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Current and Future Challenges to Energy Security
2nd AIEE Energy Symposium, Rome, Italy

Pricing Characteristics in the German Diesel Retail Market after the Introduction of the Market Transparency Unit

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Agenda

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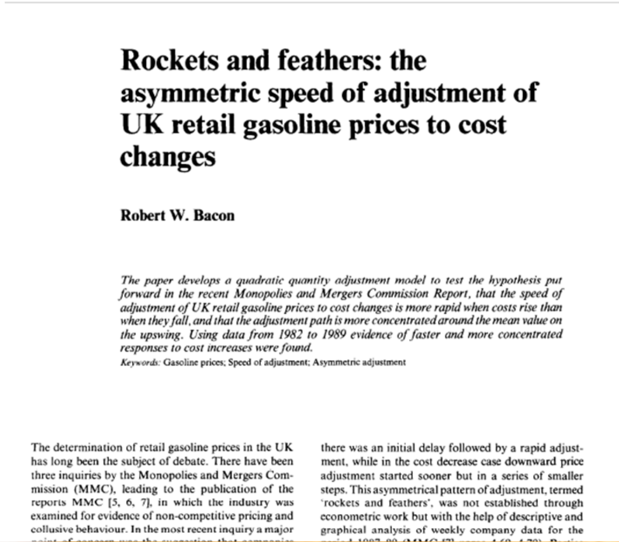
- Introduction
- Data
- Research Questions
- Methods:
  - Asymmetric Error Correction Model
  - Semi-Asymmetric Error Correction Model
- Results
- Further Research

Introduction

- High public relevance of gasoline price development
- Long tradition of research concerning relationship of gasoline and oil prices, e. g. Rockets and Feathers (Asymmetric Price Transmission) → "Rockets and Feathers are given when fuel prices increase faster than they decrease after oil price changes. "
- Widely discussed questions:
  - Do retailers increase prices faster with increasing oil prices?
  - Is market power given?



Rockets and feathers: the asymmetric speed of adjustment of UK retail gasoline prices to cost changes

Robert W. Bacon

The paper develops a quadratic quantity adjustment model to test the hypothesis put forward in the recent Monopolies and Mergers Commission Report, that the speed of adjustment of UK retail gasoline prices to cost changes is more rapid when costs rise than when they fall, and that the adjustment path is more concentrated around the mean value on the upswing. Using data from 1982 to 1989 evidence of faster and more concentrated responses to cost increases were found.

Keywords: Gasoline prices; Speed of adjustment; Asymmetric adjustment

The determination of retail gasoline prices in the UK has long been the subject of debate. There have been three inquiries by the Monopolies and Mergers Commission (MMC), leading to the publication of the reports MMC [5, 6, 7], in which the industry was examined for evidence of non-competitive pricing and collusive behaviour. In the most recent inquiry a major

there was an initial delay followed by a rapid adjustment, while in the cost decrease case downward price adjustment started sooner but in a series of smaller steps. This asymmetrical pattern of adjustment, termed 'rockets and feathers', was not established through econometric work but with the help of descriptive and graphical analysis of weekly company data for the

Data (1): Market Transparency Unit in Germany

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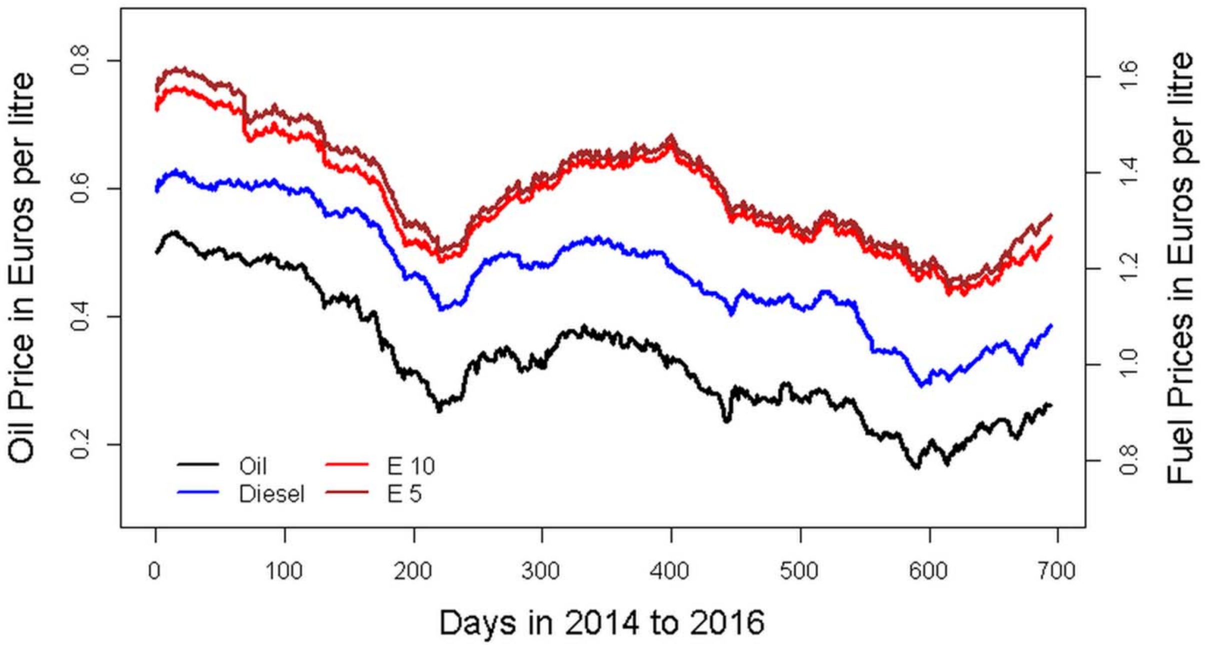
- Data set was gathered from an online platform via the market transparency unit
- Part of the german Federal Cartel Office;
  established to increase market transparency on the retail market

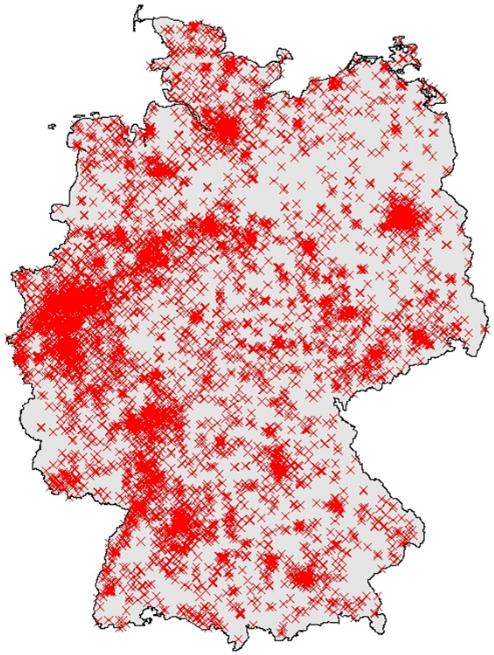
open markets | fair competition

- "Since […] 2013 companies which operate public petrol stations […] are obliged to report price changes […] of fuel […] in real time"

Data (2): Diesel Data

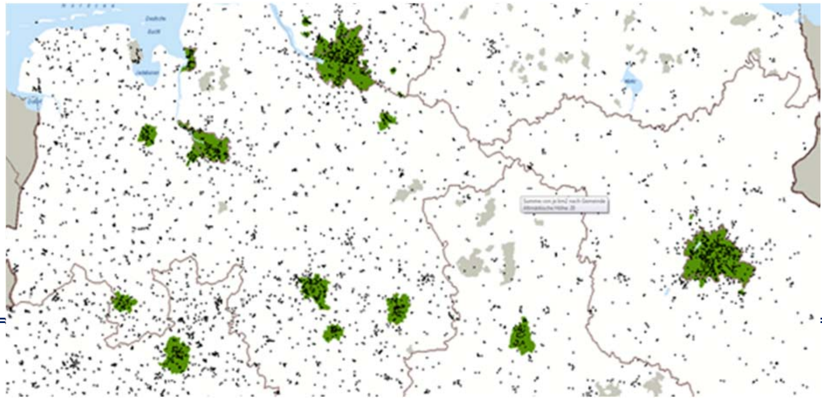
- In total: More than 20 million prices for all german fuel stations
- Daily prices for the period from June 2014 to May 2016 of about 6800 retail fuel stations → highly disaggregated data
- The database enables to differentiate between brands and regions





Research Questions

1. Do diesel prices follow oil prices in the long-run (**cointegration**)?
2. Do **major brands (Shell, Total, Jet, Esso, Aral)** show different pricing characteristics concerning asymmetry than all other stations?
3. Do **independent petrol stations** show different pricing characteristics concerning asymmetry than all other stations?
4. Do petrol stations in **lower populated regions** (PopDens low) behave differently concerning asymmetry from stations in more **urban areas** (PopDens high)?
   - Threshold: 1000 inhabitants/km²



Methods (1a): Creating the Asymmetric Error Correction Model following Engle/Granger

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Test for stationarity (ADF-Test) of fuel and oil in levels and in first differences
→ Results need to show that the data is integrated on the same scale of integration.

→

$$\Delta fuel_{i,t} = \alpha_{0,i} + \beta_i fuel_{t-1} + \sum_{m=1}^{p} \delta_{i,m} \Delta fuel_{t-m} + \varepsilon_t$$

$$\Delta oil_{i,t} = \alpha_i + \beta_i oil_{t-1} + \sum_{m=1}^{p} \delta_{i,m} \Delta oil_{t-m} + \varepsilon_t$$

↓

a) OLS: Estimate the **cointegration relationship** and testing residuals for stationarity
b) Using the residuals within the Error Correction Model

←

$$OLS: \; fuel_{i,t} = \theta_i + \sum_{l=1}^{6} \sigma_{i,l} weekday_t + \sum_{k=0}^{n} \mu_{i,k}\, oil_{t-k} + \boldsymbol{\tau_t}$$

↓

Estimate asymmetric error correction model: threshold variable for decomposing $\boldsymbol{\tau_t}$, $\boldsymbol{\Delta oil_t}$ and $\boldsymbol{\Delta fuel_t}$ is zero;

→

$$\Delta fuel_{i,t} = \boldsymbol{\gamma_i^+ \tau_{t-1}^+} + \boldsymbol{\gamma_i^- \tau_{t-1}^-} + \sum_{j=0}^{K} \vartheta_{1,i,j}^+ \Delta oil_{t-j}^+ + \sum_{j=0}^{K} \vartheta_{1,i,j}^- \Delta oil_{t-j}^- + \sum_{n=1}^{L} \vartheta_{2,i,n}^+ \Delta fuel_{t-n}^+ + \sum_{n=1}^{L} \vartheta_{2,i,n}^- \Delta fuel_{t-n}^- + \varepsilon_t$$

$$\tau_t^+ = \tau_t \wedge \tau_t^- = 0 \; if \; \tau_t > 0, \; \tau_t^- = \tau_t \wedge \tau_t^- = 0 \; if \; \tau_t < 0;$$

$$\Delta oil_t^+ = \Delta oil_t \wedge \Delta oil_t^- = 0 \; if \; \Delta oil_t > 0, \; \Delta oil_t^- = \Delta oil_t \wedge \Delta oil_t^+ = 0 \; if \; \Delta oil_t < 0; \Delta fuel_t^+ = \Delta fuel_t \wedge \Delta fuel_t^- = 0 \; if \; \Delta fuel_t > 0, \; \Delta fuel_t^- = \Delta fuel_t \wedge \Delta fuel_t^+ = 0 \; if \; \Delta fuel_t < 0$$

Methods (1b): Interpretation of model results

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$$\Delta fuel_{i,t} = \boldsymbol{\gamma_i^+ \tau_{t-1}^+} + \boldsymbol{\gamma_i^- \tau_{t-1}^-} + \sum_{j=0}^{K} \vartheta_{1,t,j}^{+} \Delta oil_{t-j}^{+} + \sum_{j=0}^{K} \vartheta_{1,t,j}^{-} \Delta oil_{t-j}^{-} + \sum_{i=1}^{L} \vartheta_{2,t,i}^{+} \Delta fuel_{t-i}^{+} + \sum_{i=1}^{L} \vartheta_{2,t,i}^{-} \Delta fuel_{t-i}^{-} + \varepsilon_t$$

Testing for speed back into the long-term equlibrium

→ Positive error term: <u>real diesel price</u> is higher than <u>equilibrium price</u> → Rockets and feathers: this reversion should be slower.

→ Negative error term: <u>real diesel price</u> is lower than <u>equilibrium price</u> → Rockets and feathers: this reversion should be faster.

- Testing for difference between $\boldsymbol{\gamma_i^+}$ and $\boldsymbol{\gamma_i^-}$ (Wald-test) → $\mathrm{H(0)}: \boldsymbol{\gamma_i^+} = \boldsymbol{\gamma_i^-}$ and $\mathrm{H1}: \boldsymbol{\gamma_i^+} \neq \boldsymbol{\gamma_i^-}$

Methods (2a): Creating the Semi-Asymmetric Error Correction Model following Engle/Granger

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Test for stationarity (ADF-Test) of fuel and oil in levels and in first differences
→ Results need to show that the data is integrated on the same scale of integration.

→

$$\Delta fuel_{i,t} = \alpha_{0,i} + \beta_i fuel_{t-1} + \sum_{m=1}^{p} \delta_{i,m} \Delta fuel_{t-m} + \varepsilon_t$$

$$\Delta oil_{i,t} = \alpha_i + \beta_i oil_{t-1} + \sum_{m=1}^{p} \delta_{i,m} \Delta oil_{t-m} + \varepsilon_t$$

↓

a) OLS: Estimate the **cointegration relationship** and testing residuals for stationarity
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$$OLS: \ fuel_{i,t} = \theta_i + \sum_{l=1}^{6} \sigma_{i,l} weekday_t + \sum_{k=0}^{n} \mu_{i,k} \, oil_{t-k} + \boldsymbol{\tau_t}$$

↓

Estimate semi-asymmetric error correction model: Threshold variable for decomposing $\boldsymbol{\tau_t}$ is sign of the mean of wholesale oil price changes (Δoil_t) over n lags (number of lags from optimal OLS)

→

$$\Delta fuel_{i,t} = \boldsymbol{\gamma_i^+ \tau_{t-1}^+} + \boldsymbol{\gamma_i^- \tau_{t-1}^-} + \sum_{j=0}^{K} \vartheta_{1,i,j} \Delta oil_{t-j} + \sum_{n=1}^{L} \vartheta_{2,i,n} \Delta diesel_{t-n} + \varepsilon_t$$

where

$$\tau_t^+ = \tau_t \wedge \tau_t^- = 0, if \frac{1}{n} \sum_{j=0}^{n} \Delta oil_{t-j} > 0, \tau_t^- = \tau_t \wedge \tau_t^+ = 0, if \frac{1}{n} \sum_{j=0}^{n} \Delta oil_{t-j} \leq 0,$$

$$\Delta oil_t = oil_t - oil_{t-1}$$

Methods (2b): Interpretation of model results

$$\Delta fuel_{i,t} = \boldsymbol{\gamma_i^+ \tau_{t-1}^+} + \boldsymbol{\gamma_i^- \tau_{t-1}^-} + \sum_{j=0}^{K} \vartheta_{1,i,j} \Delta oil_{t-j} + \sum_{n=1}^{L} \vartheta_{2,i,n} \Delta diesel_{t-n} + \varepsilon_t$$

Testing for speed back into the long-term equlibrium

- **But with different interpretation:** Are coefficients $\boldsymbol{\gamma_i^+} > \boldsymbol{\gamma_i^-}$? → faster adjustment for increasing oil prices

- Testing for difference between $\boldsymbol{\gamma_i^+}$ and $\boldsymbol{\gamma_i^-}$ (Wald-test) → $\mathrm{H}(0): \boldsymbol{\gamma_i^+} = \boldsymbol{\gamma_i^-}$ and $\mathrm{H1}: \boldsymbol{\gamma_i^+} \neq \boldsymbol{\gamma_i^-}$

Current Results

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1. Test for order of cointegration
2. **Cointegration**
3. **ECM**
   a. **Asymmetric ECM (A-ECM)**
   b. **Semi-Asymmetric ECM (SA-ECM)**

Current Results (1): Cointegration

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Cointegration-Model – lag selection by BIC	Share [%]; significance level 1 %	Share [%]; significance level 5 %
OLS max. 7 lags	85 %	96 %
OLS max. 10 lags	79 %	94 %
OLS max. 14 lags	79 %	94%

Current Results (2): Asymmetric and Semi-Asymmetric ECM for all cointegrated retail stations

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- Wald-Test: 10 % Significance level

Cases/Scenarios/Data	A-ECM (BIC)	SA-ECM (BIC)
Rockets and Feathers Asymmetry	16.87%	10.74%
Brand Asymmetry	19.77%	14.27%
Non-Brand Asymmetry	12.52%	5.43%
Independent Asymmetry	12.11%	4.41%
Non-Independent Asymmetry	17.31%	11.32%
PopDens high Asymmetry	12.55%	9.64%
PopDens low Asymmetry	18.26%	11.09%

- Comparable results for
  - different significance levels of the Wald-Test (5 % significance level),
  - DOLS cointegration relationship instead of OLS and
  - AIC as lag selection indicator instead of the BIC

Further Research

- Further models…
- Model improvements…
- Model testing…
- Displaying results…

Thank you very much for your attention.

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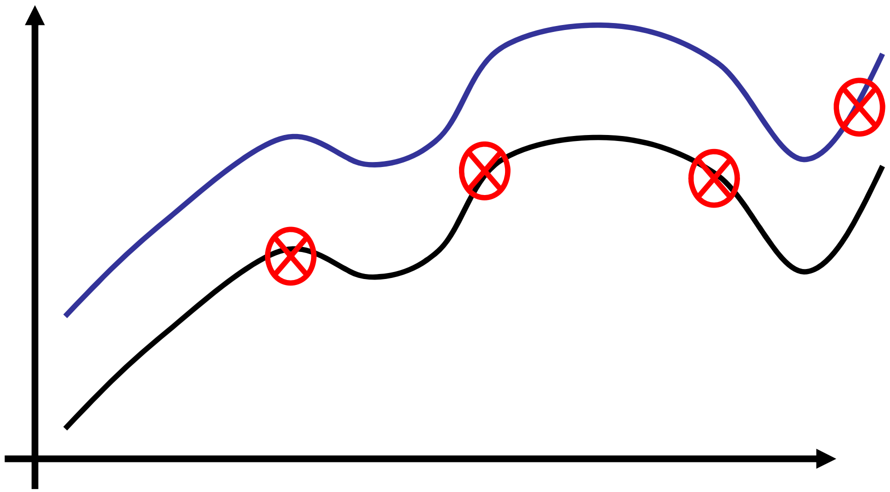
- In practical analytical work **stationarity** of a time series means → regression with lags
  - no trend
  - no systematic change of variance
  - no strictly periodic fluctuations
  - no systematically changing interdependencies between the elements of the time series
- **Cointegration** tries to investigate long-term relationships between non-stationary variables
- **ECM (with non-stationary variables):** tries to estimate the parameters of the long-term and short-term relationship between both (cointegrated) variables

Conclusion

- About 80 % of fuel station have very strong cointegration relationships with wholesale oil prices
- About 11 % to 16 % of these fuel stations show characteristics of asymmetry like Rockets and Feathers
- There seem to be higher shares of asymmetric price responses to oil price changes for mayor brands, non-independent fuel stations and fuel stations in regions with lower population densities

Current Results (1): Cointegration

Cointegration-Model – lag selection by BIC	Share [%]; significance level 1 %	Share [%]; significance level 5 %
OLS max. 7 lags	85.20%	96.10%
OLS max. 10 lags	79.37%	93.49%
OLS max. 14 lags	79.41%	94.01%
DOLS max. 7 lags	85.67%	96.32%
DOLS max. 10 lags	82.08%	95.26%
DOLS max. 14 lags	80.28%	94.35%



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$$\Delta y_{i,t} = \alpha_{0,i} + \alpha_{1,i}\rho + \beta_i y_{t-1} + \sum_{m=1}^{p} \delta_{i,m}\Delta y_{t-m} + \varepsilon_t$$

$$\Delta y_{i,t} = \alpha_i + \beta_i y_{t-1} + \sum_{m=1}^{p} \delta_{i,m}\Delta y_{t-m} + \varepsilon_t$$

a) (D)OLS: Estimate the **cointegration relationship iesel ~ oil** and testing residuals for stationarity
b) Using the residuals within the Error Correction Model

$$OLS:\ fuel_{i,t} = \theta_i + \sigma_i\ weekday_t + \sum_{k=0}^{n} \mu_{i,k}\ oil_{t-k} + \boldsymbol{\tau_t}$$

$$DOLS: fuel_{i,t} = \theta_i + \sigma_i\ weekday_t + \mu_{1,i}\ oil_t + \sum_{k=0}^{n} \mu_{2,i,k}\ \Delta oil_{t-k} + \boldsymbol{\tau_t}$$

Estimate asymmetric error correction model: threshold variable for decomposing $\boldsymbol{\tau_t}$, $\Delta \boldsymbol{oil_t}$ and $\Delta \boldsymbol{fuel_t}$ is zero;

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a) (D)OLS: Estimate the **cointegration relationship diesel ~ oil** and testing residuals for stationarity
b) Using the residuals within the Error Correction Model

$$OLS:\ fuel_{i,t} = \theta_i + \sigma_i\ weekday_t + \sum_{k=0}^{n} \mu_{i,k}\ oil_{t-k} + \boldsymbol{\tau_t}$$

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