

Integrating bottom-up and top-down analyses of the Italian energy system

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- 1. Integrating Markal-Italy with macroeconomic analyses: reasons, objectives**
2. The Energy Extended Social Accounting Matrix
 - *SAM Italy: construction methodology*
 - *Markal-Italy and SAM: an unidirectional Soft-link*
 - *Soft link: structural change and impact analysis*
3. GTAP-E ITALY general equilibrium model
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Integrating Markal-Italy with macroeconomic analyses - Political relevance: threats/opportunities

Markal-Italy developed since 90's, widely used to support policymakers:

- National Communications to UNFCCC
 - analysis of EU package 20/20/20 for the Italian government (support for EU burden sharing)
 - periodical elaboration of scenarios for the Ministry of Economic Development
- EU Commission: European firms must gain the leadership in the rapidly growing sector of low carbon technologies, because otherwise there is the risk to that "others will benefit of the transition to a low carbon economy"

▶ Model-based Analysis of the 2008 EU Policy Package on Climate Change and Renewables

By P. Capros, L. Mantzos, V. Papandreou, N. Tasios
▶ Primes Model – E3MLab/NTUA
▶ June 2008

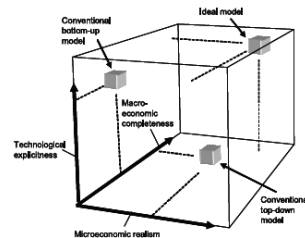


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Integrating Markal-Italy with macroeconomic analyses: modelling Energy/Economy interactions

- **Ideal** energy-environment policy model:
 - technologically explicit,
 - behaviorally realistic,
 - macroeconomic feedbacks
- **Hybrid** models: B-U or T-D that have made at least one modification that shifts them away from their conventional placement
- Reasons for moving toward hybrid from a **B-U perspective**

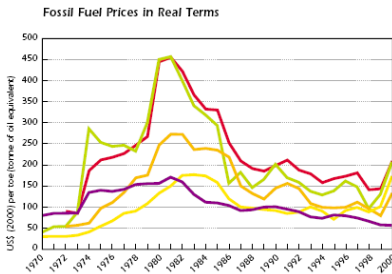
Figure 1. Three-dimensional Assessment of Energy-economy Models



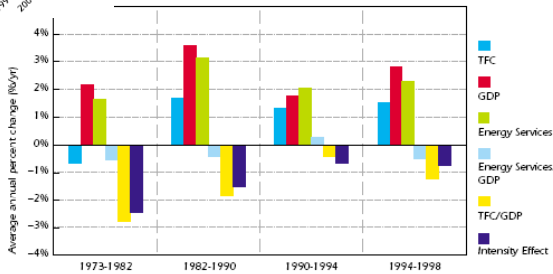
Source: Hourcade et al., Energy Journal, 2006

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Modelling energy/economy interactions from a Bottom-Up perspective



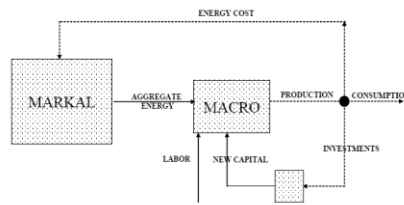
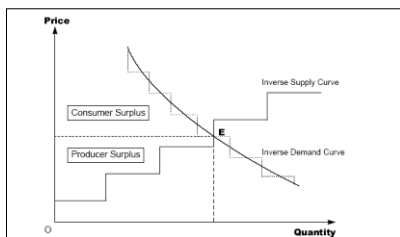
Changes in TFC, GDP, Energy Service Demand and Intensities, IEA-11



Source: IEA, 2004

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Towards hybrid from a Bottom-Up perspective – Markal-ED and Markal-Macro



- *Partial equilibrium approach do not take into account redistributive effects, feedbacks, impact on non energy sectors and prices etc.*
- *Economy-wide perspective: readjustment of the economy*
But
- *no sectoral disaggregation and*
- *"elephant and rabbit" metaphor*

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Need for a further step: to link or not to link

"Unidirectional " Soft-link

- Extend B-U models as far as possible w/o hitting technical limit and preserving technological detail
- Supplement B-U results with macroeconomic models:
 - with feedback: iterative scheme is time-consuming
 - w/o feedback: simpler implementation, quicker cycle time
- As feedback from economy to energy system are "not important"
→ no iterations

Joint analysis: different models for different needs

- Distributional issues between economic agents or countries are better addressed with macroeconomic models
- Technological opportunities, interaction between demand and supply in energy markets, better addressed with energy models

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What is SAM?

- A Social Accounting Matrix (SAM) can be defined as an organized **matrix representation of all transactions and transfers** between different production activities, factors of production and institutions (like households, firms and government) within the economy and with respect to the rest of the world
- SAM is a comprehensive **accounting framework within which the full circular flow of income** from production to factor incomes, household income to household consumption and back to production is captured
- Each row gives receipts of an account while the column gives the expenditure.
 - An entry in, say, row i and column j represents the receipts of account from account
 - The total of each row is equal to the total of each corresponding column

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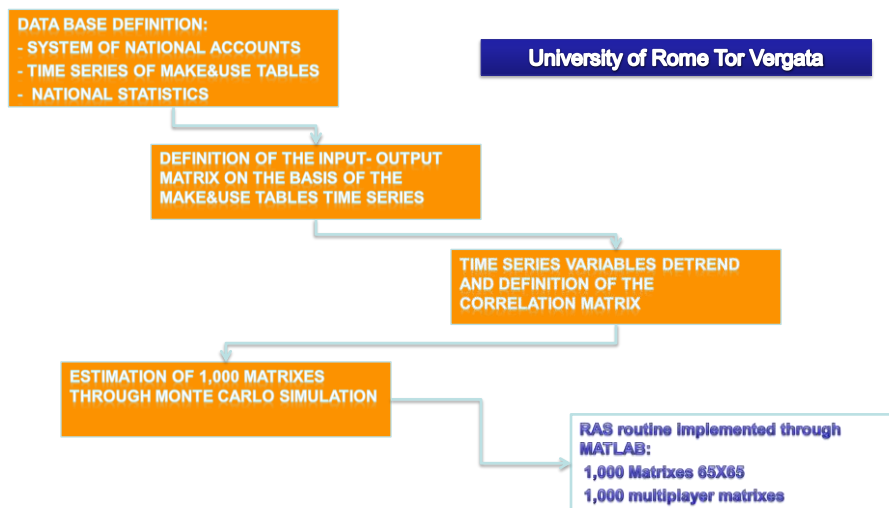
What is SAM?

- A "snapshot" of the economy in the base year: the production side is aggregated into a set of sectors, each of which usually produces a single good
- **Row**: amount of good produced must be sufficient to serve the sum of demands from other producing sectors plus the final demands of G, I, C , net EXP
- **Column**: the amount of the good produced by an industry is just exhausted in the payments to its inputs, plus taxes
- **X is the technology in use** in the benchmark year → amounts of various inputs applied to produce a unit of each sector's output (Leontief-type representation at sector level)

		Industries			Final Demands					Row Total
		← j →			← d →					
		1	...	n	Cons.	Inv.	Gov't	Exp.	Imp.	
Commodities i	↑	1								\bar{Y}_1
	↓		X				G			\bar{Y}_n
	↓									\bar{Y}_n
Factors f	↑									\bar{V}_L
	↓			V						\bar{V}_K
Resources										\bar{V}_F
Net Taxes										\bar{T}
Column Total		\bar{Y}_1	...	\bar{Y}_n	\bar{G}_C	\bar{G}_I	\bar{G}_G	\bar{G}_X	\bar{G}_M	

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The Italian SAM Estimation Methodology



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Integrating Markal-Italy with Italian SAM: a possible methodology

ENERGY SCENARIO FROM MARKAL-TIMES

Disaggregation of the original energy vectors in the SAM:

- 'Coal'
- 'Oil refining'
- From 'Mining and quarrying' in the SAM into 'Crude oil' and 'natural gas'
- From 'Electricity and gas' to 'Electricity', 'Renewable electricity' and 'Natural gas'

Definition of a "bridge matrix":

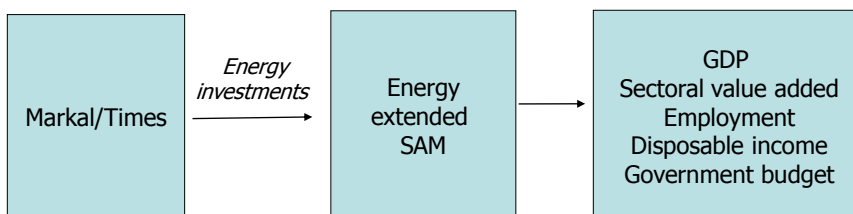
- Energy flows among energy sources and productive sectors (from Markal-Times)
- Price of the energy sources (from different statistics)

RAS ROUTINE IMPLEMENTED THROUGH MATLAB: EXTENDED ENERGY MATRIX

Bridge Matrix (gas sector flows in a SAM)

Integrating Markal-Italy with Italian SAM: impact analysis

- From the B-U model → detailed **schedule of investments and other expenditures**, and of prices, by each sub-sector, at each time-period
- These parameters are **input into the corresponding SAM**, which calculates the impacts on sectoral value added, on disposable income, on consumption, on labor and wages, etc.



Impact analysis through SAM multipliers

- The Extended SAM allows to analyze the **economic impacts at a disaggregated level** - by sectors and by socio-economic groups in the country - of energy policies.
- The **output multiplier of a sector** for example measure the amount by which the total output increases for a unit increase in the output of that sector:
 - **Total Income multipliers** give direct and indirect increase in GDP due to a unit increase in the value of output of a final demand vector
 - **Household income multiplier** gives the corresponding effect on the incomes of the household due to a unit increase in the value of output of a final demand vector

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Impact analysis through SAM multipliers: an application to the Civil Sector

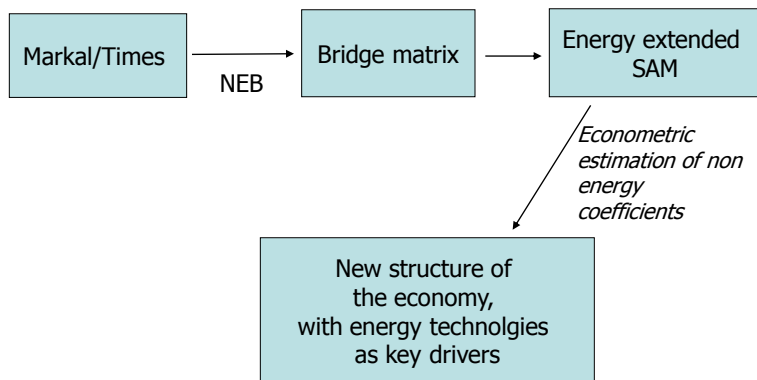
Evaluation of the economic Impact of an investment in the Italian civil sector for the energy upgrading of the public building

	NET IMPACT
INVESTMENT COST (000/€)	8.242
CROWDING OUT (%)	50%
VALUE ADDED (000/€)	14.303
PRODUCTION (000/€)	19.001
HOUSEHOLDS (000/€)	1.802
ENTERPRISES (000/€)	10.268
GOVERNMENT (000/€)	2.232
LABOUR (UNITY)	147.834
DELTA GDP (%)	0,59%

Multipliers	Impact	Historic Value	Net Impact
Value added	3,66	3,12	0,54
Input Output	4,90	4,22	0,69
Households	2,64	2,25	0,38

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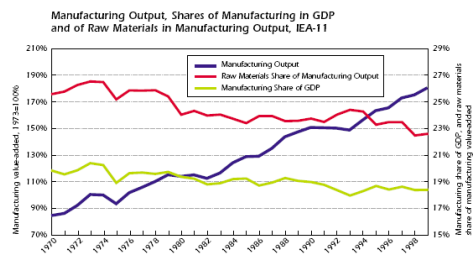
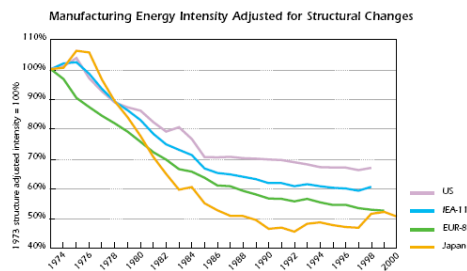
Integrating Markal-Italy with Italian SAM: modeling structural change (1a)



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Integrating Markal-Italy with Italian SAM: modeling structural change (1b)

- ✓ If mitigation strategies imply adjustments of the whole economic system (far from "marginal"): can they **stimulate innovative changes** of social/economic systems that make crisis/policies a mechanism of **economic dynamics**?
- ✓ Cost of sustainability is in fact an **investment cost**: significant adjustment costs, but ultimate extensive and positive changes of the economic systems



Source: IEA, 2004

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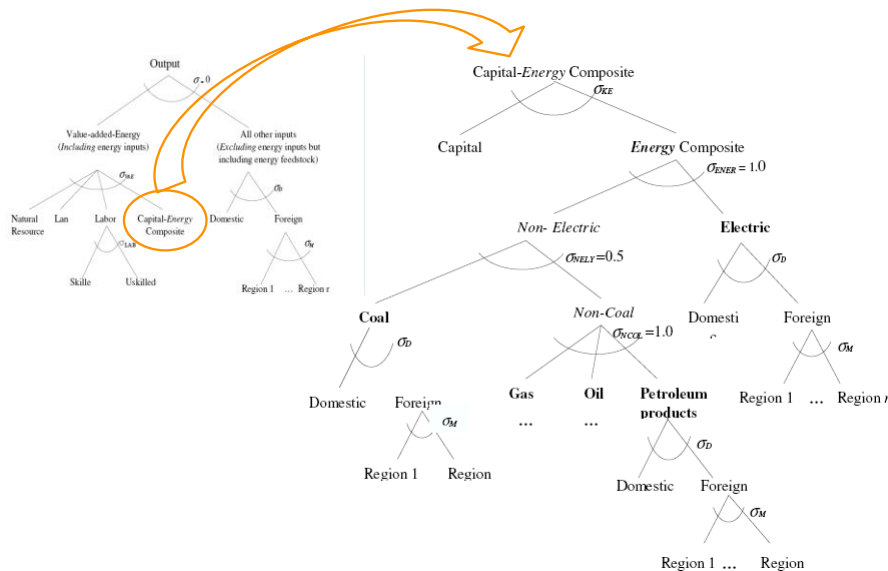
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What is GTAP?

- GTAP (Global Trade Analysis Project) is a multi-regional Applied General Equilibrium model.
- It captures world economic activity in 57 different sectors of 113 regions (Data Package 7).
- It includes two kinds of equations:
 1. accounting relationships
 2. behavioral equations
- It allows to obtain the impacts of policies in terms of GDP and trade variation, sectoral impacts, allocation effects, etc.

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GTAP-E production structure



GTAP-E ITALY construction methodology

In order to build the GTAP-E ITALY it has been necessary to:

1. Choose the GTAP-E version (McDougall, Golub, 2007);
2. Define the regional and sectoral disaggregation (reference to IEA Energy Balances);
3. Use the GTAP 7 Data Package to derive the energy data for the GTAP-E version;
4. Derive Italian CO₂ sectoral emissions from GTAP CO₂ Emissions Data;
5. Provide the files needed by RunGtap to compute the general equilibrium solution.

Regions

GTAP-E regional disaggregation	GTAP-E Italy regional disaggregation
1 USA	1 Italy
2 European Union (14 members)	2 USA
3 Eastern Europe and FSU	3 European Union (14 members)
4 Japan	4 Eastern Europe and FSU
5 Other Annex I Countries	5 Japan
6 Net Energy Exporters	6 Other Annex I Countries
7 China and India	7 Net Energy Exporters
8 Rest of World	8 China and India
	9 Rest of World

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Sectors

GTAP-E sectoral disaggregation	GTAP-E Italy sectoral disaggregation
1 Agriculture	1 Agriculture
2 Coal	2 Forestry
3 Crude Oil	3 Coal
4 Natural Gas	4 Crude Oil
5 Refined Oil Products	5 Natural Gas
6 Electricity	6 Refined Oil Products
7 Energy Intensive Industries	7 Electricity
8 Other Industry and Services	8 Mineral Products
	9 Chemical, Rubber, Plastic Products
	10 Metal Products
	11 Paper Products
	12 Transport
	13 Sea Transport
	14 Air Transport
	15 Services
	16 Dwellings
	17 Other Industry and Services

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GTAP-E ITALY potential

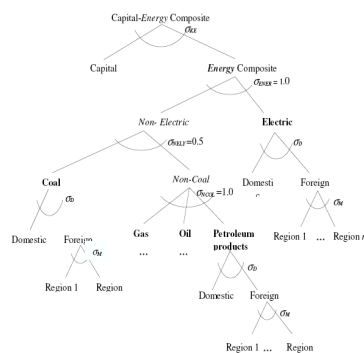
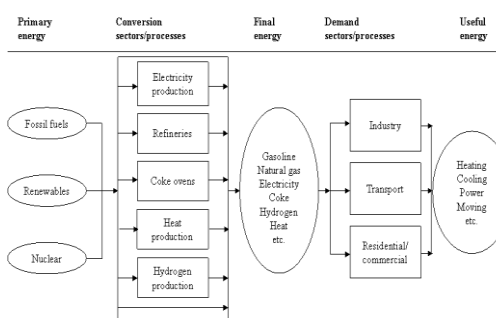
- Italian general equilibrium model calibrated on 2004 data (first time GTAP-E is updated to GTAP 7 Data Package)
- Detailed sectoral structure (energy and emissions data)
- Wide range of countries included

Possible applications:

- Computation of the economy-wide impacts of energy policies, such as carbon taxation or emission trading (i.e. carbon leakage)
- Integrated analysis with Markal-Times models

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MARKAL-ITALY AND GTAP-E: A JOINT ANALYSIS (1)



Need for:

- **internal consistency** between the different elements of a same scenario: the influence of energy costs on the energy system, as modeled by the energy model, is consistent with the influence of energy costs on the optimal mix of production factors as modeled in the macroeconomic model

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MARKAL-ITALY AND GTAP-E: A JOINT ANALYSIS (2)

- To ensure consistency, **harmonization of the two types of models** to same type of behavioural/technological assumptions: substitution elasticity of production function in macro model should reflect the technological substitution in energy model

→ **A tentative strategy**

Iterations for alignment of elasticities: convergency of energy use in the two models induced by the same variation of energy costs

- Macroeconomic model: integrate the different possible responses of the energy system to a policy
- Partial equilibrium model: integrate price mechanism to reflect the possible interaction outside the energy system

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Thanks

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