Sustainable consumption and population dynamics in Brazil

Kênia Barreiro de Souza[i], Edson Paulo Domingues[ii], Gilvan Guedes [ii], Sueli Mingoti [ii], Aline Magalhães [ii], Flaviane Santiago [iii], Débora Cardoso [ii]

[i]*Federal University of Paraná,* [ii] *Federal Univeristy of Minas Gerias;* [iii]*Federal University of Juiz de Fora*

Abstract: This paper analyses sustainable consumption in Brazil, highlighting the consumption profile of sustainable products by income level and household composition. Preference data collected in 2012 by the Brazilian Ministry of the Environment, and expenditure data from the 2008-2009 Brazilian Household Budget Survey were used in a Computable General Equilibrium model to project scenarios of demand for sustainable products and its implication for production, employment, and household income. Household income growth, economic growth, population dynamics, productivity, and energy efficiency gains were explicitly modelled. A dynamic path for consumption preferences towards organic products was also included. Our simulation assumes that preference for organic consumption increases from 2016 to 2050, varying among income deciles. By 2050, Brazil would experience an overall increase in organic consumption, despite differences between poor and rich households regarding preference and share of income spent in organic products. This result is the consequence of the combined effect of income growth (faster for poorer households) and preference change (faster for richer households). The projected consumption path suggests that increase in organic consumption may generate positive effects for all households, including the poor, by increasing production, employment demand in sectors were the poor are more likely to be employed, and family income.

Keywords: sustainable consumption; structural equations; computable general equilibrium model; Brazil

1. Introduction

To achieve sustainable development, understood as the balance between economic, social, and environmental development over successive generations, it is necessary to achieve efficiency in production. Gains from production efficiency, however, may be undermined if consumption patterns are not in line with resource use optimization and minimization of environmental degradation. Brazil has experienced important changes in its consumption pattern in the last decades, especially when it comes to the purchase of sustainable food products. Factors such as urbanization, population aging and change in household composition can influence the amount spent as well as the composition of the food basket consumed by a household. These population level changes impose new challenges for rural producers, agroindustry, the food distribution sector, and the government (Oliveira and Hoffmann, 2015).

Although household income is the main determinant of food purchase, there has been a growing preference for a more environmentally friendly lifestyle in Brazil, especially considering the group of consumers concerned with healthy eating practices (Guedes and Carmo, 2012; Brazil, 2012). This trend has established a new dimension to the way consumption occurs, increasing the desire for goods and services that compromise less environmental resources for their production. Products from companies that show a greater socio-environmental commitment, both in production and recycling, has also shown increasing acceptance among consumers even when prices are higher (Spaargeran, 2003).

Sustainable consumption is not a new concept. Since the 1992 Earth Summit it had been suggested as a key dimension of sustainable development to mitigate environmental degradation (Dolan, 2006). In this sense, the achievement of a sustainable production depends on understanding the mechanisms that foster sustainable consumption, giving greater importance to the role of citizenconsumers in the elaboration and reproduction of some central institutions, such as *production* and *consumption* (Spaagaren, 2003).

In developed countries, there is a growing literature on sustainable consumption, including non-food dimensions of consumption. In Brazil, however, little is known about the patterns of sustainable consumption and how it varies by age, sex, and income. In the economic and demographic literature, in particular, the extent to which changes in the propensity to adopt sustainable consumption practices affect the economy, the labor market, and family wellbeing in the long run is still little understood. This study contributes to the literature of the mid and long-term consequences of pro-sustainable consumption to the economic growth, labor supply, and family well-being in Brazil by establishing possible changes in consumers' preferences, such as towards organic consumption.

We developed an integrated model, coupling statistical and general equilibrium models. Propensities to consume organic products by deciles of household income are obtained from Structural Equation Models (SEM). These propensities then feed a dynamic computable general equilibrium model (CGE) as a parameter for future preferences in consumer behavior towards sustainable consumption practices. In the scenario 2016-2050, we consider an increase in the overall preference for organics by income level, and increase in the demand for organic consumption according to the growth rate of *per capita* income. Other demographic and economic simulation elements also determine the consumption of these products in our model, such as GDP and income growth, relative prices, productivity gains, sectoral and demographic dynamics (population growth, aging, and household composition effect).

This modeling strategy allows us to simulate the impact of change in preferences towards sustainable consumption by income levels on family consumption, production and demand for employment for main economic sectors. These trajectories may be decomposed by household income decile, providing evidence on how the promotion of a typically high-income behavior (consumption of organic and environmentally certified products) may generate positive externalities through increase in labor demand for sectors where the poor are more likely to be employed. Consequently, overall gains in family consumption, including the poor households, would be achieved with lower levels of income inequality.

2. Empirical Strategy

To analyze the sustainable consumption pattern in Brazil and its differences by age, sex, and household income, we integrated the results from structural equation models (SEM) to a demographic scenario and a Computable General Equilibrium (CGE) model. The SEM were estimated from survey data collected in 2012 by the Brazilian Ministry of the Environment, designed specifically to understand attitude, knowledge, and behavior towards sustainable consumption. The SEM model provided results about pro-sustainable consumption attitude, pro-sustainable consumption behavior, supply constraints, effective sustainable consumption practices, and organic consumption preferences in Brazil. Results were disaggregated by sex, age, and household income.

The results found in the structural equation model show that sustainable consumption practice is related to household income, indicating that people with higher income are more likely to practice sustainable consumption, especially the consumption of organic products (Table 1). This result is rather consistent with the literature on income and consumption of organic products in Brazil (OLIVEIRA; HOFFMAN, 2015; SAE, 2015; GUEDES ET AL., 2013; RIBEIRO; VEIGA, 2011) e and other countries (THØGERSEN, 2010; VERMEIR; VERBEKE, 2006; WEATHERELL ET AL., 2003). Income and age also positively influence the knowledge about this sustainable consumption, which in turn is a very important driver of preference for organic and environmentally friendly products.

While the SEM estimates provides a rich set of preferences for overall organic and sustainable consumption, it does not quantify actual consumption of organic and environmentally certified products, which are one of the most important categories of consumption associated with sustainability (Oliveira and Hoffman, 2015). To fill this gap, we use data from the 2008-2009 Brazilian Household Budget Survey, for 2008-2009.

The survey data suggests that the share of these products in the household budget was around 0.05%. That means that for every R$ 1,000 of total spending, households spent around R$ 0.50 with organic products (Figure 1). The expenditure on organic products grows with household income, especially in families in the ninth and tenth decile, but the share of household income spent on these products decreases among richer households. Most expenditure in sustainable consumption among Brazilian families are concentrated in products from the food industry. Consumption of organic products by age of the head of the household. Among households with older heads (60 years or more) the share of total income spent on organics is as high as 0.07% compared to only 0.02% among households headed by individuals below 29 years of age (Figure 2).

Table 1: Propensity to consume organic products by income decile – Brazil, 2012

Income decile	Mean income of the decile	Organic consumption			
		Mean score	Standard deviation	95% confidence interval	
1	186.00	0.158	0.366	0.109	0.207
2	523.01	0.206	0.405	0.151	0.260
3	700.67	0.316	0.466	0.254	0.379
4	865.63	0.266	0.443	0.207	0.326
5	1,005.09	0.383	0.487	0.318	0.449
6	1,131.13	0.326	0.470	0.263	0.388
7	1,443.08	0.388	0.488	0.322	0.453
8	2,082.20	0.316	0.466	0.254	0.379
9	2,769.50	0.388	0.488	0.322	0.453
10	5,123.97	0.449	0.499	0.382	0.515

(*) Sample size = 2.144; income in Brazilian Reais. Estimates from the Structural Equation Model (SEM).
Source: Own elaboration using data from the Ministry of Environment (2012)

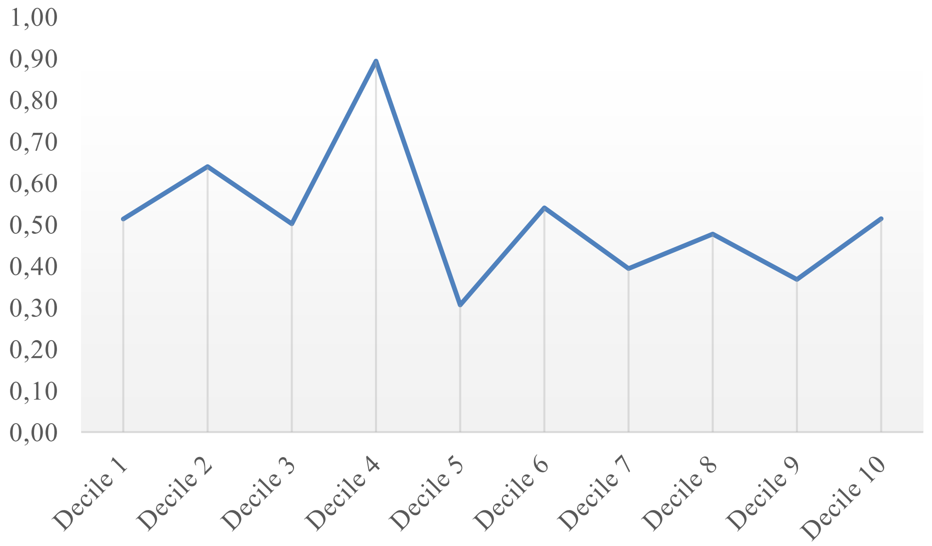

Figure 1: Organic and environmentally certified products Expenditure for each 1,000 Brazilian reais in total expenditures per income decile - Brazil, 2008/2009
Source: Own elaboration based on data from POF 2008/2009 (IBGE, 2014).

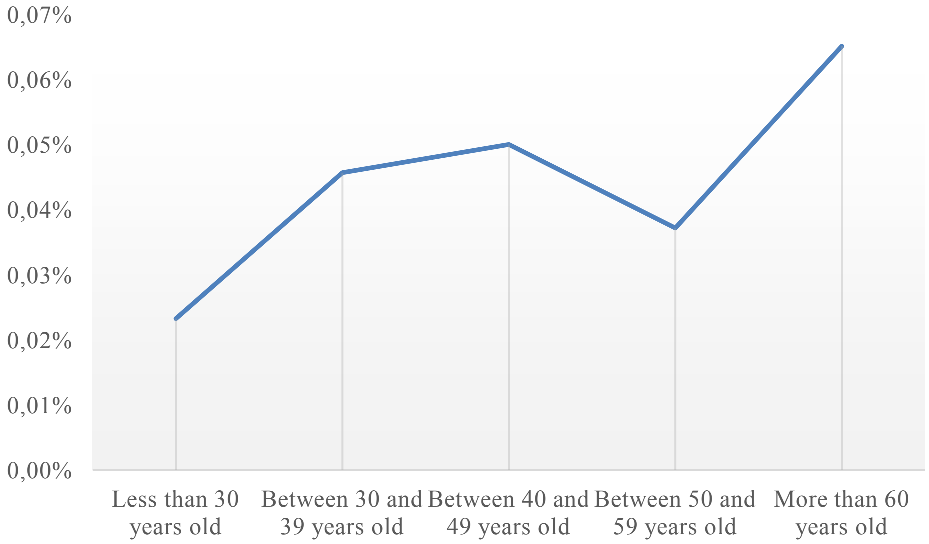

Figure 1: Organic and environmentally certified products participation in total expenditure by age group of head of household - Brazil, 2008/2009
Source: Own elaboration based on data from POF 2008/2009 (IBGE, 2014).

An important feature to consider is the response of organic consumption to price and income variations. Based on POF data from the 2008/2009, and using the methodology created by Duan *et al.* (1983) and adapted by Cardoso (2015), the elasticities-price and income elasticities of organic products were estimated. The results show that the sensitivity of the increase of organic consumption in relation to a variation in the individual's income (income elasticity of demand) for the analyzed period would be 0.05. That is, with each 1% increase in income, the demand for organic products would increase only marginally (by 0.05%). The sensitivity of demand to a variation in the price of organic product (price elasticity of demand) would be -0.49, implying that the increase of 1% in the price of organic products would reduce the quantity demanded of organic products by 0.49%.

The evidence is in line with IPD Organicos (2011), revealing that organic consumers are the least sensitive to price changes in Brazil. In turn, the effect of income on consumption is statistically significant, but is rather low. This result corroborates the results found by Oliveira and Hoffman (2015), which also indicate the positive relationship between income and organic consumption in Brazil.

These results were used to quantify and qualify estimates of future consumption of organic products in Brazil, in which the impacts of changes in household consumption preferences towards organic products were estimated using a dynamic computable general equilibrium model (Brazilian Recursive Dynamic General Equilibrium Model [BRIDGE]).

2.1.BRIDGE Model

The next step in methodological strategy is to estimate the economic impact of changes the impacts of changes in household consumption preferences towards organic products. To do that, we use the BRIDGE (Brazilian Recursive Dynamic General Equilibrium Model). The model follows the basic theoretical structure of the MONASH (Dixon e Rimmer, 2002) and ORANI (Dixon *et al.*, 1982) models. The model has a specific parameterization of economic consumption vector considering the demographic variables in the simulations. With these elements in the model, it is possible to break down the consumption vector in terms of demographic variables represented by age groups, in order to explore the relationship between the change in demographic structure in Brazil and the consumption preferences towards organic products, considering different macroeconomic and demographic scenarios over time.

BRIDGE theoretical specification follows the pattern in national CGE models. Its central structure is made up of equation blocs that determine the relationships between supply and demand, derived from optimization hypothesis and market equilibrium conditions. In these blocs, some national aggregated are defined, such as labor supply level, commercial balance and price index. Productive sectors minimize production costs liable to a constant scale return technology, in which the combination of intermediate inputs and primary factor (aggregated) is determined by fixed coefficients (Leontief).

There is a substitution in the composition of inputs by prices between domestic products and imported ones, through functions of constant elasticity of substitution (CES). There is also a substitution via price between capital and labor supply by CES functions. While all sectors present the same theoretical specification, the effects of substitution by process differ according to the domestic/imported composition of the inputs used.

Household demand is specified from a non-homothetic Stone-Geary utility function (Peter *et al.,* 1996), in which a consumption composition by product between domestic and imported is controlled by functions of CES. Sectoral exportations react to demand curves negatively, associated to domestic costs in production, and positively affected by exogenous expansion in international income, supposing we are considering a small country in the international market. The government consumption is typically endogenous, and can either be associated or not to household's consumption or to tax collection. The inventory accumulates according to the variation in production.

Recursive dynamics are specified through a modeling of the intertemporal behavior and results of previous periods (backward-looking). Since it is a long-term issue, implications of demographic changes in economy depend on projections for several years of a base case, containing growth rates of determining variables such as the GDP, consumption, investments, exportations and importations, not to mention a demographic scenario of population growth, desegregated from age groups whose growth is pre-determined according to the economy. Economic conditions such as availability of capital are endogenously dependent on subsequent periods. However, they are not affected by forward-looking expectations (Magalhães, 2013). Therefore, capital investment and stock follow mechanisms os acummulation and intersectoral displacement from pre-estabilished rules associated to depreciation and return rates. The labor market also presents an element of intertemporal adjustment, which envolves variables with real wages, actual and tendencial labor.

Appendix A displays a detailed mathematic formalization of the model.

2.2.Simulation

To simulate the impacts of changes in household consumption preferences towards organic products we simulated alternative hypotheses about the growth dynamics of the Brazilian economy, as well as about the behavior of preferences for organic consumption (by income level). The alternative scenarios were based on the results of the statistical models, allowing to map sustainable consumption attitudes, and project the economy from 2017 to 2050.

As explained in the previous section, the consumer choice in the CGE model is specified as a Stone-Geary function, where some parameters reflect consumers' preference towards certain products. Therefore, by altering theses parameters we are able to simulate preference changes. The intuition behind these changes is that the consumer becomes more wishful of certain products in their consumer basket, which ends up changing their demand for these products, the overall allocation of resources between goods, and therefore, the composition of their consumption set. The advantage of using an CGE model is that the projected change preferences is placed in a scenario of evolution of income and prices of the Brazilian economy, and considering the real households consumption profile.

As presented in Table 1, the results of the structural statistical model for the consumption of organic, that is, indexes (scores) representing the attitude or preferences towards organic consumption, according to the level of household income (decile): the higher the index, the greater the disposition in consuming such products. These results were used to the design of three scenarios, with different hypotheses about the evolution of the households' preferences in relation to organic consumption.

In the first simulation (called "convergence"), it is assumed that during the projected period (2017-2050) the organic consumption preferences of the lower income families gradually converges toward the current preferences of the highest income consumers (D10) until the end of the projected period. This "Convergence" scenario was denominated, since the preferences of all income classes would converge to the preference assigned to the highest decile (D10). This hypothesis is consistent with the diffusion of pro-environmental attitudes among the income classes observed by Nawrotzki and Pampel (2013).

In the second scenario ("convergence with growth at the top"), it is considered that consumer preferences, except for the 10% richest individuals, grow in a way that eliminates the difference that they have over those of higher income consumers. The hypothesis is that this increase follows the growth rate of the Brazilian population in this projection period (around 1% in the average of the years). However, in this scenario the richer families continue to increase their preferences for sustainable consumption, so their preferences for organic ones also increase. That is, in this way, there would be no complete convergence of preferences between poor and wealthy families by 2050, but the difference between these preferences would decrease over the period.

The third and final scenario ("limited convergence"), establishes a more moderate increase in consumers' organic consumption preferences from deciles D1 to D9 in relation to those with the highest degree of organic pro-consumption attitude (the richest, located in decile D10). In this scenario, the richest consumers (D10) maintain their current preferences, while lower income (D1 to D9) expand their organic pro-consumer attitude. The growth rate of these consumer preferences, however, is 50% lower than that required for the equalization that was adopted in scenario 1. Figure 3 summarizes the simulation scenarios.

Figure 3: Simulated scenarios of consumption of sustainable products

Simulated scenarios	Shocks of preferences by organic according household income	Structural components
Convergence	It is considered that preferences of income deciles from 1 to 9 grow over the course of the scenario in proportion to the difference that have in relation to the decile 10.	Macroeconomic scenario. Demographic growth and aging. Energy Efficiency. Dynamics of foreign markets. Productivity gains.
Convergence with growth at the top	The preference for organic grows throughout the scenario proportionally the difference they have in relation to decile 10, it also increases its preference for organic consumption by the rate of population growth.	
Limited convergence	The preferences of deciles 1 to 9 increase relative to decile 10; however, at a rate of 50% lower than that imposed in Simulation 1, so that preferences among income deciles are moderately close.	

Source: Own elaboration.

3. Simulation results

The aggregate indicators of the three scenarios show the small difference between them (Table 2). The main difference between the scenarios is in the consumption of goods and in the sustainable portion of this consumption. The scenario is characterized by export growth above GDP, followed by investment dynamics. Household and government consumption grows slightly below the GDP average, and imports are the least dynamic component. In this way, the scenario is characterized by a growth close to the Brazilian historical average, with positive trade balances. Growth in investment higher than household and government consumption indicates that the share of investment in GDP rises, and the share of consumption declines. This scenario is of less importance in this study, since the objective is to study the role of the different trajectories of preferences for sustainable consumption.

Table 2 - Simulated Scenarios (% annual change 2017-2050)

Macroeconomic Indicator	*Convergence*	*Convergence with growth at the top*	*Limited convergence*
GDP	2.415	2.416	2.414
Household Consumption	2.088	2.089	2.088
Investment	2.565	2.564	2.564
Government Consumption	2.088	2.089	2.088
Exports	2.534	2.535	2.537
Imports	0.931	0.928	0.940
Employment	3.092	3.092	3.093
Capital Stock	1.888	1.888	1.887

Source: Own elaboration.

Figure 4 shows the difference between consumption growth of each household type (by income decile) and the average growth of consumption. All household consumption trajectories are positive, but some raise faster than others. For this reason, the difference between the growth of each of these trajectories and the average constitutes the most relevant information. The result represents the accumulated difference over the 34 years scenario, indicating, for example, that in the convergence scenario the richest group (D10) would accumulate an increase of its consumption 1.79 percentage points above the average, while the consumption of the group (D1) would grow by 2.2 percentage points below the average. This result stems from the structural constraints of the scenarios, which lead to higher growth of the highest decile income and a change in prices of goods and services benefiting the richest. In addition, the changes in preferences for organic consumption alter little this structural component of the scenarios, as expected.

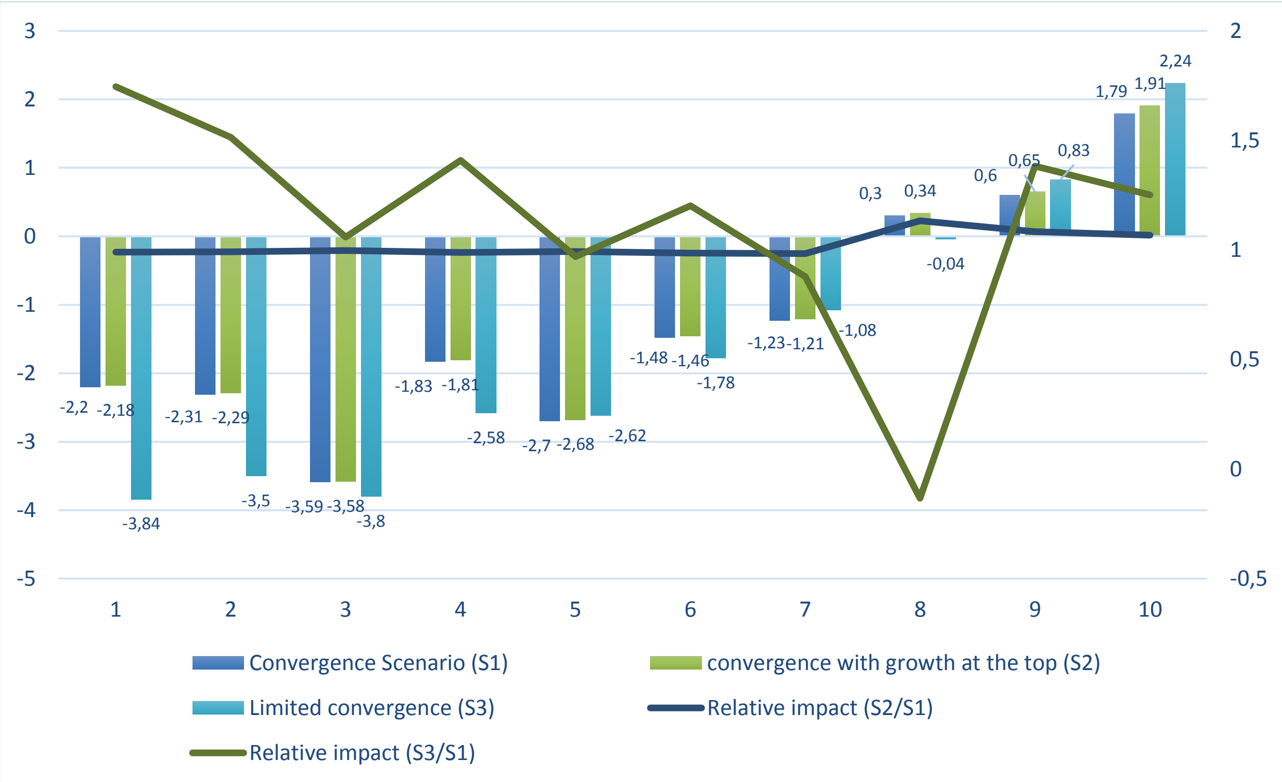

Figure 4 - Household consumption change in each scenario, by income class (decile): accumulated deviation in relation to the growth of total household consumption from 2017 to 2050 (in %)

Source: Own elaboration.

Table 3 shows the average annual percentage change in consumption only for products that have a portion of organic items, identifying the variation in the total consumption of the product and the variation of the consumption attributed to the organic portion. In general, it is possible to observe that among these products organic consumption would grow at annual rates higher than the total consumption (organic and non-organic) in the scenarios of changes of the preferences for organic consumption, because of the projected changes in preferences. However, depending on the sector or product the outcome is different.

The comparative analysis between the scenarios shows that in the convergence scenario (Simulation 1), organic consumption would grow, on average, 3.14%, a rate close to scenario 2 (3.45%), in which preference by organic D10 class also rises. In the third simulation, the results show that smaller changes in the preferences for sustainable consumption would imply a lower growth of organic consumption when compared to the other simulated scenarios. Food services would be the sector with the highest average annual growth rate of organic consumption in the scenarios of preferences changes. Wood products, Organic sugar, Forestry and forestry products, Beef and Coffee beans and benefited would also stand out due to the increased preferences towards organic consumption.

Table 3 – Household consumption change in each scenario, by all products and only organics (% variation) – Brazil, 2017 to 2050

Sectors	*Convergence*		*Convergence with growth at the top*		*Limited convergence*	
	Total*	Organic	Total*	Organic	Total*	Organic
Rice, wheat and other cereals	1.38	2.02	1.41	2.14	1.06	1.28
Other temporary crops products and services	2,11	3,09	2,25	3,40	1,77	2,15
Other products of permanent agriculture	2,15	3,15	2,21	3,35	1,77	2,14
Bovine animals and other live animals, prod. animal, hunting and related services	1,98	2,91	2,18	3,30	1,70	2,06
Milk of cow and other animals	2,03	2,97	2,26	3,42	1,78	2,15
Poultry and eggs	2,10	3,08	2,18	3,30	1,71	2,08
Logging and Forestry	1,81	2,65	1,91	2,89	1,41	1,71
Meat of cattle and other prod. of meat	2,50	3,67	2,56	3,88	2,11	2,56
Poultry meat	2,37	3,47	2,49	3,77	2,00	2,42
Cold, sterilized and pasteurized milk	1,82	2,67	1,94	2,93	1,43	1,74
Other Dairy Products	2,02	2,96	2,19	3,32	1,72	2,08
Sugar	1,98	2,90	2,21	3,35	1,69	2,05
Canned fruits, vegetables, Other vegetables and fruit juices	2,73	4,00	2,78	4,22	2,32	2,81
Coffee benefited	2,07	3,03	2,34	3,54	1,82	2,21
Rice and byproducts	2,35	3,44	2,45	3,71	1,98	2,40
Other Food Products	2,15	3,16	2,21	3,35	1,74	2,11
Drinks	1,40	2,06	1,37	2,08	1,51	1,84
Wood products, except furniture	2,10	3,08	2,29	3,48	1,82	2,21
Food services	3,02	4,42	3,32	5,03	2,72	3,30

*Total = Organic or not.
Source: Own elaboration

It is important to note that when considering changes in consumer preferences in favor of organic consumption, growth of this type of consumption is greater in those sectors where the share of these products is relevant, which tends to minimize the environmental impacts of consumption, i.e., reducing the potential of the rebound effect[1]. In the case of this study, the rebound effect could occur when, given a greater demand for food in general, there would be an increase in the ecological

[1]The "rebound" effect is well known in the economic literature, especially in the field of environmental effects of increasing energy efficiency, when, under certain conditions, greater energy efficiency (or in our case, a greater propensity to consume greener products) would increase energy demand (and, in our case, aggregate demand) as a function of total productivity gains. Consequently, efficiency gains would accommodate price increases at a higher level of consumption, increasing the emission of greenhouse gases (and thus the ecological footprint) (Khazzoom 1980; Brookes 1990).

footprint if this increase were accompanied only by changes in the quantity and not the quality of these products. An increase in the consumption of organic, in turn, being associated with production techniques that lessen the environment, would be accompanied by the quality factor, which, although it is not able to reverse the tendency of increase in the footprint, could attenuate its growth.

This result is particularly important for greenhouse gas (GHG) mitigation policies, although this issue is not the focus of this work. The rebound effect would not be eliminated entirely solely on the demand side. It is possible that greater incentives for efficiency in organic production are needed to completely neutralize GHG growth. The results of this study suggest, therefore, the need for public policies that focus on the greater diffusion of organic consumption practices, especially in the spheres of knowledge and supply, focused mainly on the lower income consumers, who are currently the lower propensity to consume these products.

4. Discussion and Conclusion

This paper analyses sustainable consumption in Brazil, highlighting the consumption profile of sustainable products and its relationship with characteristics such as age, sex and income level. Additionally, we attempted to design scenarios of future consumption in which potential changes in the consumption profile are contemplated, such as the consumption of organic products, for example. For that, an integration of econometric models was made, based on the structural equation approach, demographic scenarios and a Computable General Equilibrium model.

The results found in the statistical models indicate that organic consumption is positively related to household income. From these results, three scenarios of future consumption of Brazilian families (2017-2050) were simulated, incorporating preferences changes. The main results indicated that in all scenarios the consumption of the groups of higher income families grows above the average of the households, indicating a process of relative increase of the inequality of consumption in the coming decades.

The main results indicated that Food services would be the sector with the highest annual average growth rate of organic consumption. The sector's more pronounced growth points to an important characteristic of the future growth dynamics of the Brazilian economy, verified in all scenarios simulated and corroborated by the economic literature: the trend of increasing demand services and the participation of this sector in the economy.

Accordingly, a strategy to increase sustainable consumption should contemplate this trend (such as growth in food outside the home, tourism, leisure, health and education) and encourage the production and distribution of these services to adopt sustainability constraints. In addition, the economic sectors that have a share of organic products (such as Cattle, Other temporary crops, Coffee, Cow's milk, Forest products, Timber products, Food services) and sectors related to the production chain, such as Food products beneficiaries, beverages, tractors and other agricultural machinery, would also be the activities with the greatest expansion of consumption.

Considering the changes in preferences for sustainable consumption (in this case specifically analyzing organic consumption) in Brazil, they would have little effect on the dynamics of income generation and economic growth, but could reinforce a downward trend in the in the poorest households. To increase the effect of changes in the preferences for sustainable consumption, it would be vital to promote consumption practices, also eliminating the restrictions on the supply of sustainable production in the country. Only in this way is it possible for families to raise their percentage consumed with these products.

The information disclosed in the paper indicates that the pattern of consumption is a key item in the sustainable consumption strategy of developing countries such as Brazil. The analysis of the consumption profile and the production of sustainable goods, considering the socioeconomic and population dynamics, is essential to understand the new patterns of consumption, as well as to generate results able to subsidize public policies that encourages the production and consumption of these goods by the diffusion of organic consumption practices.

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Appendix 1 - Model and Database

The BRIDGE database and equations require the calibration of the parameters and coefficients. The structure of the BRIDGE input-output database was calibrated for Brazilian economy's data from 2013. Figure 5 provides the BRIDGE database in three parts: an absorption matrix, a joint-production matrix, and a vector of import duty. In the first row is the absorption matrix (V1,…,V6) and it presents basic flows in year *t* of commodities to producers, investors, households, exports, government and inventory variation.

Each basic flows matrix contains C x S rows. *C* is number of commodities in the model (i.e. 110 for the year 2005 database) and *S* is absorption's source (domestic and imported). Thus, the basic flows show demand at basic prices[2] (production cost) for goods (c) of domestic or imported origin (s) by firms (i) or final consumers (final demand). The V2BAS coefficient, for example, is the value of (c,s) used to create capital for industry *i*. This coefficient was distributed according to the V1CAP (remuneration of capital), because Brazilian investment data is not disaggregated by firms. V3BAS to V6BAS each, in turn, have one column. Worth mentioning that no imported good is exported directly (V4BAS (c,"imported") is zero).

The margin matrices, V1MAR,…, V6MAR, have CxSxN rows and represent the values of *M* margin commodities used in facilitating the flow of goods between origin and destination. In the model there are two margin types demanded by sectors and final users: trade and transportation services. Thus, for example, V1MAR and V2MAR are the values of margin commodity *m* required in facilitating the flow of (c,s) to industry *i* for current production and for capital creation. The Brazilian margins data are not distributed by users (industries and final

[2] It should be noted that basic prices plus margins and net taxes correspond to the flows at market prices.

users) and the solution was to use a rate (trade and transportation margin / total basic value) weighted V1BAS to V6BAS each. This procedure was not applied for Government and changes in Inventories, since both users are not, in practice, margin demanders.

Figure 5: Bridge Model: Core Database Structure

		Absorption Matrix					
		1	2	3	4	5	6
		Producers	**Investors**	**Household**	**Export**	**Government**	**Inventories**
	Size	*I*	*I*	1	1	1	1
Basic Flows	*CxS*	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Margins	CxSxM	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	V6MAR
Taxes	*CxS*	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	V6TAX
Labor	*O*	V1LAB_O					
Capital	1	V1CAP					
Land	1	V1LND					
Production Tax	1	V1PTX					
Other Costs	1	V1OCT					

C = Number of Commodities
I = Number of Industries
S = 2: Domestic,Imported,
O = Number of Occupation Types
M = Number of Commodities used as Margins

	Joint Production Matrix
Size	*I*
C	MAKE

	Import Duty
Size	1
C	V0TAR

The sales taxes matrices, V1TAX, …, V6TAX, in turn, are aggregated values (IPI, ICMS and Other taxes minus subsidies) for all users (except inventories) and have C x S rows. For example, V1TAX is the sales tax in the flow of commodities (c,s) to industry *i*. The Brazilian sales taxes data also are not distributed by users (industries and final users) and we used a same solution of the margins. We also calculated a rate (sales taxes / total basic value) weighted V1BAS to V6BAS. Although the model allows dealing with tax incidence on export flows, these flows are tax exempt by law in the Brazilian case (V4TAX = 0).

The value-added matrices show payments by industries for their use of labor, capital and land, as well as their payments of taxes on production and other costs.

V1LAB_O was calibrated with Brazilian wages and payroll taxes. In this model, there is only one labor type. Using the same database, we also calibrated the V1CAP with gross operating surplus information and the V1PTX with "other taxes on production" values. V1OCT denotes other costs and it was calculated as residuals. It is worth noting that the elements of the coefficient V1LND (land rents) had zero value, due to the absence of information in the tables used.

The other two data sets in Figure 5 are MAKE and V0TAR. V0TAR is a C x 1 vector and it represents tariff revenue by imported goods (import duty). The multiproduction matrix MAKE, in turn, is the output (valued in basic prices) of commodity (c) by industry (i) (joint production matrix). Both coefficients also were calibrated with the Brazilian input-output matrix's data. In the BRIDGE database the absorption and joint-production matrices satisfy the balance conditions, so that the test of homogeneity is verified.

Table 4 provides a stylized version of BRIDGE equations. The first group (1) represents the composition of industry outputs and inputs. Each industry (i) might produce several goods (c), using locally as inputs domestic and imported commodities, as well as primary-factor composite [labor (L) and capital (K)]. In (1), the output of each firm (i) is a function of prices (P_1) of domestic commodities and activity level [X1TOT(i)], The sum over industries of output represents total output (see 2, X0COM(c)). Assuming constant returns to scale in function production, an increase in X1TOT(i) permits industry (i) to produce proportionally more of all commodities. As the level of manufacturing activity rises, primary-factors and intermediate inputs demands in the sector increase too. Consequently, inputs and primary-factors demands depend on X1TOT (i). The demands for inputs [X1(c,s,i)] and primary-factors (L(i) and K(i)) also is function on technology variables (A_{PFi}) on their prices. The industry (i) might demands for two varieties inputs (domestic and imported) which each has a price [P_s(c), s=1,2]. The primary-factors' prices, in turn, is the wage rate (W) and the capital's rental price [Q(i)]]. Changes in the relative prices of thee primary-factors and inputs induce substitution in favor of relatively cheapening factors (cost-minimizing assumptions).

The second group (2) shows the capital-creation functions. The inputs used (in 8) to capital creation also subject to the investor's cost-minimization problem. Therefore, the demands for inputs of commodity c from source s for capital creation is function on the quantity of capital creation (X2TOT(j)) in industry j, on the prices of domestic and imported input i, and on technology variables (A_{2j}).These last two factors also determine the cost of a unit of capital (PI(j)), whose value is treated as the price which a unit can be sold (the asset price).

The third group (3) describes household demands for commodities which a single representative household maximize a Stone-Geary utility function (Stone, 1954) subject to a budged constraint. The demand equations that arise from this utility function are a linear function of prices (P3) and household budget (C), known as *Linear Expenditure System* (LES). X3SUB are "subsistence" commodities and they are purchased regardless of price. The total subsistence demand for each good c is proportional to the number of households, q_H, and to the individual household subsistence demands, $A3_{SUB}$(c). $X3_{LUX}$(c), call this "luxury" expenditure, are remnant allocated of the consumer budget. Thus, $X3_{LUX}$ are luxury usages, or the difference between the subsistence quantities and total demands (in 12).

The fourth group treats the exports. Basically, in the stylized version, the foreign demand for domestic commodity c (X4) depends to the foreign-currency price [PE(c)] to a shift variable (A_4). Usually the shift variable is exogenous and represents the movements in the foreign demand curve for good c. Thus, as export demand is a decreasing function to the foreign-currency price. Devaluation in the exchange rate causes increases the exports. The fifth group presents the governments demands for commodities. The level and composition of government consumption are exogenously determined by A_5(c,s) and A_{5TOT} variables (shift variables). A_5(c,s) allows changes on composition of government consumption, while A_{5TOT} might adjust government spending subject a budget constraint. In the absence of shocks to the shift variables, the aggregate government consumption (A_{5TOT2}) changes with real household consumption (C) [i.e. we are endogenising (A_{5TOT}) as function to C].

In the six group, the demands for margins are proportional to the commodity flow with which the margins are associated when A3MAR variable is exogenously. A3MAR variables allow for technical change in margins usage (for example, household). The seventh group includes market-clearing equations for locally-consumed commodities, both domestic and imported. The output (supply) of commodity (c,s) is equal the sum of demands for same commodity (c,s). Imported commodities are not directly exported. As balance conditions, zero-pure-profits conditions for production also is satisfied. Equation 19 shows that the revenue in industry *i* is equal to the cost.

The eighth group contains default rules for setting sales-tax for producers, investors, households and government. Sales-tax variables in the linearized model are treated as powers of the taxes. Equation 20 shows the power of indirect taxes as the product of various shift variables. These shift variables allow applying a reduction in the power of tax for a commodity to all users.

In the group 9 are macroeconomic variables. The first equation (21) shows the consumer price index (CPI) being defined by consumer prices for domestic and imported goods ($P3_1$ and $P3_2$). The real wage rate (WR) is determined as the nominal wage rate (W) deflated by the CPI. There is an overall wage shifter for money wages (A_{WR}). LTOT and KTOT are, respectively, total employment and total capital stock as sums across industries. $GDP_{expenditure}$, in turn, denotes Gross Domestic Product from expenditure side in nominal terms (equation 25). As balance condition, this variable is equal to GDP_{income} (equation 27).

The tenth group contains equations about the intertemporal adjustment in the capital stocks[3], investment and rates of return. At end of period *t*, the amount of new capital stock created for each industry *j* [K_t(j)] is function to depreciated capital stock [(1-D)(j)*K(j)] and investment [X2TOT(j)] during the year *t*. Defining the gross rate of investment as the ratio of investment to capital in industry *j* [IKRATIO(j) = X2TOT(j)/K(j)], then, by algebraic manipulation, we might achieve the capital growth [(K_t(j)/ K(j))-1= IKRATIO(j) - D(j)]. If this rate is 3% and IKRATIO(j) is 6.42%, so the calibrated rate of depreciation [D(j)] in the model results to be 3.42%. The BRIDGE model was calibrated with a steady state growth rate of 3%, with a capital depreciation rate of 3.42%. This percentage is very close to the rate of 3.5% used by Oreiro *et al.* (2005) and Haddad and Domingues (2001). We are assuming that economic growth in the steady state of the Brazilian economy is around 3%.

Changes in the capital growth [(K_t(j)/ K(j))-1] are determined by industry (j) 's expected rate of return [EROR(j)] when shift variable [A_{KG}(j)] is exogenous. The expected rate of return in industry *j* depends of the current rental rate [Q(j)] and asset price [PI(j)] of *j*'s capital, as well as Normal gross rate of return [ROR(j)]. In the case, expectations are static and adaptive. According to Dixon and Rimmer (1998), it is assumed that the capital growth in industry *j* (and therefore the levels of investment) are given by the willingness of investors to supply funds to industry *j* facing limited increases in the expected rate of return in *j*. In short-term, the growth rate of capital in industry *j* in year *t* will only be higher than its normal rate (steady state of capital growth) when the expected rate of return by the investors is higher than the normal rate of return (Dixon & Rimmer, 1998). Similarly to the ORANIG-RD model, we calibrated the normal rate of return [ROR(j)] is based on the relation between capital profitability (V1CAP) and capital stock at current prices [K(j)], whose value was 14.3%.

The eleventh group provides the intertemporal adjustment in the labor market, considering variables such as real wage (WR), current (LTOT) and trend employment ($LTOT_T$). In its adjustment mechanism, when the level of employment in $t+1$ exceeds $x\%$ in relation to the economy's trend employment, the real wage grows $\gamma x\%$. Since there is a negative relation between employment and real wage in the labor market, the increase in $\gamma x\%$ will adjust the level of employment in future periods until it converges to its trend level. For example, while employment is above its forecast level, the real wage deviation (WR/WR_0) will be increasing.

The final group (12) describes the decomposition on variations in production of a commodity. There are three reasons for these variations. First, the variation might be caused by an effect of the local market; which captures the variations in local use (domestic and imported goods). The equation (33) defines the percentage change in local sales for both origins (domestic and imported) represented by x0loc(c), weighted by the amount of local domestic sales [DOMSALES(c)]. INITSALES(c) corresponds to the initial value of total sales, adjusted by price changes in the model. Second, the variation in production might be explained by the effect of domestic participation, which refers to the change in composition of local demand between domestic and imported commodities. In this effect, the x0loc(c) variable is divided by sdom(c). Finally, the variation in production might be an export

[3] The Institute for Applied Economic Research (IPEA) supplies the data on net capital stock at 2000 prices, estimated by Moranti and Reis (2004). These values are used to the sectoral capital stock [K(j)] adjusted for 2005 prices with base on the implicit deflator of fixed capital.

effect's result. The exports component [V4BAS(c)] represents the flow of exports weighted by the demand for exports x4(c).

Table 4 - BRIDGE model: Core Equations

Number	Group	Dimension	Identifier
1	**Composition of outputs and inputs**		
	$X0(c,1,i) = X1TOT(i)*\Psi_{0c1i}(P_1)$	N_cN_i	(1)
	$X0COM(c) = \sum_i X0(c,1,i) + A(c)_{PF}$	N_c	(2)
	$X1(c,s,i) = X1TOT(i)*\Psi_{1csi}[P_1(c), P_2(c), A_{1i}, A_{TWIST}]$	$N_cN_SN_i$	(3)
	$L(i)= X1TOT(i)*\Psi_{Li}[W, Q(i),A(i)_{PF}]$	N_i	(4)
	$K(i)= X1TOT(i)*\Psi_{Ki}[W, Q(i),A(i)_{PF}]$	N_i	(5)
	$TOT_{PFc}=\sum_c A(c)_{PF}$	1	(6)
	$TOT_{PFi}=\sum_j A(i)_{PF}$	1	(7)
2	**Inputs to capital creation and asset prices**		
	$X2(c,s,j) = X2TOT(j)*\Psi_{2csj}[P_1(c), P_2(c), A_{2j}, A_{TWIST}]$	$N_cN_SN_i$	(8)
	$PI(j) = \Psi_{PIj}(P_1,P_2,A_{2j})$	N_j	(9)
3	**Household demands for commodities**		
	$X3(c,s)= \Psi_{3cs}[C, P3_1,P3_2, A_3, A_{C/GDP}]$	N_cN_S	(10)
	$X3_{SUB}(c) =q_H*A3_{SUB}(c)$	N_c	(11)
	$X3_{LUX}(c) = X3\_S(c) - X3_{SUB}(c)$	N_c	(12)
4	**Exports**		
	$X4(c)= \Psi_{4i}[PE(c)]+A_4(c)$	N_c	(13)
5	**Government demands**		
	$X5(c,s) = A_5(c,s)*A_{5TOT}$	N_cN_S	(14)
	$A5_{TOT} = C*A5_{TOT2}$	1	(15)
6	**Demands for margin services (example: households)**		
	$X3MAR(c,s,m) = A3MAR(c,s,m)*X3(c,s)$	$N_cN_SN_m$	(16)
7	**Imports and zero-pure-profits conditions**		
	$X0COM(c) = \sum_i X1(c,1,i) + \sum_i X2(c,1,i) + X3(c,1) + X4(c) + X5(c,1) + \sum_c \sum_s \sum_m X3MAR(c,s,m)$	N_c	(17)
	$X0IMP(c) = \sum_i X1(c,2,i) + \sum_i X2(c,2,i) + {}_iX3(c,2) + X5(c,2)$	N_c	(18)
	$\sum_c P_1(c)X0(c,1,j) = \sum_c \sum_S P_S(i)X1(c,s,j) + W*L(j) +Q(j)*K(j)$	N_i	(19)
8	**Indirect taxes (for example: exports)**		
	$T4(c) = A_{OT}(c)*A_{4T}(c)$	N_c	(20)
9	**Macroeconomic variables**		
	$CPI = \Psi_{CPI}(P3_1,P3_2)$	1	(21)
	$WR = (W / CPI)*A_{WR}$	1	(22)
	$LTOT = \sum_j L(j)$	1	(23)
	$KTOT = \sum_j K(j)$	1	(24)
	$GDP_{expenditure} = C + X2TOT\_i *\sum_j PI(j) + X5TOT*\sum_i P_S(i) + \sum_i [PE/\Phi]*X4(i) - \sum_i [PM/\Phi]*X0IMP(i)$	1	(25)
	$GDP_{income} = W*L(j) +Q(j)*K(j) + A(i)_{PF}$	1	(26)
	$GDP_{income} = GDP_{expenditure}$	1	(27)
10	**Capital stocks, investment and rates of return**		
	$K_t(j) = [(1-D)(j)*K(j)] + X2TOT(j)$	N_i	(28)
	$IKRATIO(j) = X2TOT(j)/K(j)$	N_i	(29)
	$[K_t(j)/ K(j)] - 1= \Psi_{KG}[EROR(j)] + A_{KG}(j) + A_{KGT}$	N_i	(30)
	$EROR(j) = \Psi_{EROR}[Q(j), PI(j), ROR(j)] + A_{EROR}(j)$	N_i	(31)
11	**Adjustment in the labor market**		
	$\Delta WR/WR_0 = \Psi_{WR} [(LTOT_0/LTOT_{T0})-1] + \Psi_{WR} \Delta(LTOT/LTOT_T) + A_{WRT}$	1	(32)

12	**Decomposition on variations in production**		
	INITSALES(c)*DECOMP(c,*"localMarket"*) = DOMSALES(c)*x0loc(c)	N_c	(33)
	INITSALES(c)*DECOMP(c,*"DomShare"*) = DOMSALES(c)*x0loc(c) / sdom(c)	N_c	(34)
	INITSALES(c)*DECOMP(c,*"Export"*) = V4BAS(c)*X4(c)	N_c	(35)