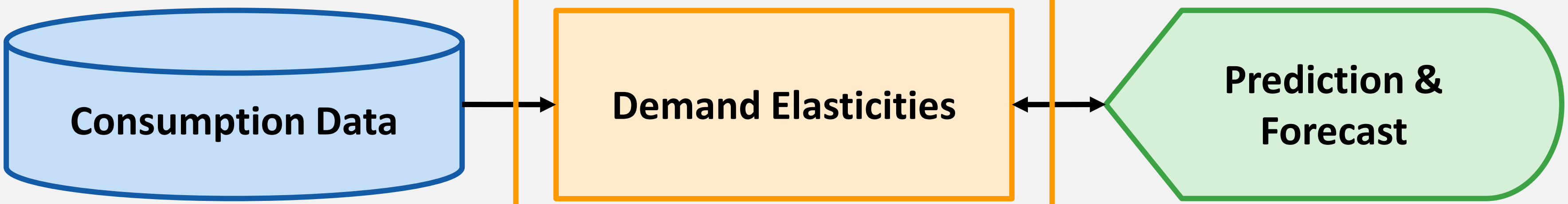
Estimating Demand Elasticities

Results from Econometric Models applied by TM-MS

What to look for in Top-Down Demand Models?



Determine	Perform	Apply

• Data **Sources**
• Data **Granularity**
  • Time Dimension
  • Sector Dimension
• Data **Timeliness**
	• Model **Specification**
	• Model **Validation**
	• Model **Inference**
		• **BLUP**
		• Prediction **Benchmarks**
		• Manual **Adjustments**

	Common Issues	
• Limited Transparency • Different Methodology • Varying Data Availability • Insufficient Comparability • Constrained Timeliness	• Limited Number of Observations • Violation of Standard Textbook Assumptions • Limited Power of Tests	• Predictors for Explanatory Variables are needed • Implementation and Prediction of Structural Breaks • Parsimony vs. Information

Specification: Heterogeneous vs. Homogeneous Models

← Theoretical Properties

Dynamic Estimation of Demand Elasticities

Heterogeneous Models	Mixed Models	Homogeneous Models
Time Series (AR, ARDL, OLS, VECM, Co-Integration)	*Shrinkage estimators*	*Pooled Models (GLS, Within-Estimators, 2SLS)*
• used due to inherent parameter heterogeneity • Superior theoretical properties of the estimators	• Combine the 2 approaches • Shrinking heterogeneous estimators towards pooled estimators	• Serial correlation between lagged dependent variable and error terms remains • Inconsistent & biased estimators

- Although there might be some theoretical caveats, in applied work, **fixed effects estimators perform sufficiently well** in MSE prediction terms
- This is especially the case in the situations of **strong autocorrelation**

Dynamic Demand Forecasts

Forecast Performance →

OBS: Forecasting with more sophisticated econometric models require a thorough future view on explanatory variables, that are usually not easily forecasted (i.e. GVA on sector-level, end-user energy prices, income, etc.)

Dynamic Panel Data: Flow Adjustment Models

- Motivated by the idea that the **stock of energy-using equipment is assumed to be fixed in the short-run** and its utilization is assumed to be a function of normal economical influences.
- Over time, observed utilization is adjusted to the desired utilization (flow adjustment mechanism).
- Assume the simple log-linear relationship between energy consumption (E^*) and real GDP (Y)

$$\boldsymbol{E^* = \alpha\, Y^{\gamma}}$$

- Adjustment to the desired consumption is assumed to follow the simple process

$$\frac{E_t}{E_{t-1}} = \left(\frac{E_t^*}{E_{t-1}}\right)^{\theta}.$$

- Inserting time and country subscripts and rearranging Equation (2) yields

$$\ln E_{it} = \theta \ln \alpha + \theta\gamma \ln Y_{it} + (1-\theta) \ln E_{i,t-1} + u_{it}\,.$$

- The above specification might be too restrictive towards lags of additional explanatory variables
- Generalization to different lag structures of additional varibales is possible, see Baltagi (1997).

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Model Specification

- Consider the following standard dynamic linear regression (DLR) model for energy demand

$$\boldsymbol{y_{i,t} = \beta_{i,0} + \beta_{i,1} y_{i,t-1} + \beta_{i,2} x_{1,i,t} + \beta_{i,3} x_{1,i,t-1} + \beta_{i,4} x_{2,i,t} + \beta_{i,5} x_{3,i,t} + u_{i,t}}$$

with $i = 1,2, \dots, 26$ (countries), $t = 2,3, \dots, 19$ spanning the period 1994-2012 and $u_{i,t} = \alpha_i + v_{i,t}$, where α_i denote the country-specific effects and $v_{i,t} \sim \text{IID}(0, \sigma_v^2)$, $\beta_{i,k}$=$\beta_{j,k}$ $\forall\ i, j \in (1,26), i \neq j$.

- Variables for the electricity regression are:
  - $\boldsymbol{y_{i,t}}$, logarithm of total electricity consumption;
  - $\boldsymbol{x_{1,i,t}}$, logarithm of real GDP at constant 2005 prices;
  - $\boldsymbol{x_{2,i,t}}$, heating degree days;
  - $\boldsymbol{x_{3,i,t}}$, cooling degree days.
- Given the definitions of the flow adjustment model, it is possible to derive short and long run elasticities of demand:
  - Short-run GDP Elasticity: $\boldsymbol{SR\eta_y = \beta_{i,2}}$
  - Long-run GDP Elasticity: $\boldsymbol{LR\eta_y = \frac{\beta_{i,2} + \beta_{i,3}}{1 - \beta_{i,1}}}$

Elasticity Models - Summary

		Aggregate Models		Sector Models		
		Model 1	Model 2	Industrial	Residential	Service
Adjustment	1 Period	0.89 ***	0.63 ***	0.76 ***	0.80 ***	0.77 ***
	2 Periods	-	0.22 ***	-	-	-
GDP, GVA, Income	Short Run	0.48 ***	0.54 ***	0.38 ***	-0.10	0.42 ***
	Long Run	**0.53** ***	**0.75** ***	**0.36** ***	**0.91** **	**0.99** ***
End-User Prices	Short Run	-	-0.03 **	-0.04 **	-0.12 ***	-0.05 *
	Long Run	**-**	**-0.19** **	**-0.18** **	**-0.59** ***	**-0.20** *
Weather	HDD	1.08E-05 ***	1.50E-05 ***	-	1.75E-05 **	-
	CDD	4.54E-05 ***	3.91E-05 **	-	3.33E-05 .	-
Indicator	Crisis	-0.02 ***	-0.01 **	-0.09 ***	-	-
Adj. R^2		0.89	0.86	0.69	0.76	0.82

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

- Adjustment factors are significant
- Demand elasticities with respect to economic activity are positive
- A one-to-one relationship is not present though
- Price elasticities are significantly negative
- Also residential electricity demand has a negative price elasticity
- In short run, residential end-users do not react to changes in income
- Weather effects do exist even on an annual level
- A lot of the information will be contained in the country specific effects, i.e. France vs. Germany

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Conclusions

- The number of valid models to choose from is obviously high

- **Keep in mind:**
  - Choosing between homogeneous and heterogeneous models for estimation is crucial.
  - Studies suggest, that a fixed-effects one-way error component model, which takes care of country-specific heterogeneity achieves sufficiently good forecast performance in applied work.
  - Hence, these kind of models where used for the estimation of electricity demand elasticities.

- **Next Steps:**
  1. Investigate robustness of estimators w.r.t. variables for economic activity and end-user prices.
  2. Apply estimators obtained from the homogeneous models in forecast procedures.
  3. Deeper investigation of sector-specific results and development of sector-specific forecasts of economic activity and end-user prices.

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Back-Up

Demand Elasticities - Literature Results

	Source	Year	Region	Method	Data	Elasticity Estimates		
						Econ. Activity	Income	End-User Price
Industry	Beenstock et. al.	1999	Israel	Cointegation	TS: 1975q2–1994q4	L: 0.99 to 1.12		L: -0.31 to -0.44
	Bose & Shukla	1999	India	Pooled Reg.	PD: 1985–1993	0.49 to 1.06		-0.04 to -0.45
	Kamerschen, Porter	2004	USA	SEM	TS: 1973-1998	-		-0.31 to -0.55
	Polemis	2007	Greece	Cointegration	TS: 1970-2004	L: 0.85, S:0.61		L: -0.85 S: -0.35
Residential	Athukorala, Wilson	2010	Sri Lanka	Johansen/VECM	TS: 1960-2007		L: 0.78 S: 0.32	L: -0.62 S: -0.16
	Dergiades,Tsoulfidis	2008	USA	BT/ARDL	TS: 1965-2006		L: 0.27 S: 0.10	L: -1.07 S: -0.39
	Halicioglu	2007	Turkey	BT/ARDL	TS: 1968-2005		L: 0.49 to 0.70	L: -0.52 to -0.63
							S: 0.37 to 0.44	S: -.033 to -0.46
	Holtedahl, Joutz	2004	Taiwan	Johansen/VECM	TS: 1955-1995		L: 1.04 to 1.57	L: -0.15
							S: 0.22	S: -0.15
	Hondroyiannis	2004	Greece	Johansen/VECM	TS: 1986M1-1999M12		L: 1.56 S: 0.20	L: -0.41
	Nakajima	2004	Japan	PC/DOLS	PD: 1975-2005		L: 0.60 to 0.65	L: -1.13 to -1.20
	Nakajima, Hamori	2010	USA	PC/DOLS	PD: 1993-2008		L: 0.38 to 0.85	L: -0.14 to -0.33
	Narayan, Smyth	2005	Australia	BT/ARDL	TS: 1969 - 2000		L: 0.32 to 0.41	L: –0.47 to –0.54
							S: 0.01 to 0.04	S: –0.26 to –0.27
	Narayan et al.	2005	G7	PC/DOLS	PD: 1978-2003		L: 0.25 to 0.31	L: –1.45 to –1.56
							S: –0.19	S: –0.11
	Zachariadis et. al.	2007	Cyprus	Johansen/VECM	TS: 1960-2004		L: 1.18	L: –0.43
	Ziramba	2007	RZA	BT/ARDL	TS: 1978-2005		L: 0.31 to 0.87	*L: –0.01 to –0.04*
							S: 0.30	*S: –0.02*

Notes: Table taken from Madlener et. al. (2011). S and L denote estimates for the short and the long run, respectively. Elasticity estimates which are not statistically significantly different from zero on conventional levels are printed in italics. T: Nu