THE WORLD INCREASE IN ETHANOL DEMAND AND POVERTY IN BRAZIL

POVERTY, TRADE POLICY AND COMPLEMENTARY POLICIES
PROJECT CEPAL/AECID

Joaquim Bento de Souza Ferreira Filho
Escola Superior de Agricultura "Luiz de Queiroz"
University of São Paulo

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Joaquim Bento de Souza Ferreira Filho[1]

1 Introduction

Brazil has traditionally been one of the most important sugarcane and ethanol producers. Since 1975, when the National Ethanol Program (Programa Nacional do Alcool – Proalcool) was created, the country has produced fuel ethanol on a large scale. The increase in sugar exports in the nineties, which competed with inputs to ethanol production, caused rationing in the Brazilian ethanol market and a decline in consumption, which lasted until 2003.

Since then the scenario for ethanol has again substantially changed. The development of flex-fuel engines (which can use either ethanol or gasoline) and the rise in oil prices granted new status to ethanol as a fuel in Brazil, allowing consumers to choose between both, depending on relative prices. According to a study of the Ministry of Energy and Mining (EPE, 2008a), in 2008 ethanol was already economically viable in 19 out of 26 states in Brazil. The expansion of the Brazilian economy in the last years dramatically increased the sales of new cars, most of them with flex-fuel engines. According to an EPE (2008a) study, from January to June, 2008, flex-fuel vehicles accounted for 87.4% of new sales of light vehicles in Brazil. Still according to that study, the demand for hydrated ethanol in 2017 is projected to be about 73% of total demand of liquid fuels (Otto cycle) in the country. This would represent a total demand for ethanol in 2017 of around 52.3 million liters, against the present use of 20.3 million liters in 2008.

Ethanol exports are also expected to increase greatly. From 4.2 billion liters in 2008, total exports are projected to double by 2017, reaching around 8.3 billion liters. And, finally, ethanol used in the chemical industry is also projected to increase

[1] Escola Superior de Agricultura “Luiz de Queiroz”, Universidade de São Paulo. Departamento de Economia, Administração e Sociologia. Av. Pádua Dias, 11. Piracicaba, SP. CEP – 13.418-900. Phone: (019) 34178700. Email: jbsferre@esalq.usp.br

substantially until 2017, with new industrial plants already under construction in Brazil (MME, 2008).

Several leading Brazilian institutions have recently produced scenarios for the ethanol and sugarcane expansions in Brazil. These scenarios comprise, in general, the increase in the sugarcane supply, land use, ethanol and energy generation, as well as projections for the demand side. A much less studied issue, however, is the social impacts to be expected with such an expansion. The technology of sugarcane production differs significantly across Brazil's regions. The same can be said about the structure of land ownership, which suggests that the pattern of sugarcane expansion will be key to distributional outcomes.

Ferreira Filho and Cunha Filho (2008), for example, showed that the sugarcane produced in Northeast Brazil is more labor intensive than the one produced in Southeast Brazil. Moreover, those regions also differ in terms of the structure of labor demand in agriculture in general, and in sugarcane in particular, with the Northeast demanding proportionately more low-skill workers than the Southeast, which demands more high-skill workers (Ferreira Filho and Cunha Filho, 2008).

Agriculture is a key sector of Brazil's economy. With strong forward and backward linkages, agriculture accounted for 5.5% of total Brazilian GDP in 2006 (IBGE, 2008), and rural population still accounted for about 19% of total population in 2003. It is natural, then, that changes in the agricultural sector have important impacts in the economy as a whole. Due to its particular characteristics in the labor market, as a food supplier and as an energy supply source, these impacts are of complex nature, with net results depending largely on the structural characteristics of the economy. The impacts of the projected sugarcane and ethanol expansion in Brazil upon labor demand, income distribution and poverty in the country is the object of this study.

2 Objective

The objective of this paper is to assess the social effects of the projected increase in domestic and world demand for ethanol on the Brazilian economy. Of particular interest in the analysis will be the effects on labor demand in the country, both in the agricultural sector and in the whole economy, and its consequences on household income distribution. The analysis will be conducted at the micro level, in order to allow the assessment of income distribution effects. Labor demand in agriculture will be disaggregated in order to allow the analysis of different kinds of workers. The regional dimension inside Brazil will be highlighted.

3 Methodology

A computable general equilibrium (CGE) model of the Brazilian economy will be used to assess the economic and distributional impact of the prospective increase in ethanol production increase in Brazil. The core CGE model is linked to a micro-simulation model of Brazil, and has its theoretical structure based on previous work of Ferreira Filho and Horridge (2006), Ferreira Filho, Santos and Lima (2007) and Ferreira Filho and Horridge (2008).

The model database used in this paper, however, is a new 2005 database. It is based on the Brazilian Input Output tables for the year 2005 and the Brazilian National Household Survey (Pesquisa Nacional por Amostragens de Domicílios – PNAD), for the year 2005 (IBGE, 2005). The main features of the model are as follows.

The CGE model used here, TERM-BR, is a static inter-regional model of Brazil based on the TERM[2] model of Australia (Horridge, Madden and Wittwer, 2005). It consists, in essence, of 27 separate CGE models (one for each Brazilian state), linked by the markets for goods and factors. For each region, each industry and final demander combines Brazilian and imported versions of each commodity to produce a user-specific constant elasticity of substitution (CES) composite good. Household consumption of these domestic/imported composites is modeled through the Linear Expenditure System, while intermediate demand has a Leontief (fixed proportions) structure. Industry demands for primary factors follow a CES pattern, while labor is itself a CES function of 10 different labor types. These different labor types are classified according to wages, as a proxy for skills. The model distinguishes 35 producing sectors (or industries) and 35 commodities. Agricultural land is distributed among the agricultural activities through a CET frontier. Export volumes are determined by constant-elasticity foreign demand schedules.

[2] Versions of TERM have been prepared for Australia, Brazil, Finland, China, Indonesia and Japan. Related material can be found at www.monash.edu.au/policy/term.htm.

These regional CGE models are linked by trade in goods underpinned by large arrays of inter-regional trade that record, for each commodity, source region and destination region, the values of Brazilian and foreign goods transported, as well as the associated transport or trade margins[3]. São Paulo[4] users of, say, vegetables substitute between vegetables produced in the 27 states according to their relative prices, under a CES demand system[5].

With 27 regions, 35 industries, 35 commodities, and 10 labor types, the model contains around 650 thousand non-linear equations. It is solved with GEMPACK (Harrison and Pearson, 1996). The CGE model is calibrated with data from two main sources: the 2005 Brazilian Input-Output Matrix, and some shares derived from the Pesquisa Agrícola Municipal (IBGE, 2005, available at http://ibge.gov.br).

On the income generation side of the model, workers are divided into 10 different categories (occupations), according to their wages. Together with the revenues from other endowments (capital and land rents) these wages contribute to regional household incomes. Each industry in each region uses a particular mix of the 10 different labor occupations (skills). Changes in activity level change employment by sector and region. This drives changes in poverty and income distribution. Using the expenditure survey (POF, mentioned below) data the CGE model was extended to cover 270 different expenditure patterns, composed of 10 different household income classes in 27 regions. In this way, all the expenditure-side detail of the micro-simulation dataset is incorporated within the main CGE model.

There are two main sources of information for the household micro-simulation model: the Pesquisa Nacional por Amostragem de Domicílios –PNAD (National Household Survey – IBGE, 2005), and the Pesquisa de Orçamentos Familiares- POF (Household Expenditure Survey, IBGE, 2004). The PNAD contains information about households and persons. The main data extracted from PNAD were wage by industry and region, as well as other personal characteristics such as years of schooling, sex, age, position in the family, and other socio-economic details.

The POF, on the other hand, is an expenditure survey that covers all the metropolitan regions in Brazil. It was undertaken during 2002-2003, and covered

[3] The dimensions of this margins matrix are: 32*2*2*27*27 [COM*SRC*MAR*REG*REG].

[4] In this paper we mean by "Rio de Janeiro" and "São Paulo" the two states which are named after their capital cities.

48,470 households in all states, with the purpose of updating the consumption bundle structure. The main information drawn from this survey was the expenditure patterns of 10 different income classes, for each state. One such pattern was assigned to each individual PNAD household, according to region and income class. After preparation, the micro-simulation database comprises 293,048 persons (older than 15 years old) and 126,007 households.

The CGE and the micro-simulation (MS) models are run sequentially, with consistency between the two models assured by constraining the micro-simulation model to agree with the CGE model. The CGE model is sufficiently detailed, and its categories and data are close enough to those of the MS model that the CGE model predicts MS aggregate behavior (that is also included in the CGE model, such as household demands or labor supplies) very closely. The role of the MS model is to provide extra information about the variance of income within income groups, or about the incidence of price and wage changes upon groups not identified by the CGE model, such as groups identified by ethnic type, educational level, or family status. Note that each household in the micro data set has one of the 270 expenditure patterns identified in the main CGE model. There is very little scope for the MS to disagree with the CGE model.

The simulation starts with a set of shocks to the model. The shocks are applied, and the results calculated for 35 commodities, 35 industries, 10 households and 10 labor occupations, all of which vary by 27 regions. Next, the results from the CGE model are used to update the MS model. At first, this update consists basically in updating wages and hours worked for the 293,048 workers in the sample. These changes have a regional (27 regions) as well as sector (42 industries) dimension.

The model then relocates jobs according to changes in labor demand[6]. This is done by changing the PNAD weight of each worker in order to mimic the change in employment. In this approach, then, there is a true job relocation process going on. Although the job relocation has very little effect on the distribution of wage income between the 270 household groups identified by the CGE model, it may have considerable impact on the variance of income within a group.

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[5] For most goods, the inter-regional elasticity of substitution is fairly high. To ease the computational burden, we assume that all users of good G in region R draw the same share of their demands from region Z.

One final point about the procedure used in this paper should be stressed. Although the changes in the labor market are simulated for each adult in the labor force, the changes in incomes and expenditures are tracked back to the household dimension. A PNAD key links persons to households, which contain one or more adults, either working in a particular sector and occupation, or unemployed, as well as dependents. Thus the model can compute changes in household incomes from the changes in individuals' employment and wages. This is a very important aspect of the model, since it is likely that family income variations are cushioned, in general, by this procedure. If, for example, one person in some household loses his job but another in the same household gets a new job, household income may change little (or even increase). Since households are the expenditure units in the model, we would expect household spending variations to be smoothed by this income pooling effect. On the other hand, the loss of a job will increase poverty more if the displaced worker is the sole earner in a household.

4 Poverty and income distribution in Brazil in the 2005 reference year

Despite recent improvement, income in Brazil is still very concentrated. If household income is split in ten groups, as displayed in Table 1, it can be seen that the first five income household groups (POF 1 to POF 5), while accounting for 67.8% of population, get only 29.3% of total household income. The two richest groups, on the other hand, while accounting for just 9.9% of the population, get 41.6% of total household income.

The poverty line used in this study was set at one third of the average household income[7]. Based on this poverty line about 28% of the Brazilian households would be poor in 2005[8].

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[6] This methodology was named by the authors as "the quantum method" in previous work, and is described in more detail elsewhere (see Ferreira Filho. and Horridge, 2005). Here only the main ideas are presented.

[7] The criterion used in this study sets the value of the poverty line in R$184.66, in 2004 values. Note that this value is not directly comparable to most other studies in the field, since it is based on an equivalent income, and not on the average household income, as many studies do.

[8] Rocha (2006), working with a set of regional poverty lines, obtained a 0.332 headcount ratio for 2004, which would amount to 57,698,000 poor people.

The figures in Table 1 also show how each POF group contributes to the Foster-Greer-Thorbecke (1984) (FGT, for short) overall measures of poverty: FGT0 – the proportion of poor households (i.e., below the poverty line) and FGT1 – the average poverty gap ratio (proportion by which household income falls below the poverty line). It can be seen from Table 1 that the share below poverty line is very high until the third household income group, and that the poverty gap is very high among the poorest household group, around 50%. Actually, this household group contributes to around 66% of the national poverty gap.

Table 1. Poverty and income distribution in Brazil. 2005.

Household income group	Proportion of population	Proportion of income	Share below poverty line (FGT0)	Household Contribution to FGT0	Average poverty gap (FGT1)	Household contribution to FGT1
1 POF[1] (poorest)	14.1	2.3	0.85	0.14	0.50	0.08
2 POF[2]	14.0	4.2	0.62	0.09	0.18	0.02
3 POF[3]	21.0	10.1	0.20	0.04	0.03	0.01
4 POF[4]	7.7	4.7	0.05	0.00	0.01	0.00
5 POF[5]	10.9	8.4	0.01	0.00	0.00	0.00
6 POF[6]	7.2	7.0	0.00	0.00	0.00	0.00
7 POF[7]	9.9	12.6	0.00	0.00	0.00	0.00
8 POF[8]	5.3	9.2	0	0	0	0
9 POF[9]	4.8	11.8	0	0	0	0
10 POF[10] (richest)	5.2	29.7	0	0	0	0
National Values	100.00	100.00	0.28	Sum = 0.28	0.12	Sum = 0.12
GINI	0.55					

Brazil is a large, heterogeneous country, with important regional differences in poverty and income distribution. These differences are shown in Table 2.

The most densely populated regions are the Northeast region (NE), with 27.83% of total population, and the SE region, with 42.51% of Brazil's population. The Northeast and North regions present the higher relative poverty levels, or share of regional population below the poverty line. When one takes into account the size of the population, however, São Paulo and Minas Gerais (both in the Southeast region of Brazil) are, with Bahia, the most important contributors to the national headcount ratio (FGT0)[9], as can be seen from the fifth column in Table 2. São Paulo is also the most important regional contributor to the poverty gap.

[9] São Paulo and Minas Gerais are two of the most industrialized states in Brazil.

Table 2. Regional poverty and income inequality figures. Brazil, 2005.

Regions	Macro-regions (*)	Regional population share in total population	Proportion of poor households in regional population (FGT0)	Regional contribution to total FGT0	Regional Average Poverty Gap (FGT1)	Regional Contribution to total Poverty Gap
1 Rondonia	N	0.80	0.29	0.00	0.10	0.00
2 Acre	N	0.30	0.43	0.00	0.17	0.00
3 Amazonas	N	1.58	0.33	0.01	0.13	0.00
4 Roraima	N	0.19	0.41	0.00	0.18	0.00
5 Pará	N	3.41	0.41	0.01	0.17	0.01
6 Amapá	N	0.29	0.30	0.00	0.11	0.00
7 Tocantins	N	0.67	0.37	0.00	0.14	0.00
8 Maranhao	NE	3.03	0.58	0.02	0.28	0.01
9 Piauí	NE	1.57	0.54	0.01	0.28	0.00
10 Ceará	NE	4.20	0.50	0.02	0.23	0.01
11 RGNorte	NE	1.60	0.45	0.01	0.19	0.00
12 Paraíba	NE	1.91	0.46	0.01	0.20	0.00
13 Pernambuco	NE	4.43	0.48	0.02	0.22	0.01
14 Alagoas	NE	1.52	0.56	0.01	0.25	0.00
15 Sergipe	NE	1.07	0.43	0.00	0.18	0.00
16 Bahia	NE	7.27	0.46	0.03	0.20	0.01
17 MinasG	SE	10.67	0.24	0.03	0.09	0.01
18 EspSanto	SE	1.87	0.25	0.00	0.10	0.00
19 RioJaneiro	SE	8.75	0.19	0.02	0.08	0.01
20 SaoPaulo	SE	22.78	0.15	0.03	0.06	0.01
21 Paraná	S	5.65	0.18	0.01	0.07	0.00
22 StaCatari	S	3.25	0.10	0.00	0.04	0.00
23 RGSul	S	6.14	0.15	0.01	0.06	0.00
24 MtGrSul	CW	1.23	0.24	0.00	0.09	0.00
25 MtGrosso	CW	1.50	0.23	0.00	0.08	0.00
26 Goiás	CW	3.06	0.24	0.01	0.09	0.00
27 DF	CW	1.25	0.19	0.00	0.09	0.00
Total	Brazil	100	-	0.28	-	0.12

*Macro-Regions: N = North; NE = North-East; SE = South-East; S = South; CW = Centerwest

The joint analysis of Table 3 and Table 4 brings important information for the problem at hand. Table 3 shows the structure of labor use by production sector in Brazil. The 35 industries have been aggregated to 5 for reporting purposes. The first line shows the upper limit, in year 2005 Reais, of the value of each wage class. For example, the wage class OCC2 includes monthly wages ranging from R$150 to

R$250, and so on. The last wage class, OCC10, includes all monthly wages higher than R$2,000.00 in 2005 values[10].

The table shows that Agriculture accounts for about 50.2% and 47.8% of total use (wages) of the less skilled (lowest wages) workers in Brazil, respectively wage classes OCC1 and OCC2, while the other sectors account for a larger share of workers in the higher wage classes. The Service sector is also an important employer of poorer workers.

Table 3. Use of labor by each aggregated activity. Shares. Brazil, 2005.

	Wage classes									
Sectors	OCC1	OCC2	OCC3	OCC4	OCC5	OCC6	OCC7	OCC8	OCC9	OCC10
Limit (R$)	150	250	300	350	400	500	620	900	1500	open
Agropec	0.50	0.44	0.17	0.19	0.13	0.10	0.08	0.05	0.04	0.06
ExtratMin	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01
Manufact	0.06	0.06	0.10	0.13	0.13	0.15	0.16	0.17	0.15	0.15
FoodInd	0.02	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.02	0.01
Services	0.41	0.47	0.71	0.65	0.70	0.71	0.73	0.74	0.78	0.78
Total	1	1	1	1	1	1	1	1	1	1

Table 4 brings information about the income composition of household classes in Brazil (POF1 to POF10, after the Pesquisa de Orçamentos Familiares – POF, the expenditure survey), the expenditure units in the model. Unsurprisingly, the income of the poorest households is mostly composed of wages coming from the worst-paid workers. The income of the poorest household (POF1), for example, is almost entirely composed of wages coming from the three lowest wage groups (OCC1 to OCC3), the less skilled workers in the economy.

[10] For the sake of reference, the monthly weighted average value of the minimum wage in Brazil in 2005 was R$286.66 (4 months at R$260.0 and 8 months at R$300). Roughly speaking, then, OCC3 is around the limit of the minimum wage value.

Table 4. Household income composition according to worker's wage class. Brazil, 2005.

	OCC1	OCC2	OCC3	OCC4	OCC5	OCC6	OCC7	OCC8	OCC9	OCC10	Total
POF[1]	0.243	0.242	0.516	0	0	0	0	0	0	0	1
POF[2]	0.107	0.118	0.165	0.121	0.207	0.282	0	0	0	0	1
POF[3]	0.056	0.083	0.179	0.058	0.105	0.138	0.194	0.186	0	0	1
POF[4]	0.040	0.066	0.144	0.051	0.088	0.162	0.192	0.222	0.036	0	1
POF[5]	0.020	0.042	0.089	0.034	0.075	0.134	0.148	0.216	0.242	0	1
POF[6]	0.012	0.026	0.067	0.024	0.055	0.105	0.112	0.235	0.362	0.002	1
POF[7]	0.006	0.016	0.038	0.018	0.039	0.075	0.086	0.175	0.340	0.206	1
POF[8]	0.002	0.008	0.022	0.009	0.023	0.048	0.051	0.126	0.297	0.414	1
POF[9]	0.001	0.004	0.010	0.004	0.011	0.023	0.026	0.063	0.205	0.652	1
POF[10]	0.000	0.001	0.003	0.001	0.002	0.005	0.006	0.014	0.060	0.907	1

(*) – POF1 is the poorest, POF10 the richest.

5 Labor demand composition in the sugarcane production complex in Brazil

Throughout the text the term "sugarcane complex" will be used to refer to sugarcane, ethanol and sugar production. Information obtained from PNAD shows the structure of labor demand, distinguished by sector, labor type, and region. This is important for this study. There are technological differences in the ethanol production chain inside Brazil; particularly in the labor composition of cane growing. According to PNAD, in 2005 there were 597,532 workers in sugarcane production, 79,901 in ethanol production and 119,746 in sugar production. Primary sugarcane, then, has a prominent role in labor income composition of the sugarcane complex in Brazil.

The first thing to take into account in this discussion is the regional distribution of sugarcane production in Brazil, shown in Figure 1, which also shows the regional wage bill share in sugarcane production and the regional shares of labor force in the sugarcane production activity.

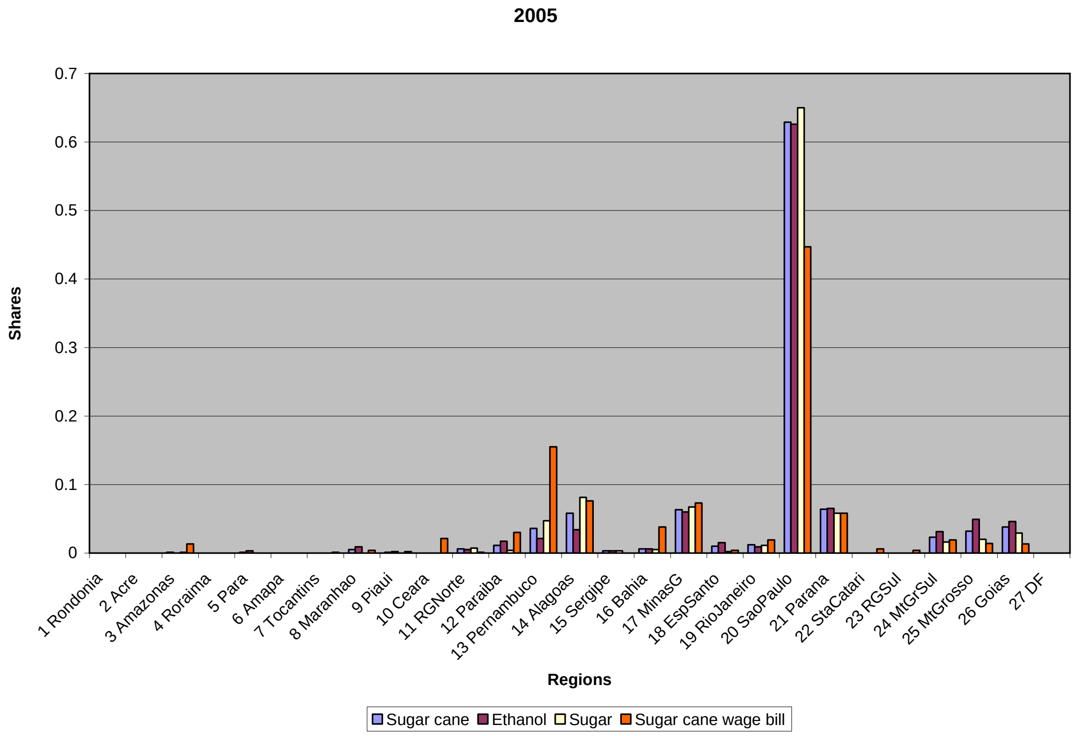

Figure 1. Sugarcane complex geographical distribution in Brazil (shares). 2005.

The figure shows that production is concentrated in São Paulo, the most industrialized state, which in 2005 still produced more sugar than ethanol. Another point to note is the almost perfect correlation of production of the three products (sugarcane, ethanol plus sugar) in the same regions. Sugarcane is bulky and cannot be transported far — forcing processing to occur close to growing. The sugar/ethanol ratio, however, varies between regions.

Note also the contrast between the total wage bill shares and the regional production shares. In Figure 1, the Northeast states (Maranhao, Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernanbuco, Alagoas, Sergipe and Bahia), though responsible for just 12.6% of total sugarcane production, account for 32.7% of wages in the sector. The NE states (of which Pernambuco and Alagoas are the most important) are much more labor intensive in sugar cane production than São Paulo, the most important producer. São Paulo, on the other hand, while accounting for 26.3% of the total labor force in sugarcane production, pays 44.7% of the total labor bill in the activity, pointing to an above-average wage in this state, in contrast to lower wages in Pernambuco, Alagoas and Minas Gerais.

Two states in Northeast Brazil, Pernambuco and Alagoas deserve special attention for this study. They are the most important states in the sugarcane complex production in Northeast Brazil. As can be seen in Figure 1, Pernambuco (a larger state with a larger population, see Table 2) produces less of both ethanol and sugar than Alagoas, a smaller state. Pernambuco has a more diversified economic structure, which implies that the sugarcane complex value of production has a smaller share in the state's total value of production. Indeed, database values show that the sugarcane complex (sugarcane, ethanol and sugar) account for 2.7% of total value of production (all producing activities) in Pernambuco, against 15.1% in Alagoas. The ratio of the value of production of sugar/ethanol is almost the same in both states, being 3.55 in Pernambuco against 3.71 in Alagoas.

Notice too that the states in the Centerwest region (Mato Grosso do Sul, Mato Grosso and Goiás), in which the sugarcane expansion is much more recent, produce more ethanol, rather than sugar. The wage bill shares of those regions are much smaller than the ethanol production shares, pointing to a more capital-intensive sugarcane production. Indeed, the flat lands and sparse populations of these regions favor mechanization, including mechanical harvesting, in contrast to the NE regions, where the bulk of the sugarcane is still manually harvested. The distribution of labor bill in sugar cane production by region, according to occupational wages can be seen in Figure 2.

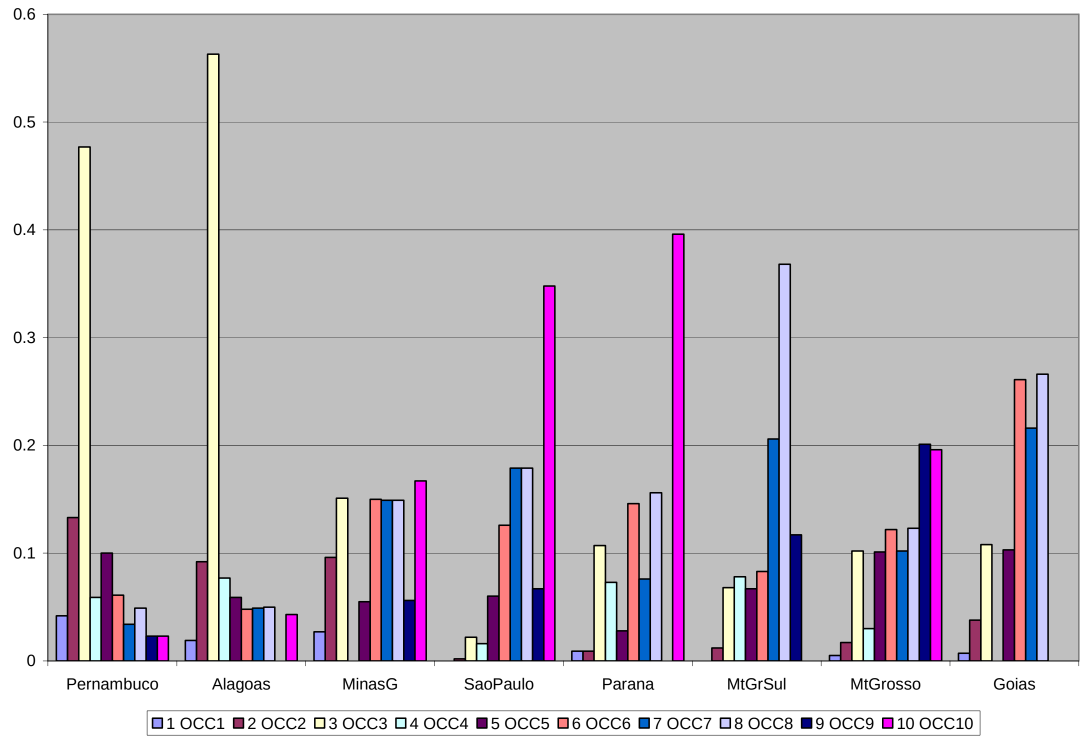

Figure 2. Share of labor bill in sugar cane production, by occupational wages and by region. Brazil, 2005.

In Figure 2 only the most important states in sugarcane production are listed, to avoid clutter. The Northeast states (Pernambuco and Alagoas) specialize in employing the less skilled workers (OCC1 to OCC3), while São Paulo (the most important producing state) concentrates in the middle to upper range. The first three occupational groups account for 65.2% and 67.4% respectively in Pernambuco and Alagoas, and only 2.4% in São Paulo. Goiás, which is representative of the new expansion area (together with Mato Grosso do Sul and Mato Grosso), has a labor demand pattern strongly concentrated on the upper wage groups, or more skilled workers. This seems to be the pattern of labor demand in the new areas, bringing important consequences for income distribution.

Another informative way of looking at the structure of labor demand in the sugar cane complex is by analyzing the type of worker in the agricultural sector according to its contractual status, that is, if the worker is a permanent worker, temporary worker of a self employed worker. This information is largely gathered from the PNAD 2005 survey, since the microdata of the Brazilian Agricultural Census is not yet available, and can be seen in Figure 3.

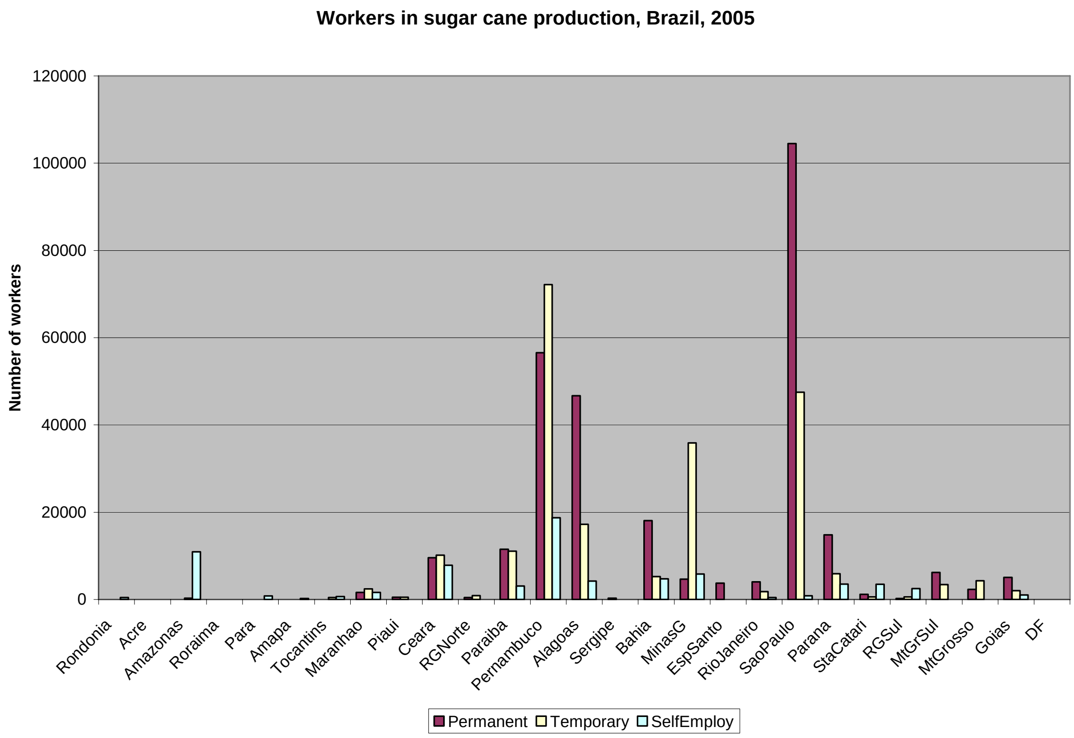

Figure 3. Labor structure in the sugar cane sector, by job type. Brazil, 2005.

The total number of workers (temporary, permanent and self employed) in the sugar cane production sector in Brazil in 2005 was 597,532 workers[11]. This total is subdivided in 222,518 temporary workers, 292,767 permanent workers, and 70,998 self employed workers (IBGE, 2005)[12]. The regional distribution of these types of workers can be seen in Figure 3. As it can be seen, Sao Paulo, the most important producer state, concentrates the bulk of workers in the sector, followed by Pernambuco and Alagoas. In Sao Paulo the number of temporary workers (47,504) is smaller than the number of permanent workers (104,499), contrary to what can be observed in Pernambuco and Minas Gerais, where the number of temporary workers is higher.

It should be noted, however, that Sao Paulo, even though concentrating the larger number of workers in the sugar cane sector has a share in total employment (0.263) in the sector that is smaller than the state's sugar cane production share (0.632), another indication of the relatively more capital extensive nature of production in Sao Paulo. Indeed, the average wage index in the sugar cane sector in Brazil in 2005 can be seen in Figure 4.

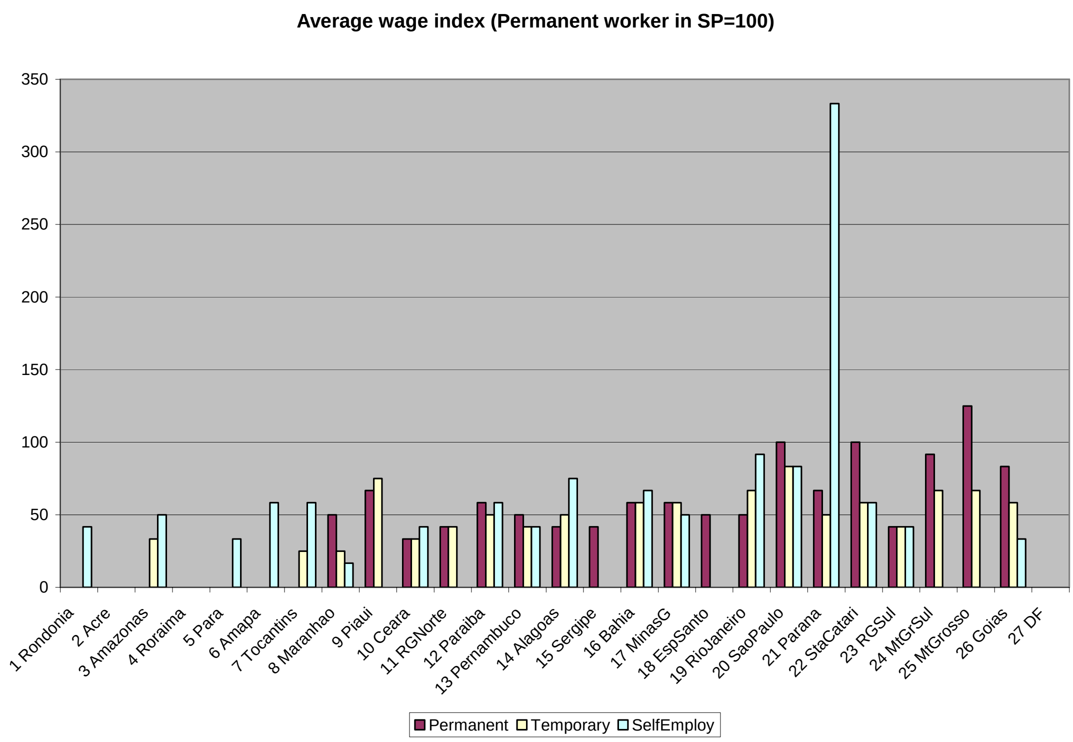

Figure 4. Average wage index in sugar cane production in Brazil. 2005.

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[11] Older than 15 years.
[12] Besides those workers the PNAD identifies an extra 11,949 who are employers.

The numbers in Figure 4 are average wages index numbers in reference to the average wage of the permanent worker in Sao Paulo (which is taken as 100). As it can be seen, in Sao Paulo the wage of the permanent worker is about 20% higher than the wage of the temporary worker. The wage of a permanent worker in Pernambuco, on the other hand, is around 50% less than the reference permanent worker in Sao Paulo[13].

6 The scenarios to be simulated

The scenarios of this study are based on the projections of EPE (2008a,b). Even though these scenarios were originally designed in October 2008 (during the first signals of the current world financial crisis), they are long-run scenarios, and should be regarded as upper-bound scenarios.

The simulated scenario entails projections for the year 2016, and takes into account a large number of variables. In what follows the main points of this scenario are presented:

- About 73% of the cars will be “flex-fuel” in Brazil in 2017.
- The blend of ethanol and gasoline in gasohol will be around the present level (25% of ethanol in the blend).
- A 0.7% a year increase in the fuel use efficiency of new cars.
- The consumer price of gasoline must be above US$1.47/litre for the whole period.
- Exports for the USA based on the forecast of the Energy International Administration (EIA)[14]. For Europe, estimates from F.O.Licht[15]. Exports to other markets are 15% of those for the main markets.

The EPE study brings several different production scenarios, including one from UNICA, the sugarcane industry producers association. The UNICA scenario is somewhat more conservative than the EPE original one, and was adopted here. The final scenario, however, gets some elements from the EPE scenario, namely the intermediate demand increase, and adapts it to the UNICA scenario. Table 5 shows the projected production and use of ethanol as for the 2016 year.

[13] The values for states where sugar cane production is small, as is the case of Amazon, Paraiba and Santa Catarina, should be regarded with care, due to possible survey problems.
[14] EIA/DOE, 2007. Anual Energy Outlook 2007 with Projections to 2030. Available at: http://www.eia.doe.gov/oiaf/archive/aeo07/pdf/0383(2007).pdf.
[15] F.O.LICHT, 2006. World Ethanol Markets – The Outlook to 2015.

Table 5. Ethanol demand projections for Brazil. Billions of liters.

Ethanol use projections	2006/2007	2015/2016	% variation
Domestic fuel use	13.55	32.65	141.0
Chemical industry use	0.65	1.95	200.0
Exports	3.7	12.3	232.4
Total	17.9	46.9	162.0

The projections in Table 5 are the UNICA projections, adapted from EPE (2008a) to include intermediate demand projections not included in the original UNICA data. These intermediate demands refer to new chemical industries using ethanol instead of petroleum products. As can be seen, the scenario entails a strong demand in ethanol in Brazil, to be matched by increases in local ethanol production.

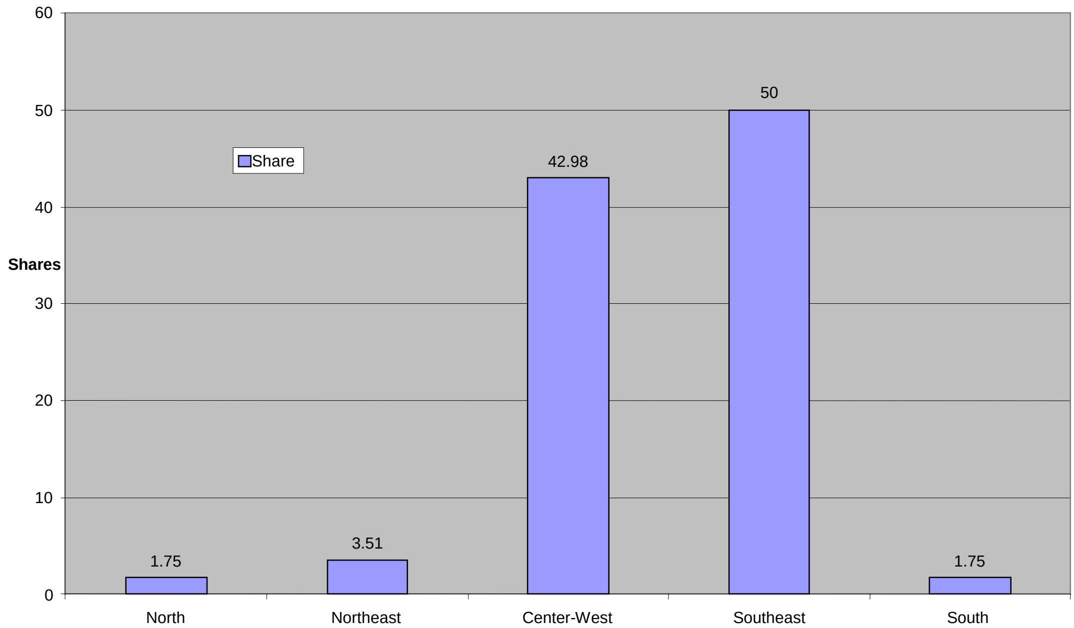


Figure 5. Regional distribution of projected new mills in Brazil, 2010.

Ethanol production is expected to increase unevenly in the Brazilian regions. EPE (2008b) forecasts that 114 new sugarcane mills will be built by 2010 (mostly for ethanol production only). About 90% of those new plants will be located in the states of Mato Grosso do Sul and Goiás, in the Centerwest region, and in Minas Gerais and São Paulo, in the Southeast. Mato Grosso do Sul and São Paulo together account for 51% of the projected new mills. The regional distribution of the new mills (according to EPE, 2008a), can be seen in Figure 5[16], while Figure 6 shows the location of mills and distilleries in Brazil, both existing and projected (EPE, 2008a).

This regional pattern of expansion of ethanol production is taken into account in the simulations, and is one of the main differences between this study and that of Giesecke, Horridge and Scaramucci (2007). As seen before, there are important regional differences in labor demand compositions in the sugarcane production in Brazil. As seen in Figure 5, the Centerwest and the Southeast regions in Brazil will likely increase their share in ethanol production in the country, while the northeast region, currently the second most important, will reduce its share.

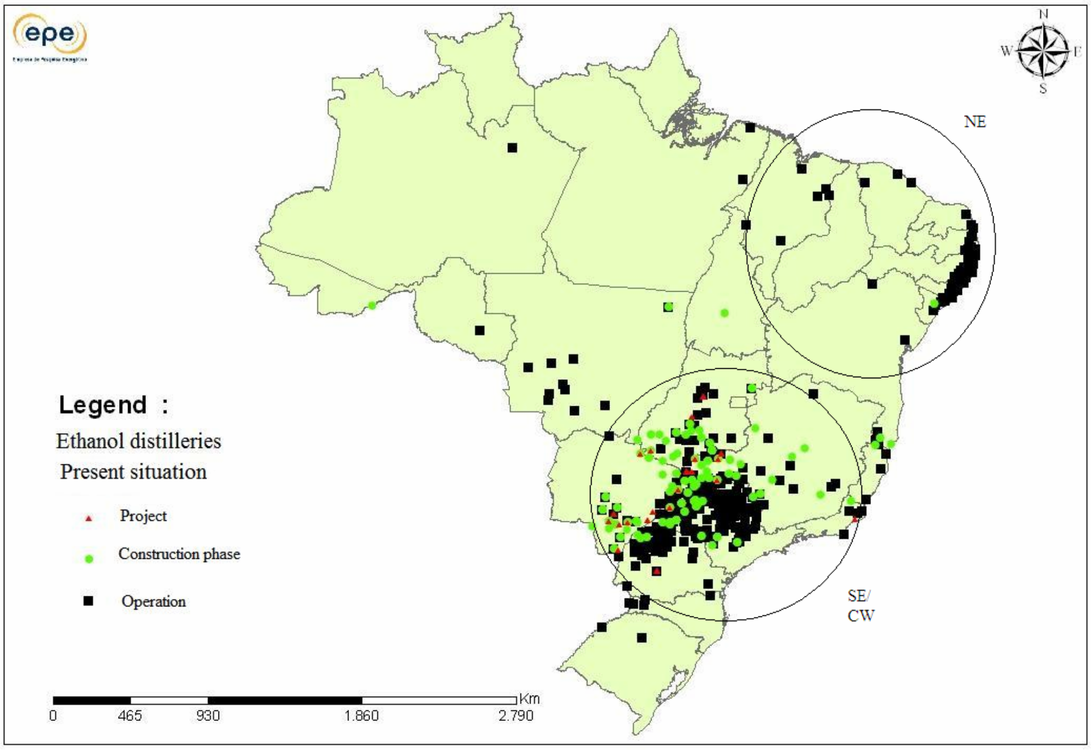


Figure 6. Location of ethanol distilleries in Brazil.

7 Simulation design

The sources of increase in demand for ethanol in the simulation are:

- Growth in household demands, generated by the increase in the flex-fuel fleet in Brazil. This growth also implies a fall in gasohol[17] use by households;
- Growth in exports of ethanol; and

[16] The total projected demand increase would require, according to EPE(2008) 132 new mills, but it is not yet possible to determine their location.
[17] Gasohol is the blend of pure gasoline (75%) and ethanol(25%) which is used regularly in Brazil.

- Growth in intermediate demands caused by a shift from petroleum products towards ethanol by parts of the chemical industry.

The simulation starts with an adjustment in the model database – as stated above this is based on 2005. The baseline projections, however, start in 2006, and depart from a level of exports and household demand larger than in 2005. That is, the exported share and household demand share in 2006, which was used to calculate the shocks, are larger than the one observed in the 2005 database. The solution for this problem was to do a preliminary simulation to adjust the database to the shares observed in 2006. With this procedure the share of exports in total use in the original database, which is 9.2% in 2005, was updated to about 20%, in line with the EPE estimates for 2006. This adjusted database was used for subsequent simulations.

The main simulation was done by imposing the demand-side projections on the model and letting supply adjust accordingly. This was done under a standard long-run closure, of which the main aspects are:

- National employment rate, national unemployment rate, participation rate and hours worked per worker are assumed not to be affected by the shocks, and hence are exogenous. Labor moves between regions driven by changes in regional real wages. Initial inter-regional wage differentials are not eliminated.
- Sectoral investment in the model is linked to sectoral profits. However, this affects only the aggregate demand profile, since the model is static.
- The trade balance is fixed (as a fraction of GDP) and total household consumption is endogenous. Government consumption follows household consumption.
- Industry-specific capital stocks are free to adjust in general, at given rates of return. The ethanol production industry, however, gets a different treatment.
- Considering that the ethanol expansion is expected to happen almost entirely in the Centerwest and Southeast regions, capital stocks in ethanol production are free to adjust in some states in these regions, and kept fixed in all other regions. This means that the expansion in demand will be mostly met by capital expansion (and ethanol supply) in ethanol production in the Centerwest and Southeast states, which comprise the states of Minas Gerais, São Paulo, Paraná, Mato Grosso do Sul, Mato Grosso, and Goiás. These regions will be referred throughout this text as the “target regions”. In these states, then, capital stocks adjust to meet the demand targets.

- Total stock of agricultural land is fixed by state, and mobile between agricultural activities through a CET mechanism.
- The increase in ethanol demand by households will substitute gasohol (which in Brazil is a blend of 75% of gasoline and 25% of ethanol, as stated before) in household use. This is endogenously done in the model through a shift in household preferences from gasoline towards ethanol, representing the increase in the flex-fuel vehicle fleet.
- The intermediate demand increase in ethanol use is implemented through a global intermediate cost-neutral shift (twist) from Basic Petrochemicals products towards ethanol. The increase in ethanol demand for intermediate consumption, then, reduces the demand for Basic Petrochemicals products.
- The increase in capital stock in the Centerwest states was accompanied by a 5% reduction in ethanol transportation costs from that region to the other regions.
- The consumer price index (CPI) is the model's numeraire.

The shocks assume that the use of ethanol by households in Brazil would increase at a 3.5% a year rate due only to the baseline growth in the Brazilian economy in the EPE (2008) scenario, a procedure also used by Giesecke, Horridge and Scaramucci (2007). The final shocks applied in the model can be seen in Table 6[18].

Table 6. Ethanol demand shocks to the model.

Shocks	% variation
Domestic household demand for fuel use	135.0
Chemical industry use	112.0
Exports	232.4

The shocks are applied to the core CGE model, and the results are transmitted to the micro-simulation model, which calculates the changes in income distribution caused by the shocks. The results are discussed in the next sections.

[18] Notice that the difference between the percent variations in Table 5 and Table 6 is due to the baseline increase in the case of households demand, and to the need to transform the projected intermediate consumption use change in the EPE projections in the corresponding variation in intermediate use in the database.

8 Results

8.1 *General results*

The production of ethanol represented, in the adjusted database, about 0.5% of total value of production in Brazil – so the shocks generate only small changes in macroeconomic variables. This can be seen in Table 7.

Table 7 Model results. Selected macroeconomic variables.

Macro variable	% variation
Real Household Consumption	0.15
Real Investment	0.21
Real Government Expenditure	0.17
Real Exports	-0.46
Real Imports	-0.77
Real GDP	0.13
Aggregate Employment	-0.00
Average real wage	0.25
Aggregated Capital Stock	0.45
GDP Price Index	0.08
Consumer Price Index (CPI)	0
Exports Price Index	-0.06
Imports Price Index	-0.87
Nominal GDP	0.21
Land price	2.61

The total shocks in ethanol demand generate a 0.13% increase in real GDP. This is accompanied by a slight appreciation of the currency (a 0.95% appreciation, measured by the difference between the variation of the imports price index and the GDP deflator percentage changes), and a 0.81% increase in the terms of trade. As a result of the shock there is a 0.45% increase in total capital stock in the economy.

Table 8 shows variations in production, exports and employment, by commodity and region; the sectors most directly linked to the ethanol production increase are shaded.

As a result of the shocks to the model, a 50.39% increase in sugarcane production is required, and a 51.25% increase in the sector's employment. Ethanol production expands by 103.5%, to meet the demand targets[19]. Ethanol exports increase by the value imposed by the shock, and the same is true for household use (shown in Table 6). Due to substitution, gasohol production must fall by 17.73%,

[19] With the baseline expansion considered, the UNICA forecast for 2015 would require a 107% increase in production. The small difference with that target and the results here presented is due to differences in database shares of household consumption.

driving the fall in Gasoline production by 5.50%. The production of Petrochemicals also falls (-7.9%) due to the change in intermediate use towards ethanol.

Table 8. Model results. Production, prices, exports and employment. Percentage changes.

Commodity	Production	Consumer prices	Exports	Employment
Rice	-0.53	-0.20	0	-0.56
Corn	-0.56	0.04	-2.75	-0.53
Wheat and Cereals	-2.20	-0.17	-1.94	-2.23
Sugar Cane	39.07	0	0	38.13
Soybeans	-2.36	0.29	-4.94	-2.43
Cassava	-0.60	-0.11	-3.14	-0.59
Tobacco	0.17	0	-2.15	0.15
Cotton	-0.83	0	-8.08	-1.03
Oranges	-0.47	0.36	-6.05	-0.19
Coffee	-2.53	0	-3.80	-2.52
Forestry	-0.79	-0.09	-3.87	-0.78
Live Animals	-0.33	-0.01	-4.72	-0.37
Raw Milk	-0.31	0.02	0	-0.38
Other Agriculture	-0.45	0.03	-4.18	-0.40
Mining, Oil, Gas	-2.88	-1.08	0.72	-4.54
Meats	-0.99	0.15	-3.81	-1.32
Edible Oils	-0.10	0.13	-3.71	-0.52
Dairy	0.12	0.17	-4.37	-0.23
Processed Rice	-0.19	0.18	-2.80	-0.49
Sugar	-0.38	0.40	-6.06	-1.13
Processed Coffee	-0.69	0.18	-6.85	-1.04
Other Food	-0.30	0.08	-3.85	-0.64
Textiles and Apparel	-0.97	0.09	-6.17	-1.13
Paper and Graphic	-0.35	-0.01	-2.84	-0.58
Gasoline	-5.50	0	-0.76	-5.61
Gasohol	-16.73	-0.42	0	-16.71
Ethanol	103.50	1.31	232.40	112.67
Combustible Oils	-0.03	-0.51	-1.18	-0.13
Petrochemicals	-7.90	-0.39	-1.80	-8.01
Other Manufacturing	-0.62	-0.16	-3.97	-0.84
Automobiles, Buses, Trucks	-2.43	-0.15	-7.80	-2.56
Metal Products	-1.44	-0.24	-3.43	-1.82
Trade	-0.90	0	-3.40	-1.03
Transport	-0.54	-0.11	-2.82	-0.70
Services	-0.06	0.02	-3.09	-0.17

The fall in production of Gasoline and Petrochemicals harm in particular the states of Bahia and Rio de Janeiro. These states have a high share in production of those products, just like São Paulo, but unlike this state Rio de Janeiro and Bahia are not important ethanol producers. The expansion in ethanol, then, will transfer part of those states' economic activity to São Paulo, which is already the economic centre of gravity of Brazil. This result also point to a possible growth in idle capacity in the contracting sectors, something for planners to take into account.

Sugar production shows a small reduction, 0.38%, mainly due to the 6.06% fall in sugar exports. This is due to the real appreciation (the “Dutch Disease” effect, a result also obtained by Giesecke, Horridge and Scaramucci, 2007), and an unchanged use of sugar by households. Even though sugar is also an ethanol input in the 2005 database, the ethanol sector expansion is not strong enough to compensate for the decrease in sugar exports. This result has consequences for the regional income distribution impacts, as it will be seen. The abovementioned results, however, vary across regions, as seen in Table 9.

Table 9. Model results. Selected regional macroeconomic variables. % variation.

State (Region)*	Real GDP	Aggregate employment	Aggregate Capital Stock	Ethanol production	Sugar production
Rondonia (N)	-0.13	-0.24	-0.13	21.43	1.68
Acre (N)	-0.25	-0.35	-0.26	21.52	1.01
Amazonas (N)	-0.61	-0.56	-0.71	20.44	1.31
Roraima (N)	-0.64	-0.61	-0.65	19.80	2.06
Pará (N)	-0.91	-0.72	-1.08	24.09	2.43
Amapá (N)	-0.58	-0.56	-0.62	26.36	2.04
Tocantins (N)	-0.10	-0.25	0.12	23.74	1.55
Maranhao (NE)	-0.72	-0.53	-0.96	34.95	2.22
Piauí (NE)	-0.42	-0.37	-0.49	33.45	2.00
Ceará (NE)	-0.66	-0.56	-0.75	37.17	2.72
RGNorte (NE)	-0.73	-0.47	-1.12	44.00	0.85
Paraíba (NE)	1.15	1.08	1.19	36.63	1.30
Pernambuco(NE)	0.28	0.26	0.31	50.72	-2.22
Alagoas (NE)	2.81	2.91	2.67	37.96	-6.32
Sergipe (NE)	-0.90	-0.59	-1.37	43.30	2.72
Bahia (NE)	-0.51	-0.55	-1.04	40.33	2.62
MinasG (SE)	0.04	-0.09	0.21	104.88	1.90
EspSanto (SE)	-0.90	-0.65	-1.16	31.06	1.44
RioJaneiro (SE)	-0.98	-0.75	-1.44	24.83	1.92
SaoPaulo (SE)	0.76	0.43	1.49	113.10	-0.29
Paraná (S)	-0.24	-0.28	0.05	83.82	0.69
StaCatari (S)	-0.42	-0.39	-0.40	17.77	1.65
RGSul (S)	-0.62	-0.49	-0.74	21.01	1.93
MtGrSul (CW)	2.56	1.25	5.03	135.66	1.41
MtGrosso (CW)	2.43	0.99	5.56	154.78	4.96
Goiás (CW)	1.61	0.77	2.94	129.48	2.40
DF (CW)	0.13	0.05	0.19	29.52	1.06

*Individual states in Brazil according to macro regions: North (N), Northeast (NE), Southeast (SE), South (S), Centerwest (CW).

In Table 9, the regions where the capital stock is free to adjust (the target regions) are shaded. As can be seen, as a result of the economic regional stimulus generated by the increase in ethanol demand, capital stock increases in all those target regions, and decrease elsewhere. The same can be said about real GDP, which increases in the target regions due to the primary factor attraction caused by capital accumulation. The only exception is Parana state, where the capital stock increase is not enough to counteract the larger increase in the other target regions. Notice that there is a fall in labor employment in Parana, which, in terms of model's closure means that part of Parana labor force has moved elsewhere, attracted by higher real wages increases in other states. Actually, the states in the new Center-west producing regions show the larger increase in real wages.

For the important sugarcane producers of the Northeast (Pernambuco and Alagoas), in which capital stock in ethanol production was fixed in the simulation, model results points to an expansion of ethanol and a fall in sugar production in both states. Real GDP increases more in Alagoas than in Pernambuco. As seen before, Pernambuco is relatively more specialized in sugar than ethanol, compared to Alagoas. The strong increase in ethanol production, which crowds out sugar production in both states, is more beneficial to Alagoas than Pernambuco, an effect strong enough to increase Alagoas' GDP. And, finally, notice that aggregate employment also increases more in Alagoas than in Pernambuco, following the aggregate capital stock in those states. As seen before, Pernambuco has a more diversified economy than Alagoas, with a larger share in manufacturing and other agricultural activities.

Model results show, then, a movement of employment towards São Paulo and the Center-west states in the target regions. Pernambuco and Alagoas also increase employment, as well as Paraiba. This last state, although not an important sugar cane producer, accounts for about 1% of total sugar cane production in the base year, and gets some benefit of its expansion too. Employment changes in the model between regions are driven by real wages, and can be seen in Table 10. Real wages, employment and labor bills increase most in the Center-west states of Mato Grosso do Sul and Mato Grosso, where a large share of the new supply is expected to come from. The shares of these states in total ethanol production increase, as expected, increasing the share of Center-west in total, from 9.2% of total production in the original database to 9.8% in the updated (after simulation) database. The Northeast region, on the other hand, reduces its share in ethanol production from 12.9% to 10.9%, even though actual output increases. The South region also decreases its share slightly, from 6.1% to 5.0%, while the Southeast's share increases from 71.5% to 74%.

Table 10. Model results. Employment, real wage and wage bill, by region. Percent variation.

State (Region)*	Aggregate employment	Real wages	Labor bills
Rondonia (N)	-0.24	0.00	-0.40
Acre (N)	-0.35	0.01	-0.49
Amazonas (N)	-0.56	-0.06	-0.82
Roraima (N)	-0.61	-0.15	-0.98
Pará (N)	-0.72	-0.28	-1.17
Amapá (N)	-0.56	-0.14	-0.88
Tocantins (N)	-0.25	0.16	-0.13
Maranhao (NE)	-0.53	-0.16	-0.76
Piauí (NE)	-0.37	-0.10	-0.51
Ceará (NE)	-0.56	-0.27	-1.02
RGNorte (NE)	-0.47	-0.18	-0.54
Paraíba (NE)	1.08	1.23	3.00
Pernambuco (NE)	0.26	0.49	1.35
Alagoas (NE)	2.91	2.99	7.39
Sergipe (NE)	-0.59	-0.26	-0.87
Bahia (NE)	-0.55	-0.22	-0.91
MinasG (SE)	-0.09	0.23	0.02
EspSanto (SE)	-0.65	-0.27	-1.03
RioJaneiro (SE)	-0.75	-0.49	-1.63
SaoPaulo (SE)	0.43	0.60	1.32
Paraná (S)	-0.28	0.00	-0.50
StaCatari (S)	-0.39	-0.04	-0.76
RGSul (S)	-0.49	-0.17	-1.08
MtGrSul (CW)	1.25	1.46	3.35
MtGrosso (CW)	0.99	1.34	2.78
Goiás (CW)	0.77	1.04	2.18
DF (CW)	0.05	0.08	0.06

*Individual states in Brazil according to macro regions: North (N), Northeast (NE), Southeast (SE), South (S), Center-west (CW).

With different labor demand composition, the demand for labor by type varies by region, as shown in Table 11. In this table, regions are aggregated according to Brazil's macro region classification. In the Southeast region, however, the São Paulo state is presented separately from the Rest of Southeast (Espírito Santo, Minas Gerais and Rio de Janeiro), due to the importance of that state in sugarcane complex production.

Table 11. Model results. Labor demand variation, by type of occupation and aggregated region. Percent variation.

	Aggregated regions*					
Type of labor	N	NE	São Paulo	RSE	S	CW
OCC1	-0.28	0.14	-0.30	0.07	-0.17	-0.15
OCC2	-0.37	0.37	-0.16	-0.08	-0.22	0.00
OCC3	-0.57	0.53	-0.07	-0.40	-0.37	0.27
OCC4	-0.55	0.15	0.41	-0.41	-0.35	1.09
OCC5	-0.76	0.20	0.35	-0.37	-0.58	1.69
OCC6	-0.62	-0.32	0.50	-0.28	-0.35	0.80
OCC7	-0.87	-0.60	0.63	-0.68	-0.69	1.66
OCC8	-0.76	-0.50	0.54	-0.70	-0.53	1.84
OCC9	-0.57	-0.35	0.45	-0.32	-0.35	0.22

OCC10	-0.35	-0.32	0.41	-0.48	-0.32	0.39

*-North (N), Northeast (NE), São Paulo state, Rest of Southeast (RSE), South (S), Center-west (CW).

In Table 11 labor demand is shown by occupational group, which, as said before, is a proxy for skills. In the table, occupation 1 (OCC1) is the lowest wage (less skilled) worker, and occupation 10 the highest. OCC1 employment tends to decrease slightly in São Paulo, in the North, in the South region (which includes Paraná state) and in the Center-west. Lower-paid employment increases, however, in the Northeast region, following the sugar cane expansion in that region, which, as seen before, is relatively more intensive in low skills workers. As it can be seen, the first 5 occupational groups (OCC1 to OCC5) increase employment in Northeast Brazil, and the contrary happens to the highest wage occupations.

The above result can be better understood taking into account what happens to different agricultural activities in each state. The sugar cane expansion in Sao Paulo and in the Center-west states attracts land from other agricultural activities more intensive in less skilled workers. That's why employment for the less skilled falls in those regions. In the Northeast states, however, the contrary happens, since sugar cane is relatively more labor intensive in those states. In this case, the expansion of sugar cane has a positive effect on the employment of the less skilled workers. This is an important result, since the Northeast region is the poorest region in Brazil. The sugar cane expansion, then, along the actual forecasted patterns, will probably imply a fall in employment of the less skilled in the agricultural sector[20].

Apart from the occupations classification, which is a proxy for skills, it's also possible to analyze the change in income in the agricultural sector according to the type of the labor status of the worker, that is, if the worker is a temporary worker, a permanent worker, a self employed worker or an employer. The wage of each of those workers can be classified in any of the ten occupations groups described before. Except for the employers, the first three groups (temporary, permanent or self employed worker) have their income updated in the model by the change in wages, what assumes that this is their main income source. Employers, however, have their income updated in the simulation by the change in the price of the primary composite factor, which is a composite of the price of capital, land and wages. The results can be seen in Figure 7.

[20] We will get back to this point later on this text.

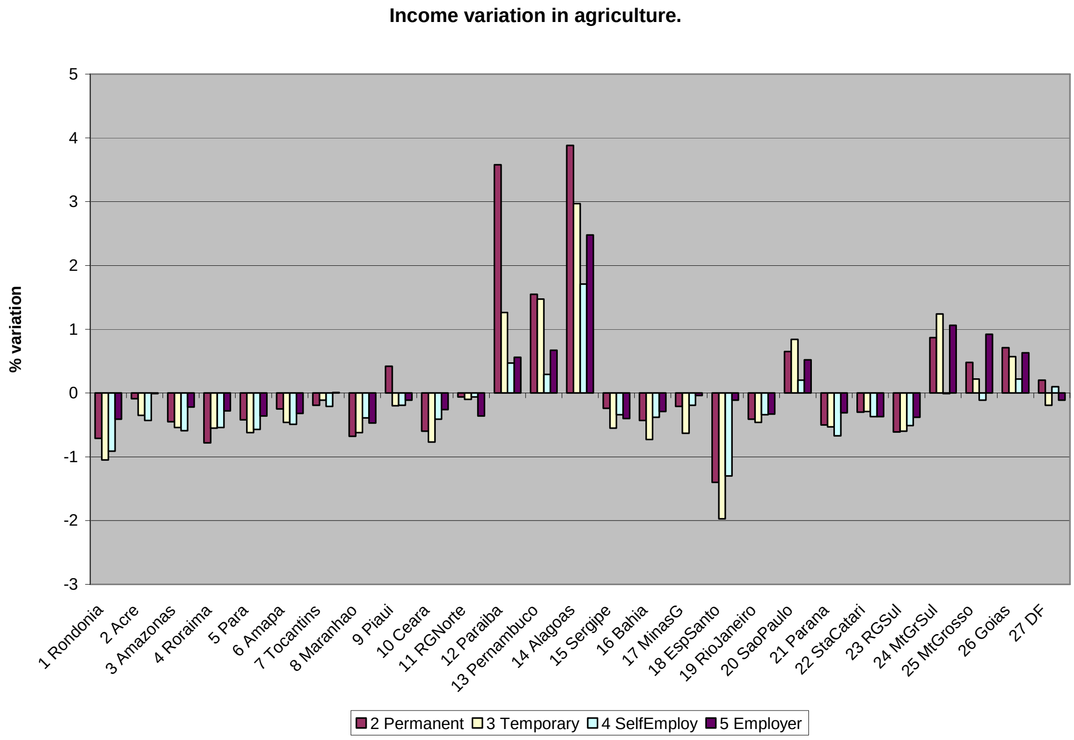


Figure 7. Model results. Average income variation in agriculture. Percent variation.

As it can be seen, the average income of those working in agriculture tends to increase in the expansion regions. Notice again that Paraiba, a small state in Northeast which is not an important sugar cane producer also tend to benefit from the ethanol and sugar cane expansion. As for the most important producer states we can see that the income of workers in agriculture experience the greatest increase in Alagoas, a small state, where permanent workers average income increases by about 3.9% and temporary workers income increase by 3.0%. In Sao Paulo, on the other hand, the increase in workers income is relatively smaller and greater for temporary workers.

The income of temporary workers experience also a relatively high increase in the new expansion areas of Mato Grosso do Sul (MtGSul) and Mato Grosso (MtGrosso), indicating the relative scarcity of workers in those regions in comparison to the strong sugar cane expected expansion. This is also related to the more capital intensive production system to be settled there compared to what has been observed so far. As mentioned before, the region's flat topography is favorable to mechanization, what would facilitate the substitution between labor and capital indicated by relative factors prices. And, finally, the income of employers increases in most expansion regions, influenced by the increase in the price of land, which drives an increase in land returns[21].

The projected sugarcane production requires, in the model, a 21.48% increase in land use for the culture. This increase in land demand for sugarcane is accommodated by a fall in agricultural land for other uses, as shown in Table 12.

Table 12. Model results. Agricultural land use change.

Commodity production	% variation
Rice	-0.42
Corn	-1.98
Wheat and Cereals	-2.09
Sugar Cane	21.47
Soybeans	-2.36
Cassava	-1.17
Tobaco	0.39
Cotton	-0.26
Oranges	-7.89
Coffee	-3.59
Forestry	-1.81
Live Animals	-1.22
Raw Milk	0
Other Agriculture	-1.88

In 2006, 6.18 million hectares were planted with sugarcane, according to the Brazilian Ministry of Agriculture and Livestock (MAPA), accounting for about 10% of total land used for agriculture (not pastures) in the same year, around 60 million hectares. The required increase in land for sugarcane production would represent around 1.4 million hectares. The total of land allocated for pastures in Brazil, however, according to 2006 Brazilian Agricultural Census (IBGE, available at http://www.sidra.ibge.gov.br) amounts to 172 million hectares. This is a point which has raised a lot of concern in the discussions about the ethanol expansion in Brazil, the ethanol *versus* food issue. As we can see, however, land availability will certainly not be a problem in Brazil, especially if one takes into account that the new expansion regions are exactly where livestock pasturing is concentrated.

Besides that, it should also be noticed that, despite the increase in sugar cane productivity observed in the last years, there is apparently still a strong potential for further productivity increases, depending on the economic conditions. In the 2005/06 harvest year, for example, Sao Paulo produced 243 millions tons out of about 387 million tons of total sugarcane production in Brazil. Marin et alii (2008), in a study

[21] The income of the employer in the model is updated by the composite price of primary factors (capital, land and labor), which is driven down by the fall in labor wages and land prices in the non-expansion states.

about the potential sugar cane productivity in Sao Paulo concluded that only about 15% of cultivated sugar cane land in the state had productivity higher than 70% of the potential productivity in the 2002/2003 harvest year. This information can be seen in Table 13 and Figure 8, bellow.

Table 13. Area of efficiency classes of sugarcane crop production, during two growing seasons, in the State of Sao Paulo, Brazil.

Crop Efficiency	Growing season		Growing season	
	1995/1996		2002/203	
	Km2	%	Km2	%
0-10%	59,285	24	55,855	22
11-30%	40,634	16	33,985	14
31-50%	42,648	17	35,185	14
50-70%	89,275	36	85,269	34
>70%	16,965	7	38,513	15

Source: Marin et alii, 2008.

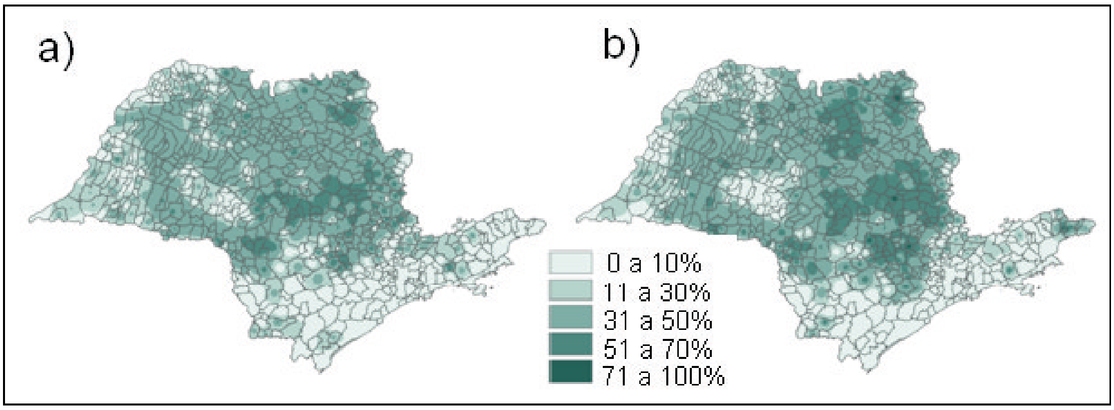


Figure 8. Spatial variation of sugarcane production efficiency, in the State of São Paulo, Brazil, during the growing seasons of 1995/1996 (A) and 2002/2003 (B). Source: Marin et alii (2008)

The model used here, of course, does not take into account productivity gains, which makes the land projections described above an upper limit projection. As it can be seen in Table 7, about 50% of the cultivated land area in the state of Sao Paulo, the most important producer in Brazil still had, in 2003, production bellow 50% of the agronomic estimated potential. Fertilizer use is found to be one of the most important determinants associated to the actual productivity, a factor that can be increased depending on economic conditions. But managerial practices were also found to be important for the results.

Model results, however, show a fall in food production (see Table 8), accompanied by an increase in the consumers' price of food. But this should not be regarded as a general welfare indicator, since there are important regional differences in employment and income changes. The income distribution and poverty impacts are evaluated in the next section.

8.2 *Distributive results*

As seen before, Brazil has important differences between states in economic structure, both in terms of composition of production and the structure of labor demand in production activities. This is true even for agriculture, and the different pattern of expansion in the agricultural activities in this simulation suggest complex compositional effects all over the country. This section will start showing some aggregated effects of the simulated scenario upon poverty and income distribution, and then the analysis will be extended to increase the detail at state level. Table 14 shows the variation in the aggregated poverty and income distribution indicators in Brazil, by household income group.

Table 14. Model results. Household poverty and income distribution results. Percent variation.

Household Income class	Average nominal income	Consumer Price Index	Average real income	Headcount ratio (FGT0)	Average poverty gap (FGT1)
1 POF[1]	3.21	0.04	3.17	-0.67	-0.83
2 POF[2]	1.09	0.02	1.07	-1.08	0.85
3 POF[3]	0.62	0.01	0.61	0.79	9.60
4 POF[4]	0.53	-0.01	0.54	12.43	48.67
5 POF[5]	0.37	0.01	0.36	45.77	157.73
6 POF[6]	0.22	0.01	0.21	138.01	681.39
7 POF[7]	-0.11	0.01	-0.12	370.87	2012.78
8 POF[8]	-0.29	0.02	-0.31	0	0
9 POF[9]	-0.61	-0.00	-0.61	0	0
10 POF[10]	-0.77	-0.04	-0.73	0	0
Original values (base year)	-	-	-	0.28	0.12
Percentage change	-	-	-	-0.02	0.83
GINI (percentage change)			-0.01		

FGT0: Foster-Greer-Torbecke proportion of poor households' index, or headcount ratio. FGT1: poverty gap. The large numbers for FGT0 and FGT1 for POF groups 4 and above have no meaning, since they represent large percentage variations on tiny base values.

Model results in Table 14 suggest that the ethanol demand increase would benefit the poorest the most, with the higher reduction in the headcount ratio appearing in POF[1], the poorest households. In aggregate, however, the net effect is only a tiny positive impact on income distribution, as can be seen by the 0.01% fall in the GINI index. This slight fall in inequality, however, is accompanied by a 0.83% increase in the average poverty gap. Poverty gap also increases for household groups 2 and 3 (POF2 and POF3) which, as seen in Table 1, accounted for about 35% of population in 2005, and had respectively 62% and 20% of families below the poverty line. The ethanol expansion, then, even though reducing slightly the number of poor people in Brazil (a 0.02% fall poverty measured by the headcount ratio), increases the average gap between poor incomes and the poverty line.

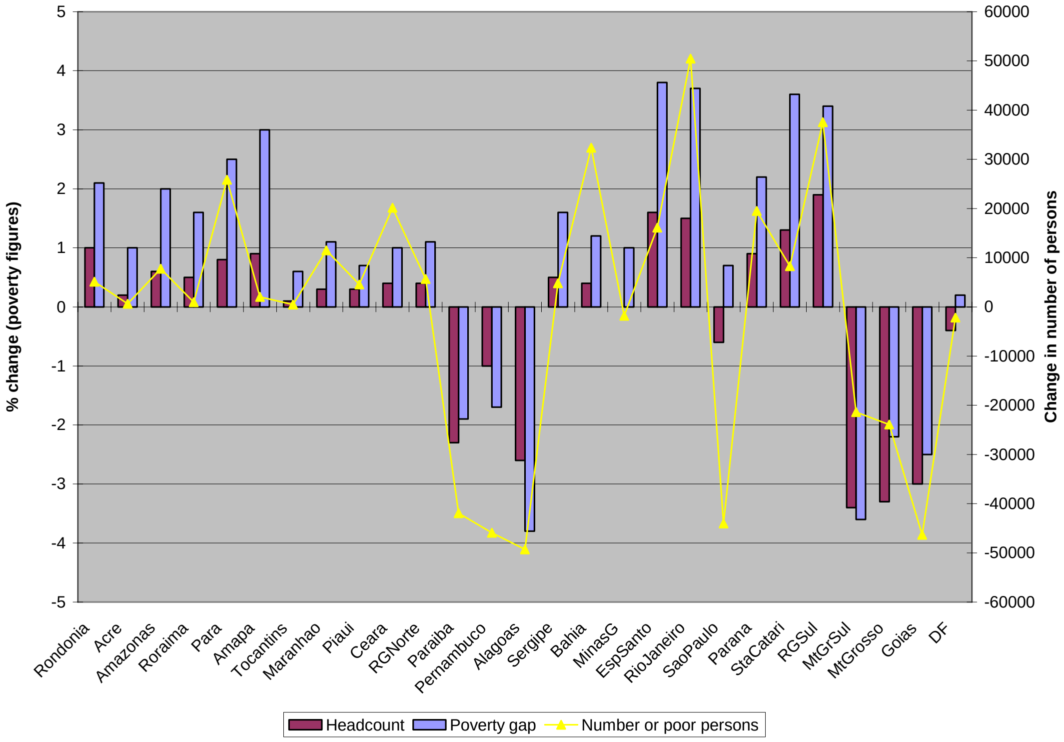
The increase in poverty gap in aggregate can be better understood taking into account what happens to the occupational wages in the simulation. As seen in Table 11, wages of the lower skilled workers increase in some regions (Northeast and the Rest of Southeast) and falls elsewhere. The total employment of workers is fixed by the closure by occupational type. The change in demand, then, changes wages and the labor bill. When the totals are computed for the whole country, the result is a fall in the aggregated labor bill of the lower skilled workers, as can be seen in Table 15. As it can be seen there, the total wage bills of the two lowest wage groups fall in the simulation, increasing the average poverty gap even though the headcount falls slightly.

Table 15. Aggregated labor bill, by wage class. Percentage change.

Wage class	Percentage change
OCC1	-0.50
OCC2	-0.26
OCC3	0.60
OCC4	0.45
OCC5	1.10
OCC6	0.65
OCC7	1.63
OCC8	1.15
OCC9	0.30
OCC10	-0.31

In regional terms, Figure 9 shows that the number of poor persons falls mostly in the states of São Paulo and in the Northeast states of Paraiba, Pernambuco and Alagoas, as well as in the Center-western states of Mato Grosso do Sul, Mato Grosso and Goiás. All the other states show an increase in the number or poor persons.

Figure 9. Regional results: percentage changes in the headcount ratio and poverty gap, and change in the number of poor persons.



Rio de Janeiro and Bahia also show a relatively large increase in poverty, which is related to the fall in activity of Petrochemicals (and related industries), which are substituted in demand by ethanol. Sugar cane is not important in these states' economies, and so they don't get the benefit of its expansion. Those states are densely populated states, and model results suggest that it will certainly require attention during the adjustment process.

The fall in the headcount ratio showed by the model corresponds to a reduction of 3,126 poor households, or 23,261 poor persons in Brazil, due to the increase in ethanol demand projected in this simulation.

It was seen before that the sugarcane expansion in Brazil is projected to happen in regions (Southeast and Center-west) where the technology in sugarcane production is more capital intensive, and in which relatively more skilled labor is demanded in the sugarcane production complex. Indeed, this seems to be the pattern that can be expected. Recent developments, especially environmental and labor regulations point to more capital intensive activity. The São Paulo state, for example, passed a law banning sugar field burning after 2012. This will have severe consequences for labor demand since non-burnt sugarcane cannot be harvested manually.

Figure 9 shows that São Paulo, already the richest state in Brazil and where relative poverty figures are one of the lowest, will be one of the most benefited with the sugar cane expansion. The same can be said about the Center-west states, where the regional headcount ratio is about half the value observed in the poorest Northeast states (Table 2). As shown by Liboni (2009), this is also the region which shows the highest educational profile for workers in the sugarcane complex, either in agriculture or in the industrial stages, in contrast to the Northeast region. But some very poor states in Northeast regions, namely Paraiba, Pernambuco and Alagoas will also be benefited by the process. Even though new industrial plants are not expected in those regions, the existing units will tend to increase their production (ethanol and sugar cane). Given the labor demand structure of sugar cane in those regions this will cause a positive effect on employment of the poorest and, consequently, on poverty.

9 Final remarks

Model results show that the expansion in ethanol demand in Brazil would slightly reduce poverty, although increasing the poverty gap. Income distribution improves very little. The main reason is that, unlike in the past, the projected expansion of the sugarcane complex has a new technological basis, which relies heavily on mechanization of agricultural activities. This raises several points for policy considerations.

The first is related to the pattern of expansion in labor demand. As shown in this paper, the increase in labor will happen mostly in São Paulo and in the Center-west regions, and among middle-waged workers, with a decrease in employment of the less skilled in many states in the Northeast region. UNICA (2008), according to Liboni (2009), estimates a loss of around 420 thousand jobs in sugarcane production in São Paulo state due only to the expansion of mechanization in harvesting. Results here presented suggest a slowing down of that movement, due to the expansion of cane-growing in São Paulo. This effect, of course, will be lost after the 2012 year, if the complete ban of manual harvest is really enforced[22]. Hence labor force training arises as a key policy problem.

[22] The extent to which the regulation will actually be enforced is uncertain. Some important producing regions in São Paulo have hilly lands, unsuitable for mechanized harvesters. Besides, these regions are the ones with a higher share of small to medium-sized producers.

Second, the results suggest that the food *versus* energy dilemma, central in recent discussions about ethanol production expansion, is not really a serious problem in Brazil. Actually, there is no factual basis for the catastrophist forecasts which became popular during the surge in international food prices observed in 2008. Even though food prices increase, due to the fall in land available for food production, the increase is small, and could easily be counteracted by small productivity increases in food production. The food price increase would actually raise the cost of the consumption bundles of the poorest, but this increase would be more than compensated by the increase in incomes, generating a net positive effect, as model results suggests. However, even though the ethanol demand expansion is shown here to be poverty-friendly in aggregate, it is only by a small amount. The distributional side-effects are positive, but not striking. The main benefits associated with Brazil's ethanol expansion are related to diversification of the energy matrix, and to reductions of greenhouse gases emissions.

The most serious imbalances associated with ethanol demand increase will likely be related to the regional redistribution of economic activity inside Brazil. The Southeast and Center-west regions, as well as the Northeast sugar cane producers are the most important winners, and the non-sugar cane producers Northeast states lose most, as well as Rio de Janeiro in the Southeast (for different reasons). This redistribution and the potential negative effects on regional equity are the main topic to deserve the attention of policymakers in Brazil regarding the sugar cane complex expansion.

10 References

EPE. 2008 a. Perspectivas Pará o etanol no Brasil. Cadernos de Energia. Ministério das Minas e Energia do Brasil. 62 p.

EPE. 2008 b. Oferta de combustíveis líquidos. Capítulo VII. Ministério das Minas e Energia do Brasil. 62 p.

Ferreira Filho; J.B.S; Cunha Filho, J.H. 2008. Uma Matriz de Contabilidade Social Pará o Setor Sucroalcooleiro do Brasil Pará 2004. Research Report to the International Labor Office – ILO. Processed.

Ferreira Filho; J.B.S; Horridge, J.M. The Doha Round, Poverty and Regional Inequality in Brazil. In: Hertel, T.W; Winters, A. (eds). 2006. “Putting Development Back into de

Doha Agenda: Poverty Impacts of a WTO Agreement". The International Bank for Reconstruction and Development. Washington, DC. Palgrave, McMillan. pp. 183-218.

Ferreira Filho; J.B.S; Horridge, J.M. 2008. Would World Agricultural Trade Liberalization Help the Poor of Brazil? in Anderson, K; Cockburn, J; Martin, W. (eds). Agricultural Price Distortions, Inequality and Poverty. Forthcoming.

Foster, J; Greer, J; Thorbecke,E. 1984. A Class of Decomposable Poverty Measures, Econometrica 52: 761-765.

Giesecke, J; Horridge, M; Scaramucci, J. A. 2007. The downside of domestic substitution between oil and biofuels: Will Brazil catch the Dutch disease? Centre of Policy Studies, Monash University. General Paper no. G-169. December.

Harrison, W.J; Pearson, K.R. 1996. Computing solutions for Large General Equilibrium Models using Gempack. Computational Economics 9:83-127.

Horridge, Madden and Wittwer (2005), The impact of the 2002-2003 drought on Australia, Journal of Policy Modeling, vol. 27, issue 3, pages 285-308

Hoffmann, R. 2006. Transferência de Renda e Redução de Desigualdade no Brasil e Cinco Regiões. Econômica, v.8, no. 1. p. 55-81. Rio de Janeiro.

IBGE - Instituto Brasileiro de Geografia e Estatística. 2005. Pesquisa Nacional por Amostragem de Domicílios. Brasil.

IBGE - Instituto Brasileiro de Geografia e Estatística. 2004. Pesquisa de Orçamentos Familiares 2002-2003. 2a. edição. 270 p. Available at http://www.ibge.gov.br/home/estatistica/populacao/condicaodevida/pof/2002/pof200220032aed.pdf .

Liboni, L.B. 2009. Perfil da mão de obra no setor sucroalcooleiro: tendências e perspectivas. Doutorado (Doctoral dissertation). Faculdade de Economia, Administração e Contabilidade. Departamento de Administração. 189 pages. Processed.

Marin, F. R; Assad, M.L.L; Assad, E.D; Vian, C.E; Santos, M.C. 2008. Sugarcane crop efficiency in two growing seasons in São Paulo State, Brazil. Pesquisa Agropecuária Brasileira. Brasília. November, v.43, no.11. PP. 1449-1455.

Rocha, S. 2006. Pobreza e Indigência no Brasil: algumas evidências empíricas com base na PNAD 2004. Revista Nova Economia. Volume 16, no. 2. pages 265-299.