labour-intensive relative to sector m with respect to capital of type N. As sector m expands, capital of type N is drained out of sector 3 to the expanding sector m. Consequently, sector 3 contracts for dearth of capital.

The effects of an inflow of foreign capital of N type can be similarly explained in the opposite fashion with the help of equations (11) – (15). But here one has to start from a decline in R. Another important point is that in this case, both sectors m and 3 using this type of capital expand.

3.2. *Effects of changes in K and N on aggregate pollution with and without transfer of EST*

Differentiating equation (5.1) and using different expressions which have already been derived[17] the following proposition can easily be established.[18]

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[16] The proofs are left to interested readers.

[17] The detailed derivations can be obtained from the authors on request.

[18] The proofs are left to interested readers.

Proposition 3: An inflow of foreign capital inflow of type K reduces the pollution level in the economy. Foreign capital inflow (of N type) in the formal sector raises pollution without transfer of EST if a_{Km} and/or a_{N3} is adequately high, as well as with a transfer of EST under an additional sufficient condition.

The intuitive explanations of proposition 3 are fairly straightforward. From equations (5) and (5.1) it is evident that the consequence on the aggregate pollution in the economy of an inflow of foreign capital of either type depends on the changes in the intersectoral output composition. Although sectors 2 and m are the two polluting sectors, sector 2 is more polluting vis-à-vis sector m. If both the polluting sectors expand pollution increases unambiguously. On the other hand, if sector m (i.e. X_m) expands at the cost of sector 2 (X_2) and the aggregate production of the polluting commodity ($X_2 + X_m = X_3$) does not at least increase, the society does have a lower level of pollution. In proposition 2 we have seen that an inflow of foreign capital of K type leads to an expansion of sector m and contractions in both sectors 2 and 3. So the share of the less polluting sector rises in a falling aggregate production of the polluting commodity thereby leading to an unambiguous reduction in the aggregate pollution level in the economy. On the contrary, when capital of type N flows in, both the polluting sectors expand and the economy's level of pollution rises unambiguously in the absence of transfer of EST. Finally, when an inflow of capital of type N is accompanied by a transfer of EST that lowers the level of pollution generated per unit of output (β) by sector m, aggregate pollution may still increase because of two reasons. First, βX_m can increase even when β falls if X_m rises sufficiently. Secondly, even if βX_m falls, the increase in αX_2 may dominate the fall in βX_m.

3.3. *Effects of changes in K and N on national income*

Now we analyze the consequences of foreign capital inflows of either type on national income of the economy. Here the expression for national income at domestic prices is given by equation (10). Capital of type K consists of both domestic capital and foreign

capital, which are perfect substitutes. On the contrary, capital of type N is completely owned by foreign capitalists. Foreign capital income of either type is completely repatriated. Totally differentiating equation (10) and using different expressions that have already been derived[19] one can prove the following proposition.[20]

Proposition 4: Foreign capital inflow of type K reduces national income if (i) a_{Km} and/or a_{N3} is adequately high; and, (ii) $K_D^* \geq (a_{K1}X_1 + a_{K2}X_2)$ while an inflow of capital of type N raises national income under the same pair of sufficient conditions.

We note that sectors 3 and m (two formal sectors) are the two higher wage-paying sectors vis-à-vis sectors 1 and 2 (two informal sectors) since $W^* > W$. As stated in proposition 1, an inflow of foreign capital of type K raises the competitive wage, W, lowers the return to this capital, r and raises the return to capital of type N, i.e. R. This also leads to an expansion (a contraction) of sector m (sector 3) (see proposition 2) if a_{Km} and/or a_{N3} is sufficiently high. So, there would be a reallocation of labour between the higher and lower wage-paying sectors. We call this the labour reallocation effect. However, it cannot be predicted unequivocally how this effect impinges on national income since the change in aggregate wage income would be ambiguous because of the following reasons: (i) W rises; (ii) sector 3 contracts; and, (iii) sector m expands. On the other hand, return to domestic capital falls unambiguously affecting national income adversely. Finally, as sector 2 contracts, the rate of pollution tax, t, on sector 3 falls. Besides, as sector 3 contracts, the aggregate pollution tax revenue, which is transferred to consumers, also decreases. We call this the pollution tax revenue effect that also works negatively on national income. Our analysis shows that even if aggregate wage income rises, it would be outweighed by the decline in domestic capital income if the size of domestic capital

[19] Interested readers may derive these results.

[20] The detailed derivations can be obtained from the authors on request.

stock (of type K) were sufficiently large,[21] so that national income of the economy plummets.

On the contrary, an inflow of foreign capital of type N lowers both W and R but raises r (see proposition 1). Furthermore, sector 2 contracts while both sectors m and 3 expand. The effect on aggregate wage income is again ambiguous. But it is easily seen that the increase in return to domestic capital dominates the change in aggregate wage income if the size of domestic capital stock (of type K) is adequately large.[22] Besides, the pollution tax rate on sector 3 rises as sector 2 expands. The aggregate tax revenue, $t(X_2)P_3X_3$, definitely rises as sector 3 also expands. National income at domestic prices, therefore, augments.

4. Concluding remarks

A major problem for the developing countries in regulating environmental standards is the persistence of a vast informal sector. Large industries shift their production to informal sector firms, mostly involving environmentally "dirty" tasks and processes on a subcontracting basis, mainly because it is an economical way for the former to avoid investment in environmentally sound technologies (ESTs) made obligatory by the regulatory authority. FDI constitutes an important catalyst for the transfer of ESTs, which protect the environment and are less polluting, to the developing economies. Various direct fiscal incentives such as the elimination or reduction of taxes on income or sales from investment, tax holidays, and taxation graded according to the level of environmental improvement achieved are provided to foreign capitalists so as to create a favourable investment environment for EST transfer.

However, there are different types of capital used in the different sectors of a developing economy. Some of them are used by both formal and informal sectors while the rest are used solely in the formal sector. There is possibility of transfer of EST only through

[21, 22] The proofs are left to interested readers.

inflows of those of types of foreign capital which are utilized in the formal sector alone. Therefore, from the point of view of pollution abatement, the inflow of this type of capital should be preferred to the type of capital that is used by both formal and informal sectors. Besides, inflows of different types of capital are likely to produce dissimilar effects on the national income of the economy. The theoretical literature on trade and environment has not yet examined the linkages between FDI, informal sector and transfer of EST in a developing economy. The paper is purported to fill in this gap by developing a three sector full-employment general equilibrium model consisting of three sectors, a rural sector, an informal and a formal sector. The formal sector has two divisions, one producing a final manufacturing good and another producing a non-traded intermediate input for production in the final good sector. The intermediate input is also produced in the informal sector. The formal and informal intermediate input producing sectors pollute the environment, although owing to use of a different type of capital that embodies transfer of EST, the formal intermediate sector produces less pollution than the informal sector per unit of output.

We find that there might exist a positive relationship between pollution and national income in the economy. An inflow of the type of foreign capital which is used both in the formal and informal sectors lowers both pollution and national income while an inflow of capital that is used solely in the formal sectors, both in the presence and absence of transfer of EST, produces exactly the opposite effects under some reasonable conditions. Despite simplicity and abstraction, the results of the model are interesting as they can at least question the desirability of transfer of EST especially when it may fail to contain pollution. Finally, the results also explain theoretically that at the initials levels of (per capita) national income, the Environmental Kuznets Curve (EKC) is indeed positively sloped that has been confirmed by numerous empirical studies.

References

Almeida de, L. T., Rocha, S. S., 2008. Beyond pollution haloes: the environmental effects of FDI in the pulp and paper and petrochemicals sectors in Brazil. Working Group on Development and Environment in the Americas, Discussion Paper No. 17.

Barrett, S., Graddy, K., 2000. Freedom, growth, and the environment. Environment and Development Economics. 5(4), 433-56.

Beckerman, W., 1992. Economic growth and the environment: whose growth? whose environment? World Development, 20, 481-496.

Beladi and Marjit (1992), Foreign Capital and Protectionism. Canadian Journal of Economics, 25, 233-238.

Bose, A. N., 1978. Calcutta and rural Bengal: small sector symbiosis. Minerva Publications. New Delhi.

Brecher, R.A., Alejandro, C.F.D., 1977. Tariffs, foreign capital and immiserizing growth. Journal of International Economics 7, 317–322.

Cagatay, S., Mihci, H., 2006. Degree of environmental stringency and the impact on trade patterns. Journal of Economic Studies. 33 (1), 30-51.

Chandra, V., Khan, M. A., 1993. Foreign investment in the presence of an informal sector. Economica. 60, 79–103.

Chaudhuri, S., 2001. Foreign capital inflow, technology transfer, and national income. Pakistan Development Review. 40(1), 49-56.

Chaudhuri, S., Mukhopadhyay, U., 2009. Revisiting the Informal Sector: A General Equilibrium Approach, Springer, New York, U.S.A.

Chaudhuri, S., Mukhopadhyay, U., 2006. Pollution and informal sector: a theoretical analysis. Journal of Economic Integration. 21(2), 363- 378.

Dietzenbacher, E., Mukhopadhyay, K., 2007. An empirical examination of the pollution haven hypothesis for India: towards a green Leontief paradox? Environmental and Resource Economics. 36 (4), 427-449.

Dominguez, V. L., 1998. Control de la contaminación en la industria de fibras químicas en un contexto de apertura económica. Paper presented at Latin American Studies Association XXI International Congress, Chicago, September.

Eskeland, G.S., Harrison, A.E., 2003. Moving to greener pastures multinationals and the pollution haven hypothesis. Journal of Development Economics. 70 (1), 1-23.

Grinols, E. L., 1991. Unemployment and foreign capital: the relative opportunity cost of domestic labour and welfare. Economica. 57, 107–21.

Grossman, G. M., Krueger, A. B., 1995. Economic growth and the environment. Quarterly Journal of Economics. 112 (2), 353-378.

Gupta, M.R., 1997. Foreign capital and informal sector: comments on Chandra and Khan. Economica. 64, 353–363.

Harris, J.R., Todaro, M. P., 1970. Migration, unemployment and development: a two - sector analysis. American Economic Review. 60, 126-42.

He, J., 2006. Pollution haven hypothesis and environmental impacts of foreign direct investment: The case of industrial emission of sulfur dioxide (SO2) in Chinese provinces. Ecological Economics. 60 (1), 228-245.

Jenkins, R., 1999. Trade, investment and industrial pollution: a Malaysia case study with some Mexican comparisons. IKMAS Working Paper.

Jha, V., Teixeira, A. P., 1994. Are environmentally sound technologies the emperor's new clothes? Discussion Papers No. 89, UNCTAD, Geneva.

Joshi, H., Joshi V., 1976. Surplus labour and the city: a Study of Bombay. Oxford University Press. New Delhi.

Juma, C., 1994. Promoting international transfer of environmentally sound technologies: the case for national incentive schemes, in: Bergesen, H. O., Parmann, G. (Eds.), Green Globe Yearbook of International Co -operation on Environment and Development. Oxford University Press, pp.137–148.

Khan, M. A., 1982. Tariffs, foreign capital and immiserizing growth with urban unemployment and specific factors of production. Journal of Development Economics. 10, 245–56.

Less, C. T., McMillan, S., 2005. Achieving the successful transfer of environmentally sound technologies: trade- related aspects. OECD Trade and Environment Working Paper No. 2005-02.

Levy, D., 1995. The environmental practices and performance of transnational corporations. Transnational Corporations. 4(1), 44-68.

López, A., Chidiak, M., 1996. La industria petroquímica, in: Chudnovsky D. et al, Los límites de la apertura. Liberalización, restructuración productiva y medio ambiente, CENIT/Alianza Editorial, Buenos Aires.

Luken, R., Rompaey, F. V., Zigová, K., 2008. The determinants of EST adoption by manufacturing plants in developing countries. Ecological Economics. 66, 141-152.

Merican, Y., Yusop, Z., Noor, Z. M., Hook, L. S., 2007. Foreign direct investment and the pollution in five ASEAN nations. International Journal of Economics and Management, 1 (2), 245–261.

Papola, T. S., 1981. Urban informal sector in a developing economy. Vikas Publishing House. New Delhi.

Perrings, C., Bhargava, S., Gupta, J., 1995. The transfer of environmentally sound technology to small and medium scale enterprises in developing countries: a survey of the issues. Paper prepared for UNCTAD, Geneva.

Rock, M.T., 2002. Pollution Control in East Asia: Lessons from Newly Industrializing Economies. Resources for the Future. Washington D.C.

Romatet, E., 1983. Calcutta's informal sector: theory and reality. Economic and Political Weekly. 18, 2115–28.

Sethuraman, S. V., 1981. The urban informal sector in developing countries: employment, poverty and environment. ILO, Geneva.

World Bank, 1992. World Development Report. Oxford University Press. New York.

Zarsky, L., 1999. Havens, halos and spaghetti: Untangling the evidence about FDI and the environment. Paper presented to OECD conference on Foreign Direct Investment and the Environment, OECD, Paris, January.