Energy demand elasticities estimated by shrinkage estimators: How much confidence can we have in them?

Odd B. Nilsen, F. Asche and R. Tveterås

25th Annual North American Conference (USAEE/IAEE)
Denver, September 2005

University of Stavanger

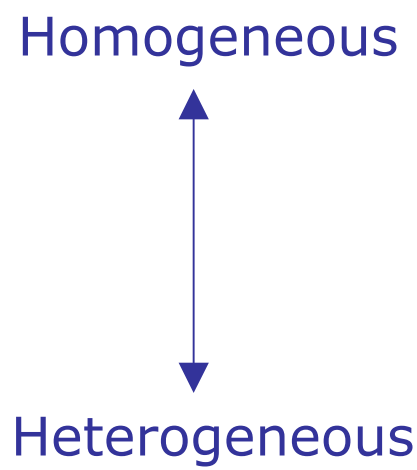
Challenges for energy demand studies based on annual data

- A limited number of observations of each time series
- Desirable to obtain individual estimates of each cross-section, but such regressions often provide implausible estimates.

University of Stavanger

Homogeneous versus heterogeneous

- Pooled estimators
- Fixed-effects estimators
- **The shrinkage estimator**
- Individual cross-section estimators



University of Stavanger

Key questions and issues

- Energy demand studies using the shrinkage estimator
  - Relatively high *t*-statistics are often reported
  - Is the *t*-statistic upward biased?

- Little focus on the method used to obtain *t*-statistics of the shrinkage elasticity estimates
  - Using the standard delta or the bootstrap method?
  - **Consequences for the economic conclusions?**

Case: Estimating elasticities of Natural Gas demand

- The European Household Sector
- Demand = f(prices, income, climate)
  - Loglinear functional form
- Observations 1978-2002 (IEA, IMF)
  - Annual, country-specific

Natural gas demand

Country-specific fixed effect

Energy prices

$$y_{t,i}^{NG} = \beta_i^0 + \beta_i^y y_{t-1,i}^{NG} + \beta_i^{NG} p_{t,i}^{NG} + \beta_i^{LFO} p_{t,i}^{LFO}$$

$$+ \beta_i^{EL} p_{t,i}^{EL} + \beta_i^m m_{t,i} + \beta_i^z z_{t,i} + \varepsilon_{t,i},$$

Energy price

Private income

Heating degree days index

University of Stavanger

The elaticities

- Short-run
  - Own-price: β^{NG}
  - Cross-prices: β^{EL} , β^{LFO}
  - Income: β^{m}
- Long-run
  - Own-price: $\beta^{NG}/(1 - \beta^{y})$
  - Cross-prices: $\beta^{EL}/(1 - \beta^{y})$, $\beta^{LFO}/(1 - \beta^{y})$
  - Income: $\beta^{m}/(1 - \beta^{y})$

University of Stavanger

The shrinkage estimator

- Assume that the individual parameters are from a common probability distribution: $\beta_i|\mu \sim N(\mu, \Sigma)$

- An empirical Bayes estimator
  - The unknown hyperparameters (μ, Σ) are pre-estimated from the sample
  - The pre-estimated hyperparameters are treated as fixed constants when the covariance matrix of the parameters are constructed

    $\Rightarrow$ The variability in the hyperparameters are ignored

- Possible economic consequences?

Confidence of the shrinkage elasticity estimates

- The delta method
  - A first order Taylor approximation based on the *estimated covariance matrix* of the parameters
- The bootstrap metod
  - Incorporates some of the variability in the hyperparameters

University of Stavanger

The bootstrap method

- Obtains bootstrap samples by resample with replacement from the observations

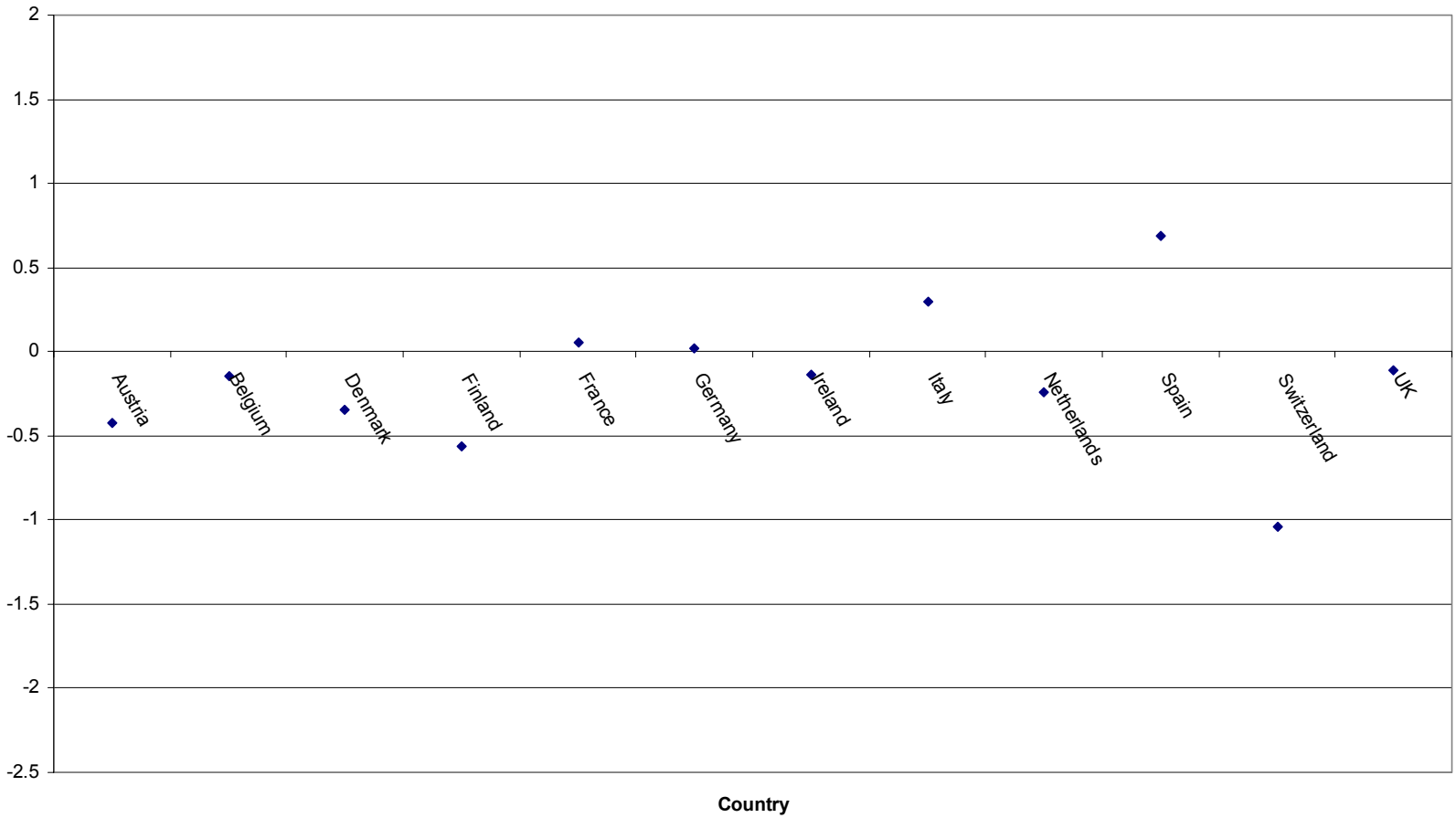
- Case: Regression model
  - Used separately on each time-section
  - Resample with replacement from the fitted residual vector ($\varepsilon_i = y_i - \mathbf{X}_i b_i$) and generate bootstrap samples
  - Shrinkage estimation on each sample

- The idea: The shrinkage estimates from the bootstrap samples represent the distribution of the shrinkage point estimates

University of Stavanger

Empirical results

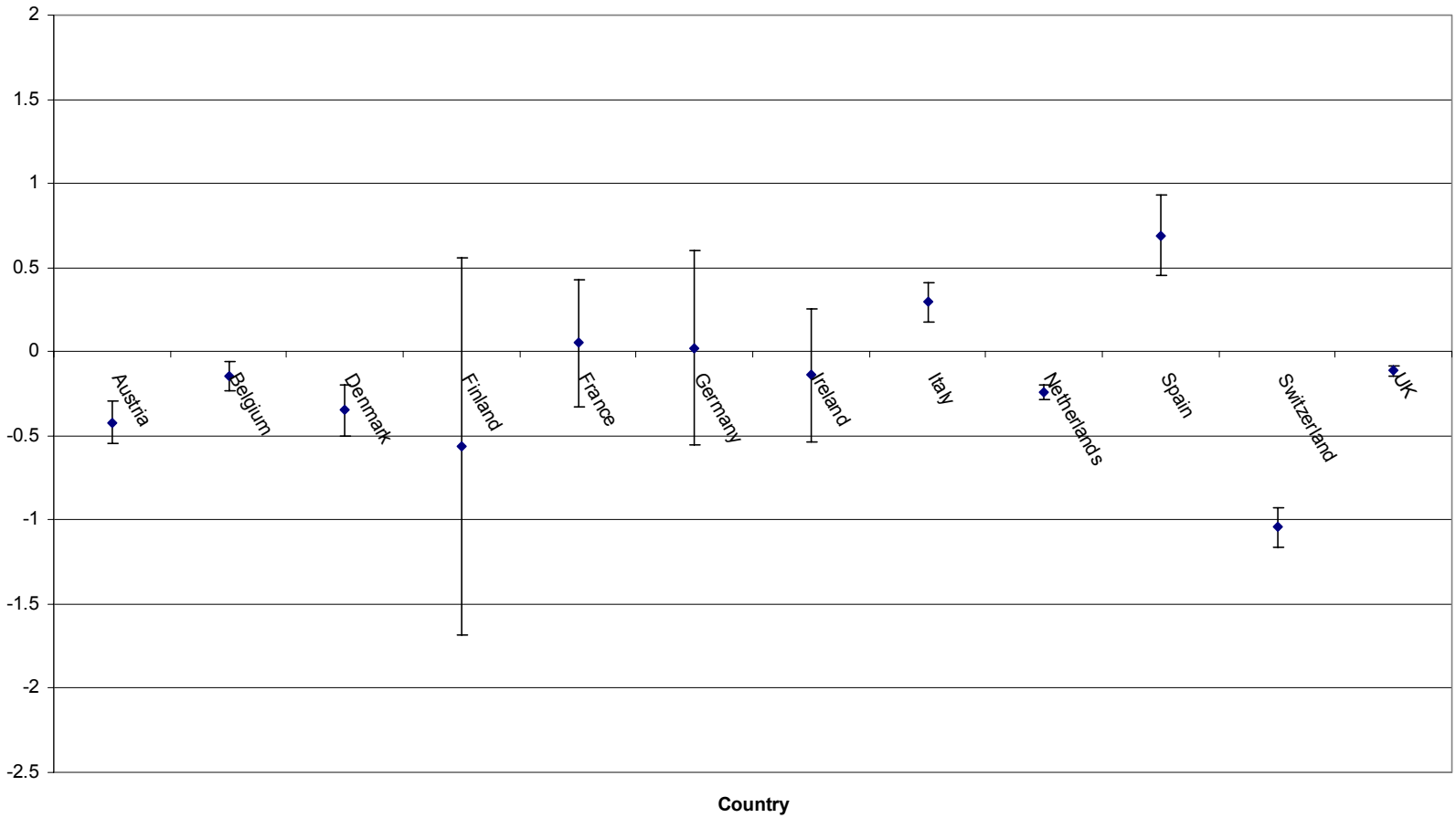
- Long-run elasticites of natural gas demand



University of Stavanger

Empirical results

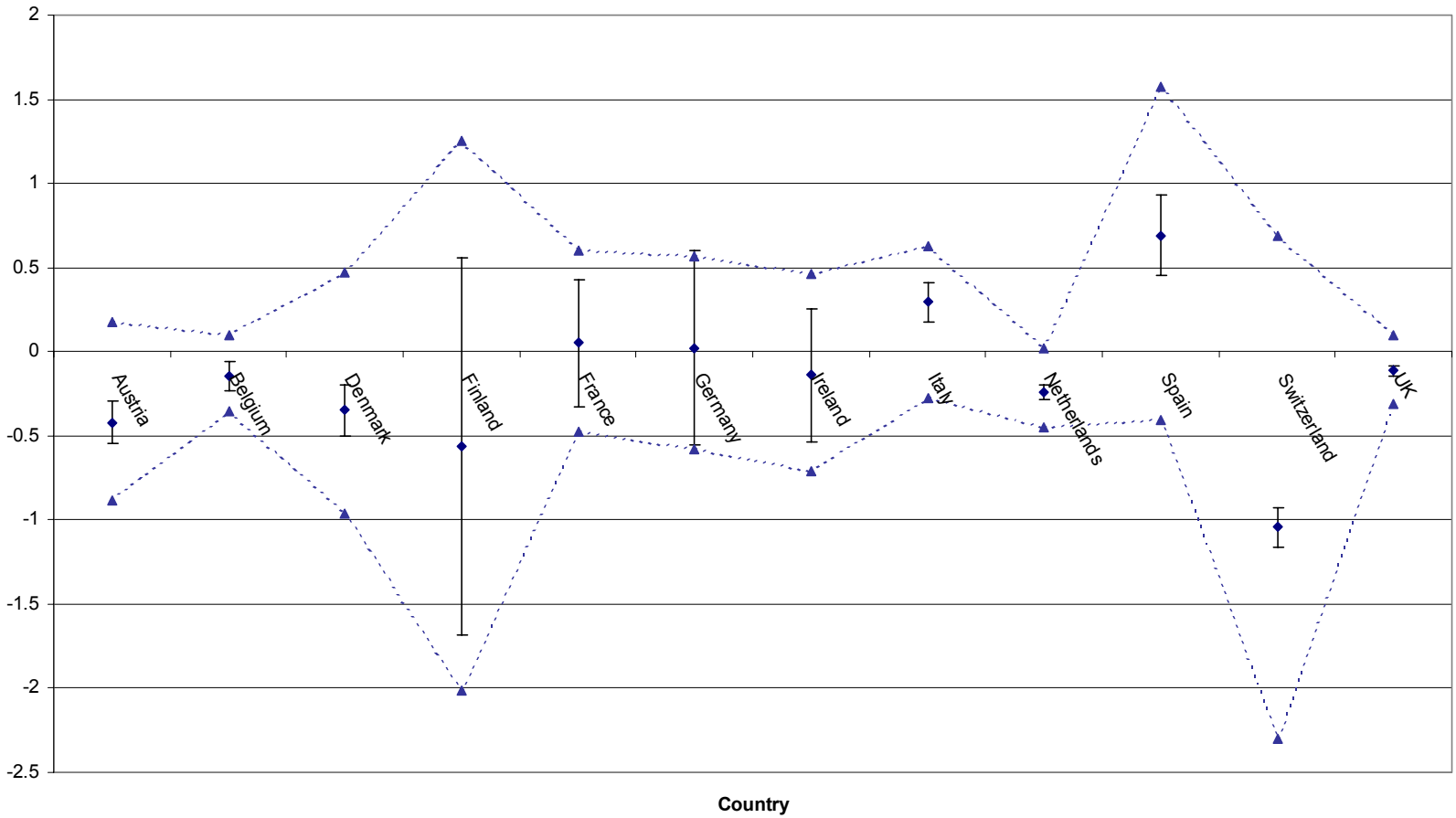
- The delta method



University of Stavanger

Empirical results

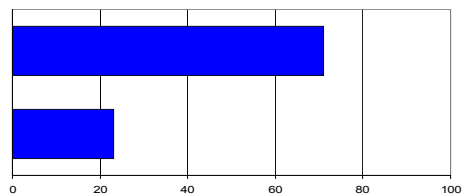
- The bootstrap method



University of Stavanger

Empirical results

- We find significant own-price and cross-price effects for several countries using the standard delta method.
- The bootstrap method does not provide a single significant own-price and cross-price elasticity.
- The number of significant country-specific elasticities at the 5% level
  - The delta method: 71%
  - The bootstrap method: 23%



University of Stavanger

Conclusions

- Energy demand studies based on annual data have some challenges
  - Limited number of time observations
  - Potential structural differences between cross-sections
- The method used to obtain confidence intervals of the shrinkage estimator may make a significant difference for the economic conclusions that is derived from the results
- One should be aware of what method is used to obtain *t*-statistics or confidence intervals of the shrinkage estimator in energy demand studies