Original Article

To What Extent is Asian Economic Growth Harmful for the Environment?*

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Abstract This article aims at challenging the Neo-Malthusian hypothesis of incompatibility between demographic growth and preservation of the environment in developing countries. This theoretical hypothesis has been tested here on an empirical data set referring to a specific environmental variable and to a specific developing country. The case study covers the projected increase in carbon dioxide emissions in India in the period 2003-2030. The contributions of the demographic, economic and technological variables are calculated relative to the growth in carbon dioxide emissions through the IPAT model. The results confirm the hypothesis that the Neo-Malthusian paradigm is not appropriate to explain the demographic impact on the environmental variable in Asian economies. Instead, evidence has been provided to consider that the main determinant for environmental impact is still going to be economic growth.

L'objectif de cette communication est d'évaluer la validité de l'hypothèse néo-malthusienne selon laquelle il existe une incompatibilité entre la croissance démographique et la préservation de l'environnement dans les pays en voie de développement Nous testons cette hypothèse théorique en utilisant un ensemble de données empiriques relatives à une variable environnementale et à un pays en voie de développement spécifiques. L'étude de cas s'intéresse à l'augmentation prévue des émissions de gaz carbonique en Inde, entre 2003 et 2030. Les contributions des variables démographiques, économiques et technologiques à l'augmentation des émissions de dioxyde de carbone sont calculées au moyen d'un modèle IPAT. Les résultats confirment que le paradigme néo-malthusien ne convient pas pour expliquer l'impact de la population sur l'environnement dans les économies asiatiques. Au contraire, ils démontrent que le principal déterminant de l'impact environnemental reste la croissance économique.

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Introduction

The depletion of global environmental resources represents one of the most important common features to emerge when comparing the traditional western model of development and the new growing economies of Asia. Despite this, the western model of capitalism claims to be more 'environmentally friendly' with respect to the new Asian model, which is often blamed by western media and policy institutions for its negative economic and demographic impact on the environment. This argument is largely debated in the academic world, and it is known as the Neo-Malthusian hypothesis.

A comparison of the trends and prospects of carbon emissions in the two capitalist models can lead to very interesting outcomes and contribute to the understanding of the pattern of capitalist growth in the emerging economies and to challenge the Neo-Malthusian argument. There are a number of reasons for this. First, carbon emissions are directly connected to demographic pressure because population growth has a direct and indirect impact on the level of emissions (Dyson, 2005). Second, carbon emissions are a reliable indicator of capitalist growth (Bongaarts, 1992). Lastly, emissions can depict very effectively the process of depletion of environmental resources. This occurs because they mostly take place as a consequence of the burning of fossil fuels (coal, oil, natural gas) for anthropogenic activities. Fossil fuels are not renewable natural resources. From a western perspective, these criticisms are especially addressed to the countries that are increasing their demand for fossil fuels in order to strengthen their capitalist growth and accelerate their 'catching up' process with the western model of production and consumption.

Among the emerging economies in Asia, India stands in a reference position for testing the Neo-Malthusian hypothesis. This is true for at least three reasons. The first is demographic. By 2030, India is expected to become the most populated country on the planet. This has clear relevance in terms of demographic pressure on carbon dioxide emissions (both direct and indirect demand effect). The second reason is economic. India represents an economy that is growing very rapidly and is expected to rely heavily upon fossil fuels. The last reason involves environmental policy. The joining of Asia Pacific Partnership for Clean Development and Climate Change in 2005 and the recent Indo-US nuclear deal represent a clear step towards a domestic consensus for the need for a new energy technology and a shift from high- to low-emission energy sources.

The IPAT model represents one possible way to test the Neo-Malthusian hypothesis (Ehrlich and Holdren, 1971) in emerging economies such as India. This model, despite some relevant criticisms, has the main advantage of being simple and intuitive and of expressing the dynamics of the Neo-Malthusian framework by disaggregating the determinants of environmental impact (I) into population growth (P), affluence (A) meaning economic growth and technology (T). Following a pessimistic approach, impact is seen as a positive function of the three independent variables (P, A and T). In this article, the IPAT model is applied to a concrete database relative to the projected trends of carbon emissions, population, GDP and GDP carbon intensity in India in the period 2003–2030 (Energy Information Administration (EIA) figures).

The main argument of this article is that the demographic variable will play a minor role in terms of environmental impact, and that the main concern for global environment will still be represented by the pattern of production and consumption of the 'old' western capitalist system. Economic growth and technology, but not population, will emerge as the main factors leading to future global environmental detriment. The example of carbon emissions in India will provide a link to connect empirical results to the theoretical Neo-Malthusian framework.

The Population-Environment-Development Debate

The basic neoclassical growth model assumes a trade-off between per capita consumption of material goods and number of children at household level (Barro and Sala-y-Martin, 1999). When environmental goods[1] are introduced in the model, a trade-off between the quality of the environment and consumption is the result. The basic concept behind environmental economics models is that of scarcity. When a resource is relatively scarce, its price is expected to go up (according to the supply-demand law). This is an incentive for producers to substitute less resource-intensive technologies and to enhance technological progress. The price of environmental goods in terms of financial assets is the so-called 'scarcity rent' (O'Neill *et al*, 2001) This 'rent' should increase over time more than the financial interest rate (owing to the fact that the supply of environmental resources is limited by nature), because if not *rentiers* would immediately withdraw their stock of resources and invest the obtained value in more profitable financial assets. This logic makes it clear that the logical choice for the owner of a resource stock would be to conserve supplies for the future in order to keep the price high, not introducing large amounts of resource into the marketplace (Pearce and Turner, 1990).

The neoclassical model also argues that the demand for environmental quality rises when income increases (Panayotou, 1994). In other words, economic growth does not exert downward pressure on environmental resources because a higher-income economy demands more environmental protection. This is a consequence of the hypothesis of low elasticity to income of the demand for basic goods. This means that as consumers' income goes up, they will demand marginally fewer and fewer primary products (generally more connected to environmental resources[2]) such as food. In contrast, the demand for environmental protection and for preservation of scarce resources will go up. The preservation of scarce resources introduces the neoclassical definition of 'environmental sustainability'. This concept is highly connected to the discount rate. The discount rate is typical of the cost-benefit models and can be described as the rate by which the value of natural resources has to be multiplied to verify their depletion across intergenerational transfer (Pearce and Turner, 1990). Obviously, the higher the discount rate is, the more the value of environmental goods declines and, hence, the less environmentally sustainable is the economy (O'Neill *et al*, 2001). The basic conclusion is that economic growth under perfect market conditions is not harmful for the preservation of natural resources. Yet, a joint conclusion on the impact of population growth on environmental resources and economic development cannot be expressed. Indeed, the neoclassical approach studies the relationship between population growth and environmental degradation by dividing the analysis into two different effects: the effect of population growth on economic growth (as seen above) and the effect of economic growth on the environment (Panayotou, 1994).

Let us refer to the role of population in environmental economics. The effect of population growth is to increase the value of the 'scarcity rent'. This induces a rise in the price of environmental resources relative to the cost of labour. As a consequence, workers have to face a lower salary whereas rent-owners experience an income rise. The income distribution is, hence, more unequal, leading to an increase in the number of poor individuals (because rent-owners normally belong to high-income groups) (O'Neill *et al*, 2001).

According to this argument, population growth can enhance distortions in the marketplace for environmental goods and lead to the misallocation of property rights.

However, as explained in the previous section, the impact of population growth on economic growth is still controversial. Consequently, is not possible to find a unidirectional causal nexus with regard to the relationship between economic growth and environmental resources.

Yet, the neoclassical population-development-environment model has some links with the optimist perspective. One of these is international trade.

Panayotou (1994) makes four points about international trade, considering it as a factor that can offset the potentially detrimental impact of population growth: the importance of trading scarce resources (ecological capital), the possibility of importing new technologies (substitution argument), the specialization in less resource-intensive production (basically Ricardo's comparative advantages argument), and the trading of less pollution-intensive or resource-intensive intermediate and final products.

To sum up, the main conclusion of the Neoclassical population-development-environment model is that population does not exert a necessarily negative impact on resources. This is true under the condition that neoclassical assumptions are verified (including efficient allocation of property rights for environmental resources, free trade and perfectly competitive markets). If some of these assumptions crumble, the results of the Neoclassical model change. And this is exactly where the Neo-Malthusian hypothesis comes in, claiming that there are limits to technological progress and to economic growth, and therefore that population growth cannot be offset and environmental degradation is inevitable.

The pessimistic view of the impact of population growth on economic and environmental resources is largely based on the demographic idea of 'carrying capacity'. Some scholars (Daly, 1992) see this concept as a factor that can exacerbate the scarcity of resources that characterizes the Earth. According to the biological definition, the 'carrying capacity' refers to the maximum number of individuals an environment can sustain (Zaba and Scoones, 1994) without being depleted.

The point of saturation is reached when the density-induced mortality rate equals the fertility rate. Any increase in the population beyond the limit of the 'carrying capacity' is harmful to the environment and to the preservation of natural resources. Several social scientists have applied the concept of 'carrying capacity' to human populations and to the Earth. Cohen (1995a) has provided different estimates for the actual number of individuals that the Earth can support, ranging from 4 to 16 billion. Other scholars, such as Smil (1994), have tried to give a measure of the 'carrying capacity' in terms of resources, such as energy and food.

However, the main insight coming from the various studies is that the concept of 'carrying capacity' is not very useful for studying human populations. Cohen (1995b) justifies this criticism, mentioning three main factors that can affect 'carrying capacity' dimensions: values (human choices), international trade of ecological capital and migration.

Neo-Malthusian scholars believe that these factors will just help to delay the problem of overpopulation but not to solve it. The Neo-Malthusian position considers the 'carrying capacity' model still applicable to social sciences arguing about the catastrophic impacts for the environment and the economy caused by demographic increase, especially in developing countries (O'Neill *et al*, 2001). The projected scenarios have mostly been alarmist and catastrophist.

In the 1972 publication of *The Limits to Growth* by the Club of Rome Meadows *et al* (1972) tried to model and test the hypothesis of incompatibility among population growth, economic development and the environment in quantitative terms. The obtained projections were extremely catastrophic, ranging from overpopulation to the collapse and exhaustion of non-renewable resources. The empirical reality has turned out to be very different than that foreseen by the Club of Rome; none of its predictions turned out to be true. Nevertheless, the Neo-Malthusian alarmism does not seem to have lost its academic and political support. In the academic world, this is especially true with regard to food issues. The argument of future food scarcity in developing countries is made by Brown *et al* (1999).[3] However, some authors have obtained different results by projecting the endowments of food in developing countries and analysing the demographic prospects (Dyson, 1996). In the political world, the Neo-Malthusian hypothesis has been redefined and improved, and has arrived to represent a mainstream consensus in the agenda of several international organizations (UNFPA, 2001). Vicious circle models are part of this agenda, and can be considered as a way of reforming the Neo-Malthusian paradigm.

The Methodology

The Ipat identity: Modelling the Neo-malthusian hypothesis

As the authors first intended it, the equation should have taken a multiplicative structure $I \equiv P \times A \times T$ where the variable impact (I) stands for natural resource consumption or a pollutant emission (O'Neill *et al*, 2001). Affluence (A) represents the effect of economic growth per capita (GDP per capita) and technology (T) indicates the intensity of the impact on economic growth (basically the ratio of impact on GDP).

The most important assumption of the model (and the most criticized) is that variables on the right-hand side of the equation are not correlated. This assumption, in a way, recalls the earlier neoclassical one of no direct correlation between economic development and population growth. The main advantage of considering such an equation is that it explains environmental impact with respect to more than one variable. Additionally, this identity can be easily used to evaluate the contribution of the demographic variable to the depletion of the environment.

The IPAT model is also relevant for political issues. Indeed, obtained results can guide policy makers as to which specific measures should be implemented in order to decrease the environmental depletion rate in a country. In fact, just by changing any of the three variables on the right side of the equation, the resulting environmental impact (I) can change significantly. To this extent, social scientists can predict the results in the application of any energy policy, economic policy or demographic policy as a tool to preserve the environment. Basically, it is possible to adjust any variable at the right side of the equation and to set different scenarios projecting the obtained results.

For instance, demographers have used this model to try to calculate the impact of population (P) on different types of environmental variables (I), ranging from energy use (MacKellar *et al*, 1995) to water consumption to fertilizer use (Harrison, 1992).

Bongaarts (1992) was the first to apply the IPAT methodology considering the atmosphere as a resource and carbon dioxide emissions as a pollutant while analysing environmental impact. He also proposed and adopted the decomposition methodology that allows the assignment of an additive rather than multiplicative form to the equation. This idea significantly simplifies the model and allows for the analysis of the impact (I) in terms of expected growth rates over time.

The decomposition method

The methodology implemented by Bongaarts (1992) allows the author to decompose the IPAT identity into an equation such as $I' = P' + A' + T'$ in which each variable is expressed in terms of average annual growth rate.

The key advantage is represented by the possibility of standardizing everything on the right side of the equation in terms of the average annual impact growth rate (simply by dividing P′, A′ and T′ by I′). In this way, it is possible to assess which of the three factors will have the greatest percentage effect on impact (I) during a certain interval of time.

In his study, Bongaarts (1992) estimates the impact (I) in terms of carbon dioxide emissions. The impact (I) measurement unit is assumed as millions of tons of carbon dioxide while population expressed in millions and GDP per capita in US dollars. The technology variable is expressed as carbon dioxide intensity – in other words, as tons of carbon dioxide emissions necessary to produce 1 dollar of GDP. Using EPA[4] figures, he shows how approximately 50 per cent of the projected carbon dioxide emissions growth rate between 1985 and 2025 is related to population. Further, he extends his forecast to 2100, estimating that population growth will account for 35 per cent of carbon dioxide emissions growth.

Mackellar *et al* (1995) show how the IPAT model can be used in the field of development studies to include population, environment and economy in a single multidisciplinary analysis and to discuss the eventual results of the projections made. For this reason, the IPAT model has been used in several fields of social science to produce projections and scenarios. However, it will be highlighted that this methodology is based on assumptions that are useful in simplifying the model but that certainly introduce limitations from both a conceptual and analytical point of view.

Criticisms of IPAT approach

The criticisms of IPAT models follow two main directions. The first (Mackellar *et al*, 1995) relates to some conceptual aspects of the model such as the unrealistic assumption of any correlation existing between P, A and T. The relevance of the debate on the effects of population growth on environment and development that we have discussed in this section provides evidence on how this assumption is a critical subject for the IPAT model.

The second direction is methodological. Indeed, there are some problems arising from the application of IPAT models to empirical data sets, considering the problems that may be related to the decomposition methodology.

The first problem is the 'offset' effect, which influences the model when one of the explanatory variables has a strong projected decreasing trend. According to the authors, 'If one of the variables on the right-hand side of the equation of the I = PAT formulation is shrinking over the time period in question, it will offset the contribution of one of the growing variables, and the third variable will be left apparently accounting for a very large proportion of total environmental impact' (O'Neill *et al*, 2001, p. 120).

In the case of Bongaarts (1992), the 35 per cent increase in carbon dioxide emissions owing to population is in fact ambiguous if compared to a 126 per cent decrease in technology and 191 per cent increase in affluence (GDP per capita).

The second point considered by the authors is the heterogeneity bias. The decomposition may be biased in two ways. The first is when population growth is associated with per capita impact. In the case of carbon emissions, it is possible to note that these are lower in the areas of highest population growth. Once again, this can hinder a correct evaluation of the contribution of demographic growth in the equation. Another source of bias can be noticed when opposite effects are aggregated for different areas. That is, if a variable increases in a region and falls in another, the model 'may appear to have undergone no change' (O'Neill *et al*, 2001, p. 121).

It has also been argued that considering the additive form of the IPAT equation is correct for continuous growth rates but not for discrete ones.[5] In the second case, one should also consider the interaction effects among all three independent variables.

Lastly, the use of annual average growth rates rather than absolute changes to describe environmental change is controversial. Indeed, the use of growth rates has been heterogeneous, and various authors have provided different approaches in considering the time frame analysed. Some authors, for instance, have tried to freeze the variable of interest to the initial level and calculate the reduction in terms of impact (Bartiaux and Van Ypersele, 1993).

Additionally, projected IPAT scenarios often compare unrealistic situations. This is especially true for population growth. The demographic variable presents two orders of problems: the first is how to take into account the *population momentum* (even a declining growth rate can have an 'absolute' effect owing to momentum), and the second is the choice of the demographic unit to be considered in the IPAT model. Empirical evidence applied to the case of energy consumption presents very different results according to whether individuals or households are considered as demographic units for the IPAT projections (MacKellar *et al*, 1995). This is a result of the fact that some resources, such as energy, are characterized by economies of scale in terms of consumption.

Challenging the IPAT Model: The Future of Indian Environmental Impact

The aim of this section is to apply the IPAT methodology to a concrete scenario. The actual reference scenario will see projected carbon dioxide emissions in India between 2003 and 2030: figures from the EIA[6] database will be used. The first part of this section will present a separate study for the projected data trends of each variable analysed in the period 2003–2030. The second part of the section will present and discuss the main results that I have obtained through this analysis. To this extent it is important to stress some of the limitations of my analysis.

First, the model suffers from the main methodological criticisms that I have reviewed in the previous section.

Second, the results obtained by the model do not allow for any policy implications (only suppositions) about the future of Indian economic, energetic and environmental strategies. Additionally, the results are not intended to give any sort of judgement about the sustainability and the quality of Indian economic growth. This is a result of the fact that the data set and the variables analysed do not take into account all aspects that would be needed for such complex and relevant study.

Third, the India trends will only be internationally compared to those of China and Organisation for Economic Co-operation and Development (OECD) countries (included as a single country). This choice has been made owing to the relevant economic and demographic dimensions of those countries.

The data: Population

According to the UN Population Projections (2004) and the World Bank Projections (2003), by 2030 India will become the most populated nation in the world. Table 1 shows the expected absolute demographic increase in India from 2003 to 2030, where population is predicted to grow from approximately 1070 billion in 2003 to 1449 billion in 2030.

Table 1: World population by region, reference case, 1990–2030 millions

Region	*History*			*Projections*					*Average annual per cent change*
	1990	*2002*	*2003*	*2010*	*2015*	*2020*	*2025*	*2030*	*2003–2030*
Non-OECD Asia	2748	33	3316	3592	3783	3958	4108	4231	0.9
China	1155	1296	1299	1355	1393	1424	1441	1446	0.4
India	849	1064	1070	1183	1260	1332	1395	1449	1
Total World	5278	6280	6312	6841	7217	7576	7906	8203	1

Source: EIA projections, www.eia.doe.gov.

The estimated average annual growth rate for population in the period 2003-2030 is 1.1 per cent. This is relevant if compared to other non-OECD Asian countries, and it is much more significant than China, whose population size will actually start to decrease by 2037 (UN Projections, 2004). The demographic dimensions of India show once again the relevance of testing Neo-Malthusian hypothesis in a relatively high-projected demographic growth rate context.

The data: Economy

Table 2 shows historical Indian GDP data and projected values for a time frame ranging from 2003 to 2030 (EIA). India's GDP will grow from 3429 billion (US dollars 2000 PPP) value in 2003 to 14 102 billion in 2030. The projected growth of the Indian economy is impressive; indeed, the estimated average annual growth rate will be 5.4 per cent. This value is less than China (about 6 per cent), but still more than some other non-OECD countries such as Mexico (4.1 per cent) and Russia (3.9 per cent).

The data: Technology

As previously mentioned, the technological variable (T) is included in the IPAT models in terms of pollutant intensity, that is, how much pollutant has to be used to create one unit of GDP.

Table 3 presents the expected Indian GDP carbon dioxide intensity in the period 2003-2030. It will decrease from 299 metric tons per 1 million of GDP (2000 US dollars at PPP) in 2003 to the expected 156 metric tons in 2030. This means that the carbon dioxide intensity of the Indian economy is expected to be reduced by almost half in the reference period. The trend is witnessed in the negative 2.4 average annual growth rate estimated in Table 3. It is interesting to see how this change is relevant if compared to the data on the OECD countries' average (−1.5 per cent decrease) and the other non-OECD countries' average (−1.9 per cent). China (−1.7 per cent) is expecting to reduce its carbon intensity on a slower trend. Only Russia (−2.4 per cent) is projected to present a similar trend to India, but this is probably a result of a de-industrialization effect.

In India this could be affected by the use of less carbon-intensive technologies in production processes, or by a switch in the energy policy from high-emissionfuels (such as fossil fuels) to less emission-intensive energy sources (such as biomass, nuclear power and renewable).

Table 2: World gross domestic product (GDP) by region using purchasing power parity, reference case, 1990–2030 (billion 2000 dollars)

Region	*History*			*Projections*					*Average annual per cent change 2003–2030*
	1990	*2002*	*2003*	*2010*	*2015*	*2020*	*2025*	*2030*	
Russia	2241	1658	1780	2531	3059	3656	4304	5005	3.9
China	1807	5494	5994	10 116	13 538	17 615	22 592	28 833	6
India	1684	3160	3429	5162	6694	8664	11 059	14 102	5.4
Mexico	680	962	976	1271	1561	1916	2346	2868	4.1

Source: EIA projections, www.eia.doe.gov.

Table 3: Carbon dioxide intensity by region and country, 1990–2030 (metric tons per million 2000 US dollars of gross domestic product)

Region	*History*		*Projections*					*Average annual per cent change 2003–2030*
	1990	*2002*	*2010*	*2015*	*2020*	*2025*	*2030*	
OECD Total	565	473	421	391	361	338	318	−1.5
China	1240	591	579	517	463	414	372	−1.7
India	343	299	265	238	208	182	156	−2.4
Russia	1042	903	711	637	579	522	474	−2.4
Non-OECD Total	723	516	466	423	380	341	207	−1.9

Source: EIA projections, www.eia.doe.gov.

The data: Emissions

The environmental impact variable considered in this case study (carbon dioxide emissions) is reported in Table 4, which provides the relative projected data for the reference period (EIA). Once again, as for the economy, the general expected trend is a rise in volume. In 2003 India emitted 1023 million metric tons of carbon dioxide globally. This value is expected to rise to 2205 in 2030, with a projected average annual growth rate of 2.9 per cent.

However, if we look carefully at Table 4, it is possible to verify that the volume of emissions is going to be more dimensionally relevant in the OECD countries (17 496 million) and in China (10 716) that are expected to become (in absolute terms, not per capita) the world's top CO_2 producers. China is also experiencing a significantly faster growth in relative terms, with an annual average growth rate of 4.2 per cent. A possible reason for this may lie in both the larger sizes of its economy and heavier reliance on fossil fuels both industrial and transport use.

The projected emissions trend suggests that the scope of carbon dioxide emissions will have a more relevant dimension in developed countries (OECD) than in emerging economies (China and India). This is a first step in challenging the Neo-Malthusian hypothesis.

The IPAT model for India

Having analysed the trends for the Indian economy in terms of all four variables of the IPAT model, it is now possible to aggregate these figures in a model that will forecast

Table 4: World carbon dioxide emissions by region, reference case, 1990–2030 (million metric tons carbon dioxide)

Region	*History*			*Projections*					*Average annual percent change*
	1990	*2002*	*2003*	*2010*	*2015*	*2020*	*2025*	*2030*	*2003–2030*
OECD Total	11 378	12 952	13 150	14 249	15 020	15 709	16 545	17 496	1.1
China	2241	3273	3541	5857	7000	8159	9349	10 716	4.2
India	578	1011	1023	1369	1592	1799	2008	2205	2.9

Source: EIA projections, www.eia.doe.gov.

Table 5: Projected population, GDP, intensity and carbon dioxide emissions India (2003–2030)

	2003	*2030*	*Average annual change %(2003–2030)*
Population (billions)	1.070	1.449	1.1
Affluence-GDP (billions of USD 2000 PPP)	3429	14 102	5.4
Technology (metric tons of carbon emissions per 1 million GDP)	299	156	−2.4
Impact (millions metric tons of CO_2)	1023	2205	2.9

Sources: www.eia.doe.gov.

which variable will play the major role in Indian's future environmental degradation. Table 5 briefly summarizes the indicators reviewed in the previous paragraph. In order to apply the data to the model, the decomposition methodology will be used.

The IPAT identity can then be transformed into additive form either taking the logarithm of both sides of the identity or applying continuous growth rates for all variables[7] (O'Neill *et al*, 2001). The second approach is therefore applicable to our example. In this case, the equation becomes:

$$\mathrm{I}' = \mathrm{P}' + \mathrm{A}' + \mathrm{T}'$$

The prime notation indicates that the average annual growth rate is considered. According to O'Neill *et al* (2001), the 'normalization of decompositions allows comparison between scenarios, time periods, regions or pollutants' (p. 20). Normalization can take place simply by dividing all the growth rates of the independent variables of the IPAT model (PAT) by the growth rate of the independent variable impact (I). The variable (I), by definition, represents the sum of the average annual growth grates of (P), (A) and (T). The equation then takes the following form:

$$1 = \mathrm{P}'/\mathrm{I}' + \mathrm{A}'/\mathrm{I}' + \mathrm{T}'/\mathrm{I}'$$

This methodology allows the representation of each variable in terms of percentage contribution to the impact growth rate. However, some important limitation to this model should be noted. For the EIA figures, the average annual growth rate has been assumed to be constant over the reference period.[8] This assumption is very strong and has to be taken into account.

Results of the projections

Table 6 shows the results of the application of the IPAT model to India in terms of expected percentage contribution of demographic growth, economic growth and technology improvements to the projected growth of carbon dioxide emissions in the evaluated reference period (2003-2030).[9]

The applied normalization method allows the evaluation of each of the three independent variables and helps to introduce a discussion on the obtained results. The first result is that population will play a relatively marginal role in determining the future growth of carbon emissions. Demographic growth is projected to account for just 26.83 per cent of total carbon dioxide growth.

The second relevant outcome is that the major role in emissions increase will be played by the impact of economic development. The fast growth rate of the Indian economy remains the main reason for future environmental impact, and will account for a contribution of 131.7 per cent to carbon dioxide growth.

As a final point, it is evident that technological change will offset the growth rate of carbon intensity down by 2030, as figures show a negative value of the percentage contribution (−58.53 per cent) of the carbon intensity of GDP. A comparison of the Indian trends and the trends of other economies, such as China and OECD countries, will complete this overview.

Figure 1, as well as Tables 6, 7 and 8, shows some data and results for the same model applied to the case of OECD countries and China (EIA).

To this extent, some considerations can be made. First, the demographic contribution to emissions seems to be low in all three scenarios. Additionally, it can be noted that population pressure will have more or less the same importance in OECD and in India (26 per cent) on the production of future emissions. By contrast, in China the demographic variable will account for just 8.5 per cent of the total emission growth.

Table 6: Percentage contribution India (2003–2030)

India (2003–2030)	*I*	*P*	*A*	*T*
Average annual change (percentage)	4.1	1.1	5.4	−2.4
Contribution (percentage)	100	26.83	131.70	−58.53

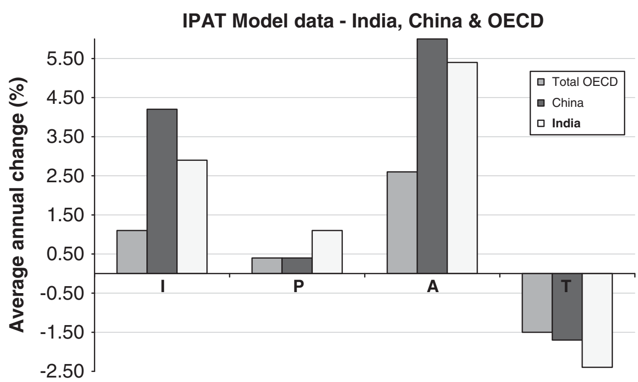

Figure 1: Average annual estimated changes for IPAT values (%) (2003–2030).

Table 7: Percentage contribution total OECD (2003–2030)

Total OECD (2003–2030)	*I*	*P*	*A*	*T*
Average annual change (percentage)	1.5	0.4	2.6	−1.5
Contribution (percentage)	100	26.6	173.3	−100.0

Table 8: Percentage contribution China (2003–2030)

China (2003–2030)	*I*	*P*	*A*	*T*
Average annual change (percentage)	4.7	0.4	6.0	−1.7
Contribution (percentage)	100	8.5	127.65	−36.17

Second, these results show that, for India, the projected outstanding economic performance in terms of GDP growth rate will represent the main determinant of the rise in carbon dioxide emissions. Surprisingly, the contribution is relatively higher in India (131.7 per cent) than in China (127.65 per cent), despite the latter supposedly experiencing a much higher GDP growth rate (6 per cent). However, both economies lag behind the OECD countries (173.3 per cent), where GDP growth is still expected to be the first source for environmental impact in terms of emissions.

Let us now focus on the third factor: technology. For this variable, the results are quite surprising for the Indian case. Indeed, by 2030 the country is projected to reduce its contribution to carbon dioxide emissions growth in terms of carbon intensity amelioration by −58.53 per cent. This result is relevant if compared to China, which is expected to achieve only a −36.17 per cent reduction owing to technological change. The OECD countries will experience a major downward push to emissions (−100 per cent) coming from the improvements in carbon intensity, and this is probably a result of policy reasons, and technological leadership.

Discussions

The results obtained by the application of IPAT methodology to India can help to being focus to some relevant points connected to the Neo-Malthusian hypothesis and to the theoretical debate reviewed in the first part of the article.

(a) The first aim of this study was to discuss and challenge the Neo-Malthusian hypothesis that has been illustrated in the first section and to test it with a concrete case study by means of the IPAT methodology. The results obtained in this case study are quite straightforward and tend to indicate that, basically, population growth does not significantly hinder the preservation of the environment. In this regard, the example of carbon emissions, as already mentioned in the first section, has been useful in evaluating an environmental variable having a very strong direct and indirect connection with demographic growth. The results of the application of the IPAT model to India have shown that the projected demographic increase will contribute only marginally to the expected internal change in the level of carbon dioxide emissions (just 26 per cent), and that other factors such as GDP growth and technology will play a much more important role. Additionally, the example of India has shown how, in relative terms, an emerging capitalist economy with relevant demographic dimensions is going to exert relatively less pressure on environmental resources than other developed economies with reduced demographic dimensions (this also confirmed by the estimated provisions for China with a contribution of only 9.5 per cent to the expected carbon dioxide increase). Therefore, the evidence provided by this case study rejects the Neo-Malthusian argument of incompatibility between demographic growth and environmental preservation, with specific reference to the reality of 'new' emerging capitalist systems of Asia.

(b) The second aim of the article was to give a clear answer on a widely debated question in the academic literature and in the international political debate: Is economic growth more harmful than demographic growth for the preservation of environmental resources? The answer that can be given according to the results provided in this article is positive. In fact, the Indian case study shows that GDP growth will account for 131. 7 per cent of the total expected environmental impact (carbon dioxide) growth rate by 2030. This conclusion still remains valid if we consider this contribution offset by the negative value of the intensity (−58.53 per cent).[10] Economic growth discounted by the effect of carbon dioxide intensity reduction will still be approximately three times more important than demographic growth to the increase in carbon dioxide emissions. In China and OECD economies the differential between demographic and economic contribution is projected to be even wider. This confirms that, in absolute and not per capita terms, the economic growth variable contributes mostly in terms of pressure on environmental resources. The projections have shown that these conclusions apply to both developing and developed countries. It seems that even in the developed world, which supposedly is more committed to the climate change reduction agenda through the binding regulations of the Kyoto Protocol and of the European Directives, much still remains to be done in terms of environmental policy and clean technology. In fact, despite the fact that China and India will experience a higher GDP growth rate (in percentage terms), the most significant carbon dioxide impact will without doubt come from the developed world (173 per cent).

(c) The third point suggested by the discussion of this case study regards the technological variable. In the IPAT model, the intensity variable is often expected to offset the positive contribution of the other two variables. The projected results for India are outstanding with –58.53 per cent in the carbon dioxide increase due to a reduction in the carbon GDP intensity. If we compare this value to China, we realize how far ahead India is of other developing countries in terms of carbon dioxide intensity reduction. Only OECD countries stay forward with a predicted reduction of 100 per cent. These figures can also lead to some interesting insights. First, India is expected to be very active in the so-called 'substitution effect'. In other words, it is predicted that it will make a dramatic switch to energy sources other than fossil fuels. Indeed, by definition, fossil fuels are the most carbon dioxide-intensive energy sources, and India currently relies to a strong degree on coal, which is the most emission-intensive fossil fuel (EIA[11]). This is quite surprising, as Neo-Malthusian scholars often blame developing countries of scarce environmental care. In contrast, the projections for India go in the opposite direction and show a renewed interest in carbon emissions reduction policies. One important thing to note is that India is in fact not obliged to meet any of the targets of the Kyoto Protocol owing to the fact that the protocol only applies to developed countries. To this extent, a further point of interest for future research is the analysis of role of small and medium enterprise versus large enterprise in the structure of Indian capitalism. Large enterprises are indeed believed to be more efficient in terms of technological substitution and more easily monitored by environmental policy tools, hence contributing less to environmental impact.

(d) As mentioned before, one of the most important advantages of the IPAT identity is that it allows one to decide what kind of policy is more desirable to preserve the environment. Two main conclusions regarding policy choice can be outlined. First, it is possible to say that almost any sort of demographic policy aimed at fertility reduction is undesirable for a significant amelioration of emissions levels. This argument can also be extended to other forms of pressure on environmental resources, and comes about from the rejection of the Neo-Malthusian paradigm that was discussed in the first section. Second, a point on environmental policy should be stressed. Having shown how GDP growth and technological improvements are the key issues on the topic, the renewed need for an environmental policy is consequently logical. However, it is also relevant to determine what kind of climate change policy is more effective for the environment. Another point to discuss is how countries try to implement policies with the goal of environmental preservation. To this extent, it might be useful to remember that many countries with relevant economies are redirecting their international environmental policy according to a domestic economic and political strategy (DeSombre, 2005). This strategy increasingly foresees environmental policies affecting technology (T) rather than GDP growth (A). In other words, the international environmental policy consensus sees a growing consensus (both from developed and developing countries) on an environmental preservation agenda not aimed at hindering economic growth. This can be shown if we take into account the shift of many countries from mandatory to voluntary climate change regimes (Betsill, 2005). Clear evidence for this argument is the US decision to quit the Kyoto agenda (fundamentally based on a reduction in economic growth) and to establish an alternative agreement such as the Asia Pacific Partnership (aimed at reducing climate change through carbon intensity amelioration) (DeSombre, 2005). This logic is also followed by an increasing number of developing countries. The main rationale is that they do not want to trade off economic development in the name of concepts strictly related to environmental preservation, and that developed countries have never really considered their own path of growth. With regard to this, the environmental policy of India provides an interesting case (Dyson *et al*, 2004). The ratification of the Asia Pacific Partnership and the renewed collaboration with the United States on the gradual switch to nuclear power and alternative sources of energy represent a clear sign of not letting development down for environmental issues. Additionally, it confirms the fact that an emerging economy, such as India, is increasingly seeking energy technology independence for strategic economic and political reasons.

Concluding Remarks

This article has focused on the issue of environmental resources in Asia, and has sought to evaluate the role of demographic pressure in the depletion of natural resources. The study has especially been aimed at challenging the Neo-Malthusian hypothesis of incompatibility between demographic growth and preservation of the environment in developing countries. This has been achieved through several steps. First, the article has contributed to reviewing the academic literature on the population, environment and development debate.

Second, the article has highlighted a way to face the problem. The choice of challenging the IPAT model methodology has represented one possible manner of applying a paradigm that derives directly from the pessimistic assumptions on population growth and preservation of the environment. The limitations of the IPAT identity and its strong assumptions have also been reviewed.

Third, this theoretical model has been tested here on an empirical example referred to a specific environmental variable and to a specific developing country. The case study has covered the projected increase in carbon dioxide emissions in India in the period 2003-2030. Contributions of demographic, economic and technological variables have been calculated relative to the growth in carbon dioxide emission. The limitations to assessing any policy implications or any argument on the 'quality' of Indian economic development have also been put forward. The results have confirmed the hypothesis that the Neo-Malthusian paradigm is not appropriate to explain the demographic impact on the environmental variable in Asian economies. Instead, evidence has been provided to consider that the main determinant for environmental impact is still going to be economic growth. As a consequence, the article has discussed some of the main points of interest arising from these conclusions in terms of how countries often see environmental and energy policies related to national economic and political interests.

The social and political relevance of this study lies in the fact that currently environmental issues represent a growing issue in development studies. The depletion of the environment connected as a result of human activities represents a common concern worldwide, and recently these phenomena have increased, especially in Asian economies. This study has referred to CO_2 as an indicator for the variables in the IPAT model, mainly because accurate databases exist for both actual and expected values. Carbon dioxide also represents a good example of an indicator that can be calculated by Life Cycle Analysis methodology while referring all non-manmade polluting activities to a unique parameter. It is useful to note once again the limitations of the IPAT methodology and the strong assumptions involved in this model exercise that could subtly affect the line of argument of this article. Yet, the results presented here are useful in understanding some broad findings.

To this extent, the issue of carbon dioxide emissions is, above all, important, and the consequences of carbon dioxide and greenhouse gas emissions are well known in terms of their responsibility for climate change. Global warming may represent a serious hindrance to development in many countries. To avoid the consequences of climate change, a collective policy action response is desirable, as well as more equality in lifestyles and in welfare between the North and the South.

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Notes

1. In these models, the environmental goods are considered both in terms of non-renewable resources and environmental 'loss' (Pearce and Turner, 1990).
2. An example is that when agricultural goods demand decreases, less deforestation is needed to gain new land.
3. Lester Brown, President of the Earth Policy Institute.
4. US Environmental Protection Agency.
5. Discrete growth rates of the IPAT decomposition still represent a good approximation for relatively small values.
6. US Energy Administration Information US.
7. The model still works for discrete growth rates that are not too high in value (O'Neill *et al*, 2001). In our case, the hypothesis of constant average growth rate in the EIA figures allows the application of the decomposition methodology.
8. The assumed formula to calculate the growth rates follows the compound interest rate model.
9. In this exercise model, the impact growth rate I is assumed to be equal to the sum of the growth rates of P, A and T, according to the definition of the IPAT identity.
10. As some IPAT methodologies collapse the A and T variables into a single variable (Bongaarts, 1992).
11. www.eia.doe.gov.

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