Energy Regulation, Household Welfare And Income Inequalities:
Distributional Analysis of Short-term Effects

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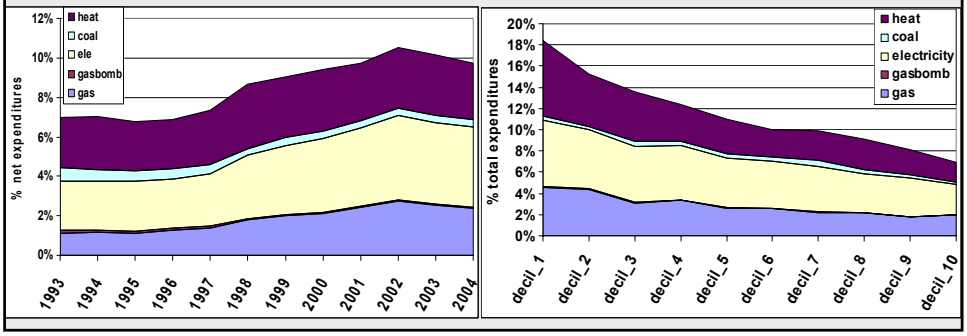
Seminar on "Implementing The 2020 Energy And Climate Package"
Charles University Prague, 16 April 2009

Motivation

- expenditures on energies present large budget share of hh
- low income hh group spends relatively more than rich hh
  - regressive impacts
  - fuel poverty
- increase in price of energy will lead in price increase of other goods (and leisure) that consequently involves further GE effects



Outline of the presentation

1. Methodology
2. Our Research (method, data)
3. The Results
4. Concluding Remarks

Methodology Incidence Measurement

- **Completely unresponsive demands**
  - change in expenditures without behavior change → 'naïve' approach
  - see the assessment of Czech ETR by Starý et al. (2006); Arthur D Little (2006)

$$\sum_k (p_{ik}^0 - p_{ik}^1) x_{ik}^0 + Y_i^1 - Y_i^0$$

- **Change in consumer surplus**
  - before-tax expenditures, change in **P** and Y, own-price elasticities

$$\Delta CS_i = \sum_k \left\{ \frac{x_{ik}^o p_{ik}^0}{\varepsilon_{ik} + 1} \left[1 - \left(\frac{p_{ik}^1}{p_{ik}^0} \right)^{\varepsilon_{ik}+1} \right] \right\} + Y_i^1 - Y_i^0$$

- **Change in compensating/equivalent variations**
  - compensated (Hicksian demand) own-price as well as cross-price elasticities
    → need to estimate household demand

Methodology
Household Demand Analysis

Energy demand is 'derived' demand

- close connection between energy consumption and relevant durables
- search for dynamic and structural models of household demand
- a two-step decision process modelled jointly (Dubin and McFadden 1984; Hanemann 1984; Vaage 2000)
  - the discrete choice of durables
  - conditional on this choice, continuous choice how to use the stock

Other possible models

- dynamic optimalization model → model development of expectations
- ignore the endowment as the stock and allocate investment over the durable lifetime
- assume implicit adjustment in the stock → estimate long time series
- ad hoc empiric specification of dynamic adjustment of the stock

Methodology
Household Demand Analysis

- **Linear Expenditure System** based on the Stone-Geary demand utility function
  - subsistence level of consumption, γ_i, irrespective of its price, p_i, or the consumer's income, y

$$q_i = \gamma_i + \frac{\beta_i}{p_i}\left(y - \sum_j \gamma_j p_j\right)$$

- **Almost Ideal Demand System** (Deaton et Muelbauer 1980) with a quadratic (Banks, Bludell, Lewbel 1997) or semi-flexible form (Moschini 1998) --- AID system of simultaneous eq.'s

$$w_i = \alpha_{i0} + \sum_h \alpha_{ih} x_h + \varepsilon_i + \sum_j \gamma_{ij} \log(p_j) + \left[\beta_{i0} + \sum_h \beta_{ih} x_h\right] \log\left(\frac{y}{P}\right)$$

- direct/ inverse **Translog** (Christensen, Jorgenson, and Lau 1975)

The research

- To measure ex ante distributional effects of higher energy prices (e.g. due to taxation, EU ETS)
- To measure effect on income inequalities and progressivity
- To consider heterogeneity in households behaviour and consumption patterns
- To use micro-simulation model that allows to simulate effect in the Czech Republic

Household Demand Estimation Econometric model

Almost **I**deal **D**emand **S**ystem (Deaton & Muelbauer, 1980) estimated by Bruha & Scasny 2006 for the households in the Czech Republic

$$w_i = \alpha_{i0} + \sum_h \alpha_{ih} x_h + \varepsilon_i + \sum_j \gamma_{ij} \log(p_j) + \left[\beta_{i0} + \sum_h \beta_{ih} x_h\right] \log\left(\frac{y}{P}\right)$$

- the Stone index estimated by non-linear GMM

$$\log P = \alpha_0 + \sum_i \alpha_i \log p_i + \frac{1}{2} \sum_{i,j} \gamma_{ij} \log p_i \log p_j .$$

- two-stage **Heckman-style correction** (1979) of zero expenditures → the inverse Mills ratios entered to the AIDS's intercept
- potential **endogeneity of prices** corrected by instrumenting the consumer energy prices by world energy prices → little changes found
- the AIDS restricts **Engel curves to be linear** in the log of expenditures
  - by a *simple linear regression* and by *non-parametric approach*
  - with and without potential *endogeneity corrections*
    - ➢ linear estims lay in 95% CI (by using a non-parametric bootstrap)

Household Demand Estimation Econometric model /2

- price responsiveness can differ among the households with different availabilities of and willingness to use the alternative
- household behaviour being analysed for various **groups**
  - income deciles/quintiles (e.g. West 2004; West and Williams 2004; Ščasný & Brůha 2003)
  - social status, number of children (e.g. Nichele and Robin 1995; Brůha & Ščasný 2004 → farmers, retired, empl.)
  - residential location (e.g. Brännlund and Nordström 2004)
- behaviour analysis for well specified household groups (still using micro data) allows to
  → more robust consumer behaviour estimates
  → overcome problem of zero expenditure occurrence

Household Demand Estimation Econometric model /2

- applying factor analysis we identify household groups assuming **certain consumer pattern**
  → type of heater
  → endowment with gas stew
  → expenditures on several types of energies

	ELEKTRINA	ELE cookGAS	HEAT cookELE	HEAT blocks	GAS heat	COAL heat
Energy % of expenses	**0.09** (std 0.06)	**0.13** (std 0.06)	**0.12** (std 0.05)	**0.12** (std 0.05)	**0.12** (std 0.06)	**0.10** (std 0.05)
Electricity	17 054	13 872	6 745	5 800	9 041	11 742
Gas	**0**	7 704	**0**	1 237	14 339	701**(12%)**
Heat	**0**	**0**	12 893	14 829	**0**	**0**
Coal	**0**	**0**	**0**	52**(12%)**	209**(20%)**	6 360

Ex ante distributional analysis

- DASMOD micro-simulation model
  - responsiveness estimated by AID system (*Deaton & Muelbauer 1980*)
    → short-run elasticities
    - separately for overall each of 30 household groups (*B&Š 2006*)
  - revenue-recycling effects
  - predictions for each individual household in the sample
  - optimization (revenues=0, welfare=0, DWL=0)
- Model limitations
  - restricted partial equilibrium effect
    - no GE effects, either 'top-down' method
    - only the first round effect (except the price of heat)
  - no tax-interaction effect
    - the effect on S_L not estimated, i.e. cross-price elasticities assumed be zero

Elasticity estimates

<< own price elasticities >>

	electricity	gas	heat	solid fuels
Household group classified according to the heat source (AIDS)				
ELECTRA	-0.52			
ELEcookGAS	-1.04	-2.26		
HEATcookELE	-0.25		-1.22	
HEATblocks	-0.32	-0.95	-0.84	
GASheat	-0.23	-0.94		
COALheat	-0.47			-0.11
*Average elasticity***	*-0.324*	*-0.978*	*-0.938*	*-0.11*
Groups classified according to the social status and the size of municipality (AIDS)				
Weighted mean	-0.63	-0.47	*	-0.03
Min among the groups	-0.45	-0.21	*	-0.03
Household of farmers	-0.53	-0.42	*	*
Households of pensioners	-0.73	-0.51	*	*
Max among the groups	-0.84	-0.56	*	-0.03
Income deciles (TS)				
Average- weighted	-0.30	-0.55	-0.48	n.a.

Elasticity Estimates

<< income elasticities >>

	electricity	gas	heat	solid fuels
Household group classified according to the heat source (AIDS)				
ELECTRA	0.36			
ELEcookGAS	0.35	0.93		
HEATcookELE	0.28		0.24	
HEATblocks	0.39	-0.19	0.17	
GASheat	0.19	0.10		
COALheat	0.31			0.22
*Average elasticity***	*0.296*	*-0.023*	*0.186*	*0.216*
Groups classified according to the social status and the size of municipality (AIDS)				
Weighted mean	0.90	0.76	0.71	0.66
Min among the groups	1.08	0.91	0.95	0.94
Household of farmers	0.97	0.82		0.89
Households of pensioners	0.83	0.75	0.85	0.59
Max among the groups	0.71	0.58	0.58	0.44
Income deciles (TS)				
Average- weighted	1.06	0.97	0.47	

EC_min (S1)	Impact on households						Public finances		
	expens	paid eco taxes	paid labor t	transfer	CV (CLI)	Welfare	public revenues	DWL	total revenues
Total for the CZ, in bln. CZK	**-0.13**	**1.81**	**0.00**	**0.00**	**5.13**	**-5.13**	**1.83**	**3.30**	**1.83**
1	51	396	0	0	1 048	-1 048	388	661	388
2	-102	349	0	0	1 039	-1 039	365	674	365
3	25	421	0	0	1 205	-1 205	417	788	417
4	-63	404	0	0	1 171	-1 171	414	757	414
5	-54	405	0	0	1 259	-1 259	414	846	414
6	44	459	0	0	1 172	-1 172	452	720	452
7	1	528	0	0	1 272	-1 272	528	745	528
8	-78	429	0	0	1 275	-1 275	441	834	441
9	-51	496	0	0	1 414	-1 414	504	910	504
10	-87	416	0	0	1 344	-1 344	429	915	429
ELEKTRINA	134	254	0	0	276	276	-233	44	233
ELEcookGAS	-546	387	0	0	577	577	-474	103	474
HEATcookGAS	-1 319	-87	0	0	1 358	1 358	-124	1 234	124
HEATblocks	325	130	0	0	1 593	1 593	-78	1 515	78
GASheat	-364	706	0	0	914	914	-764	150	764
COALheat	1 399	1 439	0	0	1 378	1 378	-1 216	163	1 216
farmer_small	396	839	0	0	931	931	-776	156	776
farmer_big	-135	652	0	0	1 117	1 117	-674	443	674

Ex ante analysis

Suits and Gini Indexes for the incomes after <u>all taxes</u>

SIM1 = EC Directive 2003/96	*regress*	*inequal*
SIM2 = SIM1 + revenue recycling *(labor tax cuts)*	≈	*even*
SIM3 = SIM1 + VAT change	*regress*	*even*
SIM4 = SIM3 + revenue recycling *(labor tax cuts)*	***progress***	≈

SIM5 = SIM3 without elasticities, i.e. ε_{ij}=0

SIM6 = 20% increase in energy & fuel prices

SIM7 = SIM6 + revenue recycling *(labor tax cuts)*

	Excise tax					P	Value Added Tax		Elasti cities	Addit tax revenues	Revenue recycling	L(tax) credit
	coal *CZK per ton*	gas *CZK per GJ*	heat *CZK per GJ*	electr *CZK per MWh*	fuels *CZK per l*	heat *CZK per GJ*	Standard rate	Reduced rate		bln. CZK		*CZK per year*
2007	0	0	0	0	11.65	362,5	19%	5%		n.a.	n.a.	7,200
SIM1	170	8.5	0	28	11.65	368	19%	5%	estim	1.98	none	7,200
SIM2	170	8.5	0	28	11.65	368	19%	5%	estim	0	tax credit	7,721
SIM3	170	8.5	0	28	11.65	382	19%	9%	estim	3.75	none	7,200
SIM4	170	8.5	0	28	11.65	382	19%	9%	estim	0	tax credit	8,189
SIM5	170	8.5	0	28	11.65	382	19%	9%	none	3.45	none	7,200
SIM6	317	20	0	500	16	386	19%	9%	estim	15.90	none	7,200
SIM7	317	20	0	500	16	386	19%	9%	estim	0	tax credit	11,531

Ex ante analysis: Suits

Suits index income / liv min	Scenario							
	Benchmark	*SC1*	*SC2*	*SC3*	*SC4*	*SC5*	*SC6*	*SC7*
Labor income tax	0,382	0,382	0,397	0,382	0,411	0,382	0,382	0,532
Insurance	0,117	0,117	0,118	0,117	0,119	0,117	0,117	0,125
LABOR taxation	0,209	0,209	0,212	0,209	0,215	0,209	0,209	0,235
ET fuel	0,043	0,043	0,043	0,043	0,044	0,043	0,043	0,048
ET ener		-0,087	-0,087	-0,087	-0,086	-0,087	-0,092	-0,087
VAT fuel	0,043	0,043	0,043	0,043	0,044	0,043	0,043	0,048
VAT (public transport)	-0,049	-0,049	-0,049	-0,049	-0,047	-0,049	-0,049	-0,042
VAT (energie)	-0,087	-0,087	-0,087	-0,087	-0,086	-0,086	-0,087	-0,083
ECO TAXES	-0,001	-0,005	-0,005	-0,007	-0,006	-0,008	-0,015	-0,009
VAT food	-0,087	-0,087	-0,086	-0,087	-0,086	-0,087	-0,087	-0,082
VAT rest	0,087	0,087	0,088	0,087	0,088	0,088	0,087	0,091
VAT all	0,060	0,060	0,061	0,059	0,060	0,059	0,059	0,063
TAX - total	0,141	0,140	0,141	0,139	0,142	0,139	0,133	0,143

Ex ante analysis: Gini

Gini Index income / persons	Scenario						
	Benchmark	*SC1*	*SC2*	*SC3*	*SC4*	*SC5*	*SC6*
Labor income tax	-0,05	-0,05	-0,05	-0,05	-0,05	-0,05	-0,05
Insurance	0,24	0,24	0,26	0,24	0,27	0,24	0,24
LABOR taxation	0,06	0,06	0,06	0,06	0,06	0,06	0,06
ET fuel	-0,13	-0,13	-0,13	-0,13	-0,13	-0,13	-0,13
ET ener		-0,21	-0,21	-0,21	-0,21	-0,21	-0,21
VAT fuel	-0,20	-0,20	-0,20	-0,20	-0,20	-0,20	-0,20
VAT (public transport)	-0,22	-0,22	-0,22	-0,20	-0,20	-0,20	-0,20
VAT (energie)	-0,13	-0,13	-0,13	-0,13	-0,13	-0,13	-0,13
ECO TAXES	-0,15	-0,15	-0,15	-0,15	-0,15	-0,15	-0,16
VAT food	-0,22	-0,22	-0,22	-0,22	-0,22	-0,22	-0,22
VAT rest	-0,06	-0,06	-0,06	-0,06	-0,06	-0,06	-0,06
VAT all	-0,08	-0,08	-0,08	-0,09	-0,09	-0,09	-0,09
TAX - total	0,47	0,48	0,46	0,45	0,47	0,46	0,34
Gini	0,25						

Ex ante analysis

- The revenue-recycling scenarios increase tax progressivity of the tax system
- labour taxation cuts overall slightly decreases the inequalities

Caveat:

- *A particular labour tax cut considered*
- *Measures indicate aggregate results, not change in distribution in subgroups*

Ex ante measurement

- **96/2003/EC implementation of minimal rates --- ECmin**
  - regressivity of overall tax system increased
  - welfare reduced mostly in the first 2 deciles (more than **Heat19)**
- **ETR with revenue recycling** via lowering of
  → **ETR_insur**: the insurance payments from 12.5% down to 10.8%
  → **ETR_labour**: the lowest rate lowered from 12.0% to 9.4%
  - energy expenditures
    - increased mostly in ELEKTRINA, COALheat, bigger families and pensioners in rural
    - reduced in HEATcookGAS, EA1/EA1+ big and 3 highest deciles
  - welfare effects, in aggregate, are comparable for two variants, but
    - **ETR_insur** yields lesser regressivity in total (reduces in decile 1-4, 10)
- **Compensations as 100€**, if energy expenditures >25% of net income
  - increased energy expenditures of pensioners and EA1 in rural
  - welfare improved for the pensioners and EA1 (decile 1-5) on detriment of EA2 and EA2+ (resp. decile 7-10)
- **50% higher excises on motor fuels**
  - more even impact; bigger impact on larger families in rural & farmers

Limitations & Future Research

- GE effects of energy price increase
  - separability of **labour supply**
    - What is the effect of increase in energy prices on labor supply (due to decrease of 'price' of leissure)?
  - feedbacks on prices
  - ongoing research (re-estimation of the AID system, include COICOP, labor supply effects, link to GE model)
- Other non-financial effects
  - benefit of unemployed from **being employed**
  - **environmental/health benefit** from improvement of environmental quality

    …both likely more distributed in low-income household groups

Conclusions

- AIDS estimation for appropriately chosen hh groups allows to better identify specific behaviour → more precise predictions on household welfare changes
  - e.g. the impact on expenditures varies between -0.16% to +0.22% for deciles, but it ranges between -2.33% and +2.06% for „energy-groups“
- Policy design will have effect on consumption, the environment, and also efficiency (DWL)

Future Research

- Use of hh demand estimation in macro modelling framework
  - macro-econometric E3ME model
  - CGE model
  - Need to estimate long run demand for the Czech Republic
- Conditional /short-run/ demand only, however
  - Ščasný et Brůha (2005) found that energy price did **not** have a significant long-term effect on household energy behavior in terms of adjusting the stock of appliances
  - **budget constraints** were found to be a barrier of adjustments, while the adjustment of retired and bigger family in big city was the slowest
  - Scasny and Urban (2009) found that 86% of households considered **higher price of energy** as important factor of **reduction in their energy consumption**
- OECD coordinated research on household consumption including in the Czech R
  - analysis of the stock of electric appliances
  - energy saving behaviour and purchases/installations
  - determinants of reduction in energy consumption in household

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Thank you for your attention