An integrated input-output and household expenditure model

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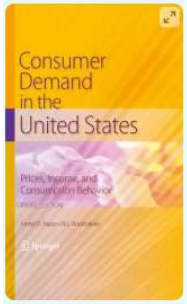
Outline

- Motivation and aims
- Taylor’s consumer expenditure model
- Internal structure of EU consumption expenditures
- Integrating the macro-micro twins
- Empirical application of increased energy prices
- Concluding remarks

Motivation and aims



Consumer Demand in the United States

Prices, Income, and Consumption Behavior

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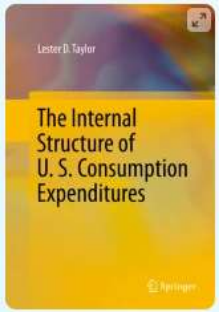
Overview

Authors: Lester D. Taylor , H.S. Houthakker

- Original editions sold 2500 copies and were among the most highly cited books in the field of demand theory
- Taylor and Houthakker are two of the most well-known scholars in the field of demand analysis and consumption behavior, and pioneered dynamic consumption models that have been workhorses of applied econometrics for over 40 years
- Most extensive coverage of price and income elasticities in relation to consumer demand to be found in any publication
- Introduces models that will help economists and industry specialists to forecast future price elasticities
- Stands at crossroads of economics and psychology, appealing to diverse audience



The Internal Structure of U. S. Consumption Expenditures

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Overview

Authors: Lester D. Taylor

- Investigates consumer behavior beyond the conventional price and income elasticities
- Provides in-depth statistical analysis of consumer spending and behavior
- Examines the US allocation of expenditures amongst different categories of consumption

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Motivation and aims

Taylor (2014), The Internal Structure of US Consumption Expenditures

- An “almost entirely statistical and mathematical” approach
- May be consistent with a variety of preference structures: neoclassical, lexicographical, hierarchical, etc.
- Direct and indirect interrelationships between all consumer expenditures
- “Sufficient stability exists in expenditure interrelationships that intra-budget coefficients can be taken as stable characteristics of household consumption behaviour” (Taylor, 2014, p. 165)

Taylor's consumer expenditure model

Run OLS regressions:

$$e_{hi} = \zeta_i + \sum_{j \neq i} \beta_{ij} e_{hj} + \gamma_i y_h + u_{hi} \quad \text{for all } i = 1, \ldots, g \tag{1}$$

Evaluate at the mean values of the variables:

$$\mathbf{e} = \begin{bmatrix} \bar{e}_1 \\ \bar{e}_2 \\ \vdots \\ \bar{e}_g \end{bmatrix}, \; y = \bar{y}, \; \boldsymbol{\zeta} = \begin{bmatrix} \hat{\zeta}_1 \\ \hat{\zeta}_2 \\ \vdots \\ \hat{\zeta}_g \end{bmatrix}, \; \mathbf{B} = \begin{bmatrix} \hat{\beta}_{11} & \hat{\beta}_{12} & \cdots & \hat{\beta}_{1g} \\ \hat{\beta}_{21} & \hat{\beta}_{22} & \cdots & \hat{\beta}_{2g} \\ \vdots & \vdots & \ddots & \vdots \\ \hat{\beta}_{g1} & \hat{\beta}_{g2} & \cdots & \hat{\beta}_{gg} \end{bmatrix}, \text{ and } \boldsymbol{\gamma} = \begin{bmatrix} \hat{\gamma}_1 \\ \hat{\gamma}_2 \\ \vdots \\ \hat{\gamma}_g \end{bmatrix}, \tag{2}$$

Structural form:

$$\mathbf{e} = \boldsymbol{\zeta} + \mathbf{B}\mathbf{e} + \boldsymbol{\gamma} y \tag{3}$$

Reduced-form:

$$\mathbf{e} = (\mathbf{I} - \mathbf{B})^{-1} (\boldsymbol{\zeta} + \boldsymbol{\gamma} y) \, . \tag{4}$$

Consumption expenditure multiplier matrix, or the Taylor inverse: $\mathbf{T} \equiv (\mathbf{I} - \mathbf{B})^{-1}$

Internal structure of EU consumption expenditures

- Data: EU HBS 2010 and 2015 waves, plus Austrian microdata for 2009-2010 and 2014-2015
- Instead of single constant, we use country dummies

$$e_{hi} = \sum_r \zeta_i^r D_r + \sum_{j \neq i} \beta_{ij} e_{hj} + \gamma_i y_h + u_{hi} \quad \text{for all } i = 1, \ldots, g, \tag{5}$$

- The corresponding reduced form, with country relative size/weights **w**:

$$\mathbf{e} = (\mathbf{I} - \mathbf{B})^{-1} (\mathbf{Z}\mathbf{w} + \boldsymbol{\gamma} y), \tag{6}$$

$\mathbf{Z} = [\boldsymbol{\zeta}^1 \, \boldsymbol{\zeta}^2 \, \cdots \, \boldsymbol{\zeta}^{n_r}]$ is the $g \times n_r$ matrix of exogenous expenditures

- Expenditures and net income are expressed per adult equivalent

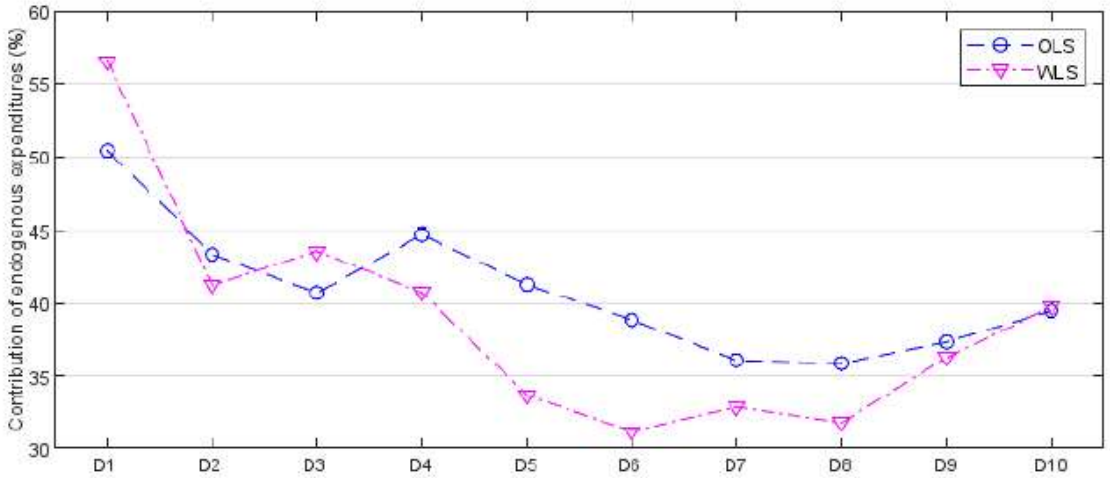
IS of EU consumption expenditures

Table 1: Coefficients of intra-budget regressions for EU26, 2015

	Category	c1	c2	c3	c4	c5	c6	c7	c8	c9	c10	c11	Zw	Inc	R2
		Coefficients of intra-budget OLS regressions													
c1	FoodNalcBvg	--	0.1999	0.1078	-0.0153	0.0395	0.0325	0.0023	0.1237	0.0224	-0.0036	0.0566	1543.0	0.0125	0.38
c2	AlcBvgTbc	0.0653	--	-0.0058	0.0119	0.0028	-0.0014	0.0012	0.0864	0.0017	0.0374	-0.0035	75.2	0.0013	0.09
c3	ClothFtwr	0.0806	-0.0133	--	0.0001	0.0289	0.0088	0.0067	0.1810	0.0309	0.1058	0.0564	27.2	0.0097	0.24
c4	HousWtrElc	-0.0595	0.1419	0.0005	--	0.0645	0.0112	-0.0069	0.6233	-0.0021	0.0412	0.0177	1827.1	0.0046	0.26
c5	FurnshHeqp	0.1134	0.0246	0.1111	0.0475	--	0.0285	0.0081	0.1233	0.0299	0.0400	0.0631	-224.6	0.0190	0.12
c6	Health	0.0641	-0.0085	0.0232	0.0057	0.0196	--	-0.0008	0.0311	0.0199	0.0048	0.0302	-3.8	0.0201	0.08
c7	Transport	0.0326	0.0515	0.1305	-0.0255	0.0407	-0.0056	--	0.5734	0.0398	0.2683	0.0933	-29.5	0.0635	0.13
c8	Communicat	0.0097	0.0208	0.0190	0.0126	0.0034	0.0012	0.0031	--	0.0050	0.0146	0.0140	285.3	0.0026	0.33
c9	RecreatCult	0.0976	0.0224	0.1803	-0.0023	0.0454	0.0438	0.0120	0.2776	--	0.1405	0.0746	-4.3	0.0288	0.20
c10	RestrntHotl	-0.0050	0.1578	0.1950	0.0146	0.0192	0.0033	0.0256	0.2554	0.0445	--	0.0600	-73.8	0.0268	0.29
c11	MiscGSEduc	0.1204	-0.0226	0.1604	0.0097	0.0468	0.0326	0.0137	0.3799	0.0364	0.0925	--	246.3	0.0297	0.37
		Coefficients of intra-budget WLS regressions													
c1	FoodNalcBvg	--	0.1770	0.0889	-0.0278	0.0525	0.0334	0.0023	0.1110	0.0263	-0.0161	0.0618	1674.0	0.0149	0.24
c2	AlcBvgTbc	0.0526	--	-0.0038	0.0119	0.0022	0.0012	0.0016	0.1059	0.0020	0.0379	-0.0043	119.5	0.0009	0.07
c3	ClothFtwr	0.0486	-0.0070	--	0.0016	0.0276	0.0140	0.0073	0.2096	0.0301	0.0944	0.0423	96.0	0.0088	0.18
c4	HousWtrElc	-0.0910	0.1316	0.0095	--	0.0446	0.0183	-0.0104	0.7744	0.0016	0.0493	-0.0081	2335.7	0.0075	0.24
c5	FurnshHeqp	0.1106	0.0155	0.1065	0.0287	--	0.0333	0.0080	0.1341	0.0367	0.0237	0.0723	-260.0	0.0201	0.10
c6	Health	0.0444	0.0053	0.0340	0.0074	0.0210	--	-0.0026	0.0249	0.0207	0.0069	0.0286	17.6	0.0154	0.06
c7	Transport	0.0253	0.0618	0.1497	-0.0357	0.0425	-0.0221	--	0.6601	0.0386	0.3579	0.0734	-5.4	0.0580	0.11
c8	Communicat	0.0062	0.0199	0.0214	0.0132	0.0036	0.0010	0.0033	--	0.0067	0.0126	0.0104	316.8	0.0020	0.26
c9	RecreatCult	0.0863	0.0216	0.1808	0.0016	0.0571	0.0510	0.0113	0.3947	--	0.1328	0.0629	5.9	0.0290	0.17
c10	RestrntHotl	-0.0197	0.1566	0.2117	0.0185	0.0138	0.0064	0.0390	0.2766	0.0496	--	0.0418	-102.1	0.0269	0.23
c11	MiscGSEduc	0.1296	-0.0305	0.1623	-0.0052	0.0720	0.0450	0.0137	0.3907	0.0402	0.0715	--	427.0	0.0305	0.29

IS of EU consumption expenditures

Figure 2: Contribution of total endogenous expenditures (%), 2015



Note: D1 and D10 refer, respectively, to the poorest and richest EU-wide deciles. This household categorization is based on equivalized net income.

The capacity of *endogenous* generation of consumption expenditures generally decreases with consumer's income level.

Mirrors the *decreasing MPC* as income rises (Keynes, 1936)

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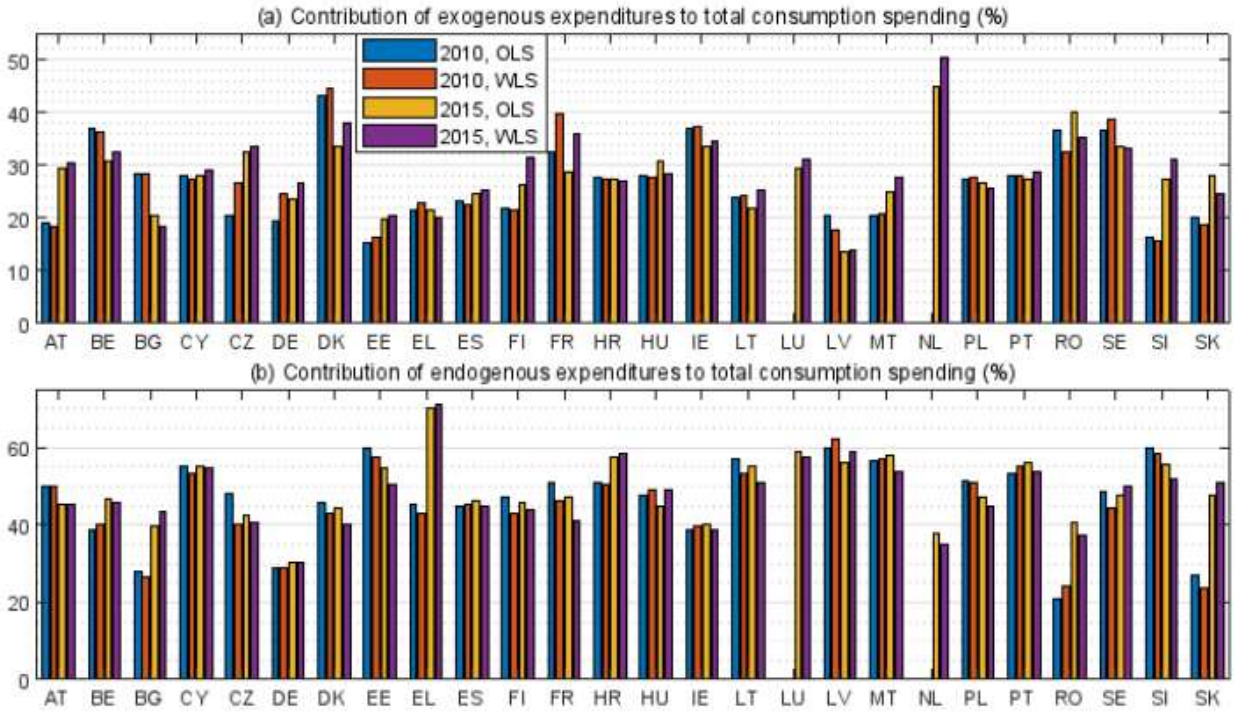
IS of EU consumption expenditures

Figure 4: Contributions of total exogenous and endogenous expenditures



On average, from 26% to 29% of total household spending is accounted for by exogenous expenditures, while the corresponding range of total endogenous expenditure contribution is 45%-49%.

A counterpart of 50% subsistence share 'rule of thumb' in LES maybe a 30% exogenous expenditure share

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Integrating the macro-micro twins to assess the effects of price changes

- A “partial equilibrium” analysis:

$$\mathbf{e}^r = \sigma_{\{\rho_r y_r\}} \mathbf{T}^r \left(\hat{\mathbf{p}}^r_{rel} \boldsymbol{\zeta}^r + \boldsymbol{\gamma}^r y_r \right), \tag{8.a}$$

$$\mathbf{c}^r = \left(\hat{\mathbf{p}}^r_{rel} \right)^{-1} \mathbf{e}^r, \tag{8.b}$$

- To account for the demand-driven multiplier process, we interlink the “macro-micro twins”:

$$\mathbf{f}^r_{grw} = \mathbf{S}^r \mathbf{c}^r_{grw}, \tag{11}$$

$$\Delta \mathbf{f}^r = \sigma_{\{\alpha \iota' \Delta \mathbf{c}^r\}} \left(\iota \otimes \widehat{\mathbf{f}^r_{grw}} \right) \mathbf{f}^r, \tag{12}$$

$$\Delta \mathbf{x} = \mathbf{L} \left(\sum_{r \in EU} \Delta \mathbf{f}^r \right), \tag{13}$$

$$\Delta y_r = \left(\mathbf{w}^r \right)' \Delta \mathbf{x}^r, \tag{14}$$

$$\mathbf{e}^r = \sigma_{\{\rho_r y_r (1 + y^r_{grw})\}} \mathbf{T}^r \left(\hat{\mathbf{p}}^r_{rel} \boldsymbol{\zeta}^r + \boldsymbol{\gamma}^r y_r (1 + y^r_{grw}) \right), \tag{15}$$

$$\mathbf{c}^r = \left(\hat{\mathbf{p}}^r_{rel} \right)^{-1} \mathbf{e}^r. \tag{16}$$

Empirical application of the integrated macro-micro twins

- Consider price changes from the MIX scenario in Weitzel et al. (2023)
- Reaching a 55% reduction in EU GHG emissions by 2030 compared to 1990 levels
- Effects of both regulatory measures and price-based policies:
  - implementation of standards for e.g. vehicles and buildings
  - Increased stringency in the EU ETS and carbon pricing for the buildings sector and transport under a second EU ETS
- We use the average EU prices, obtained from the JRC-GEM-E3 model
  - Use 11 COICOP consumption categories in the micro-model
  - Apply these prices identically to each EU country
- MRIO data from FIGARO (2015): 63 products, 28 regions (27 EU + RoW)

The micro-based impacts of (energy) price increases

Table 2: Price shocks and the initial EU consumption impacts from Taylor model

Shortcut	Consumption category description	Price change (%)	Impact on EU consumption (%) OLS	WLS
FoodNalcBvg	Food and non-alcoholic beverages	0.12	-0.76	-0.84
AlcBvgTbc	Alcoholic beverages, tobacco and narcotics	0.12	-0.40	-0.45
ClothFtwr	Clothing and footwear	0.07	-0.70	-0.76
HousWtrElc	Housing, water, electricity, gas and other fuels	4.43	-1.60	-1.49
FurnshHeqp	Furnishings, household equipment and routine maintenance of the house	0.09	-0.45	-0.53
Health	Health	0.06	-0.43	-0.48
Transport	Transport	1.26	-1.94	-2.07
Communicat	Communication	0.02	-0.47	-0.52
RecreatCult	Recreation and culture	0.20	-0.85	-0.92
RestrntHotl	Restaurants and hotels	0.20	-0.66	-0.71
MiscGSEduc	Miscellaneous goods and services, inc. education	0.03	-0.66	-0.75
Average EU price change and total EU consumption impact (%)		1.08	-1.02	-1.07

Relatively more basic or necessity nature of *HousWtrElc* compared to *Transport* (captured by **T** and **z**)

Accounting for income-induced impacts

Figure 6: Round-by-round income and consumption impacts

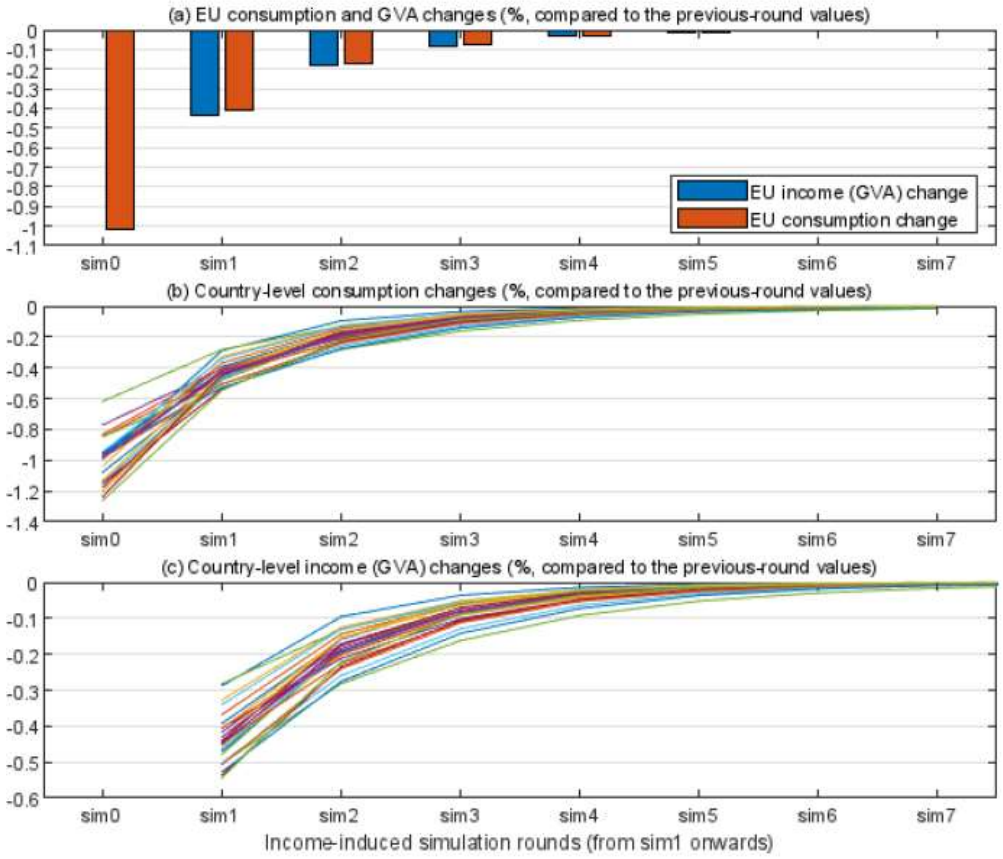
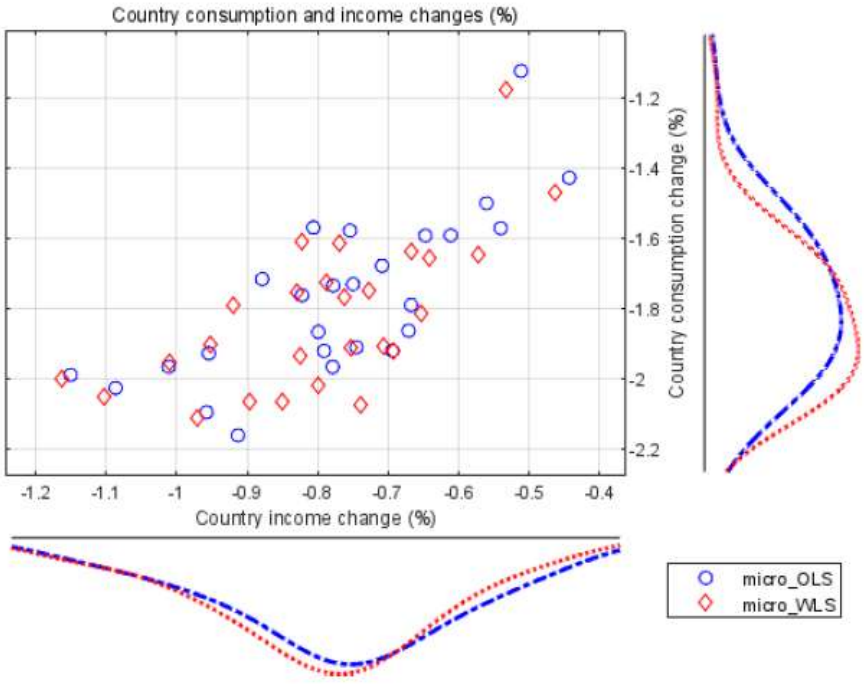


Figure 7: Total consumption and income impacts for 26 EU countries



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Accounting for income-induced impacts

Table 3: Direct price-induced and indirect income-induced consumption impacts (%)

	Micro-model based on OLS				Micro-model based on WLS			
	Direct	Indirect	Total	Direct (%)	Direct	Indirect	Total	Direct (%)
AT	-1.08	-0.79	-1.87	57.7	-1.12	-0.82	-1.93	57.8
BE	-0.99	-0.61	-1.59	62.0	-1.02	-0.64	-1.66	61.6
BG	-0.95	-0.81	-1.76	53.8	-0.93	-0.82	-1.76	53.2
CY	-0.77	-0.80	-1.57	49.1	-0.79	-0.82	-1.61	49.3
CZ	-1.20	-0.77	-1.97	60.9	-1.23	-0.79	-2.02	60.9
DE	-1.14	-0.78	-1.92	59.3	-1.22	-0.84	-2.06	59.3
DK	-1.23	-0.69	-1.92	64.3	-1.35	-0.73	-2.07	64.9
EE	-0.95	-0.64	-1.59	59.8	-0.98	-0.66	-1.64	59.8
EL	-0.85	-1.14	-1.99	42.7	-0.85	-1.15	-2.00	42.4
ES	-0.85	-0.87	-1.72	49.3	-0.88	-0.91	-1.79	49.2
FI	-1.13	-0.66	-1.79	63.1	-1.21	-0.70	-1.91	63.4
FR	-0.98	-0.70	-1.68	58.2	-1.03	-0.72	-1.75	58.9
HR	-0.96	-1.00	-1.97	49.1	-0.96	-1.00	-1.96	48.9
HU	-1.17	-0.74	-1.91	61.5	-1.17	-0.74	-1.91	61.0
IE	-0.99	-0.44	-1.43	69.3	-1.01	-0.46	-1.47	68.8
LT	-0.83	-0.75	-1.58	52.6	-0.85	-0.76	-1.61	52.7
LU	-1.04	-0.53	-1.57	66.0	-1.08	-0.57	-1.65	65.6
LV	-0.96	-0.77	-1.74	55.6	-0.95	-0.78	-1.73	54.8
MT	-0.62	-0.51	-1.13	54.8	-0.65	-0.53	-1.18	55.0
NL	-0.95	-0.56	-1.50	63.0	-1.17	-0.65	-1.82	64.4
PL	-1.15	-0.95	-2.10	54.8	-1.15	-0.96	-2.11	54.5
PT	-0.95	-1.08	-2.03	46.9	-0.96	-1.09	-2.05	46.7
RO	-0.98	-0.95	-1.93	51.0	-0.96	-0.94	-1.90	50.5
SE	-1.20	-0.66	-1.86	64.4	-1.24	-0.69	-1.92	64.4
SI	-0.99	-0.74	-1.73	57.1	-1.01	-0.75	-1.77	57.3
SK	-1.26	-0.90	-2.16	58.3	-1.18	-0.89	-2.07	57.2
EU26	-1.02	-0.71	-1.72	59.1	-1.07	-0.74	-1.80	59.2

Generally, the greater portion of consumption losses comes from the direct price-induced impacts

Country heterogeneity due to different consumer responses (micro-model), and the structure and size of global production interdependencies and private consumption demand (macro-model)

Concluding remarks

- First application of the Taylor model for the case of the EU
- Internal structure of EU consumption expenditures
- Extensive comparisons of the estimated model's components over time
- Integration with the IO quantity model and its application to assess the consumption and income impacts of energy price increases
- The Taylor micro-model can be used for a better or further understanding of the household-level consumption, income, and distributional impacts of policies

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