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CLIMATE CHANGE IMPACTS ON AGRICULTURE AND INTERNAL MIGRATIONS IN BRAZIL

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1 Introduction

Recent internal migration flows in Brazil differ from historical patterns observed since the seventies. In the past internal migration typically flowed from states in Northeast Brazil and Minas Gerais towards the richer states of São Paulo and Rio de Janeiro. According to Brito and Carvalho (2006) between 1960 and 1990 about 8.1 million people left the Northeast and 3.8 million left Minas Gerais.

This was the “normal” internal migration pattern in Brazil until the eighties, when, according to Brito and Carvalho (2006), a succession of economic crises and expansion of the agricultural frontiers changed the picture. Actually, during the nineties emigration from the Northeast region slowed down considerably; the region became a net recipient of population in recent years. At the same time, the Southeast states of São Paulo and Rio de Janeiro, the main destination for migrants until the end of the eighties, have recently lost population. Some of the migrants leaving the Southeast return to the Northeast, but many go to the dynamic new agricultural Center-west regions.

2 Objective

The objective of this paper is to assess the potential impacts on internal migration in Brazil of different climate change scenarios that impact on agriculture. Of particular interest in the analysis will be the effects on labor demand, both in the agricultural sector and in the whole economy, and its role in the inter-regional patterns of population flows. The analysis will be conducted with the aid of a dynamic general equilibrium model of Brazil, the TERM-MIG model, to be described below.

3 Internal migration in Brazil: recent patterns

The Pesquisa Nacional por Amostra de Domicílios – PNAD (National Household Survey) is the data source for the migration data in this study. The PNADs are available since the seventies, and are a comprehensive household survey, usually regarded as being of very good quality, and the main data source for many different studies. Among the many questions surveyed by PNAD are the person’s region of origin, and where each person was living in previous years. These questions allow us to identify migrants.

There is no established definition of a migrant in the literature, with different authors using different definitions, depending on their interest. For the sake of describing the migration flows and analyzing the influence that different definitions can have on them, migration flows were collected according to different definitions for the period 2001-2007, from PNAD micro data.

The criterion to define each person’s migration status was initially to compare the actual region where the person is living with the region of birth. The second step was to check if the period for which the person is living in the different region would be sufficient to define him as a “migrant”.

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Many different criteria were used, and the total number of migrants according to each definition can be seen in Table 1. In the table the criteria used to define a migrant were: a person living in a region other than region of birth for 2 years, 3 years or 5 years.

Table 1: Total internal migration in Brazil, different definitions.

Number of years living in the region	2001 20	02 20	03 20	04	2005 20	06 20	07
2	1183171	1528940 1	425925 1	433473	1502439 1	384481 1	466653
3	1169798	1322344 1	478194 1	386877	1505782 1	412310 1	493893
5	1251173	1411385	1362150	1219948	1555577	1407 262	996058

Table 1 shows that the number of migrants is fairly stable across different definitions. The Brazilian literature on migration usually takes the 5 years time span as the main criterion to define migration (see, for example, Braga, 2006; and Brito et al, 2006). We will also use this criterion, since it excludes those moving temporarily, like students. The net regional flows³ (in-migration minus out-migration) according to that criterion can be seen in Table 2. There, negative numbers mean population outflows, and positive numbers mean population inflows. The same information is also presented in Figure 1.

³ The model database includes a full bilateral table of migration flows, for each year and labor type.

Table 2: Net migration flows in Brazil, by region. Number of people.

NETFLOW	Y2001	Y2002	Y2003	Y2004	Y2005	Y2006	Y2007
1 Rondonia	-7,655	-11,319	4,210	3,054	-13,470	-2,455	-7,045
2 Acre	4,467	-4,658	1,329	3,060	-185	3,204	-2,147
3 Amazonas	917	5,662	4,199	4,763	-736	2,823	9,944
4 Roraima	9,192	-541	6,500	1,886	6,027	9,363	10,166
5 Para	-30,329	-30,750	-26,249	-16,099	-2,621	8,517	-14,963
6 Amapa	-1,016	5,401	4,932	-3,118	5,794	4,133	9,183
7 Tocantins	-3,786	-5,299	-5,402	4,901	-16,399	-8,312	10,412
8 Maranhao	300	-14,029	5,693	-6,387	24,701	-17,745	-757
9 Piaui	-20,005	9,698	4,708	6,656	888	12,062	-1,033
10 Ceara	39,182	-3,052	23,404	1,612	6,004	1,799	6,810
11 RGNorte	-3,620	1,977	11,709	3,190	17,922	-2,972	-7,551
12 Paraiba	-10,000	-21,442	-4,206	-4,769	-1,794	4,626	-11,018
13 Pernambuco	-22,765	-13,156	-33,868	-5,171	4,218	8,13,901	1,180
14 Alagoas	-20,798	-35,465	-7,607	-20,607	-5,650	-16,691	-2,774
15 Sergipe	-6,097	-14,782	-7,419	3,614	-7,826	-6,973	1,051
16 Bahia	-70,554	-10,753	-21,421	-9,667	-489	4,989	-16,417
17 MinasG	40,878	5,319	25,060	1,952	3,432	4,828	-21,769
18 EspSanto	1,285	5,521	-10,552	7,078	-6,177	18,447	4,768
19 RioJaneiro	-20,825	4,328	-3,520	9,501	-11,512	-30,143	-9,074
20 SaoPaulo	81,767	87,059	-11,967	-3,569	6,921	-7,966	-19,294
21 Parana	-17,712	2,792	16,161	-4,461	-3,880	7,285	-9,495
22 StaCatari	12,142	-8,121	-5,939	3,825	14,398	2,787	1,693
23 RGSul	-5,384	3,134	4,886	-6,913	15,578	-2,618	-11,613
24 MtGrSul	-4,213	-1,445	-1,154	7,292	-5,733	-7,019	341
25 MtGrosso	17,597	18,240	11,349	12,520	9,309	1,793	2,854
26 Goias	44,324	3,225	34,947	35,175	4,691	5,884	1,094
27 DF	-7,292	-18,570	-19,783	-2,926	-2,590	-1,689	3,204

OBS: migrant defined as someone living in a region different from its origin for 5 years.

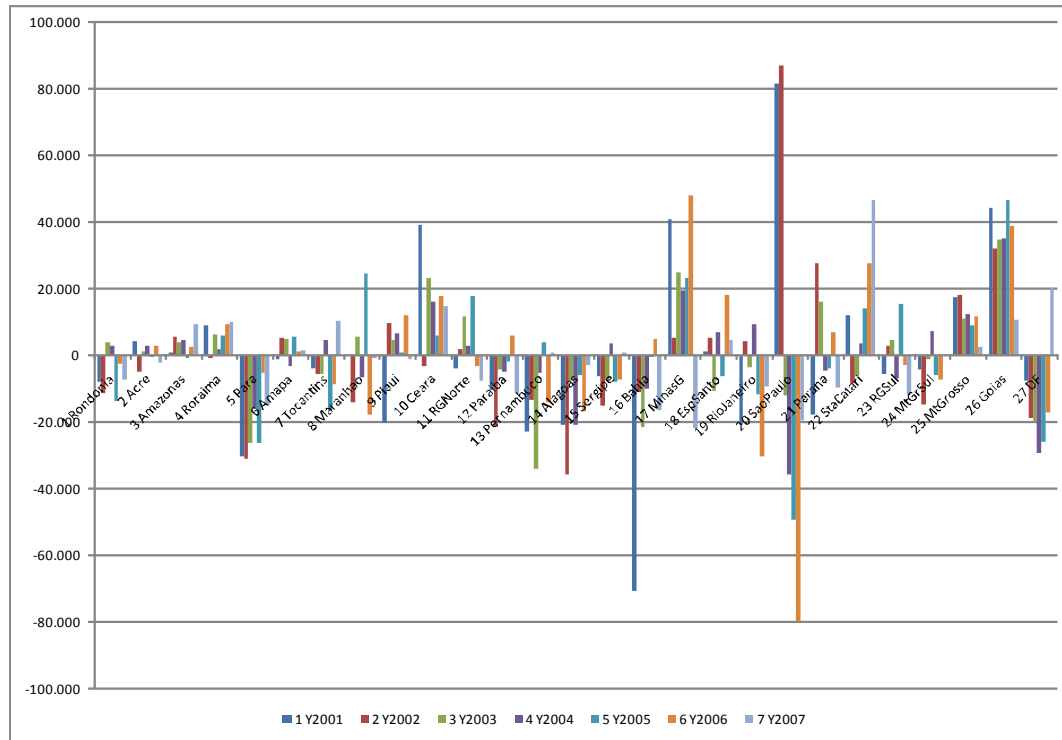


Figure 1: Net migration flows in Brazil, by region. Number of people.

Table 2 and Figure 1 illustrate the point mentioned before regarding the recent reversal of internal migration flows. The important Southeastern states of São Paulo and Rio de Janeiro, which were poles of attraction in the past, now face population outflow. The same happens to the Brazilian Federal District, to the Pará state (in the Amazon region), and to the Southern states with the exception of Santa Catarina. Two scantily populated Northern states, Roraima and Amapá, are consistently gaining population. However, Northeast Brazil, which, together with Minas Gerais, was the main supplier of migrants now shows mixed behaviour. Ceará state in this region is consistently gaining population, and the same seems to be happening to the smaller states of Piauí and Rio Grande do Norte. And, finally, Minas Gerais gains population in every year shown except 2007.



Figure 2: Brazilian states and macro regions

The geographical location of the Brazilian states listed in Table 2 can be seen in Figure 2, where the macro regions (official definition) are also shown:

- North region: states of Acre, Amazonas, Roraima, Amapá, Pará and Tocantins;
- Northeast region: Maranhão, Ceará, Piauí, Rio Grande do Norte, Paraíba, Alagoas, Sergipe and Bahia;
- Southeast region: Espírito Santo, Rio de Janeiro, Minas Gerais and São Paulo;
- South region: Paraná, Santa Catarina and Rio Grande do Sul;
- Center-west region: Mato Grosso, Mato Grosso do Sul, Goiás and Brasília (the Federal District).

As may be seen from the data, the population flows in Brazil presently follow a completely different pattern than was observed in the seventies and eighties, when there was an intense flow from the Northeast region towards the Southeast region. During that time Brazil's model of economic development entailed a transfer of population from rural areas to the cities, and from the Northeast regions to the Southeast, mainly São Paulo and Rio de Janeiro. The same phenomenon is noted by Brito et al (2006).

More recent data, however, show that São Paulo and Rio de Janeiro are the most important source of population movement to other states. The Federal District (DF -- basically Brasília, the capital) is also losing population, with a net migration outflow from 2001 (Table 2); yet this outflow is less in 2007, probably due to the recent strong increase in federal spending. Maranhão, a poor state in the Northeast, also shows negative population flows until 2007, when positive figures were registered.

It's interesting to notice that some poor Northeast states have consistently received positive migration flows since 2001, as is the case for Ceará, Rio Grande do Norte (RGNorte), Paraíba and Pernambuco. This is an inversion in the migration flows if compared to the seventies. Apparently this is due to a combination of urban congestion in the main cities (São Paulo and Rio de Janeiro), as well

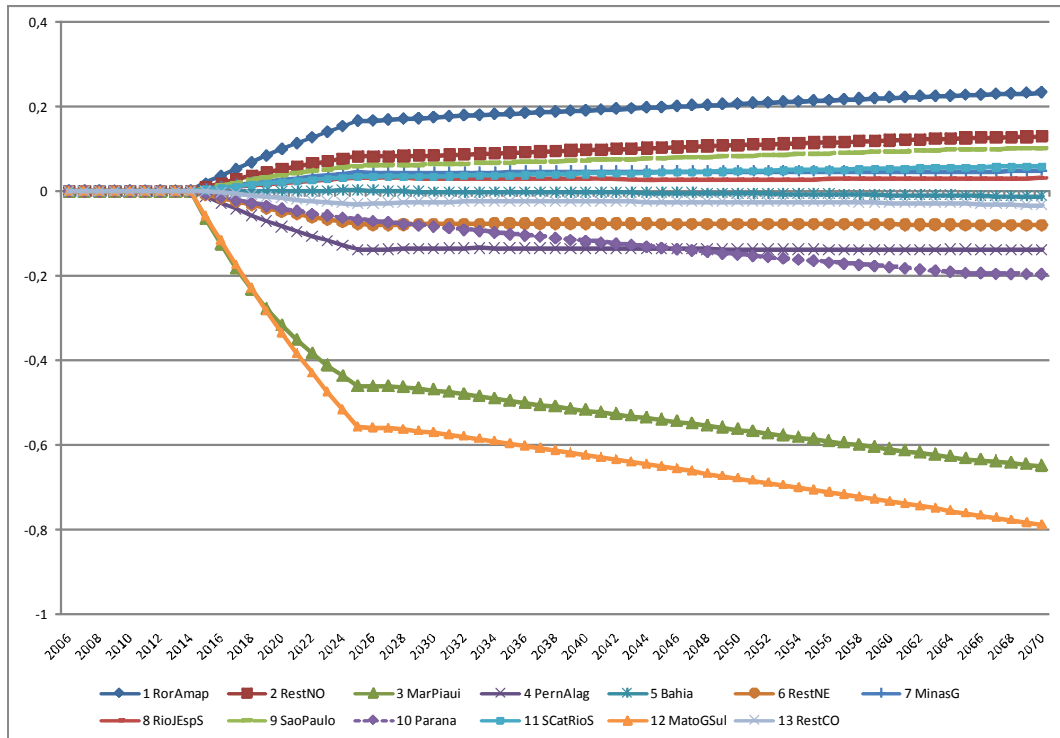


Figure 7: Regional employment variation (deviation from base line, %).

It was seen before that Mato Grosso do Sul and MarPiaui would lose the most, in terms of GDP, from the implemented scenarios. This is still the case in terms of employment: model results points to a 0.8% loss of employment in Mato Grosso do Sul and a 0.65% loss in MarPiaui. The other regions in Center-west Brazil show only a slight decline in employment. São Paulo shows a continuous increase in total employment even after 2025, when the sugar cane effect peaked. The most interesting result here, however, is the increase in employment for the Northern regions (RorAmap and RestNO). These states faced GDP losses, but gain in employment. This has to do with migration flows, to be discussed later, and could have important policy implications.

7 Migration results

The general results presented above constitute the background against which the migration results, the main objective of this paper, should be interpreted. In the model, migration is driven by the change in regional real wages: the labor force tends to move towards the regions where real wages are increasing, and vice-versa.

The model distinguishes 10 different occupations or labor types, each with region-specific wage rates. Employment of each occupation is supposed to increase in the baseline at the same rate as regional population, for which official estimates of the Brazilian Statistical Agency (IBGE) were used, as explained before. The demand for those different worker types, however, will depend on the labor mix used in production, which varies by sector and region. In what follows, the movement of total labor across regions is presented, and later the occupational composition will be discussed.

It was seen before that net inter-regional migration in Brazil flows presently from the richer Southeast region to the Center-west, some Northeast and some Northern states. Our climate change scenario, however, falls heavily on the Northeast, as seen above. The model results for the effects on migration of these impacts can be seen in Figure 8, which shows the variation in migration, by region of origin, caused by the policy scenario.

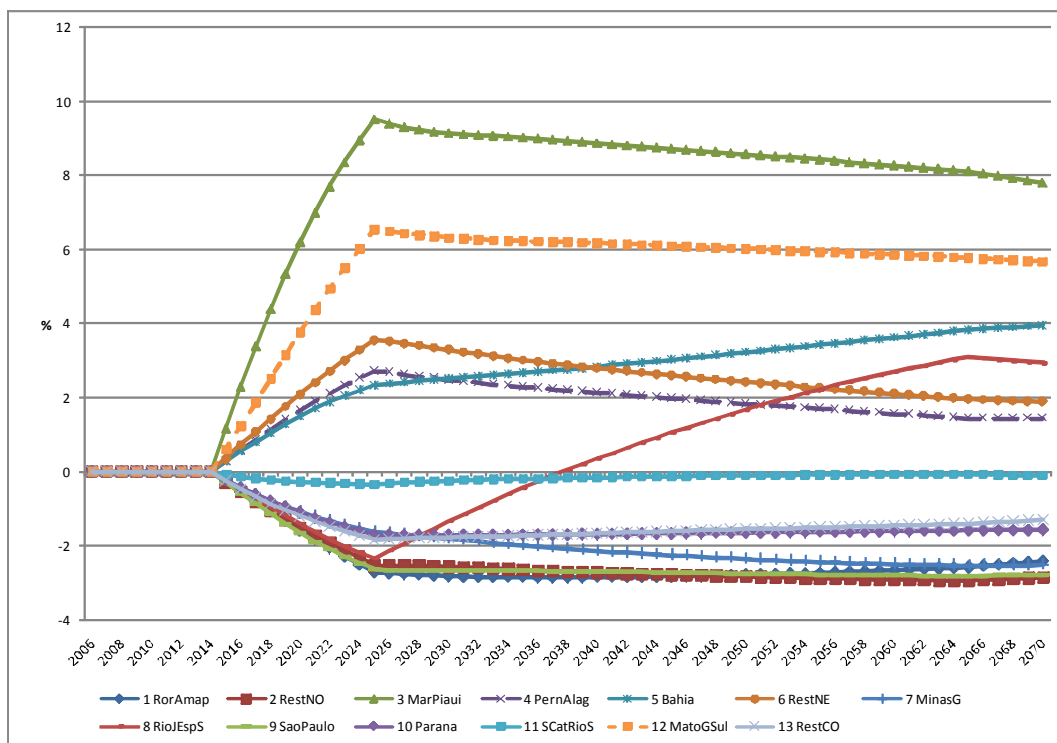


Figure 8: Model results. Inter-regional migration variation, by origin of migrants (%).

Model results presented in Figure 8 show an interesting picture of the possible effects of the simulated climate change scenarios. The first thing to be noticed is that the MarPiaui (Maranhão and Piauí states in Northeast) and MatoGSul (Mato Grosso do Sul state, in Center-west) regions are those which show the strongest increase in migration outflows, compared to the baseline. The accumulated final result for MarPiaui is an 8% increase in population outflows, and for MatGSul a 5.7% increase, compared to the baseline. However, the bulk of this effect happens during the first period scenario (2020/A2), when adaptation is not considered⁸. In 2025 the accumulated population outflow would increase by 9.5% for MarPiaui and 6.5% for MatGSul. The same pattern of migration evolution applies to the RestNE and PernAlagoas, regions inside the Northeast macroregion, although at smaller rates than MarPiaui. Again, the bulk of the effect in these regions also happens in the end of the first period scenario. After that the annual rate of population outflow falls, causing the migration path to dip, but never return to baseline values.

Bahia, the largest state in Northeast Brazil fares differently. Its outmigration flow increases continually, reaching its maximum at 2070, with an accumulated rate of 3.96% above the baseline. Despite this, the final observed result for this state is smaller than that of MarPiaui, around 4%.

The other regions inside the Southeast, South and Center-west (except MatoGSul, as seen before) would generally reduce their outmigration rates compared to the trend. The noticeable exception here is the RioJEspS sub-region, which combines the states of Rio de Janeiro and Espírito Santo in the Southeast macro region. Figure 8 shows that this region would reduce its outmigration rate in the first period. From 2026 on the yearly rate of outmigration would start to increase, causing the accumulated outmigration to become positive by 2038.

⁸ Note that the paper does not deal directly with adaptation measures, which is included in the scenarios generated by EMBRAPA.

Another possible way to analyze the results is to look at migration by destination as shown in Figure 9⁹. Note that the RorAmapa (Roraima and Amapa states, in North macro region) is the region whither migration increases the most (in percentage variation terms), and there are increases too for the other states inside the North region (RestNO sub-region). This has important economic and social implications, since the occupation of the Amazon region is presently an issue of great concern for public policy.

The increase in the rate of migration to the northern regions, caused by climate change, would reproduce the trend observed in the seventies, when the Brazilian (military) government deliberately stimulated population migration from the Northeast to the North, under the “landless people for a land without people” initiative, a policy aimed at the occupation of the vast Amazon territory, which included the construction of the Transamazônica road. The intensification of population flows toward the North, of course, will depend on other possible effects of climate change on the region, not included in this paper, like the intensification of tropical diseases and so on. The results presented here, however, point to an increase in the pressure over the region’s natural resources, arising from an increase in population.

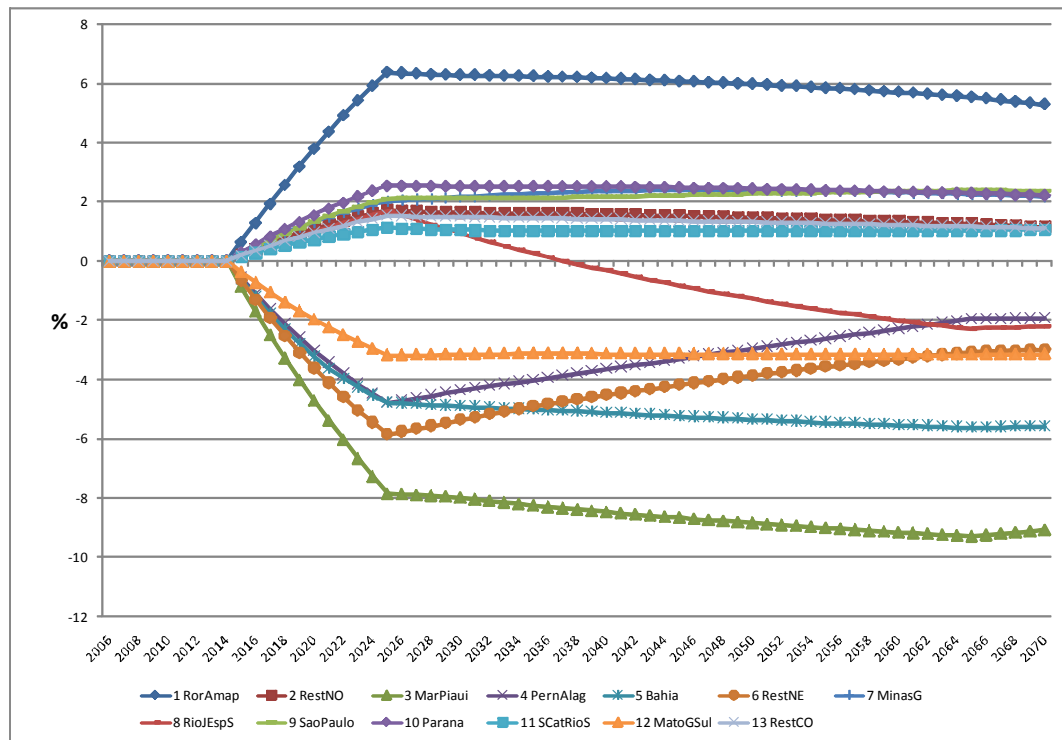


Figure 9: Regional migration in Brazil, by destination (%).

Model results show that the states in the Southeast and South macro regions would generally start to gain (relative to base) population due to the climate change scenarios. The rate of increase is not too big, reaching 2.7% for São Paulo, 2.2% for Parana and around 1% for Santa Catarina and Rio Grande do Sul). This is, however, an inversion of the migration trend observed since the beginning of the last decade, as discussed before. Again RioEspS is an exception. This region would gain population until 2025 (the end of the first scenario period), and would start to lose population from then, with a negative final result around 2.19% less immigrants arriving to the sub-region compared to the baseline in 2070.

⁹ Notice that the numbers here are not just the opposite as those seen before in Figure 8, since migration by

It should be noticed, however, that the absolute numbers of migrants involved are not very large. Figure 10 shows model results for the estimates of migration.

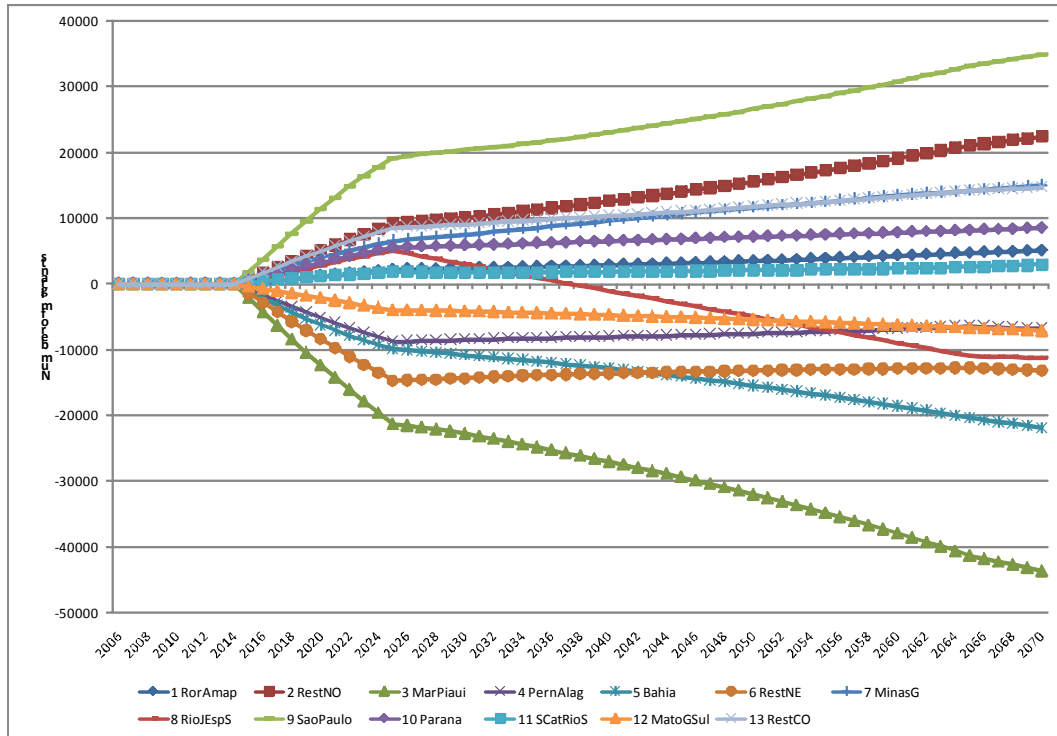


Figure 10: Net number of migrants, by destination.

It can be seen from Figure 10 that São Paulo, for example, the state that would receive the larger absolute number of migrants, would receive in the final period (2070) 34,958 more people than it would receive in the baseline, while MarPiaui, the sub-region that would lose more population, would lose 43,644 more people than in the baseline.

Another important point to be noticed here is the labor type composition of migration flows. The most negatively affected regions in the simulated scenarios are regions in Northeast Brazil, as well as in the Center-west. The structure of labor demand and different composition of agriculture in those regions will generate particular migration flows, when analyzed according to the type of labor group classification. Since it is difficult to show time, skill and regional dimensions in a single diagram, we have chosen to present the accumulated result in the last year of the period. This can be seen in Figure 11. It shows that the regions receiving most of the migration flows (RorAmap, MinasG, Sao Paulo, Parana, StaCatRioS and RestCO) all receive a higher share of the relatively unskilled workers, or those classified in occupation 1 to 3 (OCC1 to OCC3). This means that most of the migration flows would occur among the less qualified workers, which again echoes the migration patterns observed in the past¹⁰. The rapid increase in the migration of unskilled workers towards the big cities in Southeast Brazil caused the surge in the “favelas” (slums), still a very serious problem in the main cities. Again, the results here presented point to a movement in internal migration similar to what was observed in the past.

Figure 11 shows too that MatoGSul state which would be losing population in aggregate terms, would actually be receiving a positive inflow of less skilled workers (OCC1 and OCC2). This

destination computes the totals from different origins.

¹⁰ Note that our migration function does not differentiate between different skills. Whether unskilled workers have more or less difficulty to migrate than skilled workers is an empirical issue, which will have to be considered for future work.

result is strongly related to the projected increase in cassava production in the state. Inspection of labor demand composition for this crop in the database reveals that about 60% of total labor payments in cassava go to workers in the first two occupational groups. The other states where cassava tends to increase production (Sao Paulo, RioJEspS and RestCO) have a much smaller share of unskilled workers in cassava production.

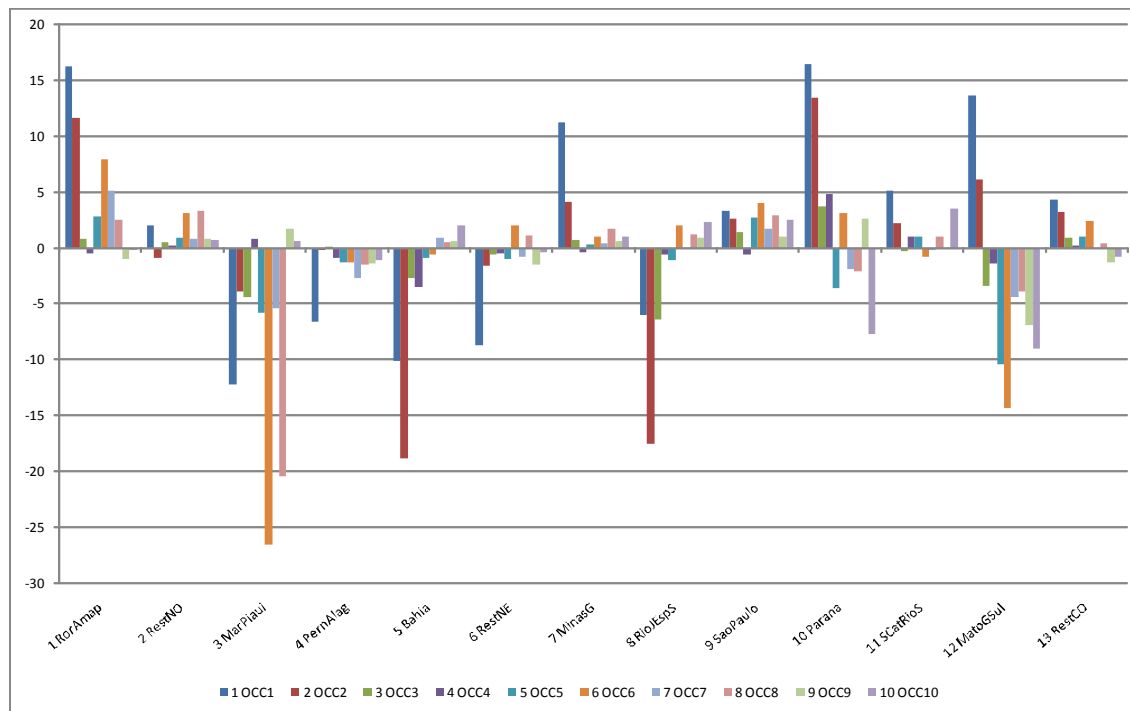


Figure 11. Migration by occupation and destination (accumulated, 2070, % change from baseline).

We should now point out that the migration concept used in this study involves only the personal (worker) dimension. Migration, however, is a complex phenomenon, and frequently involves the whole family, which may sooner or later follow the migrant worker. Indeed, Oliveira and Jannuzzi (2004) analyzed the reasons of migration in Brazil. According to those authors, based on a special supplementary survey in the PNAD 2001, the “search for jobs” is the most common reason for migration, especially among men: 34% of men and 11.8% of women have selected that as the main reason for migration. Altogether 23% of the surveyed persons declared that their main reason for migration was the search for jobs¹¹. The answer “accompanying the family”, on the other hand, accounted for 51.5% of the answers for the main reasons for migration (63% among women), and many different factors for the rest. This is, of course, due to the presence in the sample of children and teenagers below 14 years.

Our study’s migration database included only persons above 15 years old. According to the same above mentioned authors, the youngest (around 20 years old) would be more prone to migrate than any other age group, and this would be strongly correlated to movements in the labor market. In this way, the high concentration of young persons among migrants would be explained by their “sensitivity” to bids in the job market, as well as for their higher adaptability to new situations (Oliveira and Jannuzzi, 2004).

Thus it is not absurd to consider that each migrant would bring two other relatives in his wake, at least in the medium run, which might triple the numbers observed in Figure 12. This is a point that deserves further elaboration in future studies.

8 Final remarks

The climate change scenarios simulated in this paper point to a reversal of the current pattern of internal migration in Brazil. The severe climate-induced effects on some Northeast states would cause a new pressure for migrants to leave those regions. Model results presented here point to the MarPiauí sub-region (Maranhão and Piauí states) as the most adversely affected in terms of agricultural production, increasing emigration from that region. Perhaps more surprisingly, the same would happen to Mato Grosso do Sul state, in the Center-west region. The Southeast and South regions would be the recipient regions, a movement that reverses current flows.

Perhaps even more worrying is the conclusion that the less skilled workers would be the larger part of migrants. This suggests that a new surge in the population movement impetus towards the already large slums in the Southeast cities could start to appear again in the near future. These low-wage workers, which belong to the most socially vulnerable groups, would be left with no option but migration, if adaptation measures are not put into action.

Another interesting point to be observed from the results presented here is the increase in migration towards the North regions. Even though, as observed before, the forecasted numbers are not very big, they may raise policy concerns. Increased migration towards the Amazon would increase the pressure over natural resources in that region — already a matter of great concern for the Brazilian government.

And, finally, a limitation of this study is that the results should be regarded as floor estimates, since they only refer to workers, and not families. The decision to migrate is a complex one; very often the family comes to join the main migrant later. We hope to analyze this aspect of the problem in future work.

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¹¹ In the 20 to 54 years old persons the “search for work” answer varies between 33.1% to 40.1% of answers.

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