REBOUND EFFECT FOR ENERGY SERVICES: THE CASE OF UK HOUSEHOLDS

BIEE Conference, Oxford, September 21-22, 2016

Mona Chitnis (University of Surrey)

Roger Fouquet (LSE)

Steve Sorrell (University of Sussex)

Outline

- Rebound mechanisms
- Data overview
- Model
- Results
- Discussion

Rebound mechanisms for households

Embodied emissions of measure

Indirect Rebound

Lower heating cost and fuel bills

Lighting

More or less emissions

Less emissions

Higher room temperature or leaving the heating on for longer

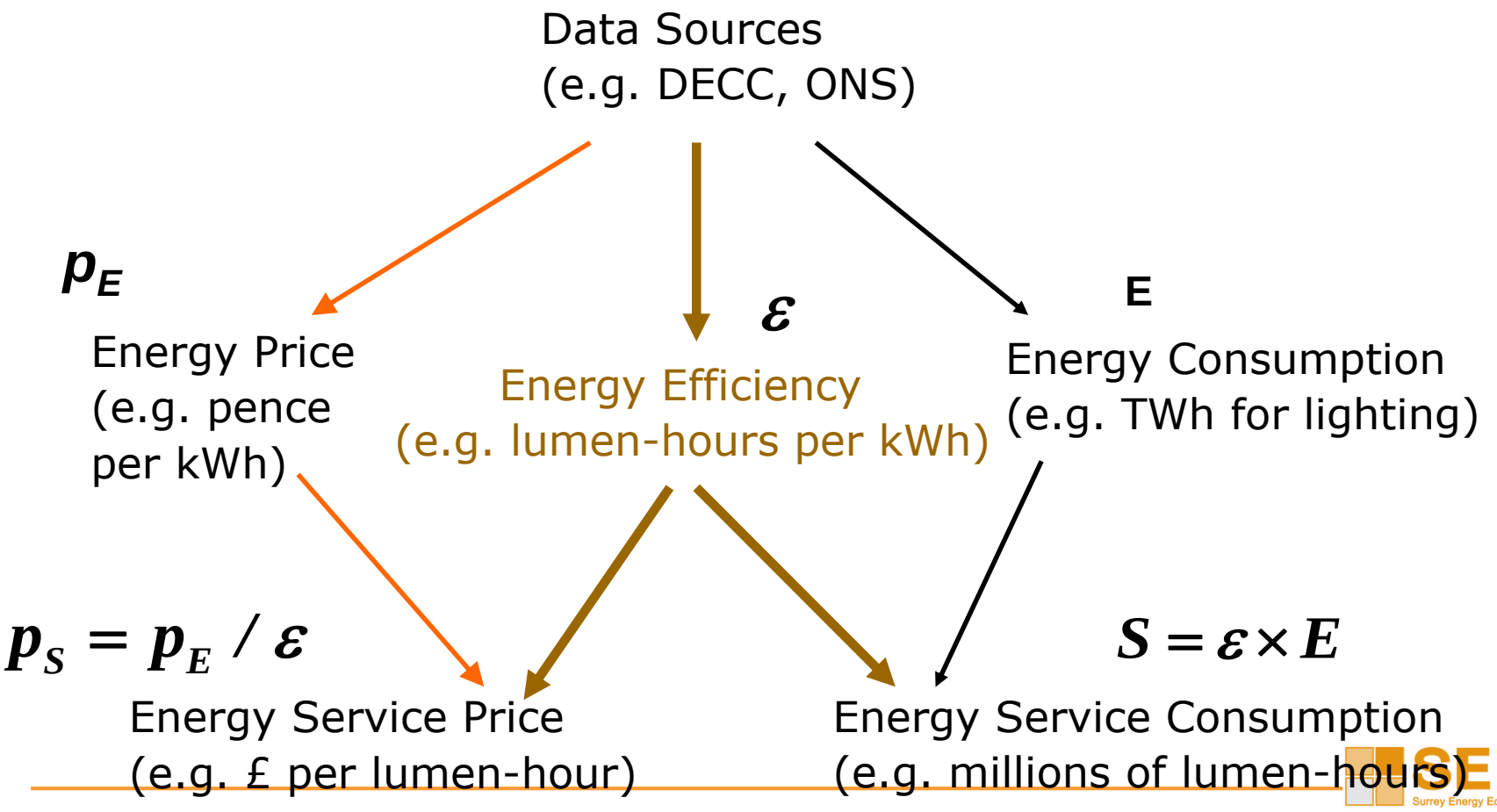
Lower running cost for heating

Direct Rebound

More emissions

SEEC
Surrey Energy Economics Centre

Measuring energy service price and Consumption



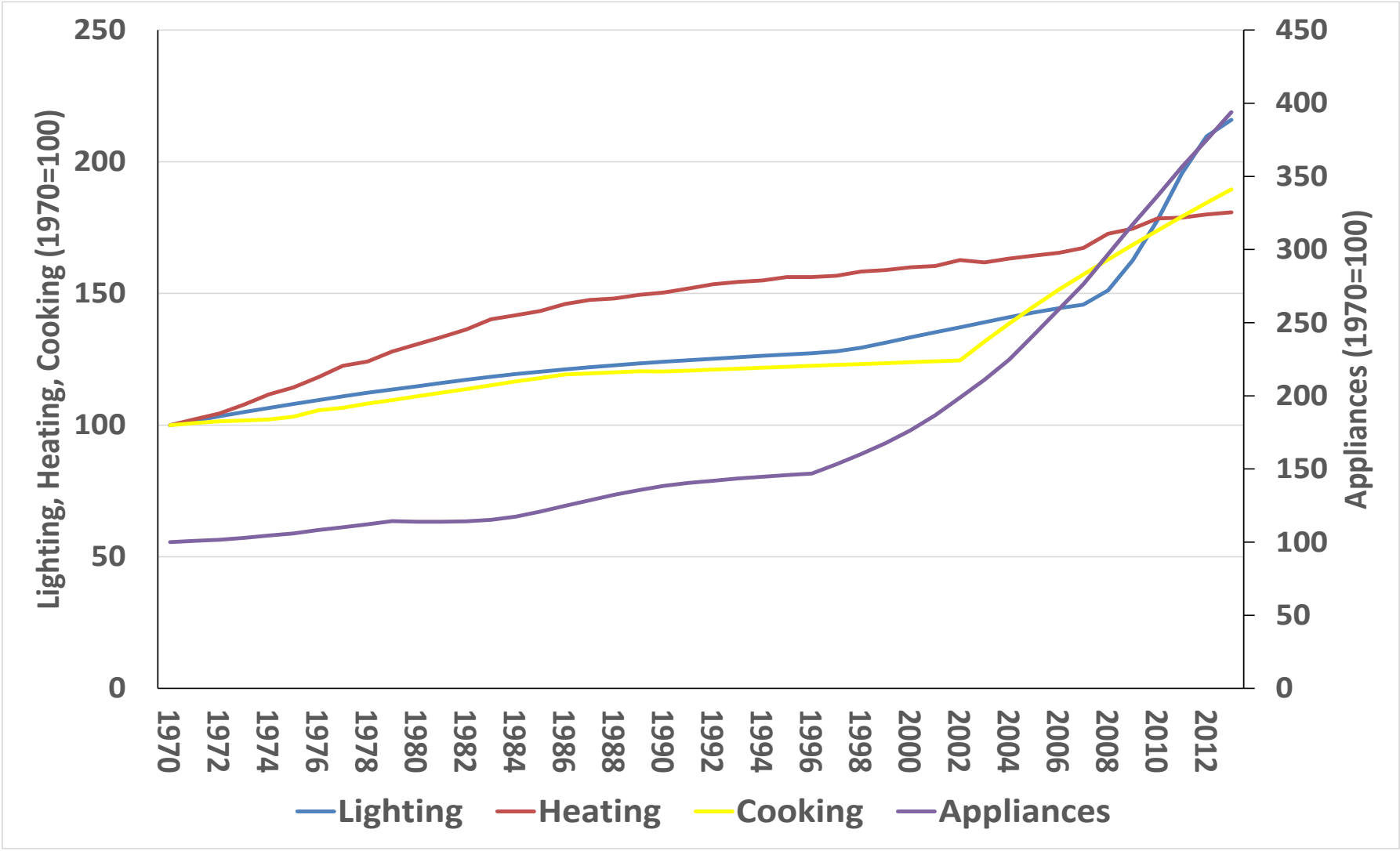
SEEC
Surrey Energy Economics Centre

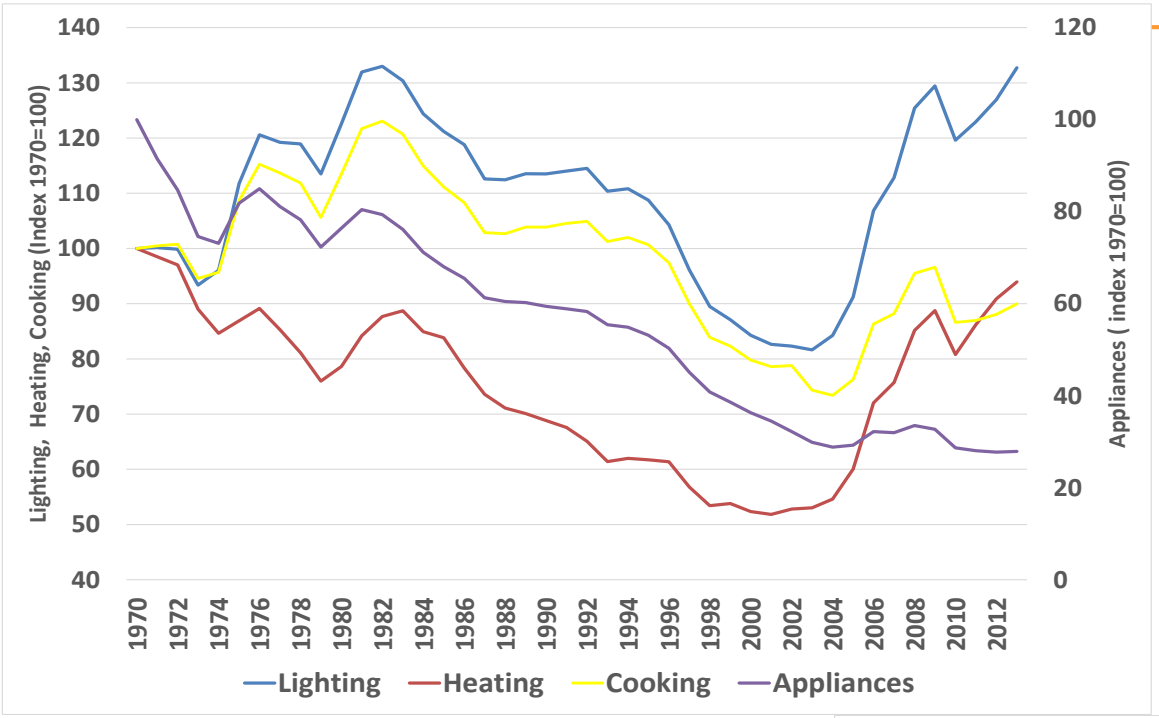
Energy services in this presentation

- Lighting
- Heating
- Appliances
- Cooking

SEEC
Surrey Energy Economics Centre

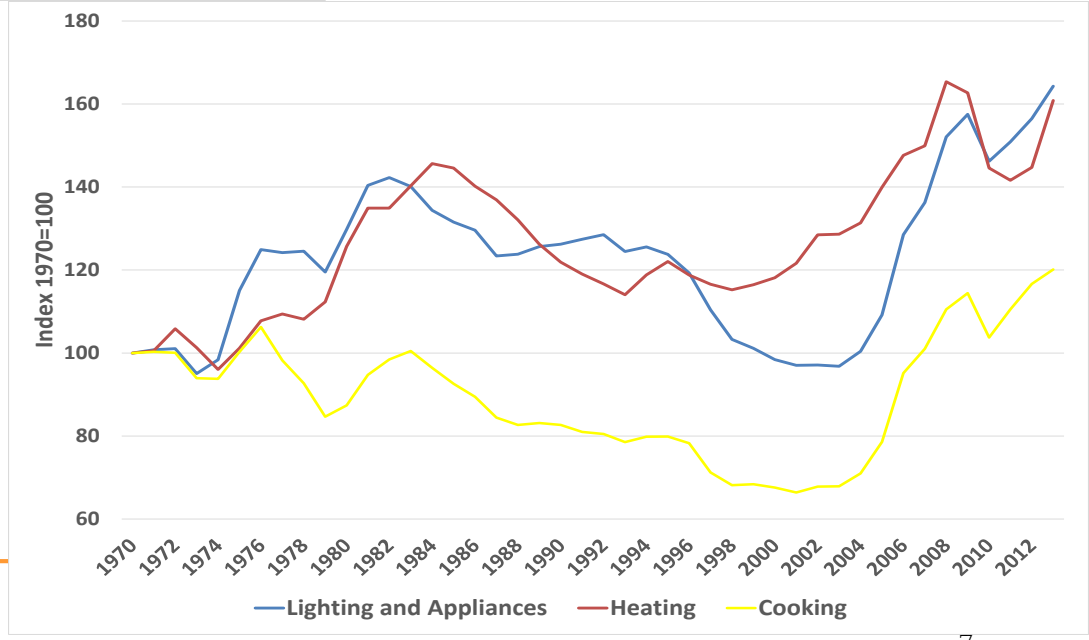
Average efficiency by energy service in the UK 1970-2013 (index, 1970=100)

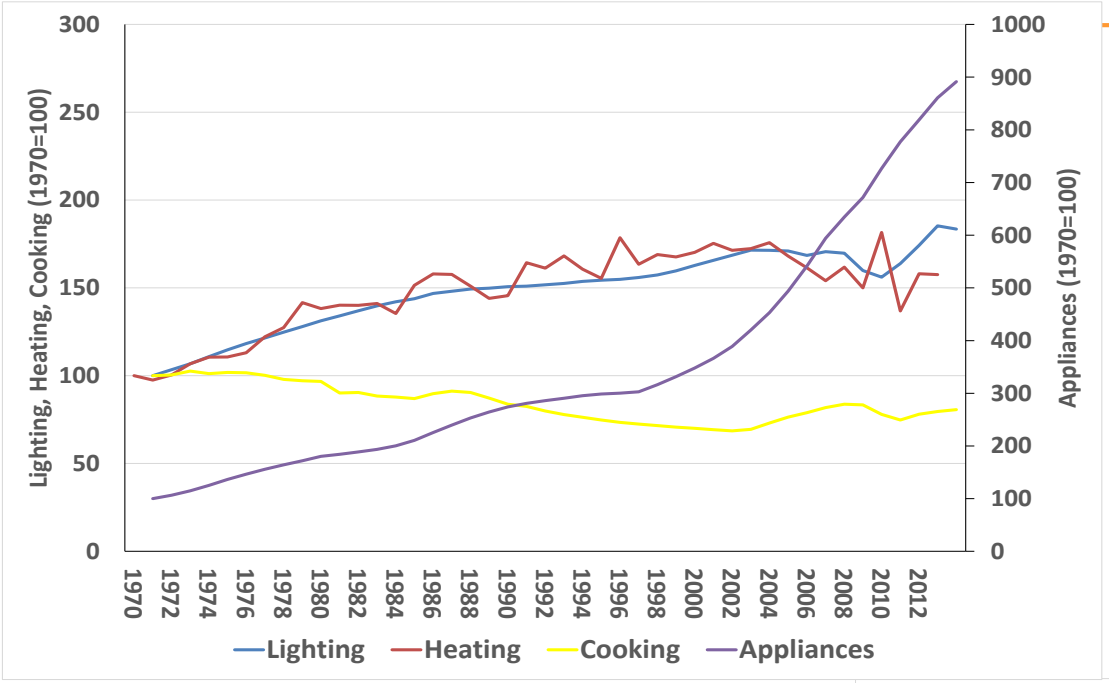




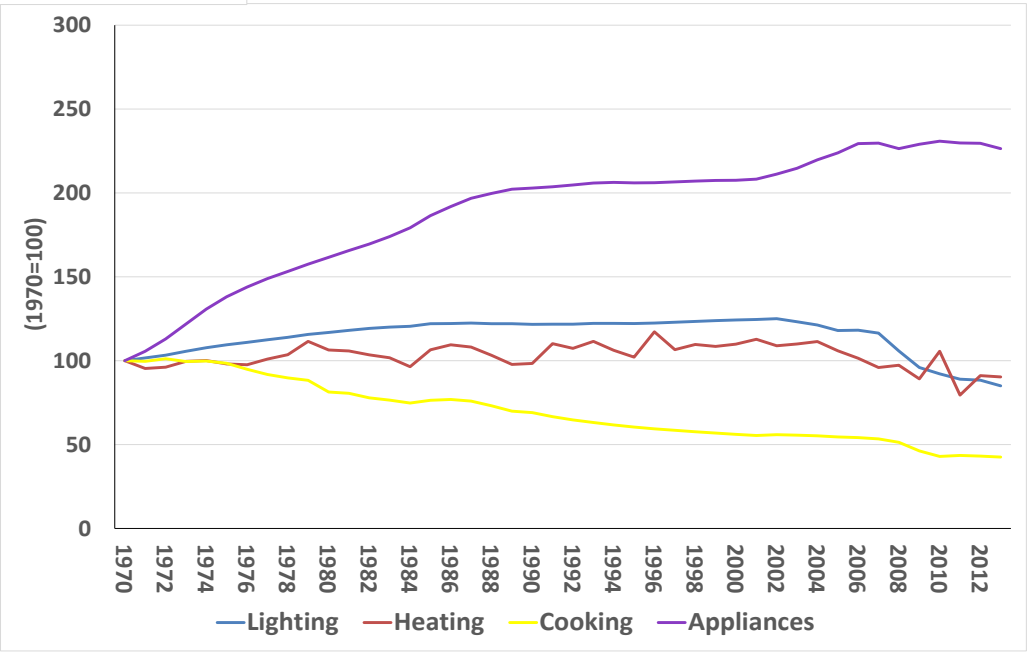
Real price of energy services (index, 1970=100)

Real price of energy for services (index, 1970=100)





Consumption of energy services per household (index, 1970=100)



Energy consumption per household (index, 1970=100)

Total rebound estimation (in terms of GHG)

Total Rebound = $-\eta_{p_S}(s) - \sum_{i(i \neq s)} \psi_i \eta_{p_S}(i)$

where:

Direct Indirect

$$\psi_i = \frac{u_i^x w_i}{u_s^x w_s}$$

$\eta_{p_S}(s)$: own-price elasticity of energy service *s*

$\eta_{p_S}(i)$: cross-price elasticity of energy service *i* with respect to energy service *s*

u_i: GHG intensity of energy service *i*

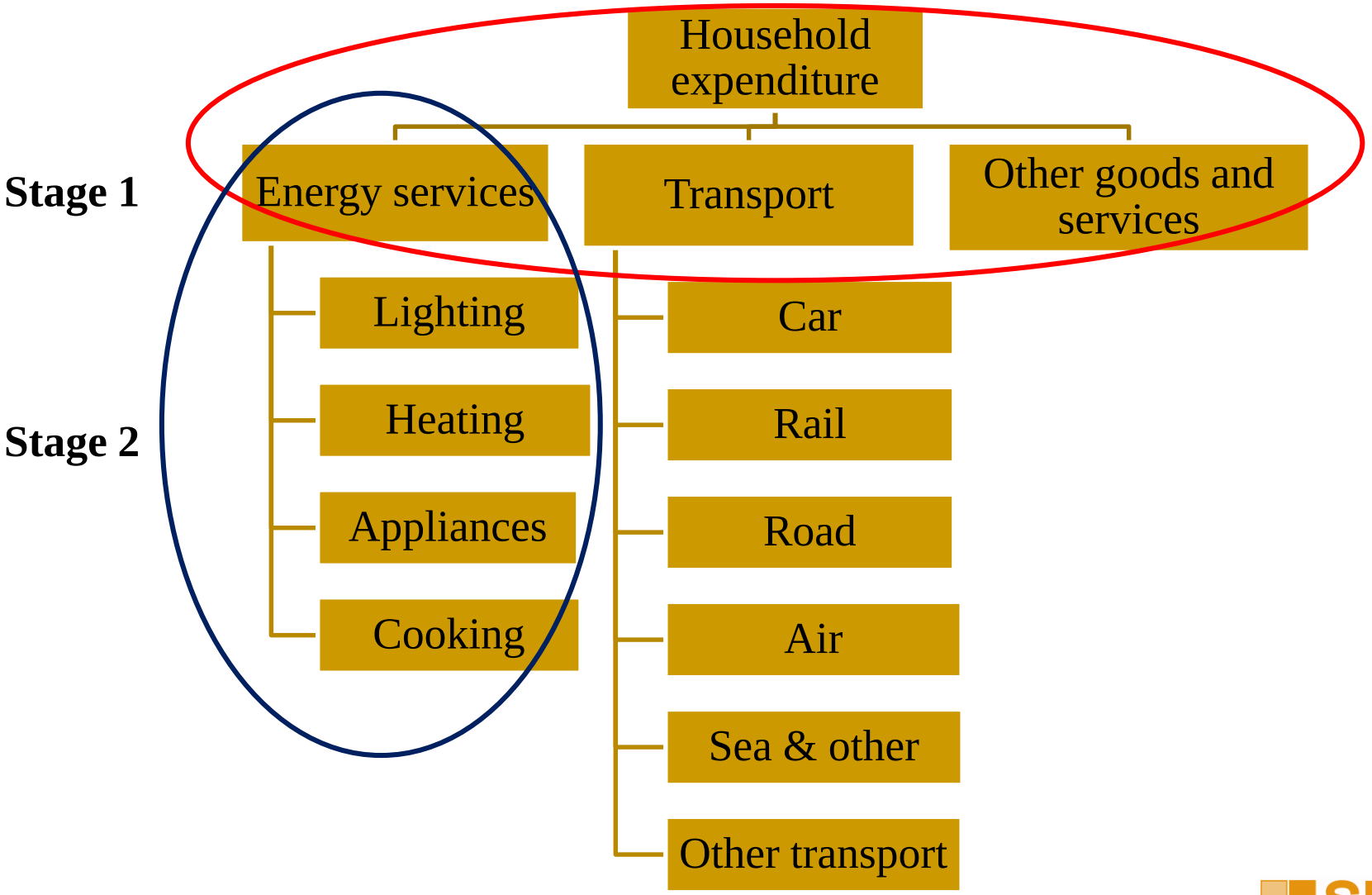
u_s: GHG intensity of energy service *s*

w_i: budget share of energy service *i*

w_s: budget share of energy service *s*

SEEC
Surrey Energy Economics Centre

Two stage budgeting model



SEEC
Surrey Energy Economics Centre

Almost Ideal Demand System (AIDS)

Stage 1:

$$w_{rt} = \alpha_r + \sum_z \gamma_{ij} \ln p_{zt} + \beta_r \ln(x_t / P_t) + \sum_z \lambda_{rz} w_{z\,t-1} + \varepsilon_t \qquad \text{r, z: 1, 2, 3}$$

where:

w_r=budget share of category r

P_z=price of category z

x=total expenditure per household

P=Stone price index $\ln P_t = \sum_r w_{rt} \ln p_{rt}$

- Adding up: $\sum_r \alpha_r = 1, \sum_r \beta_r = 0, \sum_r \gamma_{rz} = 0, \sum_r \lambda_{rz} = 0$
- Symmetry: $\gamma_{rz} = \gamma_{rz}$
- Homogeneity: $\sum_r \gamma_{rz} = 0$

SEEC
Surrey Energy Economics Centre

Almost Ideal Demand System (AIDS)

Stage 2:

$$w_{it}^{r} = \alpha_i + \sum_{j \in r} \gamma_{ij} \ln p_{jt} + \beta_i \ln(x_{rt} / P_{rt}) + \sum_{j \in r} \lambda_{ij} w_{j_{t-1}} + \upsilon_t \qquad \text{i, j: 1, …, 4}$$

where:

w_i=budget share of energy service i

P_j=price of energy service j

x_r=total expenditure on energy services per household

P_r=Stone price index $\ln P_{rt} = \sum_i w_{it} \ln p_{it}$

- Adding up: $\sum_i \alpha_i = 1, \sum_i \beta_i = 0, \sum_i \gamma_{ij} = 0, \sum_1 \lambda_{ij} = 0$
- Symmetry: $\gamma_{ij} = \gamma_{ij}$
- Homogeneity: $\sum_i \gamma_{ij} = 0$

SEEC
Surrey Energy Economics Centre

Estimation

- UK household annual time series data 1970-2013
- Iterative Seemingly Unrelated Regressions (ISUR) method for system estimation
- The estimated elasticities of stage 1 and 2 are combined to obtain total price and expenditure elasticities for each energy service (Edgerton 1997).

Estimated elasticities 2013

Total expenditure elasticities for energy services

	Lighting	Heating	Appliances	Cooking
Expenditure elasticity	0.571	1.114	0.669	0.619

Total price elasticities for energy services

	Price elasticity			
	Lighting	Heating	Appliances	Cooking
Lighting	-0.839	-0.195	0.738	0.289
Heating	-0.021	-0.137	0.126	0.016
Appliances	0.173	0.290	-0.625	0.153
Cooking	0.257	0.145	0.584	-0.995

SEEC
Surrey Energy Economics Centre

Estimated rebound effects 2013

Rebound effects between energy services

	Lighting	Heating	Appliances	Cooking
Lighting	83.9%	18.5%	-73.8%	-28.4%
Heating	2.2%	13.7%	-13.8%	-1.8%
Appliances	-17.3%	-26.5%	62.5%	-15.1%
Cooking	-26.2%	-13.3%	-59.3%	99.5%

Direct, indirect and total rebound effects for energy services

	Direct rebound	Indirect rebound (energy services only)	Total rebound
Lighting	83.9%	-83.7%	0.25%
Heating	13.7%	-13.4%	0.29%
Appliances	62.5%	-58.9%	3.61%
Cooking	99.5%	-98.8%	0.70%

Discussion

- This is a work in progress!!
- No backfire, rebound is negligible
  - Indirect rebound almost cancels out the direct rebound
- embodied emissions and capital cost is neglected
- Indirect rebound of transport and non-energy goods is neglected
  - Adding transport to the model
- Assumptions are for UK average household
  - Equivalisation scale
- Rebound for 2013
  - Average rebound over the sample period
- Data assumptions and limitations
- Investigating the alternative ways of formulating the model

SEEC
Surrey Energy Economics Centre

REBOUND EFFECT FOR ENERGY SERVICES: THE CASE OF UK HOUSEHOLDS

BIEE Conference, Oxford, September 21-22, 2016

Mona Chitnis (University of Surrey)

Roger Fouquet (LSE)

Steve Sorrell (University of Sussex)