Appendix C-12

BRAZIL ECONOMIC AND ENVIRONMENTAL MODELING WORKSHOP

Energy Consumption and Carbon Emissions from Household Expenditures in Brazil

Claude Cohen, Manfred Lenzen, and Roberto Schaeffer
Energy Planning Program, COPPE, Federal University of Rio de Janeiro

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OVERVIEW OF THE WORK

Analytical framework employed consists of two parts:

(1) A demand model describing changes in the consumption of households as a result of changes in prices and disposable income

(2) A generalized, partially closed input-output model describing requirements of production sectors, the government and households, in terms of commodity demand, value added, labour, imports, fuel use, and CO2 emissions.

OBJECTIVE

Estimate energy consumption and carbon emissions by household income level in Brazil, in order to examine effects of environmental policy (mostly related to energy consumption and climate change) on income distribution, such as: the effects of carbon taxes on household consumption and emissions, or revenue-neutral reforms for compensating adverse distributional effects

ASSUMPTIONS AND DATA PREPARATION

Main data sources:

1. *Brazilian household expenditure survey (IBGE, 1999)*
2. *Input-Output tables (IBGE 1997)*
3. *Brazilian Energy Balance (MME, 1995)*

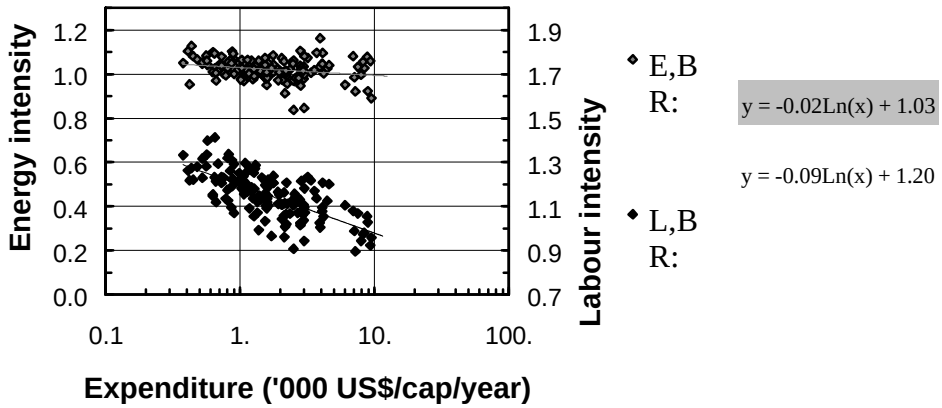
Base year: 1995

Household expenditure survey: **143 observations, 11 capital cities, 12 income classes**, **16014 households**, **112 consumer items**, **plus demographic information**

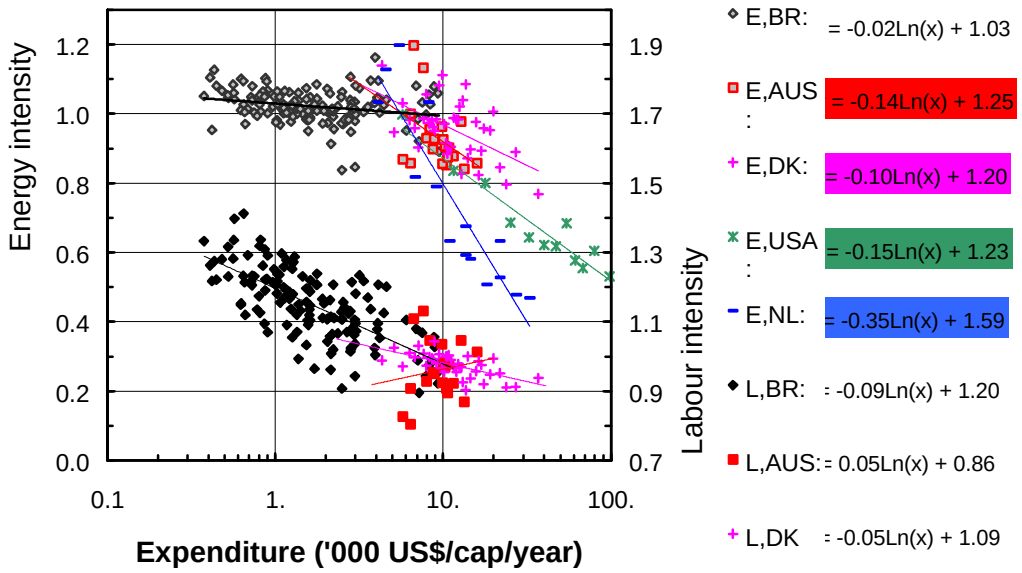
Problem: to make commodity/industrial classification systems of IO tables (IBGE), Brazilian household expenditure survey and Brazilian Energy Balance (MME) compatible

PARTIAL FINDINGS

Energy and labour intensity tendency according to expenditure in Brazil



Comparison: Energy and labour intensity tendency according to expenditure in Brazil, Australia, Denmark, USA, and Netherlands:



EXPECTED RESULTS AND POLICY IMPLICATIONS

- Interactions between environmental policy and income redistribution in Brazil
- Energy use and carbon emission key sectors in Brazil
- Energy consumption and carbon emissions from household sector in Australia, Brazil and Denmark: a comparative study

BACKGROUND

Effects of environmental policy on income distribution and vice versa have been studied previously, but some of these studies investigate the problem in only one direction, or consider only first-round effects, or do not model changes in consumer behaviour. In the most comprehensive of these studies, Symons et al. (1994) use input-output analysis and a demand model in order to determine the effects of carbon taxes on household consumption and emissions, and to examine revenue-neutral reforms for compensating adverse distributional effects.

Multivariate regression:

Explanatory variables for households energy consumption in Brazil

CORRELATION MATRIX		5	4	22	6	47	13	30
		Expenditure	Size of the family	Employment	Urbanity	Age	Number of rooms/member	Education
5	Expenditure	1.000	0.055	0.000	0.000	0.129	**0.546**	**0.830**
4	Size of the family		1.000	0.290	0.003	0.014	0.106	0.053
22	Employment			1.000	0.015	0.110	0.037	0.009
6	Urbanity				1.000	0.107	0.006	0.006
47	Age					1.000	0.076	0.183
13	Number of rooms/member						1.000	**0.502**
30	Education							1.000

		30	13	47	6	**Employment**	**Size of the family**	**Expenditure**	b		
3 VAR	*m*					-0.12	-0.09	0.76	-0.59		
	D*m*					0.04	0.02	0.01	0.09	R^2_{adj}	
	R^2 /					0.97	0.11	#N/D	#N/D		0.9749
	F					1796.97	140.00	#N/D	#N/D		
	ESS / RSS					69.68	1.81	#N/D	#N/D		
						#N/D	#N/D	#N/D	#N/D		
	t					**2.90**	**4.23**	**71.71**	**6.73**	**2.610**	$=t_{critical,0.99}$
										1.976	

METHODOLOGY

- **Demand model**

Responses of private final consumption to changes in prices and household income were modeled by employing the Almost Ideal Demand System (AIDS) introduced by Deaton and Muellbauer trough demand functions that describe budget shares of commodities. The explanatory variables are the commodity prices and the real expenditure. The coefficients describe budget shares of the reference situation ({pi}i=1,...,N=x=1), income elasticities, and price elasticities, respectively:

$$w_i = \alpha_i + \sum_{j=1}^{N} \gamma_{ij} \log p_j + \beta_i \log x,$$

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- **Production model**

The Brazilian AIDS model was estimated by linear regression of the budget shares of N=80 commodities from K=150 observations, using a Lagrangian:

$$L = \sum_{i=1}^{N} O_i + \sum_{i=1}^{N} \lambda_i \sum_{j=i+1}^{N} (\gamma_{ij} - \gamma_{ji}) + \lambda_{\frac{N(N-1)}{2}} \sum_{i=1}^{N} \beta_i ,$$

Direct and indirect effects of policies aiming at reducing resource use and environmental degradation and/or at income re-distribution are modeled using a generalised input-output framework.

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Let yD be a N×1 vector of domestically produced final demand from industry sectors i=1,...,N, and AD a direct requirements matrix (N×N) of coefficients Aij, which describe the intermediate demand of industries j=1,..., N of domestically produced commodities from industries i=1,..., N per unit of domestically produced output of industry j. The total domestically produced output xD (N×1) of industries i=1,..., N can then be described as the sum of intermediate and final demand:

xD = AD xD + yD

Solving for xD yields the basic input-output relationship

xD = (I–AD)-1 yD = L yD,

where I denotes the N×N unity matrix and L=(I–AD)-1 is called the total requirements matrix or Leontief inverse.

The domestic direct requirements matrix AD is derived in four steps:

METHODOLOGY

1. The published 80×42 use and supply matrices are augmented to symmetrical 80×80 matrices.
2. A market share matrix D is derived from the symmetrical supply matrix by dividing each entry by the total commodity output.
3. The coefficients of the symmetrical use matrix U are divided by the domestically produced output of the absorbing industry. Although the resulting matrix B with elements has an equal number of rows and columns, it is not symmetrical in the sense that it refers to commodities in its rows and to industries in its columns. Because of this asymmetry, it is unsuitable for inversion.

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4. A symmetrical industry-by-industry requirements matrix AD can be obtained in a fourth step by pre-multiplying B with the transpose of the market share matrix: AD = DtB. Since no information is available on the homogeneity of foreign industries, a one-to-one correspondence between commodities and industries is commonly assumed (that is, foreign industries are perfectly homogenous). As a consequence the symmetrical imports matrix M does not have to be pre-multiplied with Dt in order to describe industries, and create an imports requirements matrix AM.

- As with AM, the compensation R, surplus s, and taxes T were obtained by dividing the respective basic primary input data by total domestically produced output.
- Data on industrial and residential energy usage for F=24 primary and secondary fuels are published annually by the National Department for Energy Development (1999) at a 29-sector level.

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- The road transport sector contains petrol used in private vehicles, which was separated from industrial consumption and allocated to residential consumption, using data compiled by Tolmasquim and Szklo (2000). A 24×80 fuel requirements matrix F was constructed by prorating aggregated fuel use figures across 80-sector level industries according to the monetary supply of energy commodities listed in the input-output tables, and dividing by total domestically produced output. This procedure assumes that energy prices across certain groups of industries (eg agriculture, mining, services) are constant.

The energy content was set for the following fuels: natural gas, firewood, fuel oil, petrol, LPG, kerosene, gasworks gas, coal coke (instead of the primary metallurgical coal), electricity (instead of the primary energy forms steam coal and hydraulic energy), charcoal, and alcohol. Carbon contents of fuels were taken from Schechtman et al. (1999).