Welfare Accounting and the Environment: Reassessing Brazilian Economic Growth, 1965–1993

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ABSTRACT

Few countries in recent decades have experienced economic growth as rapid as that in Brazil. The period spanning the late 1960s and mid 1970s, during which GDP growth was especially strong, is often referred to as the 'economic miracle'. Yet, the use of per capita GDP growth as a proxy for economic development (or social welfare improvement) can be questioned on both distributional and environmental grounds. Scholars such as Ahluwalia and Chenery have noted that per capita GDP growth places greater weight on the income of richer income groups, and have proposed distribution-neutral and pro-poor alternatives. More recently, studies by the World Resources Institute and others have questioned the environmental sustainability of GDP growth and have introduced an alternative national income accounting methodology that factors in estimated losses associated with natural resource depletion. To date, no studies have undertaken both types of revisions concurrently, creating a revised national welfare measure based on per capita GDP, but corrected for both distributional bias and resource depletion. Such a measure is derived in this article and applied to the Brazilian case. The results cast doubt on the proposition that rapid economic growth in Brazil has resulted in comparable welfare gains.

INTRODUCTION

Since the advent of national income accounting more than half a century ago, there has been incessant debate over the policy relevance of this economic indicator. Many have regarded growth in national income as fundamental to — or even synonymous with — economic development or improvement in national well-being. Rostow's stages-of-growth theory, for instance, exemplified a belief that not only economic development but also political democracy were natural by-products of national income growth (Rostow, 1956). Sceptics have argued that income growth is too narrow a criterion for broad-based development and have proposed a variety of

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alternative measures. Among the best-known are the physical quality of life index (PQLI), the human development index (HDI), and the index of sustainable economic welfare (ISEW).[1] The first two incorporate indicators of progress in health and education, while the latter adjusts national income for various expenditures omitted from conventional income accounts.

In considering what constitutes broad-based development, it is helpful to consider two distinct problems. The first and more fundamental problem is what Sen (1981) terms *identification*: establishing an appropriate measure of well-being at the individual level. Does growth in an individual's real income necessarily result in a state of enhanced well-being, or can we envisage scenarios in which well-being might nevertheless decline due, for example, to deterioration in access to health or educational services? If well-being has non-income components, how much relative importance do we accord to each variable? The second problem is *aggregation*: deriving a national-level indicator from individual-level performances. In other words, how much relative weight does one place on changes in the well-being of particular groups or individuals?

These questions are the starting point for this article. I address the identification and aggregation problems separately in developing a national welfare indicator that accounts for income inequality and resource depletion. I argue that changes in this indicator grant us insight into the extent to which a country has experienced economic development (that is, well-being improvements) over time, and then apply my methodology to the case of Brazil. This is a country that experienced double-digit economic growth in the late 1960s and early 1970s and an annual GDP growth rate of 4.9 per cent (2.6 per cent per capita) over the twenty-eight year period from 1965 to 1993. Accompanying this growth, however, were rapid increases in the volume of natural resource depletion and worsening income inequality.

The following section discusses the distributional weighting scheme implicit in per capita GDP growth as a welfare measure, as well as alternatives to it proposed by Ahluwalia and Chenery (1974). This is followed by a review of the results of three World Resource Institute (WRI) case studies on revised income accounting (Cruz and Repetto, 1992; Repetto et al., 1989; Solórzano et al., 1991), in particular their implications and the rationale for adjusting national income for the estimated value of natural resource depletion. A concise history of Brazil's economic performance in the 1965–93 period is then provided, with particular attention to absolute versus relative welfare improvements; this section considers the effect of independent Ahluwalia/Chenery and WRI-type adjustments to the Brazilian income accounts. This is followed by a discussion of the procedure to be used in

1. The PQLI was introduced by Morris (1980). The HDI is reported annually for all countries in the United Nations Development Programme's *Human Development Reports*, first published in 1990. The ISEW was first proposed and applied to the United States by Daly and Cobb (1989), and has since been applied to other countries.

addressing the identification and aggregation problems concurrently, essentially a simultaneous application of the WRI and Ahluwalia and Chenery approaches. Here I also introduce and incorporate the notion of 'resource depletion burden' weights, and apply the welfare indicator upon which they are based to the Brazilian case. The final section offers a summary and some concluding thoughts.

THE AHLUWALIA AND CHENERY APPROACH TO WELFARE MEASUREMENT: DISTRIBUTION WEIGHTS

When taken as a measure of welfare change, per capita GDP growth embodies specific solutions not only to the identification problem — equating welfare to conventionally measured income — but also to the aggregation problem. In counting a dollar as a dollar, no matter to whom it accrues, per capita GDP growth in effect weights each individual by his or her income.

Following Ahluwalia and Chenery (1974, hereafter A&C) we can define a general income-based measure of 'welfare growth' as follows:

$$\boldsymbol{W} = \sum_i \boldsymbol{w_i g_i}, \qquad \boldsymbol{i} = 1, 2, \ldots \mathrm{n}, \tag{1}$$

where $\boldsymbol{W}$ equals 'welfare growth', $\boldsymbol{i}$ is the income group (quintile, for our purposes, ranked from richest to poorest), $\boldsymbol{g}$ represents the per capita income growth rate corresponding to group $\boldsymbol{i}$, and $\boldsymbol{w}$ is the weight accorded to group $\boldsymbol{i}$ in the determination of $\boldsymbol{W}$.

Per capita GDP growth is a special case of $\boldsymbol{W}$, in which the weights on the income growth of each group equal the share of that group in total income. In this case, assuming quintiles, $\boldsymbol{w_j} > \boldsymbol{w_{j+1}}$, for any $\boldsymbol{j} \leq 4$. Consider, for example, a case in which the wealthiest 20 per cent of the population garnered two-thirds of all national income while the poorest 20 per cent received just 2 per cent. This would imply that the income growth rate of the richest quintile has thirty-three times more weight, in the determination of per capita GDP growth, than does the income growth rate of the poorest quintile.

A&C suggested, as an alternative weighting scheme, granting equal social value to the same percentage change in the income of any individual, no matter from what income group. Under this 'equal weights' measure:

$$\boldsymbol{W} = \sum_i \boldsymbol{w_i g_i}, \qquad \boldsymbol{i} = 1, 2, \ldots 5, \tag{2}$$

with $\boldsymbol{w_j} = \boldsymbol{w_{j+1}}$ for any $\boldsymbol{j} \leq 4$.

Implicit in this scheme is the assumption that the marginal welfare obtained from an income increment diminishes as income grows, based on a utility function of the functional form $u_i = \ln y_i$, where u_i equals individual utility or welfare, and y_i equals individual income. The objection can be raised that such a scheme employs interpersonal utility comparisons, a practice considered unacceptable in neoclassical welfare economics. The same objection applies, however, to the GDP weights method, or indeed to any quantitative indicator of social welfare that aggregates individual characteristics. In this sense, the aggregation problem discussed earlier is inescapably a normative exercise.

A further alternative suggested by A&C is to base W more heavily on the income growth of the poorest groups, placing little social value on upper-income growth beyond its contribution to social saving and investment. Using such 'poverty weights':

$$W = \sum_i w_i g_i, \qquad i = 1, 2, \ldots 5, \tag{3}$$

with $w_j < w_{j+1}$ for any $j \leq 4$.

For example, A&C used poverty weights of 0.1, 0.3, and 0.6 for the richest 20 per cent, middle 40 per cent, and poorest 40 per cent of the population in their empirical application to several LDCs. In the following, I instead use 'inverse income' weights, which appear somewhat less arbitrary and offer a symmetric opposite to the GDP weights.[2]

These distribution weights schemes address the aggregation problem involved in measuring changes in national welfare, or development. Like the per capita GDP growth variant, however, such an approach to the identification problem is questionable in that it equates income and welfare. While 'extra-income' notions of welfare may prove too multifarious to quantify, we can at least, to the extent that welfare has an income component, probe more deeply into the question of whether national income is properly measured. The next section tackles one important dimension of this problem, adjusting national income for the value of depleted natural resources.

THE WORLD RESOURCES INSTITUTE APPROACH: DEPLETION-ADJUSTED INCOME ACCOUNTING

Studies by the World Resources Institute (WRI) on Indonesia (Repetto et al., 1989), Costa Rica (Solórzano et al., 1991), and the Philippines (Cruz and Repetto, 1992) recalculate the national income accounts to assess the environmental impacts of economic growth in the respective countries. The depletion-adjusted domestic product (DADP) calculated for each country is simply conventional GDP minus the monetary value of the corresponding loss associated with their three most prominent resources.[3] All of these

2. For example, inverse GDP weights in the previous example would mean that w_1 is equal to 1/.666, or 1.5, while w_5 equals 1/.02, or 50 (with Σw_i being normalized to equal one).
3. For simplicity, I use the term DADP, since the labelling of this measure varied among the different WRI studies. Petroleum, timber and soil were the three resources for Indonesia, and timber, soil and fisheries for Costa Rica and the Philippines.

studies found that the customary disregard for natural resource depletion results in substantial overestimation of national income. This is especially so in the case of Indonesia, where, for many of the years studied, DADP was less than 85 per cent of GDP.

The WRI authors base their approach on a definition of income advanced by Sir John Hicks (1946: 172): 'income is the maximum value that a person can consume during a time period and still expect to be as well off at the end of the period as at the beginning'. In other words, there is a fundamental difference between (earned) income and dissipated savings (or wealth). This premise can be extended from the individual to the national level.

The WRI authors and others (such as El Serafy and Lutz, 1990; Young and Serôa da Motta, 1995) argue that Hicks's reasoning should apply as much to 'natural capital' (K_N, e.g., minerals, timber, soil) as to physical or man-made assets (K_M, e.g., factories and machines). While this was not a major concern in past centuries, when natural resources could more plausibly be considered 'gifts from nature', the supply of which was seemingly limitless, today it would be imprudent to continue disregarding the depletion of increasingly scarce natural resources in national income account calculations. Instead of the old paradigm in which capital is 'created' from natural resources, a better characterization of the manner of thinking of these authors is to say that 'primitive' capital is *transformed* in the production process. Therefore, since K_N is another form of capital, reductions in its stock ought to be deducted from a nation's income.

A common objection to such an accounting method is the technological optimist view that natural resource constraints will be offset by technical change (for example, Simon and Kahn, 1984; Solow, 1974). Continued progress, in other words, will enable us to 'substitute' depreciated K_M for K_N in the production of new K_M (i.e., to recycle). Even if technological change allows us to slow the rate of K_M depreciation (or to improve recycling efficiency), there is, in the long run, a limit to the extent to which K_N and K_M can be substituted for each other. Moreover, even if K_M and K_N *were* perfect substitutes, this would corroborate the practice of combining K_N and K_M in the national accounts, as done in the WRI studies.[4] It would certainly not be grounds for assigning a monetary value of zero to K_N.

By 'identifying' welfare as income minus the social cost of resource depletion, the WRI method offers an alternative to equating welfare and

4. If the two types of capital were interchangeable, it would be feasible to combine the capital accounts; exhaustion of a nation's K_N stock would not matter so long as it leads to a corresponding accretion in the stock of K_M. If, on the other hand, the two types of capital were complements, a separate accounting for K_N would be necessary to ensure there is no decline to dangerously low levels (lest a nation exhaust its K_N and no longer have the wherewithal to produce K_M). Such is the thinking of, among others, Daly (1996), Krutilla (1967), and Pearce et al. (1990), who hold that non-decreasing K_N stock is a necessary condition for sustainability (what is known in the literature as the 'strong sustainability' condition).

conventional GDP. The following section includes the results of similar adjustments to Brazilian GDP, with losses estimated for the forest, mineral ore, and soil sectors.

AN APPLICATION OF THE AHLUWALIA AND CHENERY AND WRI APPROACHES TO BRAZIL

Brazil: A Recent History

Few countries have experienced economic growth as rapid as Brazil's over the past three decades. The country's GDP grew at an annual rate of 8.6 per cent (5.8 per cent per capita) from 1965 to 1973, leading many (including Hoffman, 1989; Villela, 1992) to speak of a Brazilian 'economic miracle'. Despite a slowdown in the late 1970s and erratic (sometimes even negative) growth after 1980, the average annual growth from 1965 to 1993 was still a fairly robust 4.9 per cent (2.6 per cent per capita).

A critical turning point in Brazil's history was the 1964 military coup against populist president João Goulart. The twenty-year military dictatorship that followed pursued aggressive economic growth policies in the hope of legitimizing its rule in the eyes of the Brazilian people. Starting in the late 1960s, Brazil moved toward greater openness to foreign investment, which helped the country to establish a far more diversified and manufacturing-based economy than that of most other LDCs.[5] The early years of the dictatorship also witnessed a series of new laws that offered incentives for undertaking investment projects in Brazil's tropical forest interior. On the surface, both strategies appear to have helped raise Brazilian living standards considerably. Real per capita income rose from US$ 1,244 (1995 dollars) in 1965 to US$ 3,286 in 1993.

Not all Brazilians, however, benefited equally from these policies. For example, the liberalization of profit repatriation regulations in the late 1960s, under the regime of General Castello Branco, allowed foreign investors to gain, but possibly at the expense of ordinary Brazilians. Many large domestic investors reaped enormous government subsidies. Often it was only because of these handouts that investors profited at all; for example, Browder (1988) found that the average Brazilian ranching enterprise was so unproductive that it actually generated a net *loss* not counting the subsidies. This generosity on the part of the government came at the expense of the remainder of society, contributing to worsening inequality in the early years of the dictatorship (see Table 1a). Yet, even if economic growth occurs simultaneously with worsening inequality, it often generates absolute gains

5. Nearly one-half of Brazil's exports are manufactured goods. In contrast, primary goods (e.g., minerals, crops) still represent nearly 80 per cent of exports in other Latin American countries; see Prugh (1995: 88–9).

Table 1a. Income Shares for Brazil, by Quintile

Year	Gini Coef.	Lowest Quintile	Second Quintile	Third Quintile	Fourth Quintile	Highest Quintile	Ratio of Highest to Lowest
1960	0.499	3.5%	8.1%	13.8%	20.3%	54.3%	15.5
1970	0.562	3.2%	6.9%	10.8%	16.9%	62.2%	19.4
1972	0.610	2.0%	5.0%	9.4%	17.0%	66.6%	33.3
1978	0.560	2.5%	5.9%	10.9%	18.9%	61.8%	24.7
1979	0.594	2.6%	5.7%	9.9%	17.8%	64.0%	24.6
1983	0.570	2.4%	5.7%	10.7%	18.6%	62.6%	26.1
1993	0.640	2.1%	4.9%	8.9%	16.8%	67.3%	32.0

Table 1b. Real Per Capita Income, by Quintile (1995 Reais)

Year	Lowest Quintile	Second Quintile	Third Quintile	Fourth Quintile	Highest Quintile
1960	308.4	710.0	1,204.8	1,778.5	4,747.6
1970	367.5	794.4	1,243.0	1,945.5	7,160.6
1972	270.8	679.6	1,277.5	2,304.5	9,034.2
1978	464.8	1,093.5	2,018.8	3,497.4	11,435.3
1979	501.1	1,097.3	1,909.5	3,430.1	12,338.0
1983	423.8	1,001.8	1,884.1	3,271.2	11,015.6
1993	442.7	1,033.0	1,879.7	3,545.1	14,204.9

Sources: Deininger and Squire (1996), IMF (1997), Villela (1992), and author's calculations.

for all segments of the population. In Brazil, growth did 'trickle down' since absolute incomes increased for all income groups, including the poorest quintiles, between 1960 and 1993 (Table 1b). Hence, we might conclude that Brazilian economic growth unambiguously generated broad-based improvements in well-being.

There are two potential problems with such a conclusion. First, as noted earlier, income and welfare are not equivalent. Growth in conventionally-measured Brazilian income was accompanied by rapid resource depletion and excessive deforestation. The military regime did not recognize this as a problem,[6] but many Brazilians suffered from the consequences of negative externalities such as soil erosion and riverine siltation. Those particularly ill-affected may have suffered a net loss in welfare over the period despite increased income.

Second, costs associated with resource depletion were not necessarily distributed across the Brazilian population in direct proportion to their share in national income. The fact that the wealthiest quintile received roughly

6. On the contrary, the Brazilian interior was seen as a remote, primitive backwater which stood in the way of economic development — hence Castello Branco's declaration: 'Amazonian occupation will proceed as though we are waging a strategically conducted war' (Hecht and Cockburn, 1989: 95).

two-thirds of national income does not imply that they bore two-thirds of the costs of resource depletion; nor does the fact that the poorest quintile received roughly 2.5 per cent of national income mean that they bore a commensurately small share of these costs. If, in fact, the poorest quintile(s) bore a disproportionate share of the externalities, their 'true' income may have actually declined in absolute terms over the period studied.

The work of Butts (1989), La Tour (1995) and Mahar (1989), among others, is suggestive of such a possibility. Deforestation in the Amazonian region undermined the livelihoods of some of Brazil's poorest people. Communities that had previously harvested nuts, fruits, latex, and so forth from the forest for sale in local markets found their livelihoods threatened. While Brazil's Programme for National Integration of the early 1970s sought to temper these effects by relocating affected families (as well as migrant families from the arid and impoverished North-east) to newly-established agricultural villages, the government failed to anticipate the poor soil fertility characteristic of the Brazilian interior and the widespread lack of farming skills among the new settlers.

A telling example of the unfavourable circumstances faced by many of these settlers is that some felt compelled to grow grass on their plots in order to entice nearby ranchers to buy their land, after which they hoped to find work on a large ranch or plantation (Bunker, 1981). Social conditions were such that many were forced to accept sub-minimum wages and debt peonage. The wealthier groups, on the other hand, suffered little loss from the resource depletion, since the standing forest contributed relatively little to their well-being. Such an outcome is hardly peculiar to Brazil. Indeed, Dasgupta (1995) and Martinez-Alier (1995) argue that it is generally the case that the poor absorb a disproportionate amount of the welfare loss resulting from national programmes encouraging widespread resource depletion.

For the sake of accuracy, therefore, the negative externalities should be allocated across the population according to the approximate share of the loss for each group. This matter is taken up shortly, when I simultaneously apply the A&C and WRI approaches to the Brazilian case in order to draw conclusions about welfare improvement at the national level. First, let us briefly review the results obtained by applying each of these methodologies separately.

Application of Ahluwalia and Chenery Approach to the Brazilian Case

Even considering per capita GDP without resource depletion adjustments, we see that the value of $\boldsymbol{W}$ (our welfare growth indicator) for Brazil can vary considerably depending on the weighting scheme used (see Table 2).[7]

7. A description of all the data employed for this and subsequent sections of the analysis is found in Appendix 1.

Table 2. Per Capita Welfare Growth Rates for Select Periods

	GDP Weights	Equal Weights	Poverty Weights
1965–1993	2.6%	2.2%	2.1%
1965–1973	5.8%	5.1%	4.7%
1973–1982	2.3%	3.1%	3.8%
1982–1993	0.5%	−0.6%	−1.3%

Although per capita GDP grew at 2.6 per cent per annum from 1965 to 1993, welfare per capita grew more slowly, if only slightly so. If we surmise that quintile growth rates all have equal importance (equal A&C weights), $\boldsymbol{W}$ comes out to 2.2 per cent, while assuming that the income growth of the poor quintiles deserves more weight (i.e., poverty weights), $\boldsymbol{W}$ is 2.1 per cent. These results indicate that on the whole income grew more slowly for poorer groups, which is another way of saying that income inequality worsened.

The same was true during 1965–73 (roughly the period of the 'economic miracle'), although here even the A&C poverty weights result in considerable welfare improvement at the national level ($\boldsymbol{W}$ = 4.7 per cent). During this period the rising tide did, as it were, lift all boats. In contrast, the results for 1973–82 demonstrate that national welfare improved more rapidly assuming poverty weights (3.8 per cent per annum) than under GDP weights (2.3 per cent). This is a consequence of a reduction in income inequality over the sub-period, brought about in part by the Brazilian government response to social unrest in the early 1970s (stemming, in turn, from the regressive policies pursued in the mid to late 1960s). Finally, in the sub-period following the debt crisis (1982–93), the economy faltered (per capita GDP growth of only 0.5 per cent per annum) and renewed worsening of income inequality resulted in diminished welfare for all but the wealthiest 20 per cent of the population. This result, also evident from Table A.2d (Appendix 2) is suggested by the negative values for $\boldsymbol{W}$ under equal and poverty weights.

Application of World Resource Institute Approach to the Brazilian Case

Brazilian GDP grew at an average annual rate of 4.9 per cent (2.6 per cent per capita) from 1965 to 1993, or almost a fourfold increase (Table 3). The annual forest-sector loss increased by a factor of more than four from 1965 to 1993 (from 39.5 to 174.2 billion reais, 1995 prices), increasing most rapidly from the mid-1970s to the mid-1980s. This trend and the evidenced rapid increase in the net mineral sector losses during the 1980s reflects an important change in Brazilian government policy during the period of the study. Whereas Amazonian development was primarily targeted toward ranching and agricultural investment during the 1960s and most of the 1970s, subsequent discoveries of immense mineral deposits, such as Grande Carajás in Northern Pará, initiated development of infrastructure (such as

Table 3. GDP Adjusted for Resource Depletion, Brazil, 1965–1993 (in billions of 1995 Reais)

Year	GDP	Net Loss in Forestry Sector*	Net Loss in Minerals Sector	Net Loss in Soil Sector	Net Resource Depletion (NRD)	DADP	NRD as % of GDP
1965	156.1	39.5	0.9	7.1	47.4	108.7	30.4%
1966	162.0	38.4	0.9	7.1	46.4	115.6	28.7%
1967	170.6	41.2	0.8	7.2	49.2	121.4	28.8%
1968	189.1	45.9	1.0	7.3	54.2	134.9	28.7%
1969	207.6	51.1	1.3	7.4	59.8	147.8	28.8%
1970	213.0	55.0	2.1	7.4	64.5	148.5	30.3%
1971	237.1	57.8	2.3	6.9	67.0	170.2	28.2%
1972	265.5	63.3	2.2	7.3	72.7	192.8	27.4%
1973	302.5	70.3	2.4	7.6	80.3	222.2	26.5%
1974	327.1	77.1	3.1	11.9	92.0	235.2	28.1%
1975	344.2	86.0	3.2	10.8	100.0	244.2	29.1%
1976	379.4	87.5	4.5	8.7	100.6	278.8	26.5%
1977	398.1	88.2	4.1	8.6	100.9	297.2	25.4%
1978	417.9	95.6	3.4	7.7	106.7	311.2	25.5%
1979	446.2	106.2	4.6	9.5	120.3	325.9	27.0%
1980	487.3	119.7	8.3	10.0	138.0	349.3	28.3%
1981	466.7	125.2	8.0	9.3	142.4	324.3	30.5%
1982	470.5	130.7	9.3	10.0	150.0	320.5	31.9%
1983	456.7	136.1	10.1	8.8	155.0	301.7	33.9%
1984	485.8	141.2	11.2	9.1	161.4	324.4	33.2%
1985	522.3	149.9	11.6	9.9	171.4	350.9	32.8%
1986	558.9	175.8	8.9	7.5	192.2	366.7	34.4%
1987	577.8	171.9	9.1	6.9	187.9	389.9	32.5%
1988	577.4	164.8	14.1	8.0	186.9	390.5	32.4%
1989	600.7	157.6	14.7	8.3	180.7	420.0	30.1%
1990	574.6	153.4	12.5	8.4	174.4	400.2	30.3%
1991	574.6	159.6	10.7	8.4	178.7	395.8	31.1%
1992	569.3	167.0	11.3	8.5	186.8	382.5	32.8%
1993	595.5	174.2	11.1	8.6	193.9	401.5	32.6%
Total					3,561.9		
Annual Growth	4.9%					4.8%	
Per Capita Growth	2.6%					2.5%	

*Assumes a social rate of time preference of 5% for the Amazonian TEV calculations.
Sources: IBGE (1970, 1973, 1975, 1978, 1980, 1985, 1986, 1994); IMF (1990, 1996, 1997); Solórzano et al. (1991); *Commodity Trade and Price Trends, 1989–1991*; Commodity Research Bureau (1975, 1984); *World Silver Survey, 1950–1990*; and author's calculations.

roads and processing plants) in the late 1970s, that facilitated access to these minerals and, consequently, hastened deforestation.

With strong global demand for minerals such as iron, aluminum and tin, stock depletion in the mineral sector accelerated. The steady (though gradual) increase in net soil loss was a consequence of the increased deforestation rate in the 1980s and the cumulative erosion processes unleashed in earlier years. Resource depletion as a fraction of GDP was at its highest point in 1986 (at 34.4 per cent), after which a levelling-off and decline in annual deforestation caused this ratio to drop slightly. Brazil's ratio of net resource depletion to GDP was greater in 1993 (32.6 per cent) than in 1965 (30.4 per cent). Hence DADP growth, at 4.8 per cent per annum (2.5 per cent per capita), was less than GDP growth over the same period, albeit only slightly.

SYNTHESIS: CASH-INCOME AND RESOURCE DEPLETION BURDEN WEIGHTS

Methodology

As an indicator of welfare improvement, the fact that per capita DADP grew by 2.5 per cent per annum is potentially misleading in that it assumes 'GDP weights' as defined by A&C — in other words, not accounting for the disparate income growth rates across quintiles. The essence of the aggregation problem in the present context is to make adjustments to Brazilian DADP growth along the lines proposed by A&C. The problem that such an approach confronts, however, is that while A&C could base their calculations on available data on changes in income distribution over time, no such numbers exist for DADP. Hence assumptions are required.

One possibility is simply to allocate DADP among the different quintiles according to their GDP income shares, and then aggregate using the A&C GDP, equal, and poverty weights. As discussed, doing so would imply that the share of the resource depletion burden (RDB) sustained by each income group is directly proportional to the income share of each group. Despite the caveats noted earlier, this is precisely the weighting scheme implicit in the WRI studies. In other words, they do not consider the possibility that the natural resource depletion externalities may have been disproportionately borne by the poorer segments of society. This article addresses this shortcoming by adopting two alternative RDB allocation schemes.

Since no data are available that describe the distribution of this RDB, I consider two alternative scenarios that, while hypothetical, are no less plausible (quite the contrary). In one, termed 'equal weights', the total resource depletion externality is divided into five equal parts that are subtracted from the aggregate income of each quintile. The resulting growth rates for each quintile are then based on the change in income net of the RDB share for each. The second scenario (poverty weights) is calculated the same way, the only difference being that here I assume that the poor suffer the greatest share of the RDB, and distribute it according to the inverse of the GDP weights (analogous to the A&C poverty weights).

In order to avoid confusion, in what follows I distinguish between 'cash-income' weights — $\boldsymbol{w_i}$ in the original A&C model — and 'RDB' weights — the alternative assumptions discussed above. I calculate individual quintile growth rates under each of these three sets of RDB weights, and take weighted sums based on GDP, equal, and poverty cash-income weights. The result is a three-by-three matrix of nine alternative welfare measures. The fact that there are nine distinct outcomes reflects the inherent complexity in quantifying the notion of 'development' or national welfare improvement. Although it is likely that in most cases equal or poverty RDB weights more accurately reflect the true RDB distribution than would GDP RDB weights, this cannot be verified since no data on RDB distribution presently exist. With cash-income weights the situation is even more tenuous since determination of the 'correct' weighting scheme involves an inescapable value judgement.

I should stress that because of the conceptual differences among them, there is absolutely no inconsistency in combining 'different' weighting schemes. In other words, poverty RDB weights, for example, can reasonably be combined with equal or GDP cash-income weights, just as GDP RDB weights can be coupled with equal or poverty cash-income weights. Since the two weighting schemes apply to entirely different aspects of the welfare problem, there is no inconsistency. Cash-income weights refer to the aggregation problem, as they define the relative importance to national welfare of income growth rates of the different quintiles. This is a normative issue, and all three scenarios are presented to demonstrate the effects of different normative stances. The RDB weights, in contrast, refer to the identification problem, since they are used in quantifying the (proxy for) welfare of each quintile. Although the distribution of RDB is in theory an objective matter, three alternative scenarios must be presented in the absence of adequate evidence to resolve it.

Results and Discussion

Table 4 presents nine possible outcomes for the period studied, as well as for each of the individual sub-periods.[8] Note first that per capita depletion-adjusted welfare (DAW) growth in Brazil in the 1965–93 period as a whole is relatively insensitive to changes in the cash-income weights if GDP RDB weights are assumed, varying from 2.5 per cent with GDP cash-income weights to 1.9 per cent with poverty weights (as we would expect; cf. Table 2). Similarly, DAW growth was only moderately affected by changes along the RDB continuum, as long as GDP cash-income weights are used. This is a direct consequence of Brazil's severe income inequality: under GDP cash-income weights, the growth rate of the poorest quintile has minimal effect on the overall growth rate because of its minuscule income share.

8. The individual quintile growth rates on which these results are based and a detailed explanation of the approach that I follow are found in Appendix 2.

Table 4. Per Capita Depletion-Adjusted Welfare, Growth Rates for Select Periods

(a) 1965–1993

	GDP Cash-Income Weights	**Equal Cash-Income Weights**	**Poverty Cash-Income Weights**
GDP RDB Weights	2.5%	2.1%	1.9%
Equal RDB Weights	1.7%	−1.2%	−3.3%
Poverty RDB Weights	1.7%	−2.0%	−4.1%

(b) 1965–1973

	GDP Cash-Income Weights	**Equal Cash-Income Weights**	**Poverty Cash-Income Weights**
GDP RDB Weights	6.5%	5.8%	5.4%
Equal RDB Weights	6.4%	5.3%	0.6%
Poverty RDB Weights	8.0%	12.3%	6.5%

(c) 1973–1982

	GDP Cash-Income Weights	**Equal Cash-Income Weights**	**Poverty Cash-Income Weights**
GDP RDB Weights	1.4%	2.2%	2.9%
Equal RDB Weights	0.2%	−4.8%	−7.1%
Poverty RDB Weights	1.6%	−0.0%	−2.7%

(d) 1982–1993

	GDP Cash-Income Weights	**Equal Cash-Income Weights**	**Poverty Cash-Income Weights**
GDP RDB Weights	0.4%	−0.7%	−1.3%
Equal RDB Weights	−0.4%	−3.4%	−3.5%
Poverty RDB Weights	−0.1%	−3.2%	−3.7%

The differences among the DAW growth measures are more stark, however, when we assume either equal or poverty weights for both cash-income *and* RDB. Equal or poverty RDB weights dramatically lower the growth rates for the poorest quintiles, and equal or poverty cash-income weights result in a heavier weighting of these in the determination of DAW growth. Assuming GDP weights for neither cash-income nor RDB (that is, looking at the two-by-two 'sub-matrix' on the lower right), Brazil's welfare growth in the period as a whole was negative. These outcomes are driven by large negative income growth rates for the poorest and second-poorest quintiles under either equal or poverty RDB weights.

Turning to the distinct sub-periods, we find that in 1965–73, from the beginning of the economic miracle until the first oil crisis, welfare improved irrespective of the measure used. Not only was GDP growth especially rapid over these eight years, resource depletion as a fraction of GDP diminished. The countervailing effect of worsening inequality is therefore quite minimal.[9]

The following nine years (1973–82) appear more similar to the period as a whole, although there are notable differences. First, the fact that DAW growth increases along the GDP RDB continuum as we move from GDP to poverty cash-income weights reflects the improvement in income distribution during this sub-period (also seen in Table 2). But under alternative RDB weights it is evident that the effect of the accelerated resource depletion overwhelms the inequality-reducing effect, as DAW growth rates are again strongly negative in our sub-matrix on the lower right.

For the final sub-period, spanning 1982–93, only annual growth rates for the wealthiest quintile are positive (though less than 2 per cent), irrespective of the RDB weighting scheme. Consequently, only when assuming GDP weights for *both* cash-income and RDB is DAW growth positive, and only barely (0.4 per cent). Annual DAW growth in the other eight scenarios is negative — again most strongly so in our sub-matrix — making the final sub-period the one in which national welfare most unambiguously diminished. The lack-lustre performance was undoubtedly due to other economic factors not considered in this study, mostly stemming from Brazil's debt crisis during the 1980s. Nevertheless, the shortfall between per capita GDP growth (0.5 per cent) and DAW growth (negative, often strongly so) is symptomatic of the important role played by worsening inequality and resource depletion in reducing national welfare during the 1982–93 sub-period.

SUMMARY AND CONCLUDING REMARKS

This study has sought to provide new insight into both the definition and measurement of economic development, or social welfare improvement. The indicator derived here addresses the identification problem in a manner similar to the WRI studies, and the aggregation problem along the lines proposed by Ahluwalia and Chenery. Furthermore, it accounts for the distribution of resource depletion burden (RDB), unlike the WRI studies which implicitly assume it is allocated according to income shares. A welfare measure that considers both equity and resource depletion is particularly important for Brazil, a country that has suffered losses in both areas despite — or perhaps because of — rapid GDP growth.

9. The exceptional cases (where DAW growth was 0.6 and 12.3 per cent for the sub-period) are due to anomalous growth rates for the second-poorest quintile under both equal and poverty RDB weights.

The results vary considerably depending on the combination of weighting schemes chosen. Four of the nine estimates suggest a worsening of welfare at the national level from 1965 to 1993. While the other five outcomes imply national welfare improvements, these are based on either one (or both) of two questionable assumptions. One is the claim that the wealthier groups are disproportionately affected by the resource depletion (which is reflected in the use of what I have termed GDP RDB weights). While empirical evidence, either to prove or disprove this thesis, is presently unavailable, the prevailing wisdom in the literature is that if any group suffers a greater amount from resource depletion activity it is likely to be the poor. Second is the normative judgement that the income growth of the wealthy is more socially important than that of the poor (GDP cash-income weights). While staunch 'trickle-down' advocates may hold such a view, they are likely to be in the minority on this issue.

Even if we allowed for such assumptions, and therefore the possibility that economic development was present at the national level, such 'development' unambiguously made certain segments of the population worse off over time. Except under unrealistic GDP RDB weights, per capita welfare diminished for the poorest 40 per cent of the population from 1965 to 1993. I therefore conclude that national welfare decreased from 1965 to 1993, at a rate of anywhere from 1.2 per cent to 4.1 per cent per annum.

The results imply the need for substantive reform. Public policy that is guided by flawed objectives — such as achieving rapid GDP growth — is likely to render deficient outcomes. A vivid example of this is the 'expansionary' policy followed by successive military regimes in Brazil, a policy that encouraged deforestation through ranching, mining, and large-scale agriculture while disregarding the consequences for the poorer segments of society and future generations of Brazilians. The findings of this study suggest that Brazilian economic policy (and, by extension, similar policies elsewhere) ought to be redefined to account for environmental and distributional objectives.

While a useful starting point, the results of this or other similar studies could be enhanced through further research in any of at least three areas. First, information on the actual distribution of RDB would be useful. Though difficult to measure precisely, empirically based estimates would be preferable to the hypothetical weights assigned here. Second, efforts should continue toward a more comprehensive assessment of environmental externalities. Not only were just three types of natural resources considered, but other externalities such as air and water pollution were disregarded.

Finally, the approach to welfare measurement adopted in this paper adjusts GDP only for income distribution, resource depletion, and the interaction between the two. I have not attempted further adjustments for non-income, non-environmental aspects of welfare change, such as access to health care and education. As mentioned in the introduction, there have been important efforts in this direction in recent years, and the present work could be further extended by incorporating these dimensions in a broader welfare measure. In theory, it is conceivable that the incorporation of further elements would move the resulting welfare measure back toward conventionally-measured GDP, but there is no compelling reason to believe that this would be the case. On the contrary, given the links among income distribution, environmental degradation, and other dimensions of human welfare, there can be little doubt that the welfare improvement indicator developed here represents a major improvement over per capita GDP growth.

After a brief respite during the late 1980s and the early 1990s, the deforestation rate in Brazil is presently at its highest rate ever (INPE, 1998). Furthermore, Brazilian government policies in recent years have allowed more frequent challenges to the land rights of indigenous groups and small farmers. In light of these events, the welfare measurement framework developed in this paper is all the more relevant. Such an alternative to GDP growth would give policy-makers and the public alike greater insight into whether, and to what extent, their countries are successfully developing.

APPENDIX 1

The GDP figures used in the analysis are taken from the IMF's *International Financial Statistics Yearbooks*, and the income distribution data are from Deininger and Squire (1996) and Villela (1992). Data on the physical losses in the Brazilian forestry and mineral sectors, as well as the unit values for commercial wood, are obtained from the annual statistical yearbook of the Brazilian Institute for Geography and Statistics (IBGE). Mineral prices are taken from *Commodity Trade and Price Trends 1989–1991*, the *Commodity Yearbook*, and the *World Silver Survey, 1950–1990*. Physical losses in the soil sector are inferred from the IBGE's agricultural censuses and Serôa da Motta and May (1992). The fertilizer prices used in evaluating the soil value (by the replacement value method) are taken from Solórzano et al. (1991).

In addition, I account here for natural resource values other than those associated with the 'marketable' benefits of the resource (i.e., those associated with revenue flows), at least in this respect making the resource valuation more comprehensive than either the WRI studies or related work of my own (Torras, 1999). Specifically, I estimate the *total economic value* (TEV) of a representative hectare of Brazilian Amazon forest, a notion that encompasses not only marketable values but also a host of ecological benefits that the Amazon forest delivers (such as nutrient cycling, climate regulation), as well as option and existence value estimates. The values of these 'non-market' benefits are estimated by a variety of techniques such as hedonic regression, damage avoidance, travel cost estimation, and contingent valuation. Because the resources and time required for a full TEV accounting of the entire Amazon forest are formidable, I base my estimates on figures from numerous other studies, most of which are conducted on geographical areas other than the Brazilian Amazon. My rationale for doing so is that many of these are studies based on other tropical forest areas, so that the relevant values are likely to be comparable. For more details, and for a full list of the works from which data for this portion of the analysis were obtained, see Torras (2000). Also, for more on the TEV methodology, see Groombridge (1992) and Pearce (1991). Finally, as the Brazilian Amazon comprises nine states, only the marketable values for the other eighteen states are measured here.

The data are, of course, imperfect. For example, natural resource loss is impossible to measure precisely, and simplifying assumptions (such as uniformity of mineral quality or soil type) potentially misrepresent the values. Moreover, as with any such study, it is difficult to reflect accurately the presumed rise in unit resource values as resource depletion continues, due to increased scarcity. Furthermore, the social cost of soil erosion may be significantly understated by the replacement cost technique, which considers only lost nutrients and not, for example, soil water retention capacity. Because most of the soil in Brazil's tropical forests is of relatively low fertility, its fertilizer equivalent is relatively small.

APPENDIX 2

Table A.2. Individual Quintile Growth Rates

(a) 1965–1993

	Per Capita GDP (1995 Reais)		Per Capita Resource Depletion Adjustments: GDP RDB Weights		Per Capita Resource Depletion Adjustments: Equal RDB Weights		Per Capita Resource Depletion Adjustments: Poverty RDB Weights		Individual Quintile Growth Rates 1965–1993		
	1965	**1993**	**1965**	**1993**	**1965**	**1993**	**1965**	**1993**	**GDP RDB Weights**	**Equal RDB Weights**	**Poverty RDB Weights**
Poorest Quintile	221.6	392.9	67.3	127.9	585.6	1279.5	1859.3	4369.4	1.9%	−3.2%	−3.2%
Second Quintile	539.6	923.2	164.0	300.7	585.6	1279.5	535.8	1049.2	1.8%	−7.6%	−13.4%
Third Quintile	992.5	1689.3	301.6	550.2	585.6	1279.5	301.6	550.2	1.8%	0.0%	1.8%
Fourth Quintile	1763.4	3221.5	535.8	1049.2	585.6	1279.5	164.0	300.7	2.1%	1.8%	2.2%
Richest Quintile	6119.0	13416.2	1859.3	4369.4	585.6	1279.5	67.3	127.9	2.7%	2.8%	2.8%

(b) 1965–1973

	Per Capita GDP (1995 Reais)		Per Capita Resource Depletion Adjustments: GDP RDB Weights		Per Capita Resource Depletion Adjustments: Equal RDB Weights		Per Capita Resource Depletion Adjustments: Poverty RDB Weights		Individual Quintile Growth Rates 1965–1973		
	1965	**1973**	**1965**	**1973**	**1965**	**1973**	**1965**	**1973**	**GDP RDB Weights**	**Equal RDB Weights**	**Poverty RDB Weights**
Poorest Quintile	221.6	317.9	67.3	84.4	585.6	803.8	1859.3	2644.5	5.3%	−3.7%	−4.5%
Second Quintile	539.6	787.1	164.0	209.0	585.6	803.8	535.8	695.3	5.5%	12.0%	48.9%
Third Quintile	992.5	1453.2	301.6	385.8	585.6	803.8	301.6	385.8	5.6%	6.0%	5.6%
Fourth Quintile	1763.4	2618.7	535.8	695.3	585.6	803.8	164.0	209.0	5.8%	5.6%	5.3%
Richest Quintile	6119.0	9960.2	1859.3	2644.5	585.6	803.8	67.3	84.4	7.0%	6.5%	6.3%

(c) 1973–1982

	Per Capita GDP (1995 Reais)		Per Capita Resource Depletion Adjustments: GDP RDB Weights		Per Capita Resource Depletion Adjustments: Equal RDB Weights		Per Capita Resource Depletion Adjustments: Poverty RDB Weights		Individual Quintile Growth Rates 1973–1982		
	1973	**1982**	**1973**	**1982**	**1973**	**1982**	**1973**	**1982**	**GDP RDB Weights**	**Equal RDB Weights**	**Poverty RDB Weights**
Poorest Quintile	317.9	422.3	84.4	144.8	803.8	1182.0	2644.5	3720.3	3.2%	−4.6%	−3.8%
Second Quintile	787.1	1003.1	209.0	336.9	803.8	1182.0	695.3	1087.4	2.5%	−25.2%	−3.3%
Third Quintile	1453.2	1882.9	385.8	620.5	803.8	1182.0	385.8	620.5	2.4%	1.8%	2.4%
Fourth Quintile	2618.7	3273.2	695.3	1087.4	803.8	1182.0	209.0	336.9	2.1%	2.3%	2.7%
Richest Quintile	9960.2	11016.1	2644.5	3720.3	803.8	1182.0	84.4	144.8	0.9%	1.5%	1.7%

(d) 1982–1993

	Per Capita GDP (1995 Reais)		Per Capita Resource Depletion Adjustments: GDP RDB Weights		Per Capita Resource Depletion Adjustments: Equal RDB Weights		Per Capita Resource Depletion Adjustments: Poverty RDB Weights		Individual Quintile Growth Rates 1982–1993		
	1982	1993	1982	1993	1982	1993	1982	1993	GDP RDB Weights	Equal RDB Weights	Poverty RDB Weights
Poorest Quintile	422.3	392.9	144.8	127.9	1182.0	1279.5	3720.3	4369.4	−1.4%	−1.8%	−1.8%
Second Quintile	1003.1	923.2	336.9	300.7	1182.0	1279.5	1087.4	1049.2	−1.3%	−10.0%	−13.7%
Third Quintile	1882.9	1689.3	620.5	550.2	1182.0	1279.5	620.5	550.2	−1.4%	−5.5%	−1.4%
Fourth Quintile	3273.2	3221.5	1087.4	1049.2	1182.0	1279.5	336.9	300.7	−0.6%	−1.2%	−0.5%
Richest Quintile	11016.1	13416.2	3720.3	4369.4	1182.0	1279.5	144.8	127.9	1.2%	1.3%	1.3%

Notes:

RDB refers to the deduction taken from the quintile share of GDP for the corresponding share of social cost incurred. The individual quintile growth rates are calculated for each time period and are based on the difference between GDP and RDB for the beginning and end year. For example, the growth rate for the richest quintile between 1982 and 1993 assuming poverty RDB weights is:

$$\left(\frac{13416.2 - 127.9}{11016.1 - 144.8}\right)^{\frac{1}{(1993-82)}} - 1 = 1.3\%$$

Calculation of the figures presented in Table 4 come from the quintile growth rates in Table A2. The numbers appearing in Table 2 can be reproduced by calculating the quintile GDP growth rates from the first two columns of Table A2a–d and applying equations 1, 2, and 3 from the text.

Table 4 Calculations
(numbers for 1965–93 period)

GDP RDB weights, GDP cash-income weights:
1.9 (.022) + 1.8 (.052) + 1.8 (.095) + 2.1 (.174) + 2.7 (.659) = + 2.5%
GDP RDB weights, equal cash-income weights:
1.9 (.2) + 1.8 (.2) + 1.8 (.2) + 2.1 (.2) + 2.7 (.2) = + 2.1%
GDP RDB weights, poverty cash-income weights:
1.9 (.659) + 1.8 (.174) + 1.8 (.095) + 2.1 (.052) + 2.7 (.022) = + 1.9%
Equal RDB weights, GDP cash-income weights:
– 3.2 (.022) – 7.6 (.052) + 0.0 (.095) + 1.8 (.174) + 2.8 (.659) = + 1.7%
Equal RDB weights, equal cash-income weights:
– 3.2 (.2) – 7.6 (.2) + 0.0 (.2) + 1.8 (.2) + 2.8 (.2) = – 1.2%
Equal RDB weights, poverty cash-income weights:
– 3.2 (.659) – 7.6 (.174) + 0.0 (.095) + 1.8 (.052) + 2.8 (.022) = – 3.3%
Poverty RDB weights, GDP cash-income weights:
– 3.2 (.022) – 13.4 (.052) + 1.8 (.095) + 2.2 (.174) + 2.8 (.659) = + 1.7%
Poverty RDB weights, equal cash-income weights:
– 3.2 (.2) – 13.4 (.2) + 1.8 (.2) + 2.2 (.2) + 2.8 (.2) = – 2.0%
Poverty RDB weights, poverty cash-income weights:
– 3.2 (.659) – 13.4 (.174) + 1.8 (.095) + 2.2 (.052) + 2.8 (.022) = – 4.1%

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