The Impact of Foreign Direct Investment on Developing Economies and the Environment *

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Abstract:

This article is about the impact of foreign direct investment on developing economies and the environment. All of us that are concerned about the environment should ask ourselves if the increase in capital mobility associated with the world-wide process of liberalization, deregulation and privatization, known as the Neo-liberal global regime, has contributed to the problems of higher emissions, ozone layer destruction, and pollution of water sources, as well as to create false economic bubbles that lead to increased consumption in these regions whilst forcing the destruction of the environment by the poor in order to survive and cope with the roles their society demands. Neo-liberal practices such as those enforced in developing countries like Colombia, while seeking to attract foreign investment to push their economies, tend to generate a false aggregated demand growth that in most cases is not sustainable in the long term, increases global unemployment, unleash destructive competitive processes and weaken government's ability to regulate business in the citizens` best interests.

Resumen:

Este artículo trata sobre el impacto de inversión extranjera directa en economías en vías de desarrollo y el medio ambiente. Todos los que nos preocupamos por el medio ambiente debemos preguntarnos, si el aumento en la movilidad de capitales

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asociada con el proceso mundial de liberalización, desregulación y privatización, conocido como "neoliberalismo", ha contribuido a problemas de emisiones más altas, destrucción de la capa de ozono, y polución de fuentes de agua, así como a la creación de falsas burbujas económicas que llevan a aumentar el consumo en estas regiones, obligando a los más pobres a destruir el medio ambiente para sobrevivir y poder cumplir con los roles impuestos por la sociedad. Prácticas neoliberales tales como las implantadas en países en vías de desarrollo, como Colombia, en busqueda de alcanzar mayor inversión extranjera para impulsar sus economías, tienden a generar un falso crecimiento de la demanda agregada que en la mayoría de los casos no es sostenible en el largo plazo, y generan así alto desempleo, procesos competitivos destructivos, y debilitando la habilidad de los gobiernos de regular los negocios y salvaguardar los intereses de los ciudadanos.

Key Words: Capital Mobility, EKC: Environmental Kuznet Curve, FDI: Foreign Direct Investment, Neo-liberal Regime, Emissions, Ozone Layer, Pollution, Economic bubble, Consumption.

Palabras clave: La Movilidad del capital, CMK: Curva Medioambiental de Kuznet, IED: Inversión Extranjera Directa, Régimen neoliberal, Emisiones, Capa de Ozono, Polución, Burbuja económica, Consumo.

Introduction

How does mobility of investment capital across nations affect environmental policy? Is there a direct relation between investment and the environment? Attention to these questions has concentrated mainly on the influence of capital inflows on environmental policy in recipient countries. The standard assumption in these analyses has been that capital is "disembodied" and it is installed in the region, offering the highest direct rate of return and without consideration for other channels through which the location where capital is installed affects solely the welfare of its owners. This is a rather simplistic assumption. Capital owners are residents of one country or another: for instance, in the United States at least, nearly two thirds of corporate stocks are controlled either directly or indirectly by households. Moreover, residents are rarely compensated directly for the disutility associated with pollution from local or nearby industry. It seems logical then that investors will take into consideration any effects on the quality of their local environments when deciding where to invest their capital.

The Concept of Capital Mobility

At least, in the United States and other developed economies corporate stocks are owned by households and somehow they are getting benefits and can thus decide whether to invest in such corporations and force them to regulate their emissions. But what is being done in developing countries, eager to accept "Flight" capitals to push their economies?

It has been found that trade openness has a positive association with education and social security expenditures, that financial openness does not constrain government outlays for social programs, and that democracy has a strong positive association with social spending, particularly on items that bolster human capital formation; but what about the environment and the direct impact openness has on it?

There are five views that have been identified about the effects of FDI on the trajectory of the world economy. These views are labelled "The Race to the Bottom", "The Climb to the Top", "Neo-liberal Convergence", "Uneven Development", and "Much Ado about Nothing".

According to "The Race to the Bottom" view (Bluestone and Harrison, 1982; Barnet and Cavanagh, 1994; Greider, 1997), capital will increasingly be able to play workers, communities and nations off against one another, threatening to run away if demands for tax, regulatory (environmental laws) and wage concessions are not forthcoming. From this perspective, increased capital mobility benefits corporations, while people, and therefore the environment, lose. A modified version of this view is that the winners in the race to the bottom will include highly educated and skilled workers, and those in privileged professions, no matter where they live. The losers will be the less skilled and the unemployed everywhere.

"The Climb to the Top" view takes the opposite position. It suggests that multinational corporations are attracted less by low wages and taxes than by highly educated workers, good infrastructure, and high levels of demand and agglomeration effects arising from the clustering of companies in a particular location. According to this view, competition for FDI will lead countries to try to provide well educated labour and high quality infrastructure in order to retain and attract foreign investment, albeit through the relaxing of environmental policies in most cases. Thus footloose capital and national competition for FDI will induce a global climb to the top. This climb to the top could lead to the outcome represented by "Neo-liberal Convergence". This is the widely held mainstream belief that free mobility of multinational corporations, in the context of deregulation and free trade, will produce increased living standards in all countries. These processes will, moreover, transfer capital and technology from developed to developing countries, thereby raising the standards of living of those in the poorer countries at a faster rate than those in the wealthier ones, eventually generating a world wide convergence in living standards. These same processes could, however, lead to the outcome envisaged in the fourth view, "Uneven Development".

"Uneven Development" holds that some regions of the world will grow at the expense of others. For decades the dominant version of this view was the theory of imperialism: if the South integrated itself with the North, the North would grow at the expense of the South. Now, the reverse fear holds: by forcing Northern workers to compete with cheap Southern labour, an integrated world economy will help the South grow at the expense of the North.

The previous four views take for granted that FDI has a substantial effect on national economies. In contrast, the "Much Ado About Nothing" view asserts that FDI plays a rather modest role in global economics.

Adherents argue that FDI is still a relatively small percentage of national income and most of it is between rich countries; thus, FDI can generate neither convergence nor a race to the bottom.

Which of these views is correct? A complete answer cannot be provided. We argue that foreign direct investment is neither inherently good nor bad; its effects are conditioned by the overall national and international context within which capital mobility occurs. When FDI occurs in the context of high aggregate demand and tight labour markets, effective regulatory institutions, and non-destructive competitive processes, it may indeed have a positive impact on nations and communities. In the absence of these conditions, FDI can have destructive economic and political consequences on both home and host countries.

Environmental Economic Models

One way to demonstrate whether capital mobility and deregulated FDI negatively affects the environment is through environmental economic models and simulations. There are various models proposed for the issue, but most of them have been simulated in closed economies. What this research is trying to achieve is to show how the environment in open economies is affected by the production of goods and foreign capital inflows in developing countries.

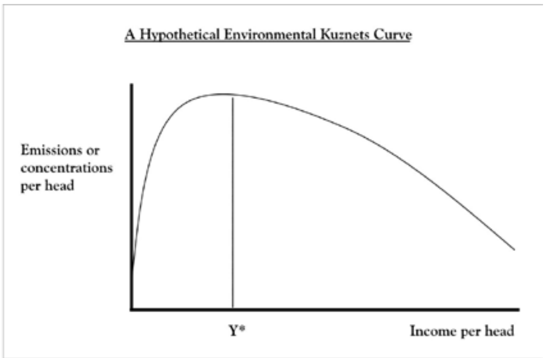
Bidisha Lahiri (2007), PhD. candidate from University of North Carolina at Chapel Hill, proposes the following model, which is especially interesting because it provides a very good explanation regarding the effects of capital mobility and its impact on environmental quality in any given open economy. Standard analyses of gains and losses from international trade use the income of the nations as the determinant of welfare.

Evolution of environmental quality is another important component of social welfare and the present analysis adds this dimension to the outcome of international trade. Empirical studies, driven primarily by cross-sectional variation, have found an inverted U shaped relation between income and environmental quality, especially for local pollutants, which is called the Environmental Kuznets curve (henceforth EKC), (Agras, J. and Chapman, D. 1999). This raises the question of whether growth in income has a negative or positive impact on environmental quality.

These studies have not incorporated the effect of international trade in an open economy and do not consider whether the EKC relation is also a given property of open economy growth in the long run, and which forces are involved in the income-environment relation. In order to achieve this, the model considers the trading partners to be different, either in environmental policy regime or in their stage of growth when they enter trade.

Allowing for the standard sources of comparative advantage in the form of two economies having different relative endowments of the internationally immobile resource, shifts only the environmental-income relation but does not change the inter temporal properties derived here.

Figure 4.1



Taken from: STERN REVIEW: "The Economics of Climate Change", Part III, The Economics of Stabilisation, 2006

Some evidence indicates that for local pollutants there is an inverted-U shaped relationship between income per head and emissions per head: the so-called 'environmental Kuznets curve', illustrated in Figure 4.1. The usual rationale for such a curve is that the demand for environmental improvements is income elastic, although explanations based on structural changes in the economy have also been put forward. So the question arises, is there such a relationship for CO_2? If so, economic development would ultimately lead to falls in global emissions (although that would be highly unlikely before greenhouse gas concentrations had risen to destructive levels). In the case of greenhouse gases, this argument is not very convincing. As societies become richer, they may want to improve their own environment, but they can do little about climate change by reducing their own CO_2 emissions alone. With CO_2, the global nature of the externality means that people in any particular high-income country cannot by themselves significantly affect global emissions and hence their own climate. This contrasts with the situation for local pollutants for which the environmental Kuznets curves has been estimated. It is easier than with greenhouse gases for the people affected to set up abatement incentives and appropriate political and regulatory mechanisms. Second, CO_2 had not been identified as a pollutant until around 20 years ago, so an explanation of past data based on the demand for environmental improvements does not provide convincing evidence. Nevertheless, patterns like the one in Figure 4.1 suggest that further empirical investigation of the relationship between income and emissions is warranted. Several empirical studies have found that a relationship looking something like the first half of an environmental Kuznets curve exists for CO_2 (after allowing for some other explanatory factors in some, but not all, cases). Even if this finding were crucial, however, it does not imply that the global relationship between GDP per head and CO_2 emissions per head is likely to disappear soon. The estimated turning points at which CO_2 emissions start to fall are at very high incomes (for example, between \$55.000 and \$90,000 in Neumayer's cross-country study, in which the maximum income level observed in the data was \$41,354). Poor and middle-income countries will have to grow for a long time before they get anywhere near these levels. Schmalensee found that, using their estimates with an implied inverted-U shape as the basis for a projection of future emissions, emissions growth was likely to be positive up to their forecast horizon of 2050. Indeed, they forecast more rapid growth than in nearly all the 1992 Intergovernmental Panel on Climate Change (IPCC) scenarios, using the same assumptions as the IPCC for future population and income growth. In any case, it is not clear that the link between emissions and income does disappear at high incomes. First, the apparent turning points in some of the studies may simply be statistical artefacts, reflecting the particular functional forms for the relationship assumed by the researchers. Second, the apparent weakening of the link may result from ignoring the implications of past changes in energy technology; after controlling for the adoption of new technologies that, incidentally, were less carbon-intensive, the link may reappear, as argued by Huntington (2005). (Stern, 2006).

The model tries to prove that if the environmental policy does not respond to the stronger valuation of pollution disutility as the residents get richer, then the environmental quality monotonically worsens as the income increases. Therefore, if environmental policy becomes stricter with growth of the economy, the environmental quality first worsens and then improves as income gets better. At early stages of economic development, production grows rapidly to meet the strong investment demand under both taxation regimes. The difference in shape occurs because if emission taxes are high at a later stage of growth, this provides incentives for producers to reduce the emission per unit of production as well as to move to cleaner sectors where the pollution tax payment is low. These two effects gradually start dominating the growth effect as capital accumulation slows down when the economy gets closer to a steady state. This improvement in environmental quality can be seen in the downward segment of the EKC. When the policy regime is so relaxed that emissions taxes do not increase with growth, these two pressures are absent and, as a result, environmental quality worsens monotonically. The model considers two economies that would have experienced an identical income-pollution trajectory with growth under autarky and finds that in the context of international trade, the economy that enters trade at an earlier stage of growth is faced with a worse environmental outcome than the one that enters trade at a later stage in development, while also experiencing a better environmental quality compared to autarky. This happens because at every point in time, the poorer economy, whatever its level of growth, values pollution less than its rich partner and it is eager to accept foreign capital inflows.

Although the returns on the foreign capital are remitted abroad, the effect of the pollution remains in the poorer economy. In this case, it would be misguided for less developed countries, at any given income level, to expect environmental quality to be the same as that which the developed country had enjoyed at an identical income level. The model allows these effects to interact in determining the final outcome, and considers the environmental policy as an endogenous variable in the model providing an instrument that may be used to influence these forces. The endogenously determined pollution tax in each country influences the overall shape of the relation, and determines the exact levels of results. This happens because the environmental policy affects the payment to capital. This influences the desire to invest in every period, and for any given period also determines the allocation of world capital stock between the two economies. Therefore, the environmental policy has both a dynamic and static role in determining the amount of accumulated capital and the location where it is employed, leading to the emission results. While using the inter temporal income-environment relation of one economy to make predictions for another economy, the model finds that one needs to account for the differences in structure of production, techniques of production, stage of development, nature of environmental policy and pattern of trade simultaneously, which is done in a tractable manner within the model. The model is a dynamic general equilibrium model of a country trading with rest of the world (Agras, J. and Chapman, D. 1999). The dynamic aspect of the model allows analyzing the growth of the economies and the scale effects on the environment. Traded commodities are classified into clean and dirty sectors. This allows analyzing the change in the mix in production composition as the system moves towards the steady state. Environmental policy is modeled as a per-unit pollution tax.

Change in the pollution tax affects the per unit emission of each good. The essence of the model is similar to the Ramsey 1928-Caas-1965-Koopman's 1965 [13] Neoclassical Growth Model with an endogenous savings rate. The model uses a system of difference equations that arise from the first order conditions of inter temporal welfare maximization, and also uses analytical results and numerical simulation to track the complete time path of income and environmental conditions of the two economies. Evolution of the variables is defined as the movement from the initial conditions, to the steady state along the saddle path. Change in the initial conditions, parameters of the model and the environmental tax rule translate into changes in the inter temporal paths and the relations between variables. These dimensions of the exercise provide a more comprehensive understanding of the economic reasons underlying the Environmental Kuznets Curve. It examines whether and when it is realistic for polluted economies to pin their hopes on higher incomes to improve environmental quality.

Model Framework

An empirical study by Grossman and Krueger (1991) [8], discovered the inverted U shaped relation between income and environmental quality for local air and water pollution. This study spawned multiple empirical studies to capture and analyze the EKC. This is a dynamic model which examines both exogenous and endogenous changes in tax policy. Also, the technique of production is determined within this model. The interaction between the two trading partners, usually absent in the EKC literature, is an important addition in the analysis. Starting with two countries that differ in capital and labour endowment, Copeland and Taylor (2004) [6] outline a static framework to examine the implication of trade on each country's production pattern and environmental outcomes. They allow capital to be mobile, so that a country could employ its domestically owned capital abroad. The present model starts from this framework and extends it to a dynamic model, so that it is suitable for analyzing the inter temporal relation between income and the environment for an economy.

The differences in initial relative endowments play a weaker role in this model because in a dynamic context the endogenously determined inter temporal savings rate is the primary determinant of the capital owned by the country. The endogenously determined pollution tax in each country has both dynamic and static implications in the model. The pollution tax path determines the amount of capital that is accumulated over time, while every period it affects the location where the capital is employed and the intensity of emissions. The interaction of the inter temporal and static effects of the tax determines the final emission outcome in the model. The classic Ramsey 1928-Caas 1965-Koopman's 1965 [13] Neoclassical Growth Model (RCK) Neoclassical Growth Model with an endogenous savings rate provides the dynamic structure for this model.

It simplifies the instantaneous utility function to be the log function instead of constant elasticity of substitution in the original RCK framework. However, the consumption equation is comprised of two goods instead of the single commodity in the RCK model, while the disutility from pollution is added in the welfare function.

While the original RCK model was for a closed economy, this model applies it to a two country trading framework. This model incorporates pollution considerations and international capital mobility in a larger country setting.

Theoretical Model

The model starts with a dynamic general equilibrium model with two types of goods (X and Y) and two inputs ($X_t$and Y_t) all indexed by time. The consumption equation is of the Cobb-Douglas form $C_t= (X_t)^{\omega}(Y_t)^{(1-\omega)}$. Expenditure on consumption is

$E_t=P_{xt}\, C_{xt}+ C_{ty} = P_tC_t$; Where:

P_t = Price index of the consumption equation.

C_t= Consumption

The inter temporal social welfare function [6],

$$U_t=\sum_{t=0}^{\infty}\rho^t\, u_t=\sum_{t=0}^{\infty}\rho^t\left[\ln(C_t)-\gamma . Z_t\right] \qquad (1)$$

Where:

ρ= Disutility parameter

u_t= Marginal utility

γ = The constant marginal disutility from pollution

Z_t= Pollution

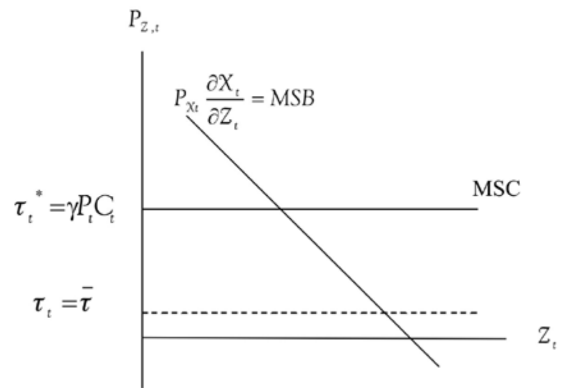
The every period utility is additive in consumption and pollution. It is concave in consumption and linear in pollution. Although the disutility parameter associated with pollution is constant, the marginal valuation of disutility increases as economies get richer. This can be seen from the ratio of the marginal utilities.

If: $P_{z,t}$= Marginal valuation of pollution

P_t = Marginal valuation of consumption, then:

$$\frac{P_{Z,t}}{P_t}=\frac{-\partial u_t/\partial Z_t}{\partial u_t/\partial C_t}\text{, or }P_{Z,t}=\gamma P_tC_t. \qquad (2)$$

Every period the government imposes a tax $\{\tau_t\}$ per unit of emission, the emission tax is available as the instrument to Maximize Social Benefits (MSB) and to control Social Consumption (SC).



Different policy regimes are considered (M Daley, Dorothy. 2007) [9]; (Meadowcroft, James. James Allan and Keith Neuman. 2007). First, as in the static model, the pollution tax is assumed to be set efficiently as the shadow price of pollution for each period in both economies. This is more realistic for developed economies where wealthier residents, who are more aware of the cost of environmental degradation, can expect the policy making agency to reflect their concerns through stricter regulations. However for economies with fewer resources, the cost of monitoring, as well as the administrative costs of changing the standards, may make periodic synchronization of pollution tax with consumer demands infeasible. Hence the second pollution tax framework is such that one economy sets efficient pollution tax every period, while the other economy keeps its pollution tax fixed for the period under consideration, zero environmental taxes being a special case of this fixed-tax. This may be a more realistic institutional set-up if one identifies the efficient-tax economy as the developed countries and the fixed-tax economy as the less developed countries.

Production of each commodity uses one specific physical input, and emits pollution *Z* as by-product. *Y* uses *K* and *X* uses *L* as specific factors. *K* can be created and accumulated and is internationally mobile. *L* is internationally immobile and also cannot be accumulated (example: land). *Y* is treated as the enumerative good (Copeland and Taylor. 2004), (Anderson D. and Cavandish, W. 2001), (Lahiri, Badisha. 2007). The production functions are decreasing returns to scale in the specific factor. *Y* emits more pollution per unit of production relative to *X*. Pollution emission can be abated if some resources are diverted for this purpose. Under some specific functional forms of this abatement technology, the production and abatement relations may be combined so that pollution appears like an input for production. However, it has to be kept in mind that higher pollution is associated with a higher production level because fewer resources are diverted for abatement of the pollution.

$$X_t = Z_t^{\beta} L_t^{s_x - \beta} \qquad (3)$$
$$Y_t = Z_t^{\alpha} K_t^{s_y - \alpha} \qquad (4)$$

Where:
α and β = Increasing returns to scale abatement technology, so $\alpha > \beta$ = Y is more pollution intensive.

s_x = Degree of returns to scale in industry X

s_y = Degree of returns to scale in industry Y.

According to this, production technology is fixed and the input mix changes as the price of the inputs changes. $Z \in [0,1]$ is the index of the technology actually adopted in an economy, depending on the prevailing incentives. Higher values of *Z* indicates that a dirtier technology is adopted which yields more goods but also more pollution. As there is no uncertainty, the emissions tax for next period is taken into account when making input decisions for the next period. If τ_t is the prevailing emissions tax, (Mcausland, Carol. 2002) [10], (Lahiri, Badisha. 2007), (Swank, Duane; Sven Steinmo. 2002) then profit maximizing leads to:

$$\tau_t = \frac{\beta P_{X_t} X_t}{Z_t} \qquad (5)$$

Using this condition to substitute for Z_t in the production function makes X_t production a function of L_t and relative prices.

$$X_t = \left(\frac{\beta P_{Xt}}{\tau}\right)^{\frac{\beta}{1-\beta}} (L_t)^{\frac{sx-\beta}{1-\beta}} \quad \text{i.e.} \quad X_t = X_t(P_{Xt}, L_t; \beta, sx, \tau) \tag{6}$$

Similarly $$Y_t = \left(\frac{\alpha}{\tau}\right)^{\frac{\alpha}{1-\alpha}} (K_t)^{\frac{sy-\alpha}{1-\alpha}} \quad \text{i.e.} \quad Y_t = Y_t(K_t; \alpha, sy, \tau) \tag{7}$$

Given the prevailing market incentives, there is efficient allocation of resources in every period, both for consumption and production. However, investment motives cause the sequence of static equilibrium to evolve and move towards the steady state, where there is no further desire for change.

Free Trade and Environmental Effects

In a free trade scenario, both goods X and Y are traded. Capital $K_t$accumulates over time without any depreciation and is internationally mobile. In every period capital moves to where the payments are higher, until the payments in both economies are equalized (Grossman, G. M. and Krueger, A. B., 1991). The second input, namely land or labour L_t, is assumed to be fixed and internationally immobile. The two economies are assumed to have identical endowment of this fixed input. To focus on environmental issues, it is assumed that exchange rate equals unity and that purchasing power parity is satisfied.

For the two economies interacting with each other, the equations are similar in form. The foreign variables are denoted with *. The model has 23 variables:

$\{C_t, K_t, B_t, P_t, r_t, C^*_t, K^*_t, C_{xt}, C_{yt}, C^*_{yt}, C^*_{xt}, Y_t, X_t, Y^*_t, X^*_t, Z_{yt}, Z_{xt}, Z_{yt}, Z_t, Z^*_{yt}, Z^*_{xt}, Z^*_t, P_{xt}\}$

Where:

B_t= An international financial market for bonds

r_t= Interest earned on each bond held

So, the strategy in solving this model is to identify a smaller subset of variables which are solved from the dynamic equations. With free trade, the core subset of dynamic relations are the seven difference equations below (Lahiri, 2007).

$$P_t C_t + (K_{t+1} - K_t) + (B_t - B_{t-1}) = Y_t + P_{xt} X_t + r_t B_t \tag{8}$$

$$P_t C^*_t + (K^*_{t+1} - K^*_t) - (B_t - B_{t-1}) = Y^*_t + P_{xt} X^*_t - r_t B_t \tag{9}$$

$$\frac{1}{P_t C_t} = \rho\left[\frac{1}{P_{t+1} C_{t+1}}\{1 + Y'_{t+1}(K_{t+1})\} - \gamma Z'_{t+1}(K_{t+1})\right] \tag{10}$$

$$\frac{1}{P_t C_t} = \rho\left[\frac{1}{P_{t+1} C_{t+1}}\{1 + r'_{t+1}\}\right] \tag{11}$$

$$\frac{1}{P_t C^*_t} = \rho\left[\frac{1}{P_{t+1} C^*_{t+1}}\{1 + Y^{*'}(K^*_{t+1})\} - \gamma Z^{*'}(K^*_{t+1})\right] \tag{12}$$

$$\frac{1}{P_t C^*_t} = \rho\left[\frac{1}{P_{t+1} C^*_{t+1}}\{1 + r_{t+1}\}\right] \tag{13}$$

$$X_t(P_t, L_t) + X^*_t(P_t, L^*_t) = \frac{wP_t C_t + wP_t C^*_t}{P_{Xt}} \tag{14}$$

$$Y_t(K_t) + Y^*_t(K^*_t) = (1-w)P_t(C_t + C^*_t) + (K_{t+1} - K_t) + (K^*_{t+1} - K^*_t) \tag{15}$$

For explanatory purposes, equations (8) and (9) are the budget equations of the two economies. While interpreting these equations it is important to distinguish between the stock of capital that is employed in an economy, and the amount of capital that is actually owned by the economy. This discrepancy occurs because the residents of an economy may own capital which they decide to employ in a foreign country, whilst also enjoying the returns earned on the capital in the foreign economy. The K_t and K^*_t in equations (8) and (9) denote the amount of capital employed in the two countries respectively. The B_t represents flow of domestic wealth to foreign nations for the purpose of consumption smoothing and investments in production, both of which earns returns at the rate r_t.

The profits from employing capital stay with the country where it is employed, while the owners receive only the rental returns. Equation (10) and (11) are the first order conditions with respect to $1 + K_t$ and B_t respectively. Equations (12) and (13) are the corresponding equations for the foreign economy. These four equations together imply that the investments in capital located domestically, capital located abroad and from bondholding earn equal marginal return every period. Equations (14) and (15) are the market clearing conditions for X and Y in the world market. For the X commodity, consumption demand is the only source of demand. Since Y commodity is used both for consumption and as capital, the demand has consumption demand and investment demand components. Since the individual budget conditions are being considered, one of the market clearing conditions given by equation (14) or (15) is redundant by Walras Law.

So equations (8) – (15) represent 7 equations in the 7 variables C_t, K_t, B_t, P_t, r_t, C^*_t, K^*_t (Note that the price index P_t for the consumption equation C_t is a transformation of Pxt : Pt = $((Pxt)\omega / [\omega^{\omega}\ (1-\omega^{(1-\omega)}])$. Once the time paths of these 7 variables are known, the remaining 16 variables of the system can be determined using the static equations.

At the start of trade, the model assumes that capital is reallocated across economies so that the marginal return to every unit of capital employed in any country is the same. This represents the familiar jump of variables as countries relocate on the new saddle path on their journey to the new steady state. There is no cost to capital reallocation in this model. Hence the jump of a large amount of capital to the country with weaker environmental standards is an expected result and serves as a check for the model rather than as an insight. The first order conditions for optimization are solved for the steady state. The steady state is defined as a situation where all variables maintain a constant level. Then the first order conditions, which are first order difference equations, are linearized around the steady state to get an idea about the evolution of the variables (Appendix B) (Lahiri, 2007). The steady state in this model exhibits saddle path stability and the stable eigenvalues define the movement of the variables along the saddle path over time. At this point, it is important to examine whether such an outcome can be sustained with decision making by private agents. The emissions tax serves the purpose of making the producers abate as long as their abatement cost is less than the per unit tax.

The amount of tax collected τZ_t on the emission actually produced is distributed in lump sum to the consumers. Comparison of equations (10) and (11) show that from the social planner's perspective, the socially efficient payment is less than the value of marginal product of capital. This is in order to internalize the disutility of pollution (even at the optimal pollution level) that is being caused by employing the capital. Payment to bonds, on the other hand does not need to be discounted because it earns interest without causing any pollution disutility. Equation (10) and (11) provide the following relation.

$$r_t = Y`(K_t) - \gamma P_t C_t Z`(K_t) \text{ Or } r_t = Y`(K_t)(1 - \gamma P_t C_t \frac{\alpha}{\tau_t}) \quad (16)$$

Under the optimal pollution tax $\tau_t = \gamma P_t C_t$, equation (16) derived from social optimum conditions is reduced to:

$$r_t = (1-\alpha)\ Y`(K_t) \quad (17)$$

However when taxes are not set in this optimal manner, e.g. taxes are low, i.e. $\tau_t < \gamma P_t C_t$, then the social optimal payment to capital as captured by equation (16) should be even lower. This is because, with low emission taxes, every unit of capital is associated with a higher emission, causing a high disutility, the valuation of which should be reduced from the payment to capital to provide it with the correct incentives.

Let us examine what the payment to capital is under profit maximization. If this is different from the socially efficient payment to capital, it would mean that an additional capital tax is required for private agents in order to implement the socially optimum outcome.

Profit maximization: $\Pi_t = Y_t - r_t K_t - \tau_t Z_t$

An additional unit of capital employed increases the amount of Y produced. However, the additional unit of capital also increases the profit maximizing amount of pollution emitted, which has to be paid as a tax at the rate τ:

$\partial \Pi_t / \partial K_t = Y`(K_t) - \tau_t Z`(K_t) - r_t$.

From the profit maximizing behaviour τ_t. $Z_t = \alpha Y_t$, the exact increase in pollution can be derived due to increase in capital employed:

$$Z'(K_t) = (\frac{\alpha}{\tau_t}) Y'(K_t)$$

Therefore

$$\partial \Pi_t / \partial K_t = 0 \Rightarrow (1-\alpha) Y'(K_t) = r_t \qquad (18)$$

Equation (18) emerges from profit maximizing conditions irrespective of the pollution-tax scenario. The profit maximizing payment to capital (18) is the same as the socially optimal payment to capital under optimal pollution tax (17). Since the incentives are perfectly aligned, any additional capital tax is not required. Setting pollution taxes optimally every period in a private agent setting, makes the system attain the social planner's outcome in terms of implementing the desirable amount of emissions every period, as well as providing correct incentives for capital accumulation (Swank & Sven (2002). In the scenario of fixed pollution taxes, the profit maximizing condition given by equation (18) is unchanged. However, the socially efficient payment to capital in the face of the resultant pollution, captured by equation (16) is now different from equation (18). With a small pollution tax τ_t, profit maximizing payment to capital $(1-\alpha)$ $Y`(K_t)$ is greater than the socially optimal payment to capital $Y'(K_t)(1-\gamma P_t C_t \frac{\alpha}{\tau_t})$. Alternately, for a prevailing interest rate, the level of capital that the consumers want employed is less than what the producers wish. This happens because capital is causing more than the socially optimal pollution every period, and hence capital accumulation should be discouraged.

Therefore, either the payment to capital needs to be corrected by the use of taxation of capital, or the private economy will follow an evolution path different from the socially optimal path. In the static case, the tax on capital was not important because once the pollution had occurred, that was the end of the story.

In the dynamic model, payment to capital is an important consideration because it determines the incentive for building future capital stock in each economy, and hence, future pollution and consumption. Rationalization of a fixed pollution tax in an economy as arising is due to the governing institution's lack of capability in evaluating pollution disutility every period, or because it wants to provide an incentive to produce for some reason other than maximizing social welfare. Therefore, it would be unrealistic to expect that this governing body will be able or willing to set a complicated and instantaneously changing capital tax in order to partially offset the effect of its inefficient pollution taxes. This makes it important to compare the evolution of an economy where emission taxes are efficient, against one where the emission taxes are suboptimal and corresponding capital taxes are absent. So the system of equations for the economy with fixed pollution tax and no subsequent tax on capital comprises of equation (18) and not equation (16). In the social welfare maximization situation, the satisfaction of equation (18) would have ensured the satisfaction of equation (16), but not in the private agent's setup with the sub-optimal emission taxes.

To Keep in Mind

The relationships shown above are more likely to hold for certain types of environmental damage, e.g., pollutants with more short-term and local impacts, rather than those with more global, indirect and long-term impacts (Arrow, 1995; Cole, 1997, John and Pecchenino, 1994, Beckerman, W. 1992) . The significant EKCs exist only for local air pollutants like SO2, SPM, NOx (Cole, 1997) and urban air concentrations, with a peak at lower income levels than total per capita emissions (Selden and Song, 1994, Baldwin, R. 1995). In contrast, the global environmental indicators (indirect impact) like CO2, municipal waste, energy consumption (Copeland and Taylor. 2004, Horvath, 1997) and traffic volumes, either increase monotonically with income or have high turning points with large standard errors (M Daley, Dorothy. 2007, Holtz-Eakin and Selden, 1995).

Similar studies have concluded that income–environmental degradation relationship is likely to be affected significantly by national and local policies *ceteris paribus*. Several studies in this issue have attempted to estimate the influence of policy explicitly. The strong policies and institutions in the form of more secure property rights, better enforcement and effective environmental regulations can help to 'flatten' the EKC (Anderson D. and Cavandish, W. 2001, Panayotou, 1997). In the case of some European countries, the impact of technological change in reducing SO2 emissions is largely attributable to the installation of better end-of-pipe (EOP) abatement technology, which is in turn related to tougher environmental policy and regulation (Mcausland, Carol. 2002). As income level rises, public spending on environmental research and development also increases.

This R&D spending may not only directly account for greater environmental improvement, but also acts as a catalyst for private spending on development of cleaner technologies. The income of a country may be significant in determining the "effectiveness" of its air pollution regulatory structure. This is mainly because a richer state is likely to have more resources available to regulatory agencies, higher public preferences for improved air quality, and a greater perceived danger from emission (Crotty, James. Gerald Epstein and Patricia Kelly. 1998). A more fruitful approach to the analysis of the relationship between economic growth and environmental impact would be the examination of historical experiences of individual countries, using econometrics as well as qualitative historical analysis (Anderson D. and Cavandish, W. 2001). Unfortunately there is not enough available data for countries in Latin America to contrast the analysis with those from developed economies or developing economies from other regions like Asia for instance. There is a large difference in regional level per capita emissions due to the enforcement of pollution laws and possibly employment of outdated industrial technology in some developed countries. On the other hand the increasing relationship between pollution and income in regions like Malaysia may be due to the fact that low-income states are still sources of emissions because of land conversion through burning and replanting of tree crops, while high-income states are emitting increasing emissions because of industrial and municipal wastes (Beckerman, W. 1992). Rapid urbanization and industrialization, which are correlated with rising income in Malaysia, are responsible for the increasing concentrations of ammoniac nitrogen and PH in water, as expansion of municipal and industrial sewage treatment has lagged behind. Some authors have attempted to explore, empirically, which structural factors are responsible for EKC behaviour. The scale and the composition of economic activity, and techniques of production (Grossman and Krueger, 1991), may lend explanatory power to the observed relationships between income levels and measures of environmental impacts. Although structural change is a very intuitive notion, empirical evidence is found for the impact of difference in the structure of production on toxic manufacturing emissions (Mcausland, Carol. 2002).

Some authors have tried to explain the downward segment of EKC in different ways. Developed countries have fairly stable production structures, whereas rapidly industrializing and developing countries have unstable production structure and the effects of structural change on emissions may be less obvious. However, in explaining declining SO_2 emissions in developed countries, structural change is less important than technological innovation, represented by the change in emission intensity across sectors (Grossman, G. M. and Krueger, A. B., 1991). Structural changes have not been a dominant factor in reduction of SO_2 emissions in such countries, at least during the 1980s. The changes in production structure in developed economies are not accompanied by equivalent changes in composition of production. The hypothesis of spatial displacement of environmental impacts and empirical evidences also reflect the composition of consumption instead of production. A change in the composition of consumption has resulted in a downward turn in pollutants (Andreoni, J. and Levinson, A. 1998). The solution of environmental problems associated with growth must mean more than "passing them off" to people in other places.

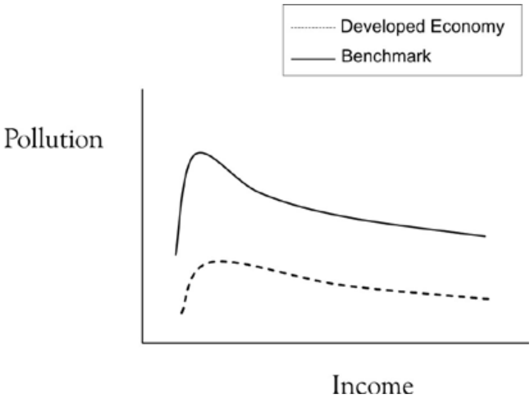
It can be speculated that improvements in environmental quality may in reality be indicators of increased ability of consumers in wealthy nations to distance themselves from environmental degradation associated with their consumption. To extend this speculation, mechanisms for such distancing might include both moving polluting sources and selected households moving away from pollution concentration. Considering general hypothesis of 'distancing' as a possible source of EKC results in internal migration playing a central explanatory role for an observed EKC for hazardous waste sides (Beckerman, W. 1992). Different social groups are differentially able to migrate away from areas with critical build-ups of hazardous waste sites; therefore a capital migration mechanism is likely to be a source of increasing environmental inequality. Thus, capital migration is an important factor behind capital mobility and environmental degradation. A large share of manufacturing in total GDP is associated with higher levels of energy consumption. The importance of trade in combination with composition of economic activity is investigated in the decomposition of EKC for SO_2 concentrations across countries (Mcausland, Carol. 2002, Lahiri, Badisha. 2007). The effect of shifts in the sector structure of economy can be represented by industry's share of GDP. It should be noted that the manufacturing share in developed economies starts to decline rapidly after oil crises.

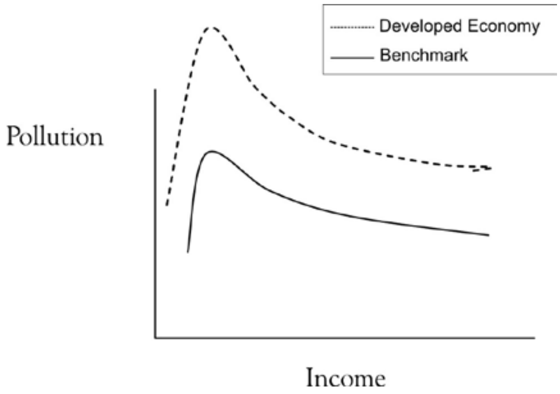
The oil crisis in the 1970s affected individual country's production. There is a positive correlation between CO_2 emissions and income for the pre- oil crisis period (before 1973) and a negative correlation for the post oil crisis. The EKC analyses is largely attributable to structural economic transition, and a significant "break" in the positive CO_2 emission–GDP correlation is found only in few developed countries. It is clear from the evidence that emission levels decline in every nation after the oil shock in the 1970s. The modified EKC analysis can be used to compare the differences in EKC between countries (developed and developing specifically, as long as enough data exists) due, for instance, to inter-country variations in the presence of corruption. One of the determinants of environmental policy is the socio-political regime of a particular country. Corruption and rent-seeking behaviour can influence the relationship between income and environment (Swank, Duane; Sven Steinmo.

2002). However, for any level of per capita income, the pollution levels corresponding to corrupt behaviour are always above the socially optimal level. So, the turning point of EKC takes place at income and pollution levels above those corresponding to the social optimum, which depends on the existing social institutions. Societies advance with their social, legal and fiscal infrastructures, all of them essential to enforce environmental regulation (Meadowcroft, James. James Allan and Keith Neuman. 2007). Institutional changes triggered by citizens' demand for cleaner environments are more likely to occur in developed countries than in developing countries. The influences of political and civil rights on these are better in more developed countries, and therefore democratic countries. However, opposite results can be found when the samples are divided into a subset of high and low income countries. Most of the pollutants investigated are substantially lower in more democratic low-income countries. Population density causes an increase in threatened species with the strongest effect in low-income countries. More species are threatened where freedom (political rights and civil liberties) is limited (M Daley, Dorothy. 2007). Generally, technological progress leads to greater efficiency in the use of energy and materials.

Thus, a given amount of goods can be produced with successively reduced burdens on natural resources and environment. One aspect of this progress may be better and more efficient recycling of materials, which (coupled with greater efficiency in use) can yield large resource savings. As income grows, people can adopt better and more efficient technology that provides for a cleaner environment. This preferential behaviour of people should be reflected through their income elasticity. The income elasticity of public research and development funding for environmental protection is positive. It is true for public expenditure on R&D for environmental protection in the case of developed countries over the period 1980–1994 (Baldwin, R. 1995). This indicates the key role of such public investments for environmental improvements in reducing environmental degradation as income levels rise, and even decreasing relationships found for some pollution indicators in developed countries. The effect of economic growth on pollution and emissions differs substantially among high-income countries. Relative income and the political framework in which policy decisions are taken, determine the emergence of downward sloping segment of EKC. This also depends on the adoption of new technology. New technologies, unambiguously, improve productivity but create potential dangers to the society, such as new hazardous wastes (cellular phones for instance), risk and other human problems. These externalities are unknown in the early phase of diffusion of technology; while in later stages regulation becomes warranted to address them. Once the technology is regulated, this may stimulate the gradual phase out of existing technology. So, a cyclical pattern arises in technologies, which first diffuse, then become regulated and finally are phased out by the next generation of technologies (Anderson D. and Cavandish, W. 2001).

Thus, an inverted-U shape can be observed with reference to each technology. Since the pattern of innovation, income growth and pollution over cycles, a sequence of Environmental Kuznets Curves emerge related to each technology. This may produce an envelope of EKCs, which may again be an inverted-U- or N-shaped or inverted-L curve (Andreoni, J. and Levinson, A. 1998). The Environmental Kuznets Curve hypothesis is confirmed with empirical evidence for several pollutants. Earlier EKCs studies provide that some pollutants follow a N-shaped relationship with income, and pollutants have different turning points.



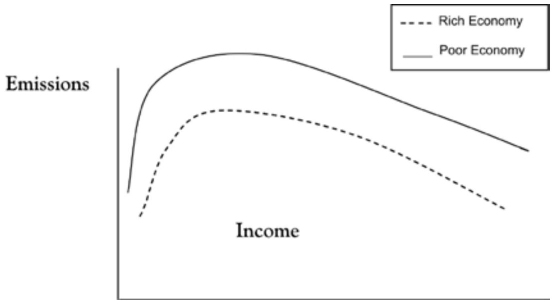


This implies that over a certain period during which income grows, one pollutant may decline whilst another may rise due to adoption of new technology. Improved technology not only significantly increases productivity in the manufacture of old products, but also the development of new products.

There is a growing trend among industries to reconsider their production processes and thereby take environmental consequences of production into account. This concerns not only traditional technological aspects, but also the organization of production as well as the design of products. Technological changes associated with the production process may also result in changes in the input mix of materials and fuels. Material substitution may be an important element of advance economics that may result in lower environmental impacts. The economy-wide reforms often contribute simultaneously to the economic, social and environmental gains (Anderson and Cavandish, 2001). The EKC approach seeks to relate the stages of economic development of a country to that of environmental degradation. Developing countries could learn from the experiences of industrialized nations, and restructure growth and development to go through any potential EKC, thereby avoiding going through the same stages of growth that involve relatively high (and even irreversible) levels of environmental harm.

Conclusions

We can conclude that during the growth of an economy, whether developed or developing, a stricter environmental standard with growth of the economy is a necessary condition for the inverted-U shaped relation between increasing capital inflows, income and emissions to emerge. This is because higher taxes in greater economic prosperity encourage profit maximizing producers to adopt cleaner technologies and, at the same time, provides reasons to move to cleaner sectors. Difference in trade patterns cause shifts in the inverted-U shape, but does not change the overall shape of the relation.



Efficient emission taxation laws correctly reflecting the increasing disutility of emissions, is a special case of the necessary condition of pollution taxes rising with capital inflows and economic growth. This efficient taxation leads to an inverted U relation between capital mobility, income improvement and pollution that is welfare maximizing for the economy. Anyhow, observing an inverted U-shape is not enough to infer efficiency of the environmental policy or the effect of capital inflows or the income environment outcomes for that economy. We cannot rely solely on higher incomes as a remedy for environmental degradation issues, whereas environmental concerns are already an important issue in developing countries agendas.

When emission tax policies do not respond to consumer disutility, pollution shows no sign of decreasing at higher income levels. As is the case in some Asian countries, sufficiently high fixed taxes may make the fixed-tax steady state outcomes consistent with the steady-state under optimal tax, but this would impose an unnecessary burden at earlier stages of development when the shadow cost of pollution to those affected is relatively smaller. However, without accounting for the difference in environmental policy between developed and developing economies, it would be misguided for all to expect that environmental degradation will decline at higher income levels. Governments need to respond to consumer preference in order to attain the optimal outcome. In a free trade, open economy framework, identical efficient policy regimes will not deliver identical environmental outcomes to economies that have different trade patterns, as is the case with Mexico and the USA. For two economies that begin international trade starting at different points on their growth path, the implications are very different. In the absence of other sources of comparative advantage caused by differences in factor endowments, the developing economy will accept foreign capital inflows and will experience a worse environmental outcome than its developed partner. The developed economy will be able to invest its capital abroad, wherever the highest returns are available, and use them to buy dirty commodities. This result highlights the fact that predictions for individual economies using analyses based on two economies might be misleading.

When Cropper and Griffiths (1994) predict that "A country with population density of 0.7 persons per hectare requires an income of $11,650 per year to achieve the same rate of deforestation" they do not consider that the timing of growth itself will have an inter temporal influence on the income-environment relation, which cannot be taken care of by country specific fixed effects or by other explanatory variables. If the developed economy adopts a suboptimal environmental policy, then the share of capital that is invested within the developed economy is large. If the developing partner implements a more efficient environmental regime, then the developed partner may end up accepting the bigger share of world capital at a bigger environmental cost to itself. Hence the inverted-U curve of the poor foreign economy is initially above that of the rich home economy. At a later stage of growth of the world economy, the inverted-U of rich home might intersect and rise above that of the poorer foreign economy.

Additional factors that affect the relationship of environmental outcomes and income are pollution disutility awareness, price changes in the sectors that the country has comparative advantage in, and the technology of production and abatement. If an economy implements a cleaner technology, the effect might not be evident in the short horizon. With prevailing emission tax structure, the scale of production might go up to such an extent that it overwhelms the cleaner effect. In the longer horizon, the effect of the lower intensity will dominate and the economy will also be able to sustain a higher income level due to lower expenditure on abatement and a higher acceptable capital stock at home. The dynamic model developed by Lahiri can analyze the differences in scale of production, composition mix and technology used. It uncovers the environmental standards prevailing in the economy as well as effect of capital inflows (level of FDI) and international trade on environmental quality. Using these dimensions the model can predict the income-environment relationship that the economy can expect to experience if the environmental policy, trade pattern or one or more of the other components change.

The decomposition of emissions of a standard developed economy is analyzed in the light of the model. Simultaneous movement toward lower emission intensity and cleaner sectors during a 10 year period indicates that emissions policy was becoming stricter for this time, which is a necessary condition for efficient policy as defined by Lahiri's model. The composition of net imports moved toward dirtier sectors, allowing a larger domestic consumption of emission intensive sectors than what is possible from domestic production. This pattern of trade also suggests that the emissions standards for the trading partners have not kept up with the emissions standards of such a developed economy. A potential extension of the current model is to incorporate inter-industry as well as international knowledge spillovers resulting in increasing returns to production which allows a greater variety of commodities. A paper by Grossman (1991) considers knowledge accumulation and investments in research-and-development, making technology endogenous. This process produces a more sophisticated evolution of technology and could serve as a starting point of incorporating environmental considerations in trade economy growth models.

Future Research

The Environmental Kuznets Curve analysis is rapidly becoming the standard in technical investigations about environmental policy. Understanding the impact of capital mobility and economic growth on environmental quality is becoming increasingly important as environmental concerns are making their way into the main public policy agenda for developed and developing countries. The general implication of EKCs is that promoting economic growth is a sufficient criterion to safeguard the environment. In the long run, the surest way to improve the environment is to become rich. But environmental policies may or may not be implemented when an economy is developing. There are several points that impede a clear policy conclusion derived from the EKCs, but the path for further investigation is being built, and the present research may be the starting point for future research, specially focusing on developing economies, as well as concentrating on the further development of economic and financial instruments such as the "Green Bonds" and its derivatives that may use this model to valuate emissions and pollution.

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