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SOCIOECONOMIC IMPACTS OF PRODUCING ETHANOL IN BRAZIL: AN INTER-REGIONAL INPUT-OUTPUT MODEL[1]

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Overview

Quantifying the overall impacts of energy use of biomass on socioeconomic indicators – such as income and employment levels – requires the activity to be analyzed in a wider economic context. The entire production chain, from biomass extraction to the final use of energy goods has to be represented – it is often necessary to look far beyond the plant, be it the agricultural product or the industrial unit processing it to generate energy.

The intensity of the socioeconomic impacts may vary largely depending on the type of the venture.

Reforming the energy system – boiler and turbo-generator – to produce excess electricity in a sugar-ethanol plant is certainly expensive. Yet, in operation, the system for generating electrical energy will cause little impact on income and employment. The chemical, machinery and equipment sectors, for instance, will provide inputs necessary for maintenance activities (direct effect). These sectors respond by expanding their output, causing production to increase in industries linked to them, such as mining, iron and steel, and so forth (indirect effect). Overall more labor and capital services will be employed, providing income to households, which will be spent in the consumption of goods and services, contributing to enlarge even more the level of economic activity.

Conversely, installing the whole sugar-ethanol plant in a given region will bring much larger direct, indirect and induced impacts. Locally, there will be an increase in the output level in many sectors, such as services – wholesale and retail trade, transport, personal services, business services, real state activities, among others, attracting more residents to the region. More income and employment will be created everywhere, bringing in benefits to the country as a whole.

Methods

Quantifying the direct, indirect and induced socioeconomic impacts requires a methodology capable to represent the entire production chain. The effects can be measured in several metrics: output value, added value (GDP) and occupied people (formal and informal jobs), among others. The basic input-output (i-o) model developed by Leontief in the 1930 decade is adequate for assessing the intersectoral linkages in the economy (Miller and Blair, 1985). However, the basic i-o model does not allow the representation of joint production or technology-differentiated sectors producing the same good or service. For instance, in Brazil, sugar mills and ethanol distilleries produce also electricity from bagasse; moreover, sugarcane can be collected manually or via harvesting machines. The extended i-o model with mixed technologies described in Scaramucci and Cunha (2006) – based on the

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theoretical framework proposed by Cunha (2005) – was modified to include also the possibility of joint production. The economies of the five macro-regions of Brazil were represented in an inter-regional input-output table containing 46 sectors.2 The result is a inter-regional extended i-o model, which was used to produce some indicators from producing fuel ethanol in autonomous distilleries (plants that produce alcohol only) from a (metric) tonne of mechanically-harvested sugarcane.

3. Results

Some of the aggregate results are summarized in the tables below.

The following assumptions were adopted:

All sugarcane is mechanically harvested, as it is expected to occur with the plants under construction;

Ethanol is produced in autonomous distilleries only;

The ethanol plant has the capacity to process 1 million tonnes in the season year;

Industrial productivity is 85 liters of ethanol per tonne of sugarcane (current average value obtained by plants located in the Southeast region of Brazil);

The distillery is able to generate excess electricity at the rate of 40 kWh per tonne of sugarcane.

Each cell in the tables contains two figures: direct and indirect effects (added together) are shown at the top; the total impacts (including the induced effect) appear below.

The line and column headers are the macro-regions of Brazil: North (N), Northeast (NE), Center-West (CW), Southeast (SE) and South (S). The lines correspond to the location of the distilleries; in operation, the ethanol plants will impact the five regions and the country as a whole, as shown in the columns.

Table 1 exhibits the impacts on occupied people (formal and informal jobs).3

Table 1: Impacts on occupied people

	N	*NE*	*CW*	*SE*	*S*	*Brazil*
N	1,340 1,476	14 622	4 203	55 1,464	14 584	1,428 4,349
NE	10 146	1,337 1,947	14 213	199 1,613	56 627	1,614 4,547
CO	13 153	58 680	871 1,074	278 1,718	84 667	1,305 4,291
SE	11 153	51 685	16 223	1,121 2,589	51 644	1,251 4,294
S	3,2 142	15,5 638	3,9 207	56,8 1,497	1,296,7 1,879	1,376 4,363

A distillery installed in the Northeast region generates locally more direct and indirect jobs (1,337) as compared to a plant operating in the Southeast (1,121). However, the Southeast region is able to retain a larger part of the impacts. Conversely, a large part of the induced impacts leaks from the Northeast region to the federal states in the Southeast, as indicated in the second (NE) line.

The impacts in the excess supply of electricity are depicted in Table 2.

[2] Details on the construction of a preliminary database for the national economy may be found in Cunha and Scaramucci (2006).

[3] It is supposed that all sugarcane will be mechanically harvested. However, in 2006, about 65% of the sugarcane produced in Brazil was collected manually – obviously, this value would yield larger impacts on occupied people.

The negative values in Table 2 correspond to energy deficits that appear in the other regions. A distillery operating in the Southeast, for instance, will make the South regions to increase its level of economic activity, causing there a total electricity deficit of 6.2 GWh (yearly average of approximately 0.71 MW). Eventually such a deficit will have to be counterbalanced by investments in local electricity generation or in transmission lines from other regions. Conversely, the ethanol plant can generate enough electricity to compensate for the larger energy requirements that occurs in the region it is located.
In the scenario considered here, it is assumed that the bagasse obtained from milling one million tonnes can produce 40 GWh of excess electricity.4 However, producing sugar and ethanol makes electricity demand to increase so that the net rate of conversion results much lower. For instance, a distillery operating in the Southeast region will generate 23.7 GWh of excess electricity for the country as a whole (Table 2).

Table 2: Impacts on excess supply of electricity

	N	*NE*	*CW*	*SE*	*S*	*Brazil*
N	41.1 39.4	-0.2 -2.1	-0.1 -1.6	-0.4 -5.5	-0.5 -5.4	39.8 24.9
NE	-0.4 -2.1	41.0 39.1	-0.2 -1.7	-1.1 -6.1	-1.1 -5.9	38.3 23.3
CO	-0.4 -2.1	-0.5 -2.5	42.3 40.8	-1.4 -6.5	-1.5 -6.4	38.5 23.2
SE	-0.5 -2.2	-0.4 -2.4	-0.3 -1.8	41.5 36.3	-1.1 -6.2	39.2 23.7
S	-0.2 -1.9	-0.2 -2.2	-0.1 -1.6	-0.4 -5.5	38.9 33.9	38.0 22.8

[GWh]

Conclusions

It is often said that when general equilibrium effects are considered, everything depends on everything and vice versa (Scaramucci et al., 2006).
Many techno-economic analyses of energy systems consider only the revenues and costs as perceived by the private agents directly involved. However, to fully assess an energy project it is important to contemplate all the implied socioeconomic (and environmental) externalities. A comprehensive benefit-cost analysis is needed for the different socioeconomic aspects to be included. After all, energy constitutes an essential good for society; as such, it is a significant component of many indices of development.
One example is cogeneration in the Brazilian sugarcane agroindustry. Burning bagasse in boilers allows sugar and ethanol plants to produce all the energy – thermal, mechanical and electrical – required by their industrial processes. More efficient boilers (at least 60 bar) are necessary for plants to generate electricity surpluses. Few sugar mills and distilleries in Brazil are able to produce excess electricity presently, as the boilers used have low nominal pressure (about 20 bar). However, the production of sugar and ethanol impact the energy requirements in all the regions. So, as a policy recommendation, it would be important to give incentives to plants to generate excess electricity from bagasse, avoiding the social, economic and environmental costs incurred by conventional, nonrenewable forms of energy.

[4] Although larger theoretical efficiencies in energy conversion are possible, the rate of 40 kWh per tonne of sugarcane is consistent with common technology currently available.

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