**GHG EMISSIONS' TAX IN BRAZIL USING AN INPUT-OUTPUT MODEL**

ABSTRACT

The emission of greenhouse gases (GHG) generated by human activity is a major cause of global warming and climate change. There is considerable debate about the choice of the best mechanism to reduce emissions under a climate policy. In this regard, the aim of this paper is to measure the impact of a policy of taxing GHG emissions in the Brazilian economy as a whole and in the different household income levels. To do so, we derive a price system from a national input-output model that incorporates the intensity of GHG emissions, as well as a consumption vector disaggregated in ten representative households with different income levels. The main results indicate that taxation was slightly regressive, and had little impact, also negative, on output. There were, however, significant emissions reduction.

Keywords : Emissions; taxation; income distribution; input-output.

JEL CODES: C67; Q52; Q54.

**1 Introduction**

Greenhouse gases (GHG) emissions generated by human activity is one of the main causes of global warming and climate changes. Magalhães and Domingues (2013) argues that the rise on average temperature observed since mid-twentieth century was largely caused by GHG concentration in atmosphere. According to these authors, Brazil has strongly predisposed to suffer negative impacts of climate change. In the last fifty years, this country accumulate an approximate heating of 0.7º Celsius, which is higher than the more optimistic estimative of global average rise (0.64º Celsius). Therefore, climate policies should be elaborated to try to reverse this scenario.

Developing countries, mainly Brazil, China and India have suffered pressure from international community regarding the implantation of climate policies due, in part, to its rapid GDP and emissions' growth (Rong, 2010). It is expected that CO2 emissions of these countries respond by more than half of global emissions in 2030, even though, in per capita terms, developed countries still occupy the first positions (Bosetti and Buchner, 2009; IEA, 2009). Figure 1 shows the percentage of global GHG emissions according to selected countries or regions.



Figure 1: Percentual of global GHG emissions per region - 2009

Source: Own elaboration based on World Input-Output Database (WIOD)

Developing countries such as Brazil, China, India and Russia responded together by 39% in 2009 of the global GHG emissions. It is important to highlight that the Chinese emissions alone accounts for 24% in the same year. On the other hand, Brazilian emissions were approximately 2.4%.

The Kyoto Protocol perhaps had been the major joint effort of policy with respect to global emissions control. Despite Brazil's participation as a non-Annex 1, the country established the National Policy on Climate Change (PNMC) through Law 12.187/2009 that defines voluntary national commitment to adoption of mitigation actions with reductions between 36.1% and 38.9% of projected GHG emissions for 2020 (Magalhães and Domingues, 2013; Palsev and Gurgel, 2014).

There is still a huge debate regarding the choice of the best mechanism to reduce emissions as part of a climate policy. Among other points of contention, we can highlight: market mechanisms, subsidies, taxes, government regulations, carbon trade, carbon tax and cap and trade. However, a topic rarely addressed in the literature, especially for the Brazilian economy, is the impact that the adoption of such a policy would have on the economy, industries and emissions (Magalhães and Domingues, 2013). More than that, what would be, for instance, the distributional impact of an emissions taxing policy in Brazil?

The distributive issue associated with GHG emissions charges was discussed by Symons, Proops and Gay (1994). For these authors, even a neutral tax reform would bring significant emission reductions in the United Kingdom, nonetheless adverse distributional effects. Tiezzi (2005), on the other hand, discussed the charge introduced in Italy on 1999. The regressivity's hypothesis of this tax, however, has not been confirmed.

In developing countries, these kinds of studies are rare. For instance, Gonzalez (2012) tested different alternatives through revenues generated by a tax in Mexico. Subsidies on food caused a more progressive distribution while a taxes' compensatory reduction on manufacture had a regressive behavior. In Russia, the best result, both on environmental and economic efficiency, was obtained from the taxing on labor (Orlov and Grethe, 2012). Given the oligopoly structure in the energy market, carbon taxation implies production decrease and induces mark-ups’ increases on some energy-intensive sectors. It is important to highlight that these two countries have more concentrated emissions in fossil fuel consumption.

In Brazil, Magalhães and Domingues (2013) applied a Computable General Equilibrium (CGE) model to endogenously determine the carbon price for achieve different emission targets. In short-run, the tax was regressive and the carbon price higher. Tourinho, Seroa da Motta and Alves (2003) simulated charges on CO2 from the burning of fossil fuels through a Brazilian environmental CGE model. As expected, the model showed the displacement of resource in GHG intensive industries to less intensive sectors. As a result, the investment has increased. Both papers found a small and negative impact on household income, output and emission levels. By its turn, Gurgel and Paltsev (2014), using a dynamic CGE model, evaluated the impact of alternative policies to achieve voluntary targets recently adopted by Brazil and concluded, among other things, that the direct emissions reduction from deforestation is the most cost-effective option.

To sum up, tax impacts vary according to production and demand structure in each country; therefore, they are not readily generalizable. For Brazil, the literature suggests a regressive tax, as indicated by the higher emissions coefficient per dollar of expenditure among the poorest families.

Given the heterogeneity of emissions among different industries, multisectoral models such as input-output (hereafter, IO) and CGE are suitable for measurement of climate policies impacts. Unlike CGE modeling, IO models are easier to operationalize. According to Rose (1995, p. 297): "The sectoral scheme of an IO table facilitates data collection, and its matrix representation facilitates data organization. The simplicity and transparency of this table are strengths rather than weaknesses".

The traditional formulation of IO models, however, treats the economy by considering the demand side. To measure a taxing policy impact through this methodology, the supply-side IO models must be used. For doing so, the literature suggests the known pricing or Ghosh Input-Output models (Ghosh 1958; Leontief 1941; 1966; Miller and Blair, 2009).

Taking into consideration the supply-side perspective, this paper aims to measure the impact of GHG emissions taxing policy in the Brazilian economy as a whole and in different households’ income levels. In this regard, we developed a pricing system from a national input-output matrix that incorporates the intensity of GHG emissions, as well as a consumption vector disaggregated into ten representative households with different income levels.

Differently from previous studies, Brazilian emissions were disaggregated into more sectors, allowing a closer look at the different consumption patterns and calculate the short-run effect on household income. This problem, when treated under a distributive perspective, becomes more relevant for Brazilian special case, since this country has historically high levels of income inequality among people and regions.

The next section describes the methodological procedures. The third section shows the database and the descriptive statistics, followed by the main results and discussion. The last section presents the main findings and policy directions.

**2 Method**

1. Input-output model

The basic equation of the IO model, according to Miller and Blair (2009), can be expressed by equation 1:

 (1)

Where *x* is the total output, *Z* is the intermediate input matrix, and *f* is the final demand. Then, the Technical Coefficient matrix is given by:

 (2)

Where each  shows the amount of input *i* used as intermediate good in the output of industry *j*. Therefore, Leontief model's solution can be represented by equation 3.

 (3)

Where *(I-A)-1* is the total impact matrix or Leontief Inverse matrix.

1. Incorporating emissions in the IO model

Emissions intensity (*e*) was calculated as the product of emissions coefficient (*m*), i.e., the ratio between emissions of each economic sector and the total impact matrix on the economy:

 (4)

The dimension of vector *e* is *56x1* and represents emissions released during the production chain of final goods.

1. Price model

Traditionally in the input-output literature are presented two price models: Ghosh model (1958) and Leontief price model (1941, 1946)[[1]](#footnote-1). In this paper, we adopted the last one, which assumes that variations in production costs are converted into price increase. Thus, price  is equal to the sum of inputs cost to the value added  components.

 (5)

Post-multiplying equation (5) by , it follows that:

 (6)

If,  and, and also called , the price index for the base year is given by:

 (7)

1. Tax on emissions

If a tax on the amount of emitted CO2 equivalent were charged in the productive sectors, the taxes vector (T) reach:

 (8)

Given , and  the rate per ton of CO2 equivalent, R$ 50.00. Finally, the adjusted prices vector () is:

 (9)

Following Gemechu et al. (2012), if the monetary values of sectoral output are held constant, before and after tax, then the sectoral output becomes:

 (10)

Total emissions after tax were calculated as:

 (11)

Where is the vector of sectoral production after tax.

1. Effects on the price index () and government revenue (*g*).

The impact on price index () is given by:

 (12)

Where  is the share which industry *j* productionrepresents in the total output. The government revenue with new tax was estimated as:

 (13)

1. Households welfare effect

Assuming households maximize their utilities using a Leontief function, and their income and savings are unchanged, none of each representative household could afford the same basket of goods. Therefore, using prices changes derived from the model, it is possible to calculate the income variation necessary to compensate households for the welfare lost. Formally, household welfare change () for decile *k* is the following:

 (14)

Where is the quantity consumed by decile *k* from industry *i*.

1. Income Effect

Knowing that  are total payments made by industry *i* to the labor related to the *k* deciles, and assuming industries usage of labor follows a constant share of production, the effect on labor income can be calculated as:

 (15)

Where , i.e., the sectoral change in production after tax.

On the other hand, the effect on total income is straightforward calculated by:

 (16)

**3 Database**

The input-output matrix used was calculated at basic prices, from Tables of Resources and Uses of Brazilian Institute of Geography and Statistics (IBGE) base on the year 2009, according to the procedures described in Guilhoto and Sesso Filho (2005) and hypothesis of "industry-based" technology (Miller and Blair, 2009).

To construct the emissions vector, the follow gases were taken into account: carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O) measured in carbon equivalents. The data was from *Estimativas anuais de emissões de gases do efeito estufa no Brasil*[[2]](#footnote-2) (MCTI, 2013). These pollutants together constitute the so-called greenhouse gases[[3]](#footnote-3) or GHG, which contribute directly to global warming.

Once the deforestation is limited to a small amount the Brazilian emissions will become more adherent to economic cycle. In the Amazon, the deforestation has fallen from 27,772 km2 to its lower level of 4,656 km2, between 2004 and 2012 (INPE, 2014). Therefore, the Brazilian Panel on Climate Change estimates the emissions will rise again after 2021 due to energy and agribusiness sectors (PBMC, 2014). The estimations for Brazilian GHG emissions measured in CO2 equivalent between 1990 and 2010 are reproduced in Figure 2.

Figure 2 – CO2 equivalent emissions by source, in Gg, between 1990 and 2010.

Source: MCT Data, 2013, p.12.

While land-use change and forestry (hereafter, LULUCF) emissions changed widely, one can observe a continuous and stable growth on other GHGs releases in the atmosphere, increasing 77% for the whole period. Given the erratic and seemingly detached behavior from the economic cycle, as well as the growing importance of other factors in the total emissions, the simulation dismissed the LULUCF.

By its turn, the household consumption disaggregation in different income deciles was made from data of Household Budget Survey (POF), while labor incomes were disaggregated according to data from the National Household Sample Survey (PNAD), both released by IBGE for 2009.

For both surveys, household per capita income was used to split data into ten deciles. In order to keep the consistence with IO data, only the shares of consumption and labor income for each household were used to disaggregate consumption and labor income vectors, respectively. Data obtained from PNAD shows clearly income concentration in Brazil, as one can observe on Table 1.

Table 1 - Descriptive statistics of the income data per month by representative household (in real R$)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Household per capital income | | | | Household labor per capita income | | | |
|  | Mean | Std. Dev | Min | Max | Mean | Std. Dev | Min | Max |
| Decile 1 | 61.67 | 32.31 | 0 | 106 | 39.13 | 104.10 | 0 | 900 |
| Decile 2 | 137.16 | 16.71 | 107 | 165 | 101.53 | 192.92 | 0 | 1,300 |
| Decile 3 | 201.47 | 21.06 | 166 | 232 | 146.43 | 246.86 | 0 | 2,000 |
| Decile 4 | 266.73 | 21.01 | 233 | 300 | 211.29 | 312.81 | 0 | 2,200 |
| Decile 5 | 337.08 | 21.72 | 301 | 375 | 255.99 | 348.91 | 0 | 2,500 |
| Decile 6 | 426.87 | 29.40 | 376 | 465 | 282.98 | 390.33 | 0 | 3,500 |
| Decile 7 | 529.77 | 40.86 | 466 | 600 | 409.76 | 491.48 | 0 | 3,890 |
| Decile 8 | 696.46 | 56.99 | 601 | 800 | 532.33 | 626.29 | 0 | 5,000 |
| Decile 9 | 1,004.92 | 135.82 | 801 | 1,293 | 740.90 | 901.66 | 0 | 9,000 |
| Decile 10 | 2,684.09 | 2,515.47 | 1,294 | 94,669 | 1,920.25 | 3,266.91 | 0 | 150,000 |
| Total | 631.20 | 1,083.89 | 0 | 94,669 | 461.25 | 1,238.536 | 0 | 150,000 |

Source: Own elaboration based on PNAD data (2009).

In 2009, the first decile had an average household income of R$ 61.67 per month, i.e., 10% of Brazilians received the equivalent of nearly 30 American dollars[[4]](#footnote-4) per person. This value reaches R$ 2,684.09 for the 10% richest people. With regard to labor income, it corresponds to around 73% of total income on average, with all deciles having similar shares.

Using the combination of income and emissions data, indeed, in 2009, it is possible to observe the significant variation in emission levels between the ranges of household, as displayed in Figure 3.



Figure 3 - Household CO2 equivalent Emissions in 2009.

\*On the left axis, for the series of consumption emission coefficients the values are in Gg per million U$. On the right axis, for emissions by households, values in 100 Gg.

Source: Own elaboration, 2014.

The emissions coefficient per dollar decrease reflects changes in consumption patterns as income rises. That year, the emissions per household remained relatively stable until the higher income deciles when the consumption scale effect is more prominent. Each considered GHG series showed similar behaviors.

As the concentration of consumer spending is higher than the concentration of emissions, a tax on GHG-intensive items would have a regressive effect on welfare as measured by consumption expenditure. The per capita household consumption ratio between the two highest income deciles and the two lower was 13.21. In the case of total emissions, the ratio was 4.09.

**4 Results and Discussions**

The results reveal that the taxation policy is capable of achieving its main goal: mitigate emissions. It was estimated a significant drop in the level of emissions, around 9.1% reduction for the whole economy. The government's estimated revenue from the new tax reached the high value of R$ 37 billion, and the production decrease was 1.54%. At sectoral level, emissions variations are heterogeneous, as showed in Table 2, for the 21 most polluting sectors.

Table 2 - Total CO2 equivalent emissions by sector before and after tax, in Gg.

|  |  |  |  |
| --- | --- | --- | --- |
| **Sectors** | **Before Tax** | **After Tax** | **Variation** |
| Livestock and fishing | 339,829.00 | 285,011.59 | -0.16 |
| Transport, storage and postal mail | 140,911.19 | 136,435.67 | -0.03 |
| Agriculture, forestry, extractive | 100,126.36 | 96,630.97 | -0.03 |
| Manufacture of steel and derivatives | 58,654.91 | 55,655.17 | -0.05 |
| Oil refining and coke | 32,650.38 | 31,916.18 | -0.02 |
| Cement | 28,402.67 | 25,068.37 | -0.12 |
| Other mining and quarrying | 21,581.18 | 20,243.87 | -0.06 |
| Oil and natural gas | 19,362.45 | 18,997.09 | -0.02 |
| Production and distribution of electricity | 17,120.65 | 16,962.35 | -0.01 |
| Chemicals | 12,671.26 | 12,397.48 | -0.02 |
| Other products of non-metallic minerals | 12,084.05 | 11,719.51 | -0.03 |
| Metallurgy of non-ferrous metals | 6,281.45 | 6,126.41 | -0.02 |
| Food and beverage | 5,404.61 | 5,154.71 | -0.05 |
| Pulp and paper products | 4,488.48 | 4,417.48 | -0.02 |
| Iron ore | 3,530.32 | 3,485.18 | -0.01 |
| Alcohol | 2,918.34 | 2,838.49 | -0.03 |
| Trade | 2,100.35 | 2,093.98 | 0.00 |
| Paints, varnishes, enamels and lacquers | 1,859.99 | 1,830.30 | -0.02 |
| Public administration and social security | 1,586.84 | 1,583.55 | 0.00 |
| Construction | 1,533.02 | 1,515.42 | -0.01 |
| Textiles | 1,311.12 | 1,297.85 | -0.01 |
| **Total for 21 sectors** | **814,408.61** | **741,381.63** | **-0.09** |
| **Total** | **822,069.73** | **748,978.31** | **-0.09** |

Source: Own elaboration, 2014.

The most intensive CO2 sector is Livestock and fishing, which accounts for the largest absolute change and percentage of emissions during the tax introduction, the same goes for Transport. The underlying hypothesis of a linear production function implies that any change in emissions leads to a decline in sectoral output, which was weighted by rising prices. The emission coefficients remained constant. Therefore, the variation of GHG released into the atmosphere is inversely related to the price change.

In the simulation exercise held here, this negative impact has reached the amount of R$ 84.4 billion, or 1.54% reduction of the total Brazilian production. Figure 5 indicates the sectors with the largest declines. The sectors displayed in Figure 5, together accounts for 79.4% of the total effect. One can note that between them are services, deeply related to household consumption, such as Transport, storage and mail, Trade and Lodging and food services. Some other sectors with high emissions (as showed in Table 2) also appears: Food and beverage, Agriculture, Livestock and fishing and Oil refining, for instance.



Figure 5: Household consumption change effect

Source: Own elaboration, 2014.

Even though the policy actives its goal of reducing emissions, with a relative small drop in production, the sectoral changes in production suggests that sectors directly related to household consumption are the most affected. Therefore, given that a significant portion of the expense of lower income households is intended for the food and transport items, the result of the tax has the largest impact on household consumption of lower level income, and distributional effects become even more important.

Implementing the taxation policy, *ceteris paribus*, implies purchasing power losses for consumers, that can firstly be captured the raising in general prices. The total estimated effect on the general price index is relatively small, 1.01%, nevertheless, Agricultural, food and beverage prices, and some CO2-intensive industries suffered the greatest variations.

According to the assumptions made about household consumption, the compensatory variation measures the income needed for each household with the same utility level after tax, and its’ price changes. Figure 4 shows the compensatory variation related to household consumption.



Figure 4 – Welfare loses measured by compensatory variation

Source: Own elaboration, 2014.

Regarding to lower income deciles, the tax losses caused above 3.09%, reaching 1.18% for the richest household. This clear regressive pattern is related to the differences in consumption and income between households. While in the beginning of income distribution items as food and transport represents a high participation, for upper levels services are the major component. Consequently, as the most affected sectors are those related to basic consumption, the most affected people are the poorest.

Results for labor and total household income exhibits a similar pattern. Figure 6 shows the labor income and total income effects over the ten income deciles.



Figure 6: Effects over labor income and total income

Source: Own elaboration, 2014.

Analogous to the compensatory variation results (Figure 4), the negative effect over income is greater for the beginning of the distribution. For the first decile, the decline is 3.72% for labor income, compared to 1.02% for the last decile. The impact is clearly smoothed when one is looking for the total income, with a more homogeneous distribution across the households. This behavior can be partially explained by the fact that the income from other sources rather than labor is basically pensions, retirement or social programs[[5]](#footnote-5).

We also calculate the Gini index[[6]](#footnote-6) related to the household income before and after tax. With the taxation policy, we can see a marginal worsening in the inequality, since the Gini coefficient increased from 0.562 to 0.564[[7]](#footnote-7). According to this index, the closer to one, greater is the income inequality.

The results obtained here are similar to previous literature. The regressive aspect of the tax over pollutants release was considered by Seroa da Motta (2002), who estimated the environmental pressure exert by income brackets in Brazil. In the specific case of GHG, Silva & Gurgel (2011) claim about the tax effectiveness, arguing that the GDP effects are small in the long run. For Tourinho, Seroa da Motta & Alves (2003), the charge over fossil fuel CO2 emissions in 1998 brought not expressive impacts for macroeconomic variables, even considering three different scenarios where the price of C02 tonnes varies between $3, $10 and $20. The most dramatic changes was on sectoral investments with the less emissions intensive sectors are the most benefited ones, as expected by the policy goals. In those papers however, the distributive aspects of emissions taxation was not treated.

Magalhães and Domingues (2013) introduce the first results for Brazil involving both: charges on GHG emissions and distributive impacts. The authors concluded that even if the families are directly compensated with the resources from the taxation the final results are still regressive, or slightly progressive if the transfer is made directly to the most poor households. The estimated cost for 10% decrease in emissions was 1.26% of GDP through 2030. The result was claimed to be related to the energy matrix little intensive on fossil fuels, and the high levels of emissions for food production, deeply related to poor households.

In sum, the exercise hold here indicates that: i) as the income concentration is greater than emissions concentration, the tax shows regressive initial effects, measured by compensatory variation on household consumption; ii) when production changes, and consequently factors payments are taken into account, the regressive impacts are smaller, and almost disappear considering total income, not only labor income; iii) the effect over the price level and production was small, because the highest tax was over livestock that has a small portion in terms of gross production value; iv) for the first deciles, the largest portion of agriculture wages on overall income generated a regressive aspect in terms of total income[[8]](#footnote-8).

Therefore, it is possible a convergence in the literature about the small change in GDP, and the regressive aspect of a tax on emissions. However, in this paper it is possible to see an important reduction on GHG emissions concomitant with a not so large change in terms of income distribution, giving support for the policy application even in the short-run. Nevertheless, other aspects not considered here can give a different result, like the implications on sectoral competitiveness, or the optimal tax value and its dynamic aspects. Other limitations are related to the applied methodology. The production, emissions and labor coefficients were constant in the simulation, and the households react to price changes keeping fixed proportions in their budget constraint.

**5 Conclusion and Policy Implications**

This paper has calculated the distributive impact on Brazilian households of a tax on GHG. In the short-term there is a significant reduction on emissions, but an uneven distribution of its burden. The poorest families are more affected in their welfare. Since these families are also those who will suffer the deeper consequences of global warming such a tax would require compensatory measures. Moreover, if GHG emissions are taken as a proxy for environmental pressure then there is already an intense inequity; those people more exposed to higher environmental risks are those who contributed less for environmental degradation.

In the near future, the main drivers of Brazilian emissions will be food production and energy consumption. While on the supply side there are promising initiatives for reducing GHG emissions in agriculture, on the demand side consumption of food tends to decrease as a proportion of household expenditures and household emissions. The energy demand however is expected to grow faster than the increase on renewable energy sources, due to investments on pre-salt oil reserves and the increasing costs of new hydropower plants. Despite its slightly regressive character a tax on GHG emissions could be important to stimulate a more sustainable path for the energy sector.

The effects on welfare of a GHG emissions tax goes far beyond the short-term changes in the price index and real income. For instance, it involves normative issues such as the preservation of future generations wellbeing, since the GHG released into the atmosphere today must have impacts on global warming in a broad time horizon.

Further investigation should also observe the impact on the long-term considering the recursive effects, as well as compensatory measures on income distribution and its implications. The model presented does not allow any changes on technological matrix in response to the relative prices modification. Nevertheless, the focus was on household expenditure and labor profiles. In comparison to other studies, a more disaggregated matrix seems to soften the regressive impact of a carbon tax. In the midterm, reorientation towards less intensive sectors could also favor higher wages sectors.

It is important to highlight that consumption and income effects do not interact in the model, therefore all estimations are a first-round effect. In real world, when income falls, household consumption also declines, and with reductions in consumptions, firms need to adjust their production creating a negative cycle. These are general equilibrium effects not taken into account here. Another improvement of this study is develop a Social Accounting Matrix (SAM) or a Computable General Equilibrium (CGE) model. The use of these kind of modeling allow us identify the compensatory effects from the government. This is possible because these models have the flows between households and government. In this way, it is possible to do a simulation giving the money back to the poorest households.

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ANNEX 1 – MATCHING GHG EMISSIONS TO INPUT-OUTPUT SECTORS

The second Brazilian communication of the National Inventory Report brings the greenhouse gases emissions from 1990 to 2010. The data were presented according to both methodologies suggested by IPCC. The *Top Dow*, when the total supply of goods whose consumption causes GHG is taken as a reference for emissions. And the *Bottom Up*, the emissions are set to economic sectors following their consumption of those goods.

The correspondence between GHG sources to input-output sectors is shown in Figure A1. If an inventoried source matched more than one economic sector then its emissions were distributed accordingly to sectoral share on production or consumption. All the same, the emissions were made equivalent to intermediate consumption or sectoral production taken from Use and Make Tables. Hence the CO2 emissions from fossil fuel burning by the energetic source were set trough the sectors: “Oil and natural gas”, “Oil refining and coke” and “Production and distribution of electricity”, accordingly to theirs fossil fuel consumption in the *Top Dow* inventory. Matching the input-output sectors to the National Inventory’s sources of GHG was made possible by the National Economic Activities Classification (CNAE). The CNAE codes are the reference for both, the Brazilian Energy Balance and the National Accounting System. The inventoried sources had theirs PRODLIST codes matched to CNAE codes.

Figure A1: Correspondence between GHG sources to input-output sectors (continues...)



Source: Own elaboration, 2014.

Figure A1: Correspondence between GHG sources to input-output sectors (conclusion)



Source: Own elaboration, 2014.

1. It is important to highlight, however, according to Miller and Blair (2009), that both models produce the same results. For different interpretations of Ghosh model, see Dietzenbacher (1997), Oosterhaven (1996) and Mesnard (2009). [↑](#footnote-ref-1)
2. *Annual estimates of greenhouse gases emissions in Brazil* (own translation). The steps to reconcile the surveyed sectors and the sectors in the input-output matrix are described on Annex 1. [↑](#footnote-ref-2)
3. Despite the Sulfur Hexafluoride (SF6), Chlorofluorocarbons (CFCs) and Hydrofluorocarbons (HFCs) are also considered as greenhouse gases, according to Genty *et al*. (2012), they have a small impact on global warming. [↑](#footnote-ref-3)
4. Using the average exchange rate for 2009, when one U.S. dollar was equivalent to 1.99 reals. [↑](#footnote-ref-4)
5. It is worth mentioning that the *"Bolsa família"* program was created in 2004. Broadly speaking, the program goal was to transfer money for poor or extreme poor households. [↑](#footnote-ref-5)
6. . Where G is the Gini coefficient; X and Y are the cumulative proportion of the variables" population" and "income", respectively. [↑](#footnote-ref-6)
7. The index was calculated using PNAD/2009 data on household income. For the index after tax, household income from labor was updated according to sectoral changes observed in the exercise. Therefore, it is worth nothing that the change in inequality here only captures changes in labor income between sectors, but cannot address eventual wage changes within sectors. [↑](#footnote-ref-7)
8. For example, for the first decile 36.75% of labor income comes from activities related to Agriculture, silviculture and forestry. [↑](#footnote-ref-8)