DEPARTAMENTO DE ECONOMIA
PUC-RIO

TEXTO PARA DISCUSSÃO
Nº 329

GROWTH AND ENVIRONMENT TRADE-OFFS: THREE-GAP SIMULATIONS FOR BRAZIL

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Dezembro 1994

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Ideally, the trade-offs between growth and environmental conservation in Brazil should be dealt with in the context of the analysis of development sustainability, through the use of counterfactuals implying non-declining capital stocks and including different kinds of natural capital stocks with a varying degree of substitutability in relation to man-made or human capital. This would, however, be well beyond the scope of this paper as there is no readily available basic information on the relevant capital stocks. This paper will concentrate instead on the study of trade-offs between growth and environmental conservation in Brazil taking into account environmental targets not necessarily consistent with sustainable development.

The paper is divided into five sections. The first section considers domestic externalities, which do not spill over significantly across national borders. Then attention is concentrated on global externalities, such as global warming and reduction of biodiversity, which affect economic agents in other countries and consequently cause major inter-country distributional problems. This is followed by an analysis of alternatives and costs of curtailing global warming as well as the reduction of biodiversity. Basic and environment-friendly scenarios are defined and discussed in section four. Finally, the relevant trade-offs between growth and environment conservation are presented and discussed.

1. Domestic Externalities: Industrial Pollution and Poverty-Related Externalities

It is important to consider separately domestic externalities, which affect economic agent inside national borders, from global externalities, which affect economic agents across national borders, because the latter raise more complex redistributive questions. The design of an adequate system of incentives faces problems raised by the lack of a common legal background and the visibility of international, rather than interagent, transfers.

Under the heading of domestic externalities are treated costs for all purposes mainly non-crossborder entailed by industrial and agricultural pollution, including cleanup of the cumulative effects of pollution in the past, improved access to water and sanitation as well as other mainly poverty-related externalities.[2]

There is no comprehensive information on industrial and agricultural pollution. Air pollution is a significant problem in the larger metropolitan areas and While industrial air pollution control in the main metropolitan **areas** has improved conditions in the recent past in specific areas - the curtailment of pollution in Cubatão being the best example - the problem remains significant in the larger metropolitan areas, especially São Paulo, the and in the South, as a result of thermoelectricity generation. Water pollution is relevant in almost all big metropolitan areas because both of industrial discharge and the lack of sewage treatment. It is also important in or near the Amazon region[3], due to tin mining, and in many agricultural areas due to the misuse of pesticides and other agrochemical products[4].

Cleanup of the Tietê basin in the state of São Paulo is estimated to cost US$ 2.6 billion, of which US$ 0.5 billion refers to industrial pollution control[5]. The first stage of the cleanup of Guanabara Bay in Rio de Janeiro is to

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2 Some of these, however, such as noise pollution in metropolitan areas are not necessarily related to poverty.

3 North of Manaus, south of Porto Velho and in South Pará. See IBGE (1988), p. 72.

4 Contraction of agricultural credit also resulted in an improvement of the position in the 1980s. For data on sales of agrochemical products by state and type of crop see IBGE (1988), pp. 123 e 125.

5 *Financial Times*, 16.10.91.

cost around US$ 0.5 billion. Implementation of whole complete project is thought to require US$ 2 billion[6]. Available estimates of aggregate financial requirements to reach "adequate standards" concerning pollution in Brazil are extremely tentative. In Jaguaribe et al. (1989) it is suggested that expenditure of the order of 0.3% of GDP will be required by the "introduction and enforcement of international environmental standards"[7]. This seems somewhat underestimated if contrasted with the rough projections of the World Bank for estimated yearly costs of environmental programs for developing countries as a whole and with the sparsely available estimates concerning the big Guanabara and Tietê water pollution clean up projects[8]. A mid-range estimate is more likely to be around 0.6% of GDP yearly in conjunction with closely related expenditures related to water supply and sanitation of 0.8% of GDP yearly.

The convergence between substandard social indicators and minimum thresholds in a given time span for Brazil has been examined Abreu (1987) and led to the proposal of criteria based on the application of ideas advanced by Sen (1980) on the comparability of heterogeneous experiences in achieving social policy targets. The basic principle is to distribute evenly over time the relative effort to improve given social indicators taking as target the steady reduction of a certain proportion of the gap between actual levels and desired levels of indicators. This is especially useful in the cases where biologically determined asymptotic patterns exist as in the case infant mortality or life expectancy but can also be applied to determine desired paths for the evolution of indicators such as water and sewage connections.

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6 Câmara de Comércio Brasil-Canadá (1991), p. 81.

7 The unpublished report by F. A. de Almeida quoted by Jaguaribe et al. (1989), which is the source for the estimate, does not throw additional light on the methodology used to suggest 0.3% of GDP.

8 World Bank (1992), pp. 173-4.

Inter and intraregional differences of social indicators are very substantial in Brazil. Infant mortality in the poorest region - the Northeast - is roughly 60% higher than in the richest. The same heterogeneity applies to the availability of basic services such as water supply and sewage. The proportion of households having access to adequate water supply and sewage in the Northeast is 35% and 75%, respectively, below such ratios for the Southeast[9]. National average indicators are substantially below those which would be predicted based on cross section data on GDP per capita: Brazilian average infant mortality rate is still above South Africa's[10].

In Jaguaribe et al (1989) a mixed target for the year 2000 was established so that the poorest region reached the 1987 level of water and sewage connections for the Southeast region in the year 2000 and that the other regions would improve their indicators at the same rate these had been improving in the recent past. With information on the cost of water and sanitation it was then possible to roughly estimate in 0.6% of GDP the level of expenditure required to reach the year 2000 target[11]. If account is taken of the shortcomings of investment in water and sanitation in the recent past this estimate needs to be increased to 0.8% of GDP if the initial target in the year 2000 is maintained.[12]

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9 Data from IBGE (1991) and (1992).

10 Improvement since 1970 in Brazil has been, however, faster than in South Africa. See World Bank (1993), appendix tables. See Abreu (1987) for the a comparison of Brazilian social indicators and social policies with those of other developing countries.

11 Given certain assumptions about GDP growth. See Guimarães (1989), pp. 39 and 42, Rodrigues (1985), chapter 5. Guimarães (1989) estimates water connection costs to be around US$ 420 of 1987 per household and sewage system connections around US$ 600 per household. These are in the mid-range of World Bank (1992), chapter 5, estimates.

12 After 2000 efforts would be concentrated in bringing substandard areas into line with the those Southeast. It should be noted that these estimates refer to connections of the estimated number of dwellings to sewage and water systems. To the extent that some effort is directed to providing roof for those homeless additional efforts are also required in connection with water and sanitation programs.

Environmental problems in the category of poverty-related domestic externalities are generally treated as including only water supply and sanitation. This is arbitrary, as several other poverty-related externalities such as those related in certain conditions to housing and transportation standards, educational standards of specific social groups, crime and contagious diseases are unrelated or not necessarily related to the inadequate standards of water supply and sanitation[13]. A reasonable range of guesses, reflecting the generalized ignorance on the subject, would span from 0.6 to 1.0% of GDP to cope with modest improvement in primary education and health standards, curbing poverty-related crime, controlling poverty-related diseases, improving housing conditions and public transportation.

2. Global Externalities: Global Warming and Biodiversity

Global externalties, understood as externalities which affect economic agents not only across borders, but also on a global planetary basis are of great importance in the analysis of growth prospects for Brazil because of the great relative size of the Brazilian rain forest and the established causality link between deforestation and global warming/reduction in biodiversity. The preservation of Indian cultures is also an important joint product of global warming control through preservation of the rain forest.

In the long term energy absorbed by the earth from solar radiation must be balanced by outgoing radiation from the earth and its atmosphere. Temperature will adjust to assure this radiation balance. Energy is emitted by the earth and atmosphere through long-wave radiation which is partly absorbed

[13] AIDS is likely to be especially serious as it will impose severe strains on the already inadequate public health services which are unable to cope with diseases for which there is known effective treatment. See Cuddington (1993) for the growth implications of AIDS in Tanzania.

by the greenhouse gases (CO_2, CH_4, CFC-11 and 12, H_20, O_3, N_2O).[14] With the exception of water all of these gases have important anthropogenic sources. The most important of the anthropogenic gases is CO_2 with an atmospheric concentration of 0.04%. The total absence of greenhouse gases would lower mean temperatures by about 33 degrees Celsius. A doubling of the CO_2 content of the atmosphere could raise temperatures by 4 degrees. This is called global warming.[15]

Different gases contribute differently to the greenhouse effect because of their different concentration in the atmosphere, their different life span and their different relative efficiency in absorbing radiant heat. Table 1 summarizes the relevant data on different gases as well as indicates their relative contribution to the greenhouse effect both in stock and in marginal terms.

The contribution of deforestation in the Brazilian Amazon to global warming, contrary to what is frequently thought, is not very significant. The share of CO_2 in the generation of greenhouse gases is of about 50%. Deforestation accounts for roughly 25% of CO_2 generation and deforestation in the Brazilian Amazon is about 25% of world deforestation. A mid-estimate of about 3% for the contribution of deforestation in Brazil to global warming seems reasonable.[16] Reis and Margulis (1992) presented updated estimates of CO_2 emissions caused by burning logtrees in the Brazilian Amazon which are in the range of 0.29-0.41 gigaton per year, that is from 4.7 to 6.6 % of global CO_2 emissions and 2.4 to 3.3% of the greenhouse effect. These are based on

[14] The greenhouse gases are respectively carbon dioxide, methane, chlorofluorcarbons-11 and 12, water vapor, tropospheric ozone and nitrous dioxide.
[15] See Solow (1992) and Nordhaus (1992), pp. 34-9. The estimated temperature range due to global warming is subject of much disagreement in the literature.
[16] See Reis and Margulis (1992), p. 335. Such contribution seems to be rising since the early 1980s.

downward revisions of estimated areas affected by deforestation and are consequently lower than previous estimates.[17]

Table 1

Contribution to increase of the greenhouse effect by different gases

	CO_2	CFCs	CH_4	O_3	N_2O
Atmospheric concentration (ppmv*)	346-351	0.2-0.6**	1.7	0.02	0.3
Atmospheric life span (years)	2-5	75-111	0-11	0.1-0.3	150
Annual increase (%)	0.4-0.5	5.0-7.0	1.0-1.1	0.5-2.0	0.2-0.3
Relative efficiency (CO_2=1)	1	10.000-15.000	11-32	2.000	150
Past cumulative contribution (%)	50	12-17	17-25	8	4-6
Current marginal contribution (%)	46-57	24-25	12-18	7	5-6

* Ppmv= parts per million by volume.
** In parts per billion by volume.
Source: Reis e Margulis (1992) quoting Arrhenius and Waltz (1990); WRI/IED (1988); Houghton and Woodwell (1989), Mintzer (1987); Flavin (1990); Bouwman (1990); Bowman (1990); Grubb (1989).

Deforestation, besides contributing to global warming reduces biodiversity and affects the preservation of Indian cultures. The Amazon forest is estimated to hold between 0.8 and 5 million species, corresponding to 15 to 30% of the estimated total number of existing species[18]. A high of proportion of plant (33%), insect (97%) and other invertebrate and microorganism species (91%) are thought not to have been identified. Most of these are in tropical moist forests[19]. It is, however, extremely difficult to assess even roughly the

[17] Reis and Margulis (1992), p. 335 and, for other estimates, p. 349.
[18] Alternatively Amazonian biodiversity is indicated by comparative data: in an area of 0.2 hectares near Manaus ten times more species of trees of more than 2.5 meters were found than in the whole of France, see Reis and Margulis (1992), p.343.
[19] World Bank (1992), pp. 59-61.

aggregate benefits of maintaining biodiversity as well as of preserving Indian cultures.

3. Reduction in Deforestation and Control of Global Warming

Roughly 95% of CO emissions are generated by the energy sector and deforestation. CO_2 emissions due to fuel use are equivalent to the deforestation of one Amazonia per decade but what is relevant here is cost effectiveness. In principle the most economic way to reduce emissions is by discontinuing deforestation. This is cheaper than reforestation and much cheaper than controlling the use of fossil fuels. But the comparison may be misleading unless difficulties concerning the effectiveness of side payments as an instrument to control deforestation are properly faced.

There is much disagreement concerning the costs of reducing deforestation in Brazil. The upper bound is a scenario corresponding to interrupting all agricultural activities in the region, including cattle raising. The share of agriculture and livestock in the region's GDP is around 17% but linkages with industry and services would amplify the consequences, halving the region's GDP. This upper bound would be around 2% of Brazil's GDP. There are many reasons to believe that this an overestimation, among other things because it is unreasonable to believe that present agricultural activities are wholly unsustainable, that is, dependent on continuous deforestation, or that agriculture would be totally unable to adjust to deforestation control. In other extreme, Cline (1992a) and (1992b) has suggested first US$ 4/ton, then US$ 1/ton of carbon as the opportunity cost of retaining carbon in the Brazilian

Amazon, entailing total costs of 0.4% and 0.1% of GDP, respectively[20]. It is however unlikely that only 25% of agricultural GDP would be affected or that the shrinkage in agriculture would not affect other sectors.

Estimates by Pearce (1992)[21] are roughly midway between the upper bound and Cline's lowest. On a "damage avoided" approach, which would also have to be taken into account to discuss the outcome of deforestation control negotiations, Pearce (1992) suggests that to stop deforestation altogether would be worth around US$ 6.5 billion yearly[22]. An estimate of 1.2% of GDP yearly has been adopted as a mid-range value.[23] Since attention in this paper is concentrated on the cost side, preservation of biodiversity and of alternative cultures can be thought as being jointly produced with the freezing of deforestation.

The Brazilian Amazon plays a major global role in the retention of CO_2. If on a global basis it is cheaper to reduce such CO_2 emissions by freezing deforestation rather than only by controlling the use of fossil fuels it makes sense not to consider the services provided by the forest as free. It is in this context that it seems reasonable to consider as a possible scenario one in which Brazil would be a major recipient of international yearly payments as a country with a high forest/CO_2 emission ratio. Main payers would be those countries with a low forest/CO_2 emission ratio. The range of possible payments is an open question but relevant data include the costs (for Brazil) of interrupting

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[20] Cline (1992b). pp. 220-221 also quotes Darmstadter and Plantinga (1991) who suggest a cost of US$ 2.30/ton.

[21] All mining, ranching and logging activities would cease and crop production reduced by half. This would be equivalent to around US$ 5.8 billion in 1980.

[22] Pearce (1992) also includes considerations based on "willingness to pay" criteria.

[23] In principle effects on hydroelectricity generation could impose additional costs but the average area of reservoir/generating capacity ratio of 0.6 Km^2/MW indicates that this a problem of a different order of magnitude if compared to deforestation due to agricultural activities. Envisaged investment programs of 1,000 MW/year would entail deforestation equivalent to 2-3% of that related to agricultural activities. See Serra (1989).

deforestation and the costs (for the world) of inaction in relation to global warming. There are very complex problems to solve in relation to enforcement of agreed limitations but this should not prevent considering this alternative.

The already complex difficulties of providing adequate incentives for freezing deforestation even in a closed system are significantly increased when transborder or global externalities are involved. The control of global externalities require multilateral agreements and naturally invite cross-country comparisons of efficiency in the use of natural resources and effectiveness of enforcement. There is a permanent temptation to oversimplify in the search for corrective solutions by choosing unilateral decisions rather than multilateral cooperation and failing to recognize that in developing economies concern with the global environment faces competition of concern with basic needs, that is, the income elasticity of demand for environmental quality is very high.[24] Sovereign-encroaching solutions tend to obscure the difficulties of design and implementation of incentives even if transborder problems were eliminated.

Environmental questions are certain to occupy a very important place in trade negotiations in the post-Uruguay Round era. From past experience and recent policy statements it is likely that developed countries, and particularly the United States, will increasingly press for across-country "policy harmonization". Environmental policies are very high in the list of candidates for such harmonization. Closely related to misconceptions on "policy harmonization" are recommendations on instruments to be used to enforce the adoption of standards more often than not unilaterally defined.

The concepts of "policy harmonization" and its next of kin "level playing field" are difficult to reconcile with widely accepted ideas about

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24 See Low (1993).

comparative advantage. Shall wage policies, education subsidies, public transportation policies, fiscal policies, and what not be "harmonized" then? International organizations including the World Bank and GATT[25] have taken the stance that claims for compensation related to the use of cheaper and dirtier technologies in developing countries, the so-called ecological dumping, should be rejected as they are based on shaky economic grounds and will introduce a major element of disruption in the multilateral trading system. If global externalities are involved, the picture is, of course, different but given the overwhelming importance of fuel emissions to explain global warming it is difficult to see how corrective policies could be defined on a non-multilateral basis.

It has been shown that proposed bans on certain imports due to environmental reasons tend to be self defeating just as any other trade policy is inefficient to correct domestic distortions. The effect of the ban of trade in logs has been examined by Braga (1992) which came to the conclusion that the imposition of export taxes or import bans on logs generally backfires as an effort of environment preservation due to various reasons, which include the lower technological level of furniture industry in developing countries and the impact of a lower log price on forest conservation. For the time being in any case Brazil has been a minor player in the hardwood market.[26] The distributive impact of such policies is also likely to hurt the poor. It not only makes more economic sense but also seem likely to be more effective to pay countries such as Brazil for carbon absorption services than to rely on the use of non-optimal policies to correct domestic distortions.

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25 GATT (1992), part III.

26 See Braga (1992).

As matters stand it is impossible to estimate even roughly the impact of possible future non-tariff barriers imposed by developed countries in the context of an effort to harmonize environmental policies. However, such an impact is likely to become relevant only if "indirect eco-labeling" becomes the rule: labels would have to show that certain ecological standards have been met in the production of all inputs and services used in the production of a given good or service.

4. ENVIRONMENT-FRIENDLY SCENARIOS

Table 2 summarizes estimates of costs of environment abatement discussed in the previous sections. There has been an attempt to define low, mid-range and high cost estimates for externalities mentioned before. Costs related to global warming abatement (and biodiversity conservation) vary more significantly to reflect the different views on the subject as reported in section 3.

Table 2

Summary of estimated costs as % of GDP

	Low cost	Mid-range cost	High cost
Activities			
Reduction of global warming	0.4	1.2	2.0
Domestic externalities	1.6	2.2	2.8
Reduction of domestic pollution	0.4	0.6	0.8
Water supply and sanitation	0.6	0.8	1.0
Other poverty-related externalities	0.6	0.8	1.0
Total	2.0	3.4	4.8

All activities are supposed to be domestically financed, with the exception of global warming control and biodoversity protection for which alternative combinations of foreign and domestic funding are possible. The more likely scenarios are, of course, due to the problems raised by the inter-country appropriation of benefits, those in which most of the funding is foreign.

To a large extent estimated costs for control of domestic externalities are net costs since the actual direct links between control of externalities and growth seem slight. There is implicit, however, the idea that growth sustainability depends on the achievement of a minimum level of improvement in the quality of life of the poor.

5. GROWTH-ENVIRONMENT TRADE-OFFS

The evaluation of the impact of environment-related policies and their respective sources of finance is based on a three-gap simulation macroeconomic model[27] developed and explored by the authors elsewhere[28]. The model defines three constraints for the maximum rate of investment allowed respectively by the total availability of savings, by the fiscal budget and by the maximum inflow of external finance to sustain a current account deficit. In the present version of the model, growth rates are affected by a variable, referred below as λ, which corresponds to the proportion of GDP represented by government expenditures in activities which affect positively both investment productivity and the amount of private savings which is used for the accumulation of physical capital. Growth rates are thus affected by other expenditures such as government consumption and environment-related programs. Furthermore, the sources and patterns of financing of such activities are bound to have an impact on equilibrium growth rates inasmuch as they affect the budget constraint (e.g. requiring more deficit spending), the savings

[27] See Taylor (1993), chapter 2

[28] See Abreu, Carneiro and Werneck (1994)

constraint (e.g. requiring higher taxes), or the external constraint (e.g. giving access to external funds which are earmarked for environmental protection).

In the basic scenario, the post-stabilization feasible average annual economic growth rate is supposed to be the result of a more open economy and under a more growth-oriented pattern of public expenditure. The constructed scenario assumes a considerable liberalization of imports of both capital goods and construction services: enough to increase the import coefficient of capital goods from 0.15 to 0.3 of GDP and give rise to a much higher investment productivity. The scenario also assumes a significant post-stabilization fiscal-adjustment effort, equal to 3.6% of GDP. Because the Brazilian economy would be emerging from a fifteen-year long high inflation experience, it was prudently assumed that the sustainable public-sector deficit would actually be negative: it was made equal to -0.8% of GDP. On the other hand, given the many years of favorable external accounts following the debt-crisis, and assuming the maintenance of the external liberalization policy adopted after 1990, it seemed to assume that the sustainable current account deficit, could be equal to 1.3% of GDP. The growth possibilities of such scenario lead to a maximum feasible growth rate consistent with the three constraints of roughly 6.3%.

The impact on feasible growth rates of introducing the midrange cost estimates for global warming control and biodiversity protection (1.2% of GDP, wholly financed abroad) and domestic externalities, including domestic pollution, water and sewage, as well as other poverty-related externalities (2.2% of GDP), is that the external constraint ceases to be relevant (for the optimal level of increment in productivity-inducing public expenditures, the external-deficit-constrained rate of growth is 7.8%) and growth is limited by the fiscal constraint to 4.1% (the growth rate constrained by savings is 5.9%).[29] This is intuitive: the slack in the foreign constraint results from the form of financing global warming control activities (100% externally) but other externality abatement costs have a direct impact on the fiscal constraint and, and to a lesser extent (also due to external financing) on the savings constraint, making both of them more restrictive.[30]

Increasing costs of the control of domestic externalities control make the fiscal constraint (and to a lesser extent the savings constraint) increasingly binding. In the scenario of high costs of table 2 (2.8% of GDP), and supposing no global warming abatement domestically financed effort, the maximum GDP growth rate would decline to 3.6%. For the low cost scenario possible GDP growth rate would be of 4.7%.

For each additional 1% of GDP spent in the control of domestic externalities the fiscal and savings-constrained growth rates are reduced by 0.96% and 0.38% respectively. Taking the midrange cost scenarios defined in table 2 and since the fiscal constraint is binding domestic pollution control entails a reduction in GDP growth of 0.6%, to assure defined targets for sanitation and water supply would cost 0.8% in GDP growth and to cope with other poverty-related externalities another 0.8% in GDP growth.

These results would not be affected by considering the joint effect of programs related to domestic and global externalities as it is the fiscal constraint which is binding and this is invariant in relation the costs of global warming

29 The optimal value for λ_* of 0.7 % of GDP rather than 1.7% without taking into account externalities, would make possible a GDP growth rate of 4.6%.

30 The sensitivity of the maximum growth rate allowed by the fiscal constraint to the expenditure in environment and poverty-related externalities crucially depends on the value of parameter Ω, linking public and private investment ($i_g = i_0 + \Omega i_p$). The higher Ω the lower the sensitivity. In the basic scenarios the value of Ω was assumed to be 0.66.

control. In the midrange scenarios for both the control of domestic externalities and of global warming the fiscal binding constraint would limit the growth rate to 4.1%, as already mentioned, but this should not hide the fact that the growth rates bound by savings and the balance of payments increase from 6.4% to 7% and from 6.8% to 8.8%, respectively, when the low and high scenarios for global warming control are compared. Increasing the effort to control global warming with full external financing increases not only the slack concerning the foreign constraint but also makes less binding the savings constraint as the level of foreign savings is favorably affected.

Varying the proportion of global warming costs financed abroad has important consequences as for each 10% reduction in the share of costs financed abroad the impact on the relevant fiscal constraint is of 0.1% of GDP. This effect is entirely due to the impact of such reorientation on the fiscal constraint as there is no additional effect on the savings constraint.

In short, the average estimated net cost of controlling domestic externalities is in the region of 2.2% of reduced GDP growth. The rate of growth of GDP would be of 4.1% instead of 6.3%. Depending on negotiations on the financing of global warming control activities burden sharing could result in an additional reduction of GDP growth rates by up to one further percentage point, lowering the maximum feasible growth rate to around 3.1%. This underlines the difficulties that Brazil has to face to significantly contribute to global warming control, given competitive uses in relation to which there are much less serious externality appropriation problems. It also brings attention to the very significant reduction in achievable growth rates brought about by the implementation of policies designed to control poverty-related externalities.

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