C.I.R.E.D.
Centre International de Recherche sur l'Environnement et le Développement

Benchmark energy-economy data and price-quantity decomposition

Impact on energy policy assessment

E. Combet, ADEME

F. Ghersi, CNRS

J. Lefèvre, AgroParistech

G. Le Treut, Chaire MPDD

C.I.R.E.D. Unité mixte de recherche EHESS et CNRS - UMR 8568
Jardin Tropical
45 bis avenue de la Belle Gabrielle
94736 Nogent-sur-Marne cedex - France

Presentation overview

- What is at stake
- Some history
- Data treatment methods
- France example
- Impact on economic assessment
- Key messages

What is at stake

Bridging the gap between the engineer's and the economist's visions of energy systems

The energy/economy conundrum

- Climate alert strengthening with the progresses of climatology and damage assessment
- Mitigation action consecutively strengthening its mid- to long-term ambition…
  - From ‘Factor 4’ to ‘Factor 5’ to ‘Zero Net Emissions’
  - From the NDCs of the Paris Agreement to 2°C to 1.5°C cap
- … but missing windows of opportunity one after the other
- This results in evermore ambitious decoupling of C from E and of E from social welfare—to the point of jeopardizing economic growth?

Confronting physics and money-metrics

- Physics of C and E decoupling at the heart of the mitigation challenge: the engineer's view on energy systems
- Money-metrics of mitigation costs key to social welfare impacts of the transition: the economist's view on energy systems
- Reconciling the 2 views is necessary to produce relevant energy/economy outlooks into futures deeply transformed by technical change within activities and structural change across activities
- Upstream research question of the benchmark energy/economy data

Some history

Of energy/economy modelling
and the underlying benchmark data

The KLE(M) model

- The first oil crisis prompted investigating the substitutability of other factors capital (K) labour (L) and materials (M) to E
- Applied both at economy-wide level and at industry level on energy consumption and pricing data
  - On primary E input and price at economy-wide level (Hogan and Manne, 1977)
  - On Divisia indexes of energy volumes and E expenses at industry level (Berndt and Wood, 1975)

Multi-sector developments

- Pioneered by Hudson and Jorgenson (1975)
  - On the inter-industry data used by Berndt and Wood (1975) but without aggregation: 9 sectors among which 5 energy sectors
  - Outlook of the US economy and attached energy consumptions at 5-year intervals from 1970 to 2000
- Flourished in the 1990's
  - Increased computational power pushes back sector/region limits and data availability dramatically expands
  - Explosion of applications to climate policy analysis… with lessened perception of limitations of underlying data and modelling paradigms?
- A research frontier of 'hybrid' approaches from the 2000's on

Data treatment methods

backing up economy-wide
energy/economy models

The CGE standard

- Dataset concentrated in Input-Output Table (IOT) ⇨ E data consists of cost and budget shares only
- Normalization of all output prices to 1 equates volume units to money units
- Non commensurability of energy consumptions expressed in money units
- Connexion to engineer’s description of physical flows through indexes only
- Prices to agents differentiated by ‘market wedges’ only (if at all): trade & transport margins, taxes & subsidies ⇨ settles on distribution of E volumes similar to that of E expenses

However

- E expenses of national accounts not direct *p* x *E* statistics
  - Firms' data collected by branch for reference years, submitted to efficiency gains assumptions, transformed from branch to product,
  - Households' data from multiple survey and administrative sources for reference years, submitted to price & volume variations
  - Further process to balance uses and resources
- Physical E flows induced by single-price assumption contradict E-flow statistics
  - Heterogeneity of E products questions using average output cost when pricing contrasted mixes e.g. heavy fuel oil vs. kerosene
  - Even for homogeneous E products as electricity and natural gas,

Hybrid approaches

- Satellite accounts of E flows and prices to enhance relevance
- Nomenclature issue of translating Energy Balance (EB) accounts and corresponding price data into IOT framework
  - Transportation end-use
  - Bunkers
  - Autoconsumptions
- Consistency issues between price, physical flow and expense data (from national accounts)
- Rebalancing issue when importing into IOT specific to importing method

Hybrid approaches outside CIRED

- The GTAP approach
  - Trade priority of E balances at global level induces national biases
  - Transparency issue
- Least-square approaches at national levels
  - Conciliate average-priced energy flows and national accounting E expenses
- The SGM approach
  - Considers energy balance + quasi-units for non-E goods
  - Solving for the set of output prices that restores uses and resources balances of energy goods

IMACLIM approach at CIRED

- Construction of hybrid matrices
  - Substitution of prices x volumes of energy balance and statistics to E expenses of national accounting
  - Homothetical adjustment of non-E resources of E producing sectors
  - Restoration of CI, C, X, L, K, M, T totals by adjustments on non-E sectors
- Introduction of ‘specific margins’ to differentiate market prices
  - Ad valorem deviations from the average output price (cost)
  - Of zero-sum total for each energy output
  - Subject to specific assumptions in modelled outlooks

The example of 2010 France

Resulting from hybridisation process on detailed IEA balance and 88-sector INSEE IOT

INSEE vs. IMACLIM France 2010 matrix

INSEE, G€	COMPOSITE	ENERGY	C	G	I	X	
COMPOSITE	1 564	40	1 011	522	377	445	**3 958**
ENERGY	80	89	80	-	-	16	**265**
L	1 134	12					
T1	55	2					
K	522	16					
M	449	64					
T2	155	41					
	3 958	**265**					

INSEE data

Hybrid, G€	COMPOSITE	ENERGY	C	G	I	X	
COMPOSITE	1 652	28	1 019	522	377	443	**4 040**
ENERGY	59	34	72	-	-	17	**183**
L	1 136	9					
T1	56	1					
K	526	12					
M	455	58					
T2	156	40					
	4 040	**183**					

INSEE data

IEA, ENERDATA data

Remainder of INSEE use / resource

IMACLIM 2010 France with specific margins

Hybrid, G€	COMPOSITE	ENERGY	C	G	I	X	
COMPOSITE	1 652	28	1 019	522	377	443	**4 040**
ENERGY	59	34	72	-	-	17	**183**
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SM E COMP		9					
SM E ENER		-17					
SM C		9					
SM X		-1					
T2	156	40					
	4 040	**183**					

INSEE data
IEA, ENERDATA data
Remainder of INSEE use / resource
By calibration to reproduce IEA prices

Distorsion of calibration data

2010 France	INSEE w. uniform pricing	SGM	IMACLIM
Total E uses (inc. exports), G€	265 (reference)	228 (-14%)	183 (-31%)
Share of energy uses in total uses	6.3% (reference)	5.4% (-13%)	4.3% (-31%)
Share of firms/households in E expenses (exc. exports)	68%/32% (reference)	64%/36% (-6%/+12%)	56%/44% (-17%/+35%)
Share of firms/households in E cons. (exc. exports)	72%/28% (reference)	75%/25% (+3%/-9%)	75%/25% (+3%/-9%)

Impact on policy analysis

For 3 assessment methods of increasing complexity
on quantity or price instruments

The aggregate cost-share model

- Hogan and Manne (1977) propose… an elephant-and-rabbit stew
- If total output Y is a CES of E and other inputs R then the elasticity of Y to E is E's cost share
- Compared to INSEE,
  - The SGM hybridisation method reduces the 2010 marginal cost of energy control by 18%
  - The IMACLIM hybridisation method reduces the 2010 marginal cost of energy control by 42%

The IO-loop price-signal multiplier (1)

- Variations of input prices induce variations of output costs which further raise input prices—looping to equilibrium
- Energy expenses determine where the looping process lands for any given ad valorem tax on energy
- Energy flows determine where it lands for excise taxes or imported price shocks
- Analytical expression with numerical exploration in the case of normalisation of output prices to 1
  - Without loss of generality
  - Keeping agent-specific pricing in the case of IMACLIM—i.e. only changing the unit of measurement of E

The IO-loop price-signal multiplier (2)

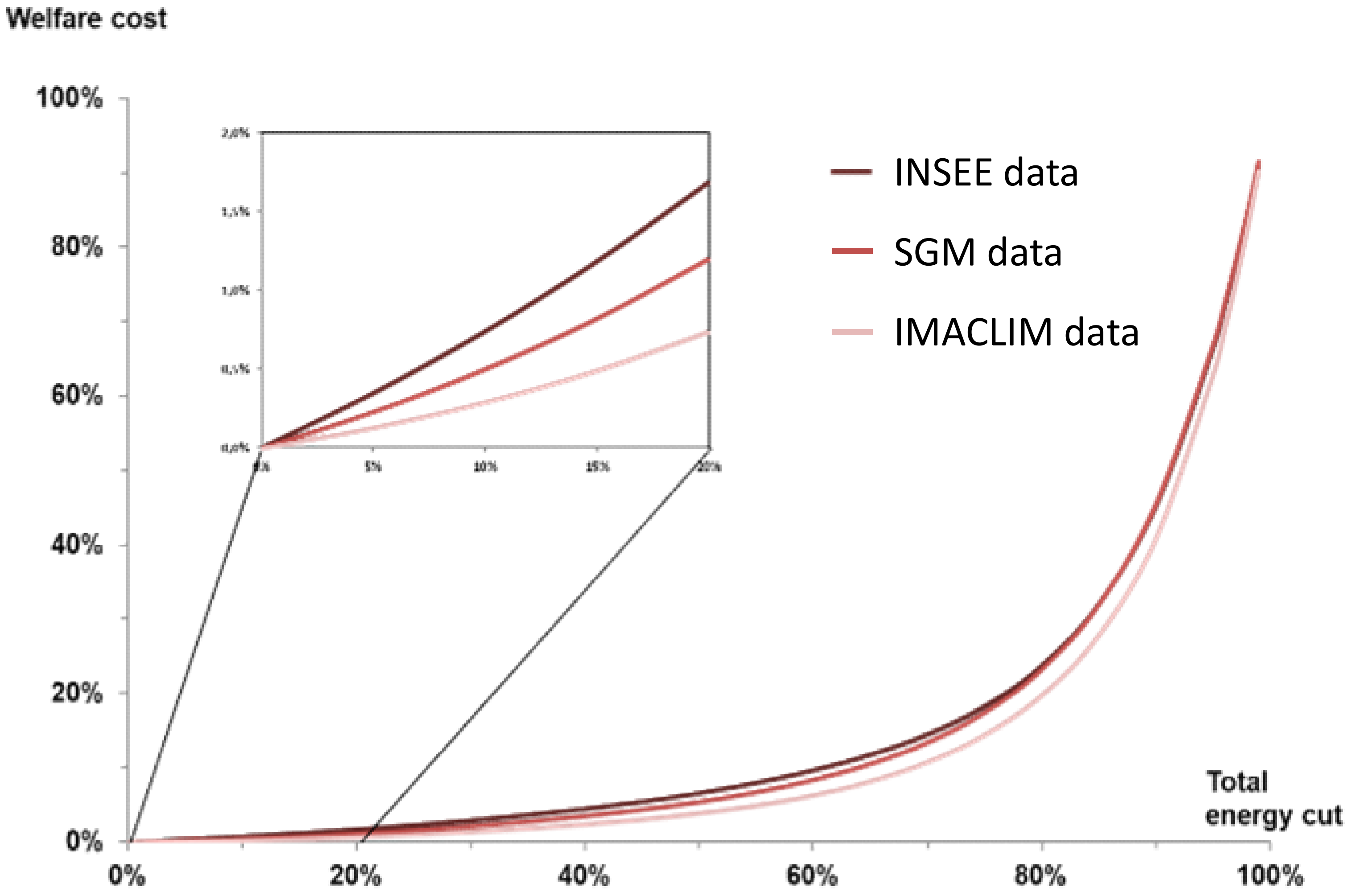
- Marginal impact of an excise tax t or an ad valorem tax τ on the output price of energy normed to 1

	With IMACLIM data, marginal price increase	…Relative to increase with INSEE data	…Relative to increase with SGM data
$\frac{\partial p_E}{\partial t}$	0.889	-14%	+43%
$\frac{\partial p_E}{\partial \tau}$ **at** $\tau = 0\%$	0.520	-42%	-8%
$\frac{\partial p_E}{\partial \tau}$ **at** $\tau = 5\%$	0.551	-45%	-8%
$\frac{\partial p_E}{\partial \tau}$ **at** $\tau = 10\%$	0.584	-48%	-9%
$\frac{\partial p_E}{\partial \tau}$ **at** $\tau = 15\%$	0.621	-51%	-9%
$\frac{\partial p_E}{\partial \tau}$ **at** $\tau = 20\%$	0.662	-54%	-10%

A basic 2-sector CGE model (1)

- E and non-E outputs nested CESs of K and L, KL and E, KLE and non-E
- Household's welfare a CES of E and non-E consumptions
- Public consumption and investment constant shares of GDP spent on non-E good
- Price-elastic import shares of resources / export shares of output
- Uniform pricing for INSEE and SGM e.g. nil specific margins versus agent-specific pricing for IMACLIM e.g. specific margins calibrated on exogenous set of market prices
- Applied to comparative-statics assessment of the welfare impact of energy quotas on firms/households/both

A basic 2-sector CGE model (2)



A basic 2-sector CGE model (3)

- Results echo the direction and size of departure from INSEE data (with uniform pricing)
- For households energy quotas, INSEE welfare cost up to 10% higher than IMACLIM, in line with expense discrepancy
- For firms energy quotas, welfare-cost gap largely exceeds expense discrepancy
  - INSEE cost up to 548% above IMACLIM cost, for a 5% cut
  - INSEE cost more than 100% above IMACLIM cost up to a 70% cut
- …taking account of artefact of costs converging to 100% for a 100% cut (CES consequence)

Key messages

From a too-long presentation

Key messages

- ‘Data hybridisation’ through reference to satellite accounts of E flows and prices is necessary to energy/economy analysis
- Different data hybridisation methods produce different benchmark datasets
- Price/quantity disaggregation via uniform pricing on ‘proper’ E expenses distorts the distribution of E flows
- Price/quantity disaggregation via uniform pricing on ‘proper’ E flows distorts E expenses
- Both distortions have strong impacts on policy analysis in the case of France