Pitfalls in Empirical Spatial Market Delineation: Impact of false estimation on Market Power in European Power Markets

Veit Böckers and Dr. Ulrich Heimeshoff

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Agenda

1. **Motivation**
2. **Literature Review**
3. **Methodology**
4. **Data**
5. **Preliminary Results**
6. **Extension and Problems**

Motivation

- Power markets in Europe to undergo drastic changes (RES and Low-Carbon policy, even market design change)

- Extent of the market crucial to the assessment of market power

- Empirical spatial delineation mostly done by testing the hypothesis of the “Law of One Price”

- Are the European wholesale energy markets still geographically bound to their national border or are they already integrated on a European level?
- What statistical pitfalls should be avoided when applying
  - Correlation-Tests
  - Price-Difference-Stationarity
  - Cointegration analysis

- Using national holidays as unique identifier in the cointegration analysis

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Literature Review

Nitsche et al. (2010)

- Test for integration of the Central European energy markets, especially the role of Germany, using day-ahead spot prices of Germany and its neighbouring countries

- Price Correlation and cointegration tests define the geographical market dimension

- They find that the degree of integration has increased and the hypothesis of an integrated European market cannot be rejected

- No implementation of seasonal variables and (common) drivers such as input prices

- Trend variable was only included after visual inspection of the time series

Literature Review

Bencivenga and Sargenti (2010)

- Long and short-run relationship of crude oil, gas and electricity prices for the US and Europe for 2001-2009

- Short-run analysis is done via rolling correlation inspection (unconditional and interval of 100 days)

- Long-run analysis by examination of the cointegration relationship

- Difference between unconditional correlation and the mean of the rolling correlation

- The degree of integration of energy and fuel markets is lower in Europe than in the US

Literature Review

Mjelde and Bessler (2009)

- Empiricial analysis of integration of two electricity wholesale spot markets taking into account the reciprocal relationship between fuel and electricity wholesale prices

- Spot price data from 2001-2008 for spot markets of PJM and Mid-C, each split-up in peak and off-peak price time series, fuel price data for uranium, West Texas sweet crude oil, Henry Hub natural gas, Penn. Railcar coal

- Specific testing of causal direction in the long-run equilibrium matrix

- Dynamic relationship between fuel and energy prices confirmed, the two spot markets react similar to shocks in fuel prices

- Cointegration of both spot markets cannot be rejected, however full integration cannot be confirmed

Literature Review

Vany and Walls (1999)

- Empirical analysis of integration of eleven electricity wholesale spot markets, all active in the regional transmission group Western System Coordinated Council (WSCC)

- Spot price data from 1994-1996, each split-up in peak and off-peak prices

- Pair wise testing of cointegration relationship for each off-peak and peak prices

- Cointegration confirmed for each off-peak pairing and 87% of the peak pairings

Literature Review

Forni (2004)

• Simple stationarity test of price Cointegration analysis between two variables (e.g. two regions) necessitates a unit-root for each

• An increase in market integration should lead to a decrease in arbitrage

•Spatial delineation of the Italian milk market based on a unit-root test on weekly data from 1999-2001

Hosken-Taylor (2004)

• Forni neglects the fact that strong knowledge on an industrial level is crucial for the empirical analysis of competition cases (persistence of rice difference due to natural restraints)

• Tests used may suffer from small-sample bias

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Methodology

Basics on Time Series

Univariate Autoregression (AR)

$$y_t = \alpha_o + \sum_{n=1}^{p} \alpha_n y_{t-n} + u_t$$

Multivariate Autoregression (VAR)*

$$Y_t = \alpha + \sum_{n=1}^{p} A_n Y_{t-n} + U_t$$

Vector Error Correction Model (VECM)*

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{n=1}^{p} \Gamma \Delta Y_{t-n+1} + U_t$$

*Matrix notation

$$Y_t = (y_{1,t}, y_{2,t}, y_{3,t}, .. y_{K,t})$$

$$A, \Pi, \Gamma = Coefficent\ Matrix$$

Different Tests

Information Criteria

- AIC
- SBIC
- HQIC

Unit Root Tests

- ADF
- PPERRON

Cointegration Analysis

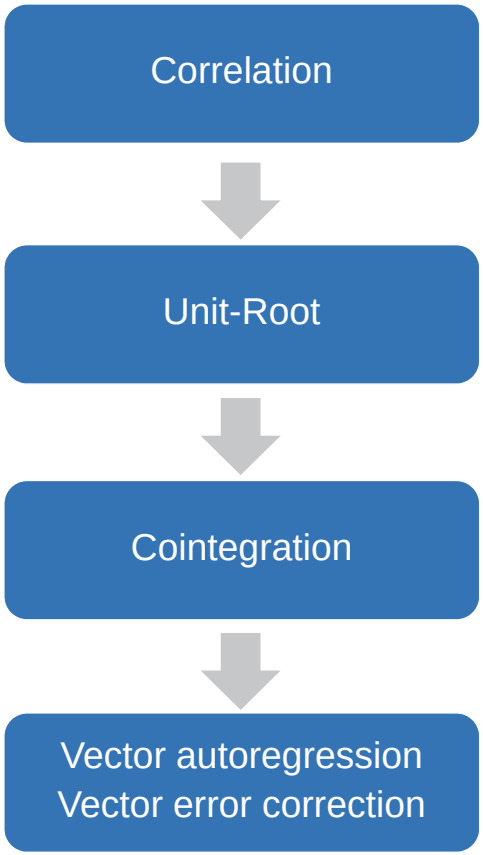
- Johansen Trace Test

Causality Analysis

- Granger Causality
- Impulse Response Analysis

Methodology

Test Procedure integration



1. Full Sample Correlation
2. Rolling Correlation, 100 days
3. Yearly Correlation

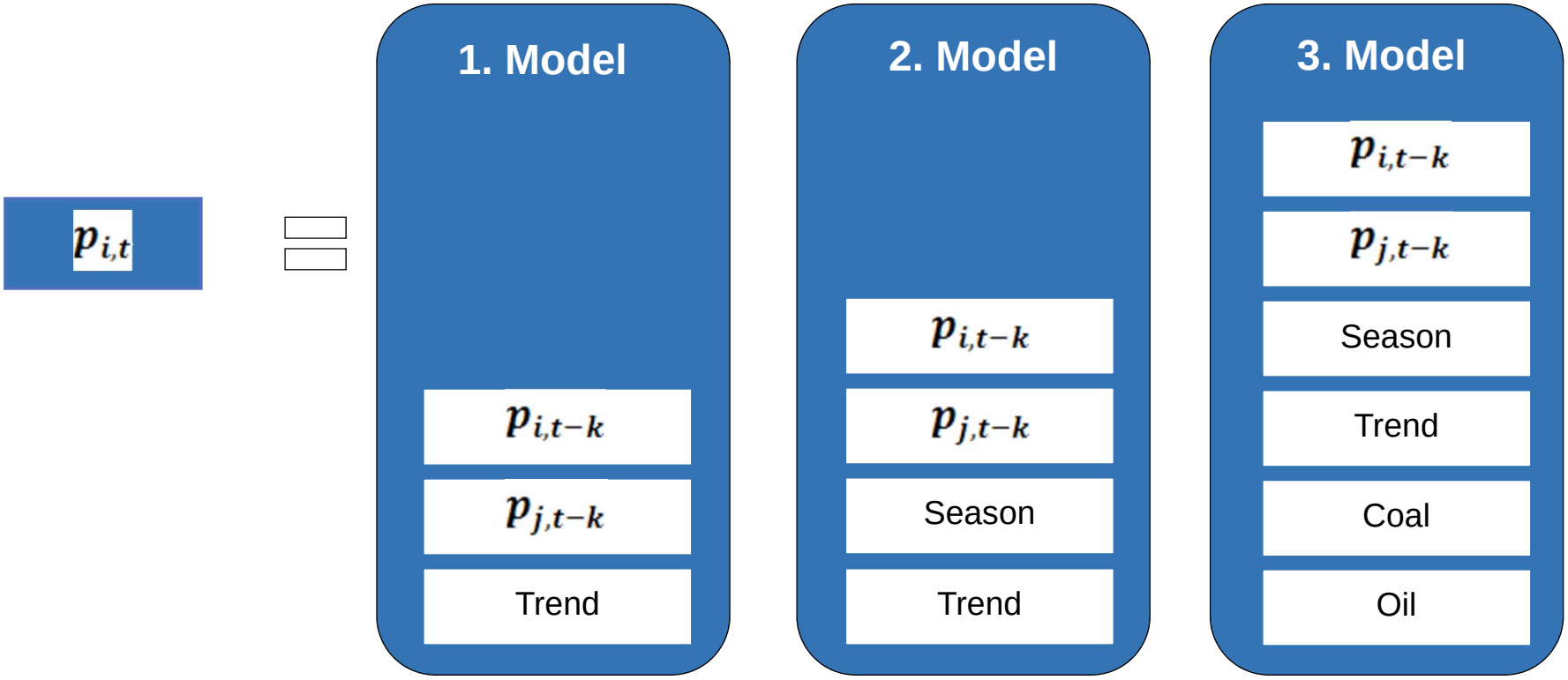
- Does the series exhibit a unit root? Is the log price ratio stable around a certain mean or zero at best?

- Do the energy price series exhibit a common trend?
- Is the common trend mainly if not solely driven by input prices?

- Testing causality and hence relationship of (direct) neighbours
- Is the common trend mainly if not solely driven by input prices?

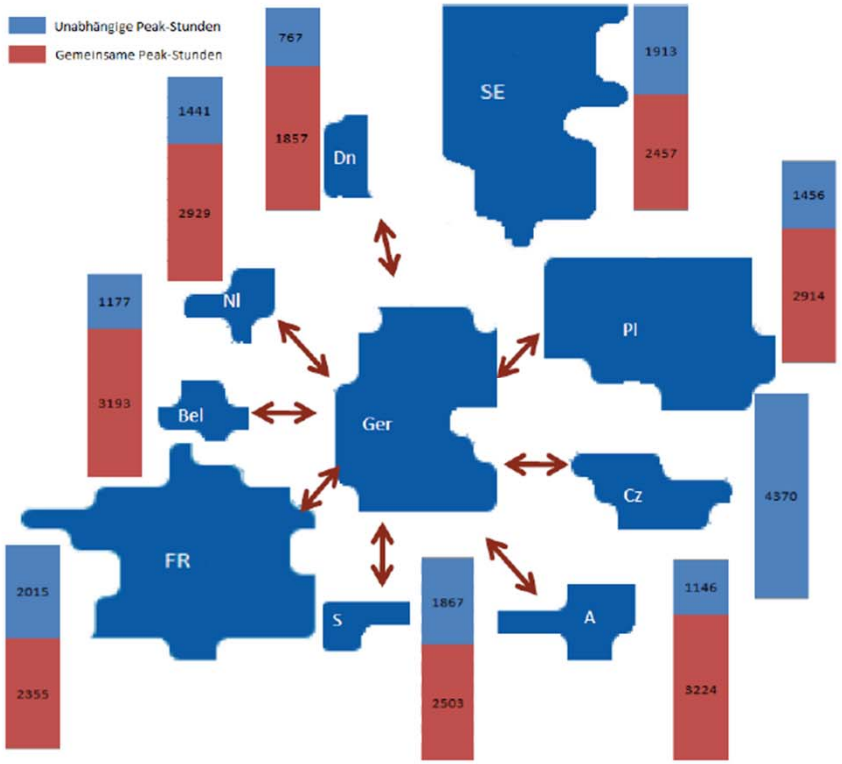
Methodology

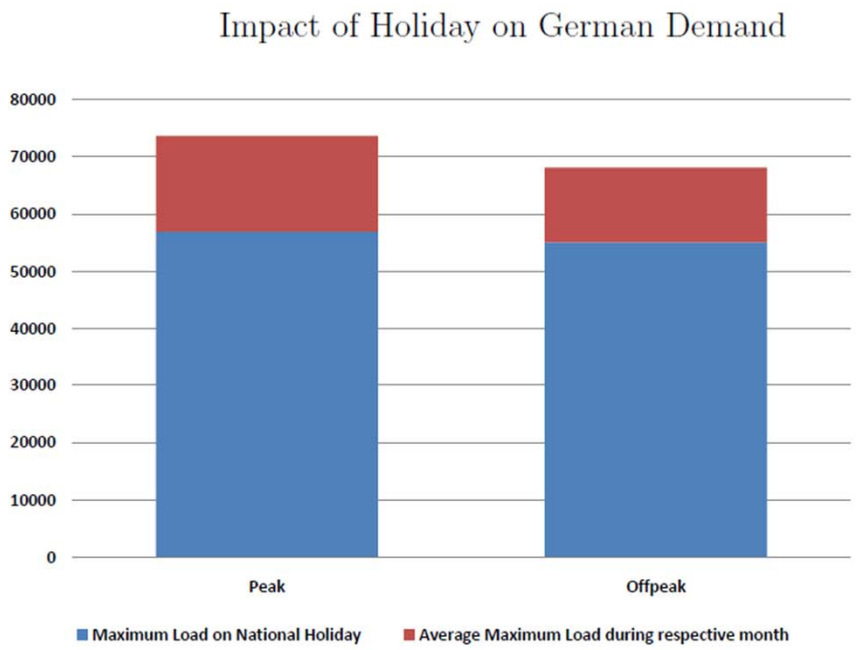
Each price test is done thrice in order to check for input prices and seasonalities



Methodology

Motivation of bank holidays as identification strategy





- European countries share common peak load hours
- Exogenous shock in country *A* should have an impact on country *B*

- German Holidays significantly impact load
- Exogenous shock on price

Methodology

Implementing holidays to identify impact without reliance on cointegration

$$p_{i,t} = \sum_{n=1}^{\rho} \beta_n p_{i,t-n} + \sum_{n=1}^{\rho} \gamma_n p_{j,t-n}$$
$$+ \sum_{n=1}^{\rho} p_{uranium} + \sum_{n=1}^{\rho} p_{coal} + \sum_{n=1}^{\rho} p_{oil}$$
$$+ \sum_{s=1}^{3} \delta_s d_{season} + d_{weekday} + holiday_i + holiday_j + \epsilon$$

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Data

Energy wholesale prices

- *Fuel Prices : Oil (ICE BRENT), Nuclear (UX Consulting, Coal (Platts)*
- Hourly day-ahead spot market prices from 2004-2011 for the following regions:
  - EEX,G (Germany)
  - EEX,A (Austria)
  - APXNL (Netherlands, UK)
  - Belpex (Belgium), data from 2006 onwards available
  - Nordpool (Denmark, Norway, Sweden)
  - PPX (Poland)
  - OTE (Czech Republic)
  - SwissIX (Switzerland), from 2006 onwards available

- Controlled for different currencies, all prices in €
- Data transformed into daily means, loss of data but necessary for comparability
- Clock change lead to double entries for some time points, these were deleted

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Results-Average Price Correlation

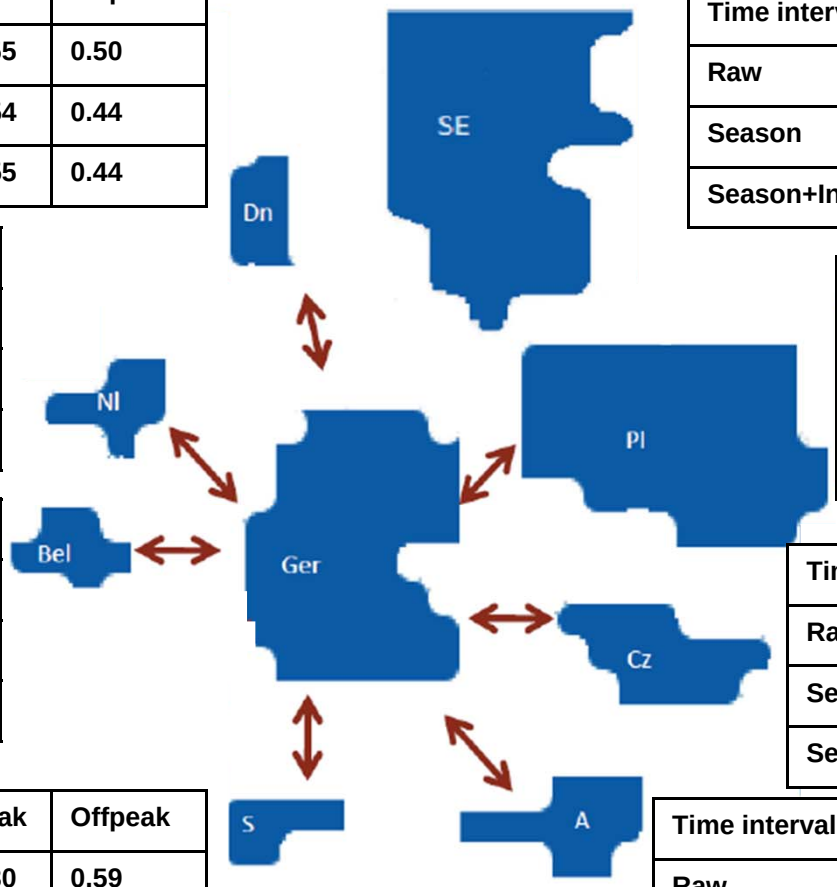
Correlation tests indicate large increase

- Almost uniform increase from 2007 onwards

Preliminary Results – Average Price Correlation of Germany with its neighbouring countries

Time interval	Peak	Offpeak
Raw	0.55	0.50
Season	0,54	0.44
Season+Input	0,55	0.44

Time interval	Peak	Offpeak
Raw	0.46	0.42
Season	0.31	0.36
Season+Input	0.32	0.36



Time interval	Peak	Offpeak
Raw	0.78	0.80
Season	0,69	0.75
Season+Input	0,70	0.75

Time interval	Peak	Offpeak
Raw	0.49	0.40
Season	0.35	0.30
Season+Input	0.29	0.30

Time interval	Peak	Offpeak
Raw	0.82	0.71
Season	0,73	0.65
Season+Input	0,66	0.59

Time interval	Peak	Offpeak
Raw	0.74	0.64
Season	0.66	0.55
Season+Input	0.66	0.55

Time interval	Peak	Offpeak
Raw	0.80	0.59
Season	0,70	0.53
Season+Input	0.60	0.47

Time interval	Peak	Offpeak
Raw	0.88	0.80
Season	0,83	0.74
Season+Input	0.83	0.74

Stationarity of Price Differences

- Almost every single tests points towards stationarity
- What is the mean value around which the process fluctuates?
  - Estimating Autoregressive Process and testing constant for null hypothesis of insignificance
  - Descriptive Analysis of mean value

Stationarity of Price Differences

Test	ADF-Value Sample 1	ADF-Value Sample 2
Peak		
Belgium	-	-10.50*
Netherlands	-15.506*	-16.555*
Switzerland	-	4.581*
Austria	-13.683*	-10.611*
Czech Republic	-6.562*	-3.822*
Poland	-6.225*	-6.785*
Denmark East	-7.637*	-7.971*
Denmark West	-7.019*	-4.663*
Sweden	-5.693*	-7.590*
Nordic System	-6.103*	-2.680***
Offpeak		
Belgium	-	-8.554*
Netherlands	-16.760*	-15.851*
Switzerland	-	-7.479*
Austria	-5.773*	-9.523
Czech Republic	-9.825*	-15.051*
Poland	-4.274*	-7.922*
Denmark East	-4.102*	-6.758*
Denmark West	-5.132*	-10.056*
Sweden	-3.197**	-5.709*
Nordic System	-3.108**	-4.932*

Null hypothesis of nonstationarity is rejected on a 1%, 5%, 10% level.

Stationarity of Price Differences

- Distributions have changed. Price differences are more skewed around zero
- Mean values indicate that the stationary process fluctuates around zero
- Austria, Denmark West and Netherlands to be closest candidates for zero-stationary process

Distribution of Price Differences

Test	KS-Test	Mean /Variance Sample 1	Mean /Variance Sample 2
Peak			
Belgium	-	-	-1.17/410.56
Netherlands	0.1701*	-0.38/554.01	0.28/216.20
Switzerland	-	-	-1.12/230.69
Austria	0.0485	0.05/199.65	-0.04/79.46
Czech Republic	0.2000*	0.55/445.34	-0.41/90.60
Poland	0.0354	0.98/655.71	-0.73/276.69
Denmark East	0.2084*	-0.37/593.84	0.28/914.53
Denmark West	0.124*	0.04/576	-0.03/206.41
Sweden	0.2206*	-0.68/717.27	0.51/917.24
Nordic System	0.1782*	-0.92/709.57	0.68/346.85
Offpeak			
Belgium	-	-	0.5980/91.41
Netherlands	0.1040*	-0.08/14.38	0.06/41.14
Switzerland	-	-	-0.69/105.41
Austria	0.1535*	0.06/15.69	-0.04/65.24
Czech Republic	0.1338*	0.23/81.01	-0.17/49.35
Poland	0.0585**	0.62/76.56	-0.46/92.41
Denmark East	0.1272*	-0.5/93.56	0.38/150.47
Denmark West	0.0592*	-0.16/46.60	0.12/43.64
Sweden	0.1580*	-1.07/134.50	0.80/177.60
Nordic System	0.1496*	-1.29/139.97	0.96/136.98

Null hypothesis of Equal Distribution is rejected on a 1%, 5%, 10% level.

Cointegration analysis

Seasonalities had large impact on cointegration tests

- Neglect of seasonalities lead to many positive tests for cointegration relationships
- After implementation, most cointegration relationships did not match the intended interepretation of a common price area: P(1)-P(2)=C, C=constant
- Either many long-run relationships were found or none. Neither of which fits the actual interpretation

Cointegration Vector

Test	Cointegration Vector
Peak	
Austria 2007-2011	-1.066
Switzerland 2007-2011	-0.5888
Nordpool System 2007-2011	-0.201
Offpeak	
Austria 2007-2011	-0.722
Nordpool System 2007-2011	-0.534
Sweden 2007-2011	-0.111
Poland 2007-2011	-1.099

Cointegration analysis

Bank holidays mark Germany-Austria

Influence of National Holiday

Test	German Holiday	Other Holiday
Peak		
Austria 2004-2006	-8.782	-7.943
Austria 2007-2011	-15.812*	-17.161*
Denmark West 2007-2011	-13.911*	-1.359
Offpeak		
Austria 2004-2006	-5.241**	-5.279**
Austria 2007-2011	-5.947**	-1.058

Null hypothesis of indifference from zero is rejected on a 1%, 5%, 10% level.

- Impact of holiday is negative as expected
- Only one pair to be significantly influenced: Germany-Austria, impact of holiday on Denmark west to be found significant only in the second peak sample
- Other pairs also have a negative impact but are insignificant

Implication of results

National delineation too narrow

- While only one pair has passed every test (Germany/Austria), correlation and price difference analysis indicate that the degree of integration seems to have increased significantly
- Neglect of common drivers leads to biased results towards confirmation of assumption of law of one price
- Concentration ratio of Germany's three largest suppliers decreases significantly with the extent of the market

Scenario	Base scenario	Correlation	Price-Difference	Cointegration
Country	Germany only	Austria, Netherlands, Denmark West	Austria, Netherlands, Denmark West	Austria
Market Share* of RWE, E.ON and Vattenfall	57,79%	41,91%	41,91%	43,74%

*** Net owned installed capacity, Source: Platts (2011)**

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Extensions and Problems

Market integration to increase – So does competition policy?

- The advent of the market coupling of Northern and Central-Western European (CWE/EMCC) and implicit cross-border pricing to sharply decrease price differences
- Policy makers/Competition authorities have to recognize this development and hence establish a solid energy policy / framework in order to support the process
- The current discussion of market design further stresses out the importance of a correct spatial market delineation
- Further analysis necessary to confirm the process

Thank you for your attention!