IMPACTS OF GREENHOUSE GAS EMISSION REDUCTION POLICIES ON INCOME INEQUALITY IN BRAZIL

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Abstract

The introduction of a tax on GHG emissions enables the agents involved to become aware of the real costs of economic activities. In the absence of such tax, these activities generate negative externalities, a market failure that imposes costs on others, including future generations. Developing countries have increasingly contributed to climate change, and emissions mitigation policies are therefore also required in these economies. Among the priorities in their political agendas, however, are the reduction of income concentration and poverty eradication. Climate policies should therefore be implemented without interfering with such social goals. The present study uses a Social Accounting Matrix for Brazil in 2005 to analyze the impact of implementing a charge per ton of CO_2e emitted on income distribution in Brazil. The results differ as much in relation to the tax applied as to the means whereby the revenue thus raised is reinserted in the economy. Two option paths are simulated: direct transfer to low income families and exemption from labor taxes. As complementary results, impacts on GDP, on employment levels and on GHG emissions are also analyzed.

1. Introduction

Developing countries currently do not have formal commitments to reduce GHG emissions. However some countries, such as China, India and Brazil, already contribute significantly to the higher concentration of these gases in the atmosphere and, given their patterns of economic and demographic growth, the trend is worsening. These countries have experienced increasing pressures to commit to efforts to reduce GHG emissions (Timilsina & Shresta, 2002; González, 2012).

The reduction of GHG emissions in developing countries involves distinct peculiarities. In addition to the commitment to economic activity and competitiveness (see Aldy & Pizer, 2009 and Heil & Sender, 2001) issues arise related to the reduction of income inequality and poverty eradication, priority goals in the political agendas of these countries. González (2012) emphasizes that the different impacts which environmental policies can generate on income classes deserve to be treated with special attention, since the lower income classes tend to live in extreme poverty.

The reduction of GHG emissions is of undeniable interest for developing countries, quite apart from the co-benefits which it brings, among them the reduction of local air pollutants (e.g. SO_2 and NO_x), increased energy security and the incentive to development of alternative energy sources (Shrestha & Pradhan, 2010). It is estimated that the worst effects of climate change will fall precisely on the poor, since they are the most vulnerable to extreme weather events and have the least capacity to adapt. Moreover, many of these countries depend on agricultural activities, whose productivity can be severely jeopardized.

In the case of Brazil, it would be interesting to curb the effects of climate change for several reasons. The biodiversity of the Amazon biome is shown to be irreversibly imperiled in the most extreme global warming scenarios. Moreover, it is estimated that the most severe impacts will be in the North and Northeast regions, precisely the poorest in the country, contributing to the worsening of social disparities (Margulis, Dubeux and Marcovitch, 2010).

In 2009, during the 15th Conference of the Parties to the United Nations (COP-15), Brazil announced its voluntary commitment to reducing its GHG emissions. The goal presented was a reduction of 36.1% to 38.9% of projected emissions by 2020 and was reinforced by the National Policy on Climate Change (PNMC[1]). The emission reduction was to be achieved by combating deforestation in the Amazon and Cerrado biomes, by the recovery of pastures, crop-livestock integration, zero tillage farming, nitrogen fixation, and through energy efficiency measures, such as increased use of biofuels and expansion of hydro power plants and renewable energy sources, amongst others.

Efforts to mitigate GHG emissions should not, however, be given priority over the goal of improving the living conditions of the population. Brazil is among the countries that have the highest levels of income concentration. In 2006, the share of total income appropriated by the richest 1% portion of the population was equal to that received by the poorest 50% (Barros *et al*, 2006a).

Nevertheless, Brazil has experienced a continuous and accelerating fall in levels of income concentration. Between 2001 and 2004, the Gini coefficient fell by 4% from 0.593 to 0.569. It is estimated that approximately 5 million people have been taken out of the condition of extreme poverty. To achieve this without changing levels of income distribution would require an economic growth of 6% p.a. (Barros *et al*, 2006a).

The main reason for the recent drop in the concentration of income in the country lies in increased government transfers to families, both in coverage and in amount. Pensions and retirement benefits feature prominently, as well as the Continuous Cash Benefit (BPC) and the Bolsa Familia, together with other similar income transfer programs, which together represent 90% of total public transfers.

As the efforts to mitigate GHG emissions in Brazil take shape, so does the debate over their effect on income distribution in the country. The process still needs careful analysis, since harmonization of the objectives of both policies is highly desirable.

With this in mind, it is the aim of this work to develop a model which allows the evaluation of the impact of GHG emission mitigation policies on Brazilian income distribution. A complementary analysis will examine the effect on the level of output, on employment and on emissions.

The introduction of a carbon tax on emissions from productive sectors of the economy is simulated. The income earned by the measure can be recycled in various

[1] Acronym in Portuguese.

ways, such as by direct transfer to lower income class families or via exemption from labor taxes.

The chosen methodology involves the development of a Social Accounting Matrix (SAM) for Brazil with 2005 as the base year. The choice of this base year is justified by the availability of data regarding both the National Accounts, as well as GHG emissions for Brazil. The productive sectors are divided into 8 (Agriculture and Livestock, Forestry, Industrial, Energy-Electricity, Energy-Others, Transportation, Services and Waste) and households are broken into 10 different income classes. The SAM structure also includes three factors (labor, capital and land), other entities (government, business and the rest of the world), apart from the capital accumulation and savings account. The matrix is further enhanced with the total of GHG emissions for each sector (Brasil, 2010; La Rovere *et al*, 2013) thus allowing the simulation of a carbon tax.

The hypothesis teis sted that inequality levels, GDP, employment and emissions are all affected, though in distinct forms, both by the level of the carbon tax as well as by the method of reinsertion of the revenues into the economy.

Section 2 presents a general framework of carbon taxes as a way to mitigate GHG emissions. Section 3 presents the fundamentals of the input-output analysis and the means by which the model was constructed for this study, including the breakdown of households by income. Section 4 describes the simulations and section 5 presents and discusses the main results. Finally, section 6 presents the conclusions and limitations of the study.

2. Carbon taxes and their distributional effects in developing countries

Carbon taxes are a fixed price to be paid for a certain amount of CO_2, or CO_2e, emitted due to anthropogenic activities (Rich, 2004). The purpose of a carbon tax is to internalize the externalities associated with climate change caused by anthropogenic activities. In the absence of such a tax, individuals are faced with price distortions. This happens because economic activities emitting GHGs are relatively inexpensive, since they do not take into account the costs imposed on others, including future generations. The implementation of a carbon tax leads individuals to fully consider the consequences of GHG emissions (Metcalf and Weisbach, 2009)[2]. Carbon taxes generally have a regressive character. Since lower income group families generally spend a higher proportion of their income on energy and natural resources than higher income class families, the implementation of a carbon tax usually burdens the former more than the latter. (Baranzini, 1997; Baranzini et al, 2000; Callan et al, 2009).

It is possible to avoid negative effects of carbon taxation through some alternatives. Reducing or exempting the rate for vulnerable groups, as already occurs with other taxes such as on electricity, or compensating them are some options. Another alternative would be to impose the tax only after a certain level, ensuring that resources required to meet the basic needs of the population remain exempt from taxation (Speck, 1999; Baranzini *et al*, 2000)[3].

The income earned through the tax could also be used to mitigate the undesirable effects. The way the tax revenue is recycled in the economy determines whether its

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[2] In addition to carbon taxes, there are other climate policy instruments, such as cap-and-trade, and command-and-control systems of pollution standards for example. It was felt, however, that carbon taxes are the most appropriate tool for the analysis undertaken in this paper.

[3] Baranzini *et al* (2000) point to the possible existence of high administrative costs.

effect will be regressive, progressive, or neutral (West and Williams, 2004; Heutel Fullerton, 2007; Metcalf, 2009; González, 2012).

Some of the options for using the revenue earned from carbon taxes include its allocation for the relief of existing and naturally distorting taxes on labor and on income, or for the improvement of the social security system (Speck, 1999). Baranzini *et al* (2000) point out that this type of measure has a peculiarity in developing countries. Since the poorest sectors of the population, due to the magnitude of the informal sector, are often not included in institutional, legal and tax systems, they may well fail to be included in compensation programs.

Another form of recycling, often found in the literature, is in the form of government transfers to households, as proposed in Timilsina & Shresta (2002). The revenue collected from the tax is directly distributed to the population, allocated either following certain criteria or equally to all. Poorer class families would receive an amount proportionately larger to their income than higher income class families.

This type of option makes clear the existence of the possibility of the so-called double dividend: environmental policies generate revenues that can be used to cover expenses previously funded from other sources. They make it possible to transfer the encumbrance away from positive factors, such as capital and labor, and onto undesirable factors, in this case pollution and depletion of natural resources (Seroa da Motta, 2006; Baranzini *et al*, 2000). This allows a more intensive use of such factors as labor and capital, thereby generating improvements in such aspects as levels of output and employment.

Hourcade (1996 in Baranzini *et al*, 2000) registers the possibility of an environmental double dividend: the reduction of GHG emissions can result in a reduction in emissions of local pollutants. Van Heerden *et al* (2006) and Wrinkler & Marquard (2011) already suggest the possibility of obtaining a “triple dividend”, in which the recycling of the tax contributes to a reduction in the levels of inequality.

Literature on distributional effects of carbon taxes in developed countries is somewhat consolidated. However, results found in these studies cannot be easily replicated in developing countries, for which research is still incipient. There are considerable differences with regard to the means of transport used, heating, industrial goods consumed and the use of biofuels. In Brazil there is additionally the magnitude of the informal sector and the amount of emissions from agriculture and land use in general. To a brief overview of the impact of carbon taxation on income distribution in developing countries see Brenner *et al* (2007), González (2012), Timilsina & Shresta (2002), Timilsina & Chen (2012), Van Heerden *et al* (2006), Fisher-Vanden *et al* (1997), Shah & Larsen (1992) and Jensen & Tarr (2002).

3. The Social Accounting Matrix

This work uses an input-output framework to assess the effect of carbon taxes on income inequality and other aspects. For an introduction to the generalised input-output theory see Leontief & Ford (1970), Heredeen (1978) and Miller & Blair (2009).

Since one of the goals of this study is to examine the recycling of the revenue raised by charging for carbon emissions, a more extensive matrix than the Input-Output Matrix (IOM) will be required. The SAM developed for this study fulfills this role well because it supplements IOM data with Integrated Economic Accounts (CEI[4]) data, such as the income of the factors capital, labor and land, and family entities, government, business and the rest of the world, apart from the capital accumulation account. For further information on social accounting matrices, see STONE *et al* (1962) and Miller & Blair (2009).

The SAM was developed from the environmental input-output matrix for Brazil in 2005, which was itself based on the aggregation of the sectors and initial products of the economy into eight in number, namely: Agriculture and Livestock, Forestry, Energy-Electricity, Energy-Others, Industry, Transportation, Services and Waste. The aim of this aggregation was to allow the reconciliation of national accounts monetary flows with GHG emissions data available in La Rovere *et al* (2013) and Brasil (2010).

The 'Agriculture and Livestock' sector includes the products of agriculture and livestock. The 'Forestry' sector covers the products of the timber industry and forestry. The 'Energy - Others' sector includes primary and secondary sources of energy other than electricity, which was treated as a separate sector. The 'Industrial' sector comprises all the activities of the Brazilian industry including mining, manufacturing, process industries, food and beverages, textiles, pulp and paper, cement and chemicals, among others. The 'Energy-Electricity' sector comprises activities related to the generation, distribution and transmission of electricity in the country. The 'Transportation' sector covers activities related to the transport of passengers and cargo. The 'Services' sector comprises all activities related to construction, commerce, rental, education, healthcare, and financial services, among others. Finally, the 'Waste' sector is comprised of activities related to sewage and urban cleaning.

The framework is complemented with data for three productive factors (labor, capital and land) and the accounts for enterprises, government, rest of the world and

[4] Acronym in Portuguese.

households, which is split into 10 different income classes. Finally, data for the capital accumulation account contains the savings of the various institutional sectors.

3.2 The breakdown of households by income groups

To analyze the impact of environmental policies on income distribution, a finer detailing of the household sector is required. To this aim, information was drawn from the Household Budget Survey 2002-2003 (IBGE, 2004), which allows the breakdown of this sector into 10 different income brackets.

Income groups are determined starting from the number of minimum wages[5] received by the consumption unit, with the lowest income class receiving from zero to 2 minimum wages, and the highest more than 30 minimum wages:

The breakdown was achieved as follows:

$$\mu_{c,i} = (Q_{c,i} * F_c) / \Sigma (Q_{c,i} * F_c) \qquad (1)$$

Where:

$\mu_{c,i}$ represents the share of class *c* in the total expenditure/income with item *i* in percentage terms

$Q_{c,i}$ represents the total spent or received by the family in class *c* with item *i*
F_c represents the number of families belonging to the class *c*

and $\Sigma (Q_{c,i} * F_c)$ represents the sum of the total spent or received by all households in the economy with item *i*.

POF[6] 2002-03 domestic expenditure and food acquisition tables were used to break down the expenditures of households on goods and services, taxes, transfers and

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[5] The value used is R$200.00 (two hundred Reais), the rate in effect on January 15, 2003, reference date of the research.

[6] The Family Budget Research (POF).

social contributions. Household income from labor, capital and transfers was likewise broken down with the aid of the POF 2002-03 income table.

The difference between total income and total expenditure shows that the only classes whose income exceeded expenditure were the three highest placed in the income table[7]. The total saving of SAM households was therefore apportioned so that the seven lower income level classes should present negative savings and the three the highest income level classes should present positive savings.

[7] In the 2002-2003 POF, 85.3% of the families with the lowest incomes had, on average, expenditure in excess monthly receipts. 68.4% with the lowest incomes were already in this situation in 2008-2009. Source: IBGE (2010b).

4. Carbon Tax Impacts

4.1 Analysis of total GHG emissions in economic activities

The SAM developed for Brazil in 2005 was updated in accordance with data extracted from La Rovere *et al* (2013) and Brasil (2010) (see Table 1) to show estimated total GHG emissions for the eight productive sectors of the Brazilian economy.

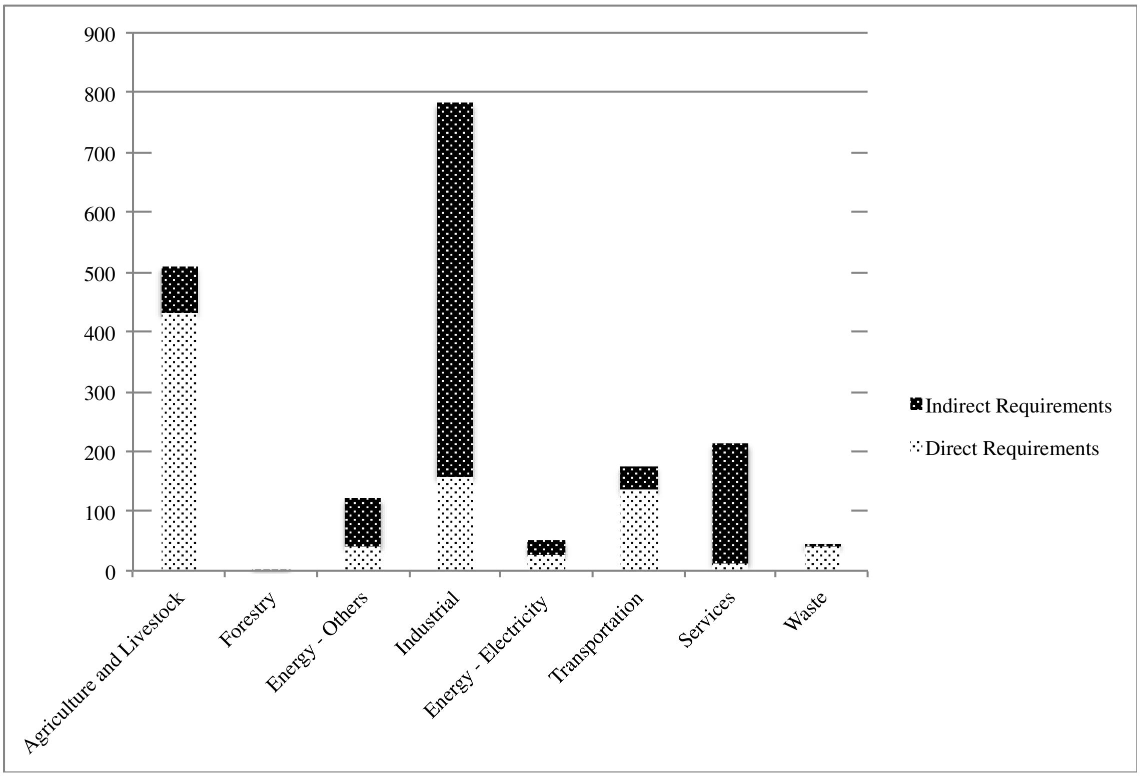
Table **1 - GHG emissions estimated for the productive sectors of the Brazilian economy in 2005**

Activity Sector	Emissions (in Mt CO2e)
Agriculture and Livestock	431
Forestry	1329
Energy - Others	42
Industrial	157
Energy - Electricity	28
Transportation	135
Services	13
Waste	41

Source: The authors, based on La Rovere *et al* (2013) and Brasil (2010).

The calculation of the direct and indirect emission requirements for the productive sectors of the economy, which arose from the environmental 2005 input-output matrix for Brazil, enables the checking of the emissions profile associated with each activity.

Figure 1 – Direct and indirect carbon emissions requirements by sector (Mt CO_2e)



Source: The authors

The 'Agriculture and Livestock' sector has a high level of direct requirements, especially related to the use of land for grazing and agriculture, methane emission by livestock and fertilizer use, well above the indirect requirements, linked to energy use in these activities

The 'Industrial' sector, in turn, has a low level of direct requirements, and a fairly high level of indirect requirements. These results are partially related to the fact that this sector comprises the transformation, manufacturing, and food processing industries, among others, all responsible for indirect emissions. Moreover, the sector also includes industrial polluting activities such as cement production, which contributes to the direct requirements of the sector.

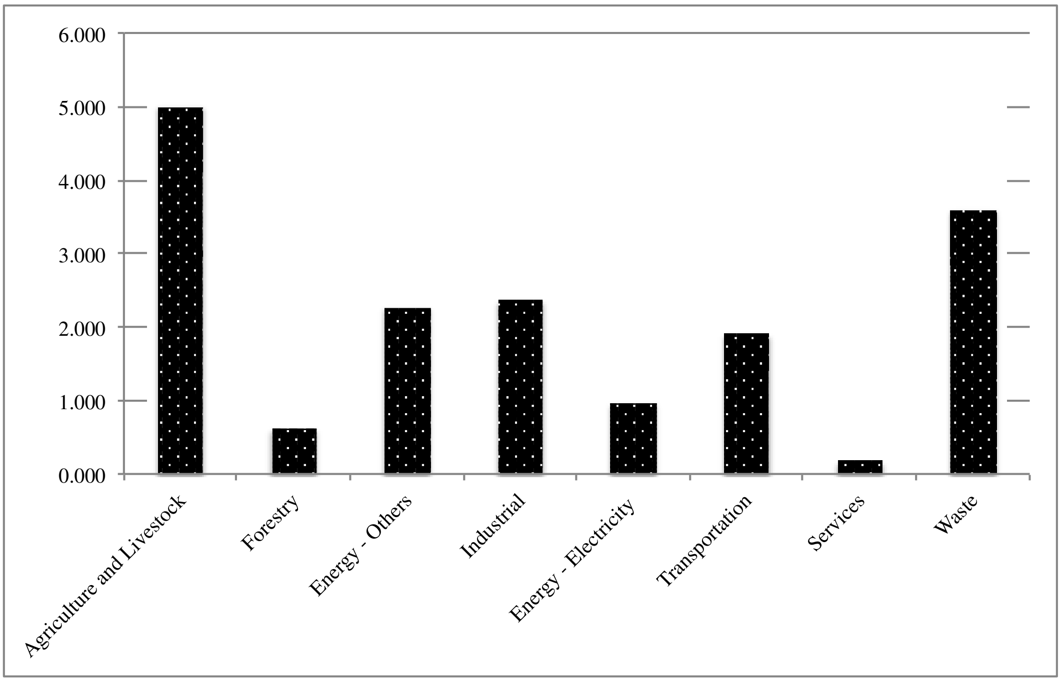
As the Brazilian energy matrix is primarily composed of renewable energy arising from hydroelectricity, the requirements both direct and indirect of the 'Energy-Electricity' sector are very low.

The 'Services' sector essentially uses inputs from other sectors to generate output, having therefore a high degree of indirect requirements, but requiring virtually no direct emissions in its activities.

Direct emissions related to the 'Forestry' sector were 1,329 $MtCO_2e$. However, since these are the result of essentially illegal activities they can hardly be included in economic policies to mitigate emissions[8]. These emissions were therefore considered nil in the environmental input-output matrix. The 'Forestry' sector has therefore only been burdened with its indirect emissions, which are minor.

The carbon intensity of the sectors corresponds to the CO_2e content embedded in one monetary unit of the product of each sector. Its calculation provides interesting results, because the coefficient varies widely for different sectors and gives an indication of how much these would be taxed should a charge per ton of CO_2e emitted be implemented.

Figure 2 – Carbon intensity (in Mt CO_2e/1000 R$) by sector



Source: The authors

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[8] There are effective economic policies to combat illegal logging, such as payment for environmental services and agricultural credit policies (see ASSUNÇÃO *et al*, 2013). However these policies do not apply to the model used.

The 'Agriculture and Livestock' and 'Waste' sectors are those with the highest carbon intensities and at levels much higher than observed in other sectors. This is due to the fact that these activities, apart from being highly polluting, have low Value Added. The opposite occurs with the 'Services' sector, which, despite having considerable emissions requirements, presents high Value Added, which contributes to reduce its coefficient.

4.2 Simulations

The imposition of a tax per ton of CO_2e emitted by productive sectors was simulated using the SAM developed for Brazil in 2005. The rates used were R$25 per ton of CO_2e emitted and R$50 per ton of CO_2e emitted.

It should be noted that the emissions attributed to the productive 'Forestry' sector are mostly the result of illicit activities related to deforestation. The collection of payment for the ton of CO_2e emitted would, in this case, be inoperative since both monitoring and verification are *a priori* compromised. It is assumed that in the case of illegal deforestation the reduction of emissions should be sought through the use of command and control mechanisms designed to ensure the applicability of standards. For this reason, it was decided not to charge the direct emissions related to this sector.

4.2.1 The model of the SAM multipliers for Brazil in 2005

The multiplier model used was extracted from Tourinho *et al* (2006). Generally, the use of multipliers in input-output analysis requires the prior definition of which variables are determined by the model and which are exogenous to it. It is common to 'close' the model with regard to households, a component that initially belongs to Final Demand, and with regard to the respective factors, in order to allow its income to be treated as an endogenously determined variable (Thorbecke , 2000).

The accounts corresponding to the 8 productive sectors, to the 10 different household classes, and to the “Capital” and “Labor” sectors were thus considered as endogenous. It was decided to treat these factors as endogenous since they are considered to be held by the households. The factor “Land”, enterprises, government, the rest of the world, and the capital accumulation and savings accounts were considered as exogenous to the model.

4.2.2 Simulation of the imposition of the carbon tax in the model

Let *t* be the carbon tax (R$/t CO_2e) applied to the productive sectors and C the amount of CO_2e (Mt) emitted by each productive sector. The expression $T_j = t*C_j$ determines by how much each sector should be charged according to the tax per ton of carbon emitted. The sum $\sum_j T_j$ represents the total tax collected by the government in millions.

However, it was decided to rate the activities not in accordance with their direct GHG emissions, but in terms of total GHG emissions, i.e. direct and indirect.

Let R_j be the total requirements of GHG emissions of the production sector j.

$r_j = R_j / \sum_j R_j$ corresponds to the proportion of the total requirements of the economy attributed to sector i.

This coefficient is used to weight how each sector should effectively pay for their emissions, i.e.

$$T_j' = r_j * T_j \qquad (7)$$

It is noted that $\sum_j T_j = \sum_j T'_j$.

The ratio T'_j / Y_j represents the proportion of the amount paid by sector j relative to its total production.

The expression $E_j = [1 - (T'_j / Y_j)]$ determines the reduction in the total output of production sector j due to the imposition of the carbon tax. There is thus a vector-column (8x8) E, containing all the coefficients E_j, which is used to pre-multiply the technical coefficients matrix (A_n), which affects directly the interdependency coefficients matrix (Ma). This procedure generates a new level of final demand and consequently of total production.

The difference between the new total output (Y_t) and the total original output (Y) determines how much each variable is affected by the imposition of the tax on emissions. Since it is intended to simulate an increase in taxes and, therefore, on the total output of the economy, this value can be added to the original production[9]:

4.2.3 Impact of carbon tax on the Value Added, employment, GHG emissions and income inequality

As described in the previous section, the imposition of a carbon tax alters the An matrix and consequently the Ma matrix, which becomes Ma_{ij}.

Let VA_j be the Value Added of sector j, Y_{jf} the value of the total output of industry j after applying the tax and Ma_{ij}' the transposition of matrix $Ma_{ij;}$

$m(h)_{ij} = VA_j/Y_{jf} * Ma_{ij}'$ then represents the variation of the Value Added of sector i in function of the taxation of the sector j.

The sum $\Sigma\ m(h)_{ij}$ equals the total impact of taxing the Value Added of sector i.

The same procedure was used to check the impact of the carbon tax on the level of employment (L_j) and on GHG (C_j) emissions.

The variable chosen to measure the impacts of mitigation policies on income inequality was the Gini coefficient, which varies from 0 to 1. A Gini coefficient equal to 1 corresponds to the most unequal distribution possible, whereas a Gini coefficient equal to 0 denotes a situation in which all enjoy the same income level (see Gini, 1909 and Barros *et al*, 2006a).

4.3 The recycling of the carbon tax revenue

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[9] Although it is possible to simulate what would be the change of the VA_j numerator after applying the carbon tax, it would be difficult to do this for the variables L_j (employment) and C_j (GHG). For simulation purposes, the Y_{jf} denominator was therefore changed, adding the total amount of tax collected to the total original value.

Three different scenarios for the usage of the tax revenue were simulated. In the first case, there is no recycling. The government collects the revenue, but it is not reinserted directly into the economy. It could be used, for example, for public debt repayment purposes, a situation in which the government does not remain fiscally neutral with respect to the tax measure. In the second case, all the revenue from the tax is passed on in the form of direct transfers to the first seven lower income classes, the ones that present negative savings levels in the reference scenario. The amount collected is added directly to the final demand of each class in accordance to the proportion it represents of negative saving in the base case. In the third case, the revenue collected is used to relieve taxation on the labor factor.

5 Results and discussion

5.1 Carbon tax of R$25/t$CO_2$e

A R$25 carbon tax has the following impacts on GDP, employment, emissions and Gini coefficient[10]:

Table 2 - Results with a R$25 tax rate

	GDP	(1 / Gini coefficient)	Employment	Avoided GHG emissions
No recycling	-3,06%	0,05%	-3,76%	5,94%
Direct transfer to households	-1,54%	1,40%	-2,38%	3,92%
Reduction of labor taxes	0,29%	-0,13%	-1,10%	2,96%

Source: The authors

When there is no recycling of revenues, avoided emissions are of 5.94% of the base case level, GDP falls by 3.06% and employment levels by 3.76%. The Gini coefficient inverse increases by 0.05%. The imposition of charges for GHG emissions takes effect gradually, thereby helping to reduce income inequality.

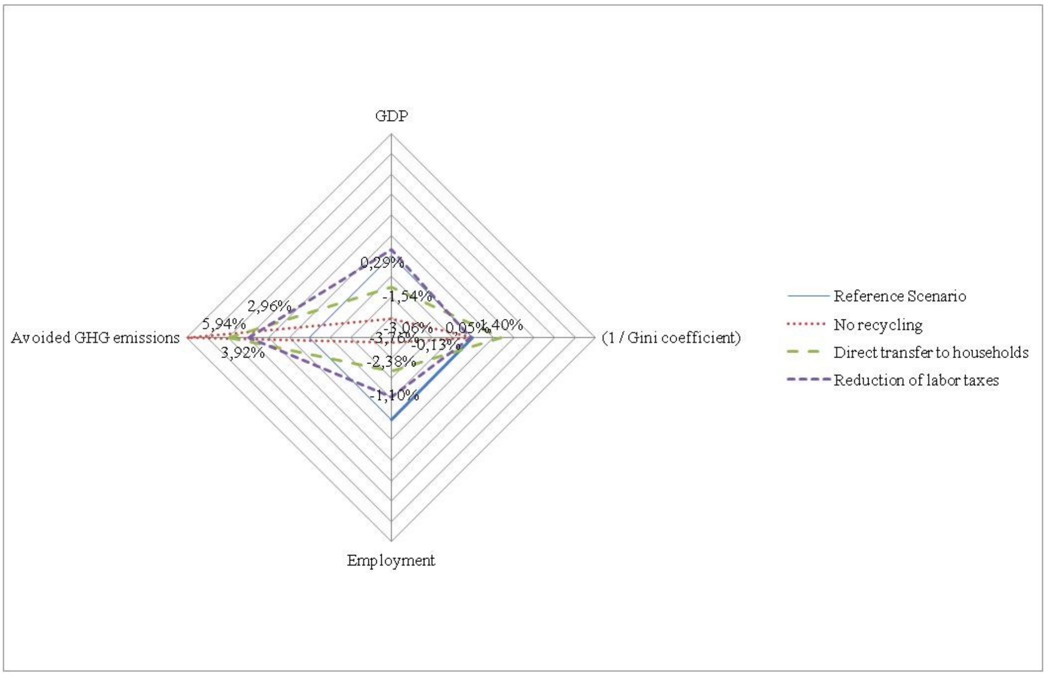
When the revenue is transferred directly to households, avoided emissions are of 3.92% only, GDP falls by 1.54% and employment levels by 2.38%. A rebound effect is perceived, whereby the recycling-generated increase in the income of one component of the economy brings about an increase in its final demand, which in turn creates a multiplier effect in the economy, offsetting the recessive effect of the taxation. In the case of direct transfer, the effect is caused by the higher level of consumption to which lower income households are given access. This measure is the one which most contributes to the reduction of income inequality in the economy. There is an increase in the Gini coefficient inverse of 1.4%.

[10] In order to obtain more illustrative results, it was chosen to present the impacts of GHG emissions as `Avoided GHG emissions` and the impacts on income inequality as the inverse of the Gini coefficient. This way, positive variations in all variables analyzed are desirable and negative variations are undesirable.

Finally, if the revenue is used to reduce fiscal burdens on the labor factor, avoided GHG emissions are down to 2.96%, while a co-occurring 0.29% increase in GDP is noted. It is thus observed that there is a double dividend, as indicated by Bohringer & Rutherford (1997), Parry & Benedict (2002), van Heerden *et al* (2006) and Alton *et al* (2012). There is a reduction of 1.1% in employment levels. In this case, the rebound effect is brought about by the creation of more employment opportunities, which in turn generates a greater consumption demand. Both in the case of transfers to households as of the easing of labor charges, the effect gives rise to greater economic activity, with the associated generation of GHG emissions.

The exemption of taxes on labor contributes, however, to effectively increase income inequality in the economy since the Gini coefficient inverse decreases 0.13%. One possible explanation is that many low income households belong to the informal labor market, hence they do not benefit directly from this measure[11].

Figure 3 - Results with a R$25 tax rate



Source: The authors

[11] The exoneration of charges on labor helps to create more jobs and reduce levels of informality in the economy, which would benefit the lower income classes and possibly improve the distribution of income in the economy. However, these effects are difficult to obtain in a static analysis.

5.2 Carbon taxation at 50 R$/t$CO_2$e

When the carbon tax is set at R$50, we obtain the following results:

Table 3 - Results with a R$50 tax rate

	GDP	(1 / Gini coefficient)	Employment	Avoided GHG emissions
No recycling	-5,42%	0,09%	-6,68%	10,56%
Direct transfer to households	-2,48%	2,77%	-4,05%	6,81%
Reduction of labor taxes	-2,09%	-0,08%	-3,88%	7,45%

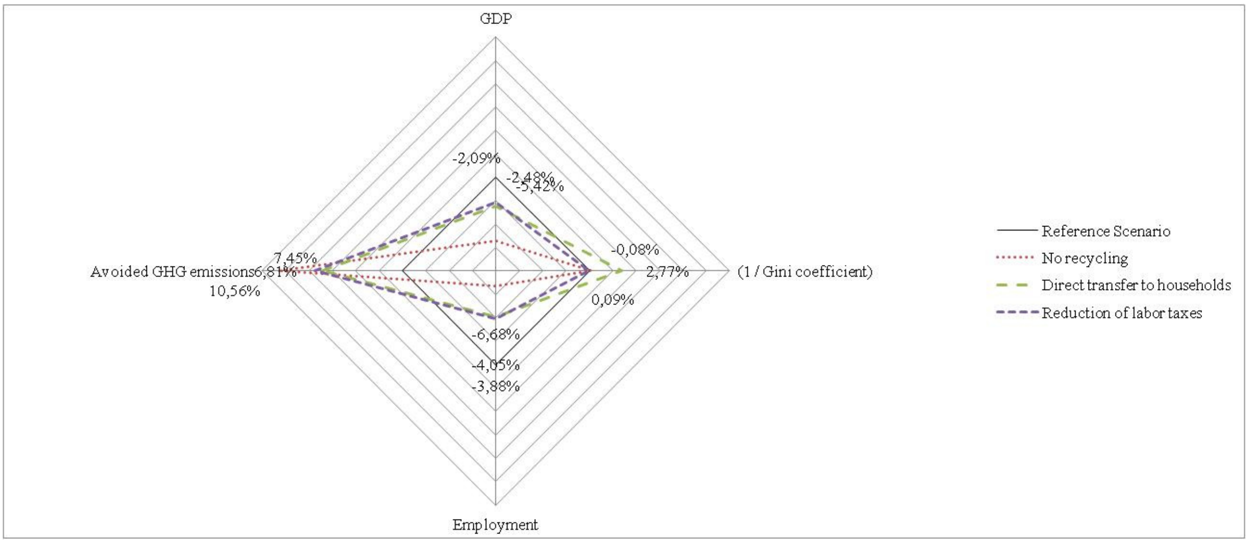
Source: The authors

A marked recessive effect is observed when the revenue is not reinserted into the economy. There is a reduction of 5.42% in GDP and 6.68% in employment levels. On the other hand, avoided GHG emissions reach the highest level: 10.56%. As in the case of R$25 per ton emitted, the effect of the measure is progressive: the Gini coefficient decreases.

When the revenue is reinserted into the economy by direct transfer to households, a 6.81% level of avoided emissions is recorded, the lowest observed for all alternatives. Again, this is due to the existence of the rebound effect which also affects GDP and employment, but with smaller reductions than in the case where revenue is not recycled, 2.48% and 4.05%, respectively. This measure helps to considerably reduce income inequality, since the Gini coefficient inverse increases 2.77%.

When the revenue is used to reduce taxes on the labor factor there is a rebound effect but, unlike the case where the ton is set at R$25, there is no double dividend. Avoided GHG emissions are at an intermediate level of 7.45%, while GDP and employment fall 9.2% and 3.88%, respectively. This measure, however, contributes to increasing income inequality.

Figure 4 - Results with a R$50 tax rate



Source: The authors

When comparing the results obtained for carbon tax rates of R$25 and R$50, it is seen that, as the rate increases, GHG emissions are reduced less than proportionally to GDP and employment level reductions. The decrease in welfare of the agents ceases to be justified by the lower GHG emissions, which leads to the conclusion that the optimal rate would be closer to R$25 than R$50.

Nevertheless, whichever tax is chosen, no measure is absolutely preferable to the others since there are different trade-offs. For example, the direct transfer measure, which most contributes to the reduction of inequality, is the one shown to result in the smallest reduction in emissions. On the other hand, labor tax reductions generate a significant reduction in GHG emissions without jeopardizing the GDP and employment levels, and may even produce a double dividend, but effectively increases income inequality. The choice of the best alternative in the use of carbon tax revenues will depend on the priorities held by policy makers and if the emphasis is on reducing emissions or on socioeconomic issues.

6 Conclusions

The current study sought to analyze the possible effects of a carbon tax on the concentration of income by means of a static analysis using a Social Accounting Matrix for Brazil in 2005. It was concluded that both the level of the tax as well as the method whereby the revenue is reinserted in the economy affect the levels of income inequality. The impacts on GDP, employment levels and GHG emissions were also analyzed.

It is concluded that no one option is incontestably preferable to the others. We observe an inversely proportional and growing relationship between the carbon tax level and GDP, employment, equity and emission levels, bearing in mind that emissions present the greater elasticity with respect to the measure taken. When the tax revenue is recycled, either by transfer to the lower income classes, or via exemptions of labor charges, the relationship ceases. The level of the tax and the method used to reinsert the revenue into the economy bring about observable increases in GDP and income concentration, apart from milder effects on the reduction of all aggregates, due to the so called rebound effect.

It should be stressed that the results are a product of a static general equilibrium model which has some limitations. As pointed out by Pandey (2002), many difficulties accompany the economic modeling of developing countries and the realistic representation of some of their characteristics. In addition to the great social and regional disparities previously mentioned, these countries generally have a significant informal economy sector, barriers to capital inflows and present considerable regulatory and institutional uncertainties. Given this fact, the model does not take into account emissions from forestry activities that are legal and therefore subject to taxation.

Moreover, it is worth enumerating the limitations inherent in the approach chosen, the input-output analysis. Noticeable here is the Leontief function used, which considers constant returns to scale, at the expense of a marginal analysis, and the hypothesis of an inherent homogeneity in the sector by sector technology used, often somewhat inconsistent with the reality of some productive activities. Possible constraints to the supply of production factors such as labor and capital are not taken into account[12] and, since it is a static analysis, the model presents stocks at a given period of time, regardless of the wealth accumulated in the past, which compromises the

[12] Since these results only include an increase in GDP of 0.29% at the most, this limitation does not in fact undermine the model. It was, however, considered relevant to highlight it.

determination of levels of consumption and investment. Finally, the model cannot predict the technological innovations sought by producers when faced with the obligation of paying for their emissions. Nor is it possible to estimate to what extent losses in competitiveness affect the observed results[13].

Finally it is important to stress that the task performed involves the simulation of a shock in the SAM without it being rebalanced later. Even so, the model used allows the monitoring of intersectoral relations, enabling to capture the direct, indirect and induced impacts of carbon taxes.

Disclaimer

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[13] For a more detailed study of the effects of mitigation measures on the competitiveness of Brazilian industry see Henriques Jr. (2010) and Rathmann (2012).

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