

# Forward Markets in the Electricity Industry: an Experimental Investigation

*WORK IN PROGRESS*

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Forward Markets in the Electricity Industry:  
an Experimental Investigation

Introduction Setup Results

Background Question Literature

- Market power in generator markets is a key problem in the EU electricity markets (European Commission, 2007)
- Remedies
  - Structural
  - Behavioral

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Forward Markets in the Electricity Industry:  
an Experimental Investigation

- Structural remedies lower concentration
  - Divestiture
  - Blocking mergers
  - New entry
- Focused on increasing number of competitors

- Behavioral measures do not change concentration
  - Organize electricity markets in ways that prevents the **use of** market power
  - Preferred over structural measures (European Commission, 2006).
- Allaz and Vila (JET 1993)
  - Introducing a forward market increases supply in Cournot competition

## Our question

What is the most effective policy in the EU electricity markets?

- Structural measure
  - Add more competitors
- Behavioral measure
  - Introduce a forward market

For external validity: what are the main stylized facts of the EU electricity market?

1. Markets with 2 and 3 generator firms
  - EU-15: typically 3 firms
    - HHI=3786
    - 3 symmetrical firms results in HHI=3333.
  - In NMS-10: typically 2 firms
    - HHI =5558
    - 2 symmetrical firms results in HHI=5000.

2. Electricity generators have steeply increasing marginal costs (Newbery, EER 2002).

- For external validity we thus use quadratic marginal costs

$$mc_3(q) = 2q^2$$

$$c_3(q) = \sum_{x=1}^q 2x^2$$

- LeCoq and Orzen (JEBO 2006)

	2 producers	4 producers
<b>Without Forward Market, zero costs</b>	M2zc	M4zc
<b>With Forward Market, zero costs</b>	M2Fzc	M4Fzc

Diagram illustrating the relationship between market configurations (2 producers vs. 4 producers) and the presence of a forward market (zero costs vs. without forward market).

Arrows indicate transitions: M2zc → M4zc (orange arrow), M2Fzc → M4Fzc (orange arrow), M2zc → M2Fzc (orange arrow), and M4zc → M4Fzc (orange arrow).

## Conclusions

- Forward market increased output
- Adding two more producers increased output
- Two more producers increases output more than introducing a forward market.

- LeCoq and Orzen (2006)
- Drawbacks
  - Zero costs
    - more realistic: steeply rising marginal costs
  - Structural measure: M2 → M4
    - more realistic:
      - for NMS-10: M2 → M3
      - for EU-15: M3 → M4

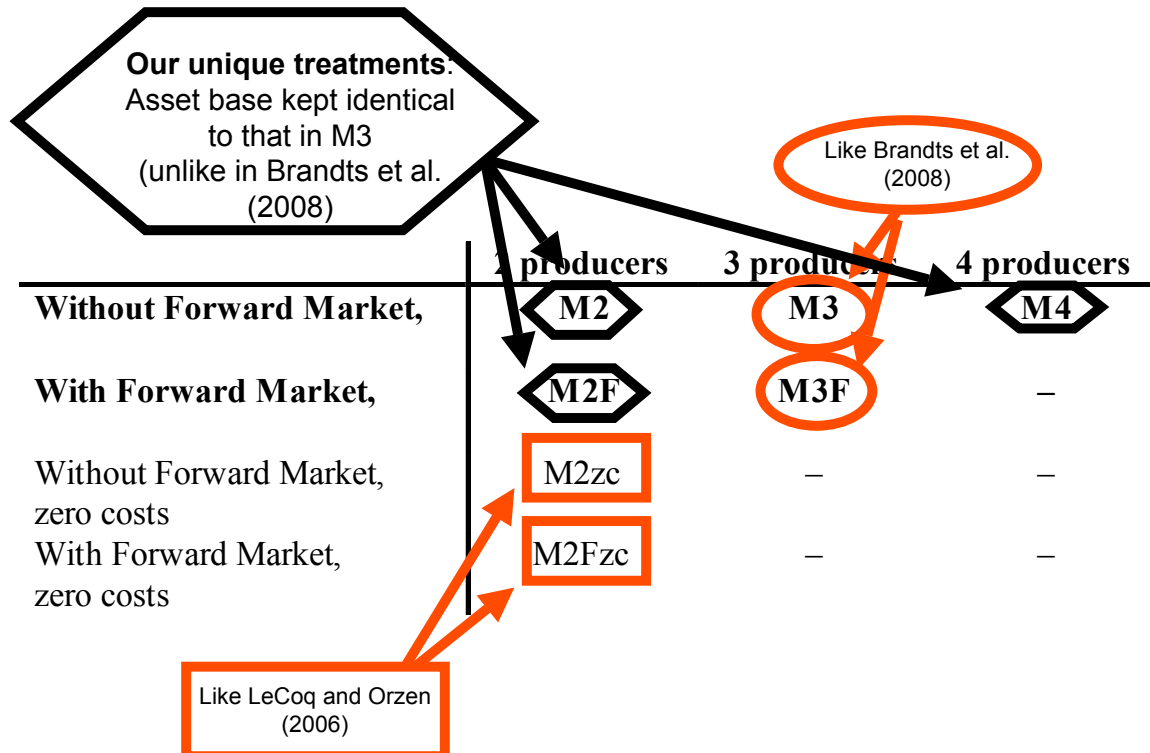
- Brandts, Pezanis-Christou, and Schram (EJ 2008)

	3 producers	4 producers
Without Forward Market , Quadratic MC	M3	M4
With Forward Market Quadratic MC	M3F	–

*Note: In the original image, orange arrows indicate a downward arrow from M3 to M3F and a rightward arrow from M3 to M4.*

- Conclusions
  - Forward market increases output
  - Adding **ONE** more producer increases output
  - Adding **ONE** more producer increases output more than introducing a forward market.

- Brandts, Pezanis-Christou, and Schram (2008)
- Drawbacks
  - Not realistic for NMS-10
    - 2 firms
  - Brandts et al. (2008) confound the number effect with an asset effect
    - The asset effect advantages adding one more competitor



**M3**

**M4**



**M3**

**M4**



M4 has SAME aggregate assets as M3

**Brandts et al.**

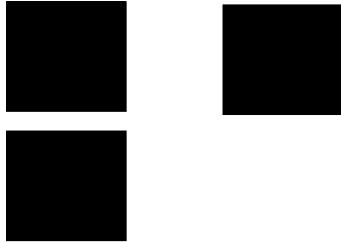


**M4 has MORE aggregate assets than M3!**



**M3**

**M2**



**M3**

**M2**



M2 has SAME aggregate  
sets as M3



Market with TWO producers (after merger)			Market with THREE producers (original market)			Market with FOUR producers (after divestment)		
Total Product -ion	Cost each	Total Costs	Total Product -ion	Cost each	Total Costs	Total Product -ion	Cost each	Total Costs
2*N	TC	2*TC	3*TC	4* N	TC	4*TC		
0	0	0	0	0	0	0		
2	1		6					
4	6	11						11
6	15	56	6	10	30			
8	31	62						62
10	55	111	9	28	84			
12	90	364	12	60	180	12	45	112
14	137	273	15	110	330			
16	197	394				16	99	394
18	273	1140	18	182	546			
20	366	733				20	183	733

More expensive with method Brandts et al. (2008)!!!

Cheaper in Brandts et al. (2008)

Introduction Setup Results

Design & Implementation Predictions

- Demand simulated
 
$$p(Q) = \text{Max}(0, 2000 - 27Q)$$
  - Identical to Brandts et al. (2008)
- Trading was simulated
  - Simulated traders,
    - predict spot market price given the total number of units sold in the forward market.
    - As in LeCoq and Orzen (2006)

- Ran sessions in
  - October 2009, December 2009, and April 2010
- 11 independent groups for each treatment
- In total 198 subjects
  - Students mainly of the Prague business school, the economic institute and the Prague technical school

Remaining time [sec]: 41

Choose the quantity you want to produce in the right upper box and press OK

Period 1 of 24  
There are - including you - 3 producers in your group

Total Production	Price/Unit
0	2000
1	1973
2	1946
3	1919
4	1892
5	1865
6	1838
7	1811
8	1784
9	1757
10	1730
11	1703

Produce Units	Marginal Cost	Total Cost
0	0	0
1	2	2
2	8	10
3	18	28
4	32	60
5	50	110
6	70	180
7	100	280
8	130	410
9	160	570
10	200	770
11	250	1020

OK

My Production ---

Production of Others ---

Total Production ---

Price per Unit ---

**Outcomes for Period 1**

My Production ---

Price ---

My Return ---

My Production ---

Cost of the last unit (Marginal Cost) ---

My Total Cost ---

My Profit (My Return - My Total Cost) ---

History

Period	My Production	Cost of the last unit (Marginal Cost)	My Total Cost	Total Production	Price/Unit	My Return	My Profit (My Return - My Total Cost)	Cummulative Profit
1	---	---	---	---	---	---	---	2750

Choose the quantity you want to produce for STAGE A in the right upper box and press OK

Remaining time [sec]: 28

Period 1 of 24

Stage A

There are - including you - 3 producers in your group

Aggregate Production STAGES A + B	Price/Unit STAGE B
0	2000
1	1973
2	1946
3	1919
4	1892
5	1865
6	1838
7	1811
8	1784
9	1757
10	1730

Total Production STAGE A	Price/Unit STAGE A
0	833
1	829
2	824
3	820
4	816
5	811
6	807
7	803
8	799
9	794
10	790

Produce Units in STAGE A	Marginal Cost	Total Cost
0	0	0
1	2	2
2	8	10
3	18	28
4	32	60
5	50	110
6	70	180
7	100	280
8	130	410

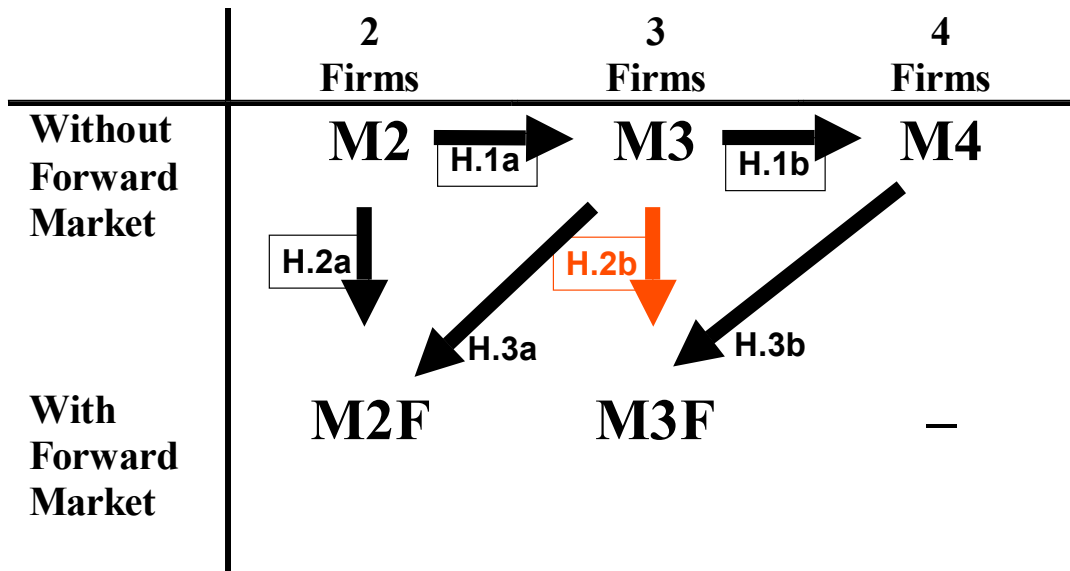
This period - Outcomes for Stage A

My Production in Stage A ---	My Production ---	My Production ---
Production of Others in Stage A ---	Price ---	Cost of the last unit (Marginal Cost) ---
Total Production in Stage A ---	My Return ---	My Total Cost ---
Price per Unit ---	My Profit (My Return - My Total Cost) ---	

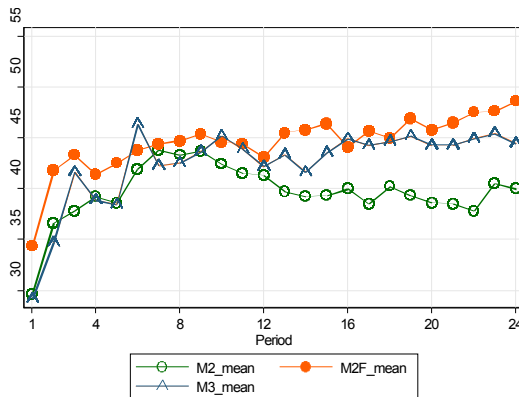
History

Period	Stage	My Production	Cost of the last unit (Marginal Cost)	My Total Cost	Total Production	Aggregate Production (A+B)	Price/Unit	My Return	My Profit (My Return - My Total Cost)	Cummulative Profit
1	A	---	---	---	---	---	---	---	---	2750

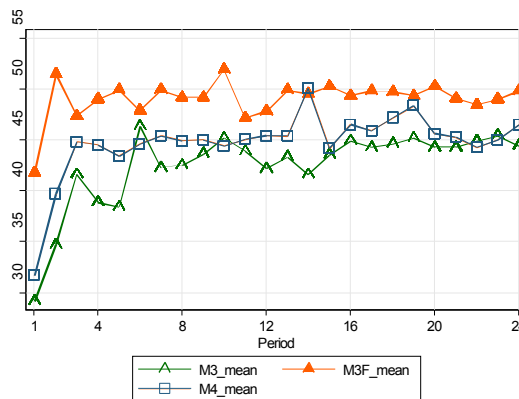
	NE M2	NE M2F		NE M3	NE M3F	NE M4
	—	2	11	—	5	—
	20	20	22	14/15	15	11
	<b>40</b>	<b>40</b>	<b>44</b>	<b>43</b>	<b>45</b>	<b>44</b>



M2, M2F, M3



M3, M3F, M4



## Averages

Standard errors based on groups (N=11)

	2 Firms	3 Firms	4 Firms
<b>Without Forward Market</b>	<b>M2</b> 39.4 (1.51)	<b>M3</b> 44.1 (1.26)	<b>M4</b>
<b>With Forward Market</b>	<b>M2F</b> 46.1 (2.12)	<b>M3F</b>	—

Arrows indicate transitions: M2 to M3 (horizontal), M2 to M3F (diagonal down-right).

## Averages

Standard errors based on groups (N=11)

	2 Firms	3 Firms	4 Firms
<b>Without Forward Market</b>	<b>M2</b> 39.4 (1.51)	<b>M3</b> 44.1 (1.26)	<b>M4</b> 46.1 (1.01)
<b>With Forward Market</b>	<b>M2F</b> 46.1 (2.12)	<b>M3F</b> 49.4 (0.64)	—

Arrows indicate transitions: M3 to M4 (horizontal), M3 to M3F (diagonal down-right).

## Averages

Standard errors based on groups (N=11)

	2 Firms	3 Firms	4 Firms
<b>Without Forward Market</b>	<b>M2</b>	<b>M3</b>	<b>M4</b>
	39.4	44.1	46.1
	<b>98.7%</b>	<b>102.5%</b>	<b>104.9%</b>
	92.7%	102.7%	102.9%
Confirming meta-analysis Huck et al. (JEBO 2004)			
<b>With Forward Market</b>	<b>M2F</b>	<b>M3F</b>	—
	46.1	49.4	
	<b>115%</b>	<b>110.0%</b>	<i>Percentages of the Nash-equilibrium prediction</i>
	<b>105%</b>		

$$AggSupply = \beta_1 \times M2 + \beta_2 \times M2F + \beta_3 \times M3 + \beta_4 \times M3F + \beta_5 \times M4 + \varepsilon$$

F-tests on the equality of the  $\beta_i$  coefficients

	2 Firms	3 Firms	4 Firms
<b>Without Forward Market</b>	<b>M2</b>	<b>M3</b>	<b>M4</b>
	39.4 (1.51)	44.1 (1.26)	46.1 (1.01)
	<b>***</b> →	<b>*</b> →	
	$p=0.009$ H.1a	$p=0.096$ H.1b	
Confirming Brandts et al. (2004)			
<b>With Forward Market</b>	<b>M2F</b>	<b>M3F</b>	—
	46.1 (2.12)	49.4 (0.64)	

$$AggSupply = \beta_1 x M2 + \beta_2 x M2F + \beta_3 x M3 + \beta_4 x M3F + \beta_5 x M4 + \varepsilon$$

F-tests on the equality of the  $\beta_i$  coefficients

	2 Firms	3 Firms	4 Firms
<b>Without Forward Market</b>	<b>M2</b> 39.4 (1.51)	<b>M3</b> 44.1 (1.26)	<b>M4</b> 46.1 (1.01)
	*** ↓ p=0.006 H.2a	*** ↓ p=0.0001 H.2b	
<b>With Forward Market</b>	<b>M2F</b> 46.1 (2.12)	<b>M3F</b> 49.4 (0.64)	—

Confirming Brandts et al. (2004)

$$AggSupply = \beta_1 x M2 + \beta_2 x M2F + \beta_3 x M3 + \beta_4 x M3F + \beta_5 x M4 + \varepsilon$$

F-tests on the equality of the  $\beta_i$  coefficients

	2 Firms	3 Firms	4 Firms
<b>Without Forward Market</b>	<b>M2</b> 39.4 (1.51)	<b>M3</b> 44.1 (1.26)	<b>M4</b> 46.1 (1.01)
		p=0.204 H.3a	*** p=0.003 H.3b
<b>With Forward Market</b>	<b>M2F</b> 46.1 (2.12)	<b>M3F</b> 49.4 (0.64)	—

**Contradicting Brandts et al. (2004)**

## Our results confirm earlier findings:

- Structural measure is effective
  - Adding one more competitor increases supply
- Behavioral measure is effective
  - Introducing a forward market increases supply

## Regarding which measure is most effective we obtain a new result

- **Behavioral measure** increases supply significantly MORE than the structural measure in markets with 3 producers

For markets with 3 producers

- **The behavioral measure** is more effective than the structural measure
- Good news for EU policymakers

Our result contradicts Brandts et al. (2008)

- Brandts et al. confound a number effect with an asset effect
- The asset effect makes structural measure look more favourable
- We control for the asset effect



- For markets with 2 producers
  - Behavioral measure is as effective as the structural measure
- Thus EU policy makers can chose for their preferred option (behavioural measure)

# Questions?

Remaining time [sec]: 41

Choose the quantity you want to produce for STAGE B in the right upper box and press OK

Period 1 of 24  
Stage B

There are - including you - 3  
producers in your group

Aggregate Production STAGES A + B	Price/Unit STAGE B
0	2000
1	1973
2	1946
3	1919
4	1892
5	1865
6	1838
7	1811
8	1784
9	1757
10	1730

Total Production STAGE B	Price/Unit STAGE B
0	1865
1	1838
2	1811
3	1784
4	1757
5	1730
6	1703
7	1676
8	1649
9	1622
10	1595

Produce Units in STAGE B	Marginal Cost	Total Cost
0	0	0
1	70	70
2	100	170
3	130	300
4	160	460
5	200	660
6	240	900
7	290	1190
8	340	1530

This period - Outcomes for Stage B

My Production in Stage A: 5	My Production in Stage B: ---	My Production in Stage B: ---
Production of Other in Stage A: 0	Price: ---	Cost of the last unit (Marginal Cost): ---
<b>Total Production Stage A: 5</b>	My Return: ---	My Total Cost: ---
My Production in Stage B: ---		
Production of Others in Stage A: ---		
<b>Total Production Stage B: ---</b>		
<b>Aggregate Production Stage A+B: ---</b>		
Resulting Price: ---	My Profit (My Return - My Total Cost): ---	

History

Period	Stage	My Production	Cost of the last unit (Marginal Cost)	My Total Cost	Total Production	Aggregate Production (A+B)	Price/Unit	My Return	My Profit (My Return - My Total Cost)	Cummulative Profit
1	A	5	50	110	5	---	811	4055	3945	6695
1	B	---	---	---	---	---	---	---	---	6695

**Hq.1**

a.  $q(M2) < q(M3)$

b.  $q(M3) < q(M4)$

**Hq.2**

a.  $q(M2) < q(M2F)$

b.  $q(M3) < q(M3F)$

**Hq.3**

a.  $q(M3) < q(M2F)$

b.  $q(M4) < q(M3F)$