Cross-ownership and Nuclear Production in the Nordic Electricity Market

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Work in early progress – all comments welcome!

Background

- The Nordic power exchange Nordpool serves around 30 million people with electricity. 80% of all electricity produced in the region is sold through the spot market (Nordpool Spot).

- The three largest plants in the system are Swedish nuclear plants. These plants account for 20% of the production in the spot market.

- The nuclear plants are cross-owned by three dominant producers. A given ownership share in a plant gives the right to a corresponding share of the output from that plant.

- Since marginal cost of nuclear is very low, there should be strong incentives to maintain a high capacity utilization. But low capacity utilization last decade (77%) due to maintenance. Has market power provided incentives to engage in excessive maintenance in order to increase the spot price?

Background

- *" Sometimes we reduced [nuclear] production when prices were above the variable cost…so that prices would increase…but we never did it in agreement with the other co-owners".*
  (Seth Persson 2006, production planner at Vattenfall, radio interview freely translated from Swedish).

- Competition authorities initiated an investigation of collusion in 2006 and found nothing, but has ever since tried to make the producers voluntarily dissolve the cross-ownership.

- Methodological advantage of working with the spot market: Market participants submit a supply- or demand function, the auctioneer stacks the bids horizontally and the market is cleared where supply meets demand.

- We have access to aggregate bidding curves (at the moment we are working on getting individual bidding data).

Research question

- We construct three simplified static models:

  1) **Semi-collusion**, in which nuclear producers will cooperate on nuclear production (due to cross-ownership) but nothing else.
  2) **Cournot**, where the majority owner of each nuclear plant decides on production levels (taking ownership shares into account).
  3) **Social planner,** i.e. produce at full capacity as long as price is above the marginal cost of nuclear production.

The models give us hourly production levels that we can compare with observed production levels.

- Assume ”state-of-the-art” nuclear plants with constant marginal cost (very low), and no need for maintenance. → (Almost) all incentives to reduce production must be due to market power. No ramping costs.

- While we can never say whether maintenance was in fact necessary from an engineering point of view, we can investigate whether there are economic incentives to reduce output in order to raise the spot price.

Preliminary main findings

- Observed average production levels coincide with the model of semi-collusion. However, predicted production levels are much more volatile than in the data (find a way to model ramping costs?).

- Cournot model generates very limited incentives to reduce output.

- If plants would have been run by a social planner, prices would have decreased by on average 12%, or 4.5 EUR/MWh.

Contribution

- First study to use actual bidding curves to study market power in the Nordic Spot market.

- To the best of my knowledge, the first study to empirically distinguish between the anti-competitive effects of cross-ownership: Is it due to collusion or through a distortion of the Cournot equilibrium?

Brief empirical literature review

Market power in the Nordic electricity market

- ***Liski and Kauppi (2009)*** Hydro power simulation
- ***Damsgaard et al. (2007)*** Hydro power simulation
- ***Hjalmarsson (2000)*** Bresnahan-Lau framework
- ***Tangerås and Fridolfsson (2009)*** Discussion on nuclear capacity reductions

Market power in other electricity spot markets (very incomplete)

- ***Wolak and Patrick (1997)*** Capacity reductions of low-cost generation (England)
- ***Borenstein et al. (2002)*** Californian electricity crisis
- ***McRae and Wolak (2009)*** New Zealand market

Cross-ownership and market power

- **Alley (1997)** US and Japanese Automobile industry
- **Dietzenbacher et al (2000)** Dutch banking sector
- **Parker and Röller (1997)** Mobile telephone industry

Institutional setup and data

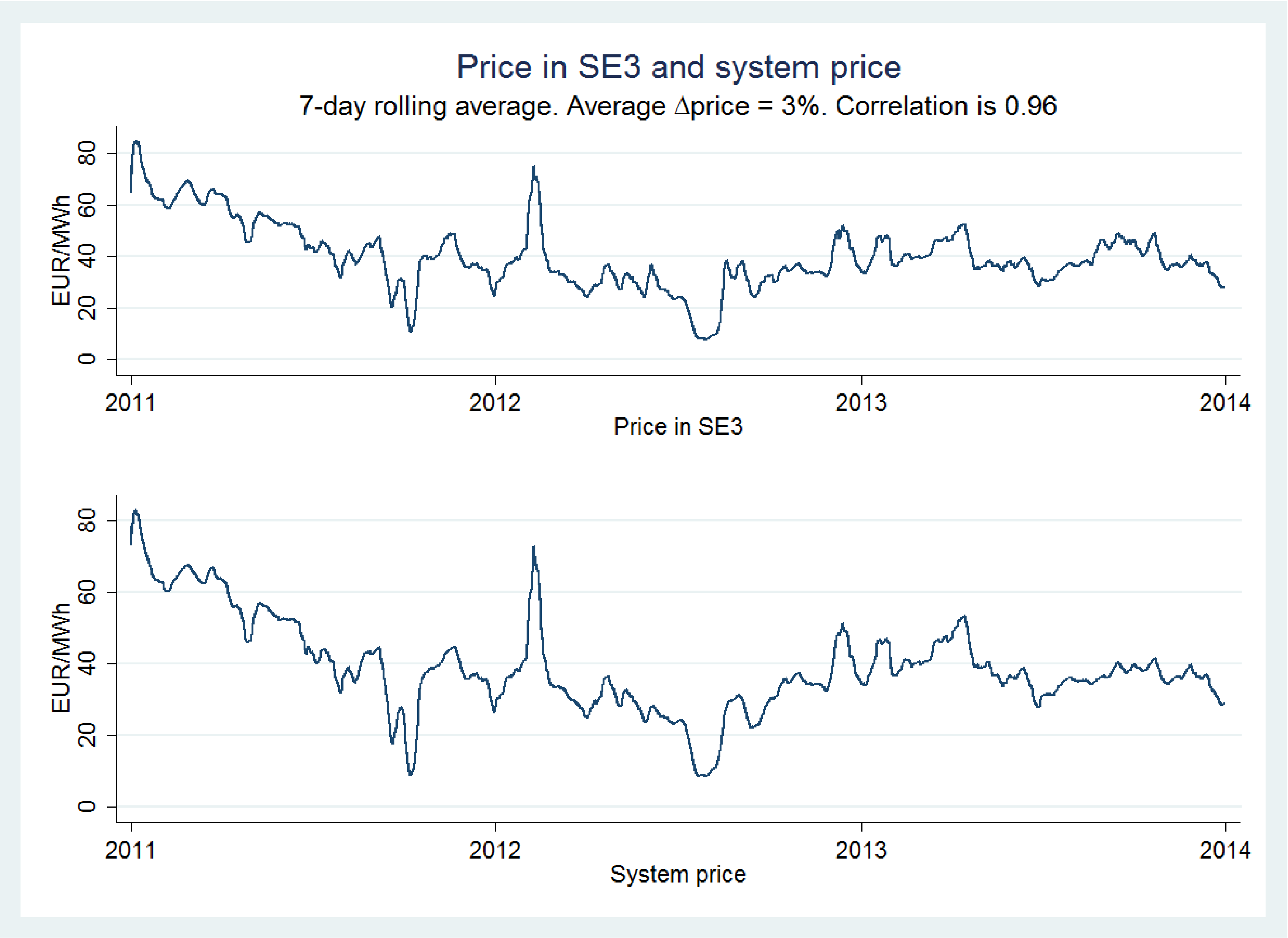
- Nuclear producers sell all their production (nuclear and non-nuclear) on the spot market. Market share of Swedish nuclear plants´ is 20%. Nuclear producers´ market share on non-nuclear production is 25%.

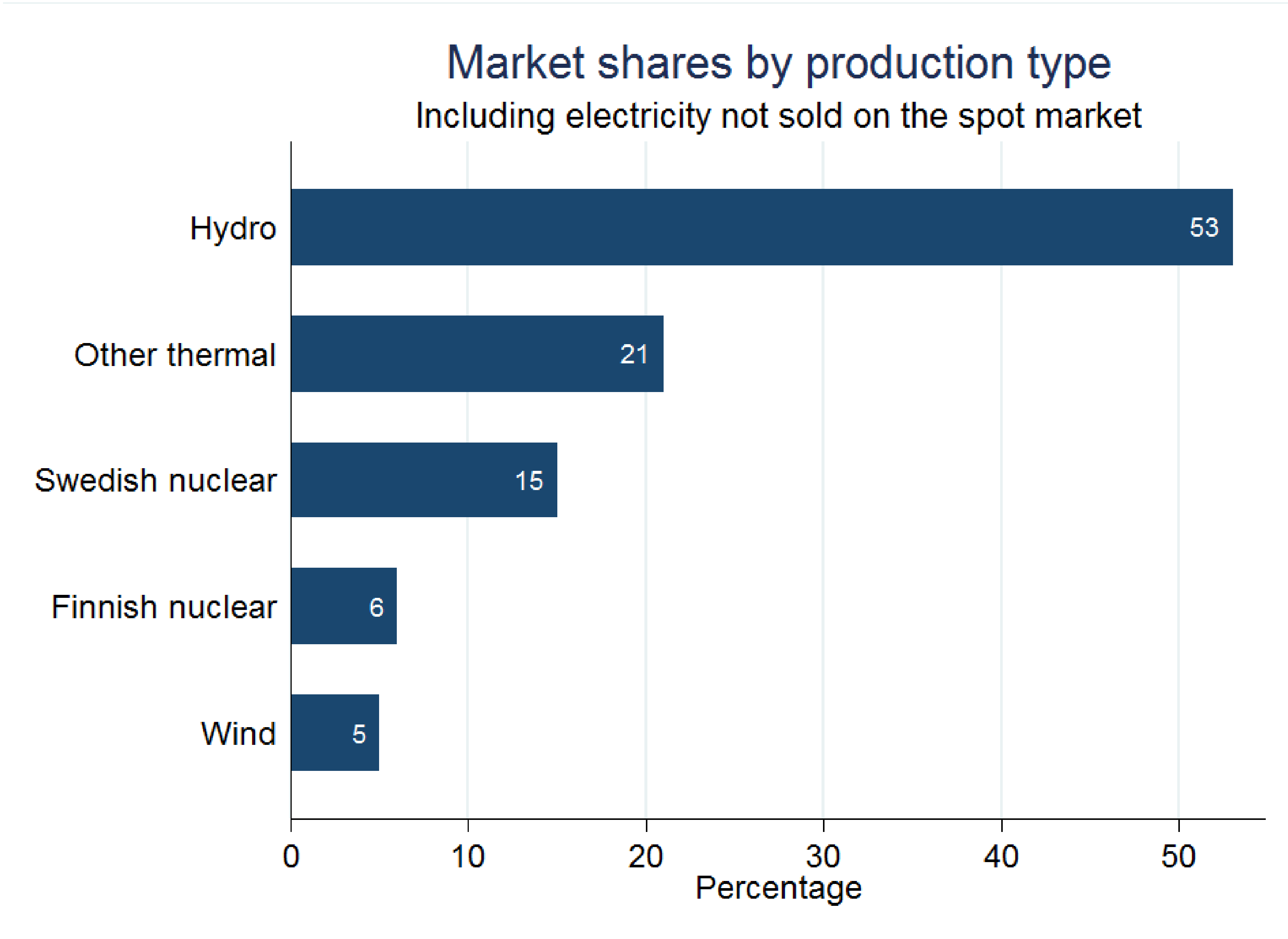
- Caveat: We do not know the financial positions of the producers, so for now we assume that they maximize their surplus in the spot market. Including forward markets should create less incentives of exercising market power in the spot market.

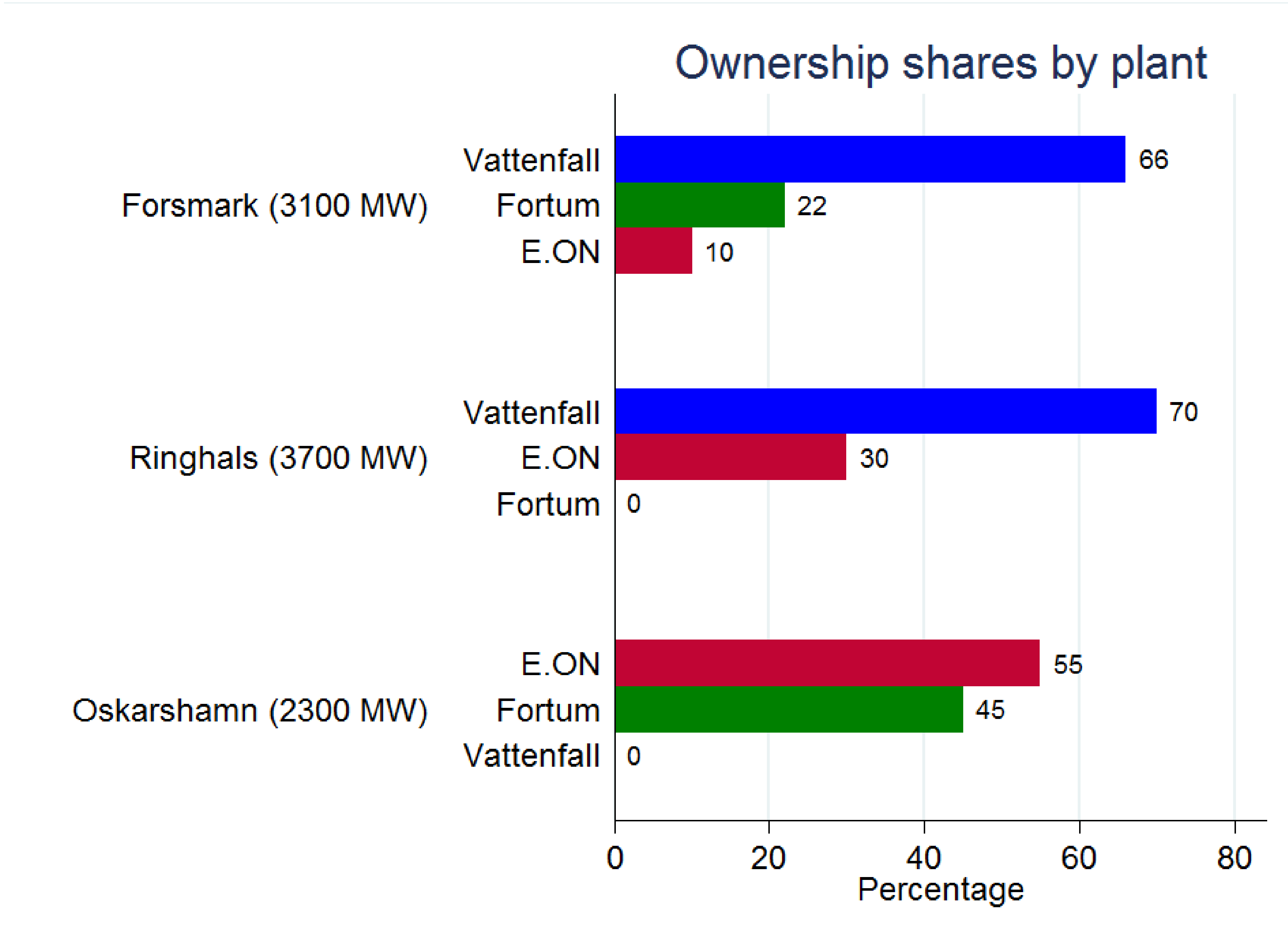
- There are 24 separate auctions each day. Market equilibrium is calculated by linear interpolation.

- If there are transmission constraints, there may be up to 15 prices at the same time. All Swedish nuclear is in the same price area (SE3).

- The price in SE3 follows system price very closely, so system price is a good proxy for the price in SE3.


Price in SE3 and system price
7-day rolling average. Average Δprice = 3%. Correlation is 0.96
EUR/MWh
0
20
40
60
80
2011
2012
2013
2014
Price in SE3
EUR/MWh
0
20
40
60
80
2011
2012
2013
2014
System price


Market shares by production type
Including electricity not sold on the spot market
Hydro
Other thermal
Swedish nuclear
Finnish nuclear
Wind
53
21
15
6
5
0
10
20
30
40
50
Percentage


Ownership shares by plant
Forsmark (3100 MW)
Vattenfall
66
Fortum
22
E.ON
10
Ringhals (3700 MW)
Vattenfall
70
E.ON
30
Fortum
0
Oskarshamn (2300 MW)
E.ON
55
Fortum
45
Vattenfall
0
0
20
40
60
80
Percentage

Data 2011-2013

- Aggregate supply- and bidding curves for each hour (around 600 price/quantity pairs per curve).

- Individual production data for each nuclear plant and hour.

- Urgent Market Messages (UMM:s). Unique information system on maintenance decisions and production failures in each nuclear plant. Around 400 separate messages for the whole period.

- Yearly market shares on non-nuclear production for each company that owns shares in the nuclear plants (so not very precise).

Method and assumptions

- Assume nuclear producers choose the capacity available to the market and then submit a zero-price bid of that capacity. → Price effect of reducing nuclear output can be found by shifting the aggregate supply curve.

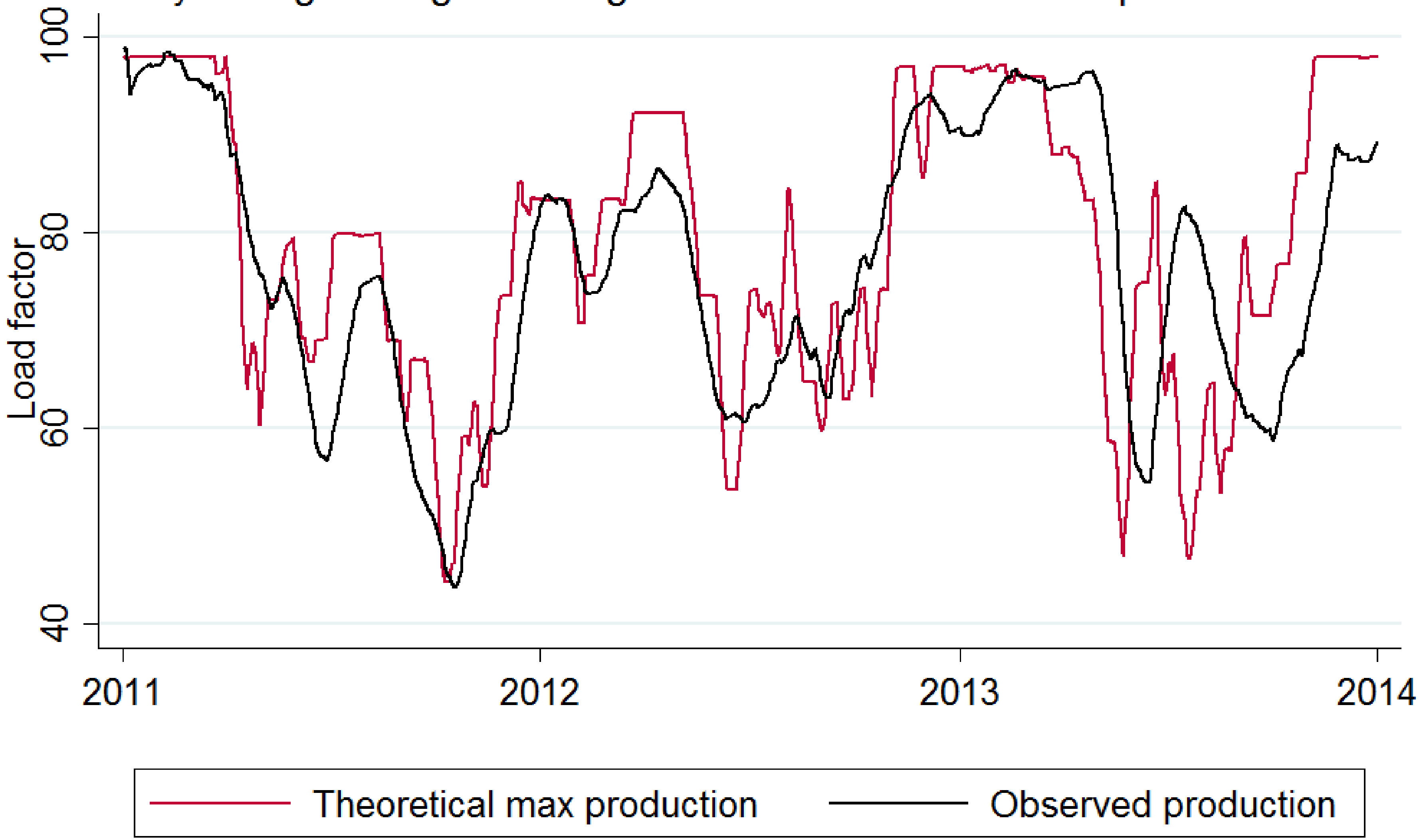
- After netting out reported capacity reductions due to maintenance in the Urgent Market Messages reporting system we can (at least on average) replicate observed production levels, which justifies the assumption above. See figure on the next slide. (Note: the UMM:s are only used to show the importance of maintenance and are not used in the actual simulation).

- Assume that everything but nuclear production is supplied at marginal cost, and that nuclear producers have the same cost-structure on non-nuclear production as other producers.

- We can relax the zero-markup assumption by e.g. assuming a 10% mark-up on all bids from non-nuclear production, but we get only minor adjustments to the optimal nuclear output in the models.

Theoretical max production net of maintenance

30-day rolling average. Average deviation from observed production = 2%.



Note: If also netting out production failures, average deviation is 1%.

Method and assumptions

- Why not instead withdraw high-cost units like fossile plants? Needs a lot of coordination, and many plants are needed to achieve the same price effect. Easier for regulator to detect manipulation if many fossile plants are taken down simultaneously.

- There are also internal market rules for Nordpool Spot:

  "Any engagement in or attempt to engage in, Market Manipulation on the Physical Markets shall be prohibited"

  (Nordpool 2014)

- Market manipulation through hydro? May take place, but no obvious way to account for this in the present model.

Method and assumptions

- Assume a constant marginal cost of 4 EUR/MWh (approximately the cost of nuclear fuel).

- No ramping constraints – nuclear plants can vary the production at no cost.
  → we will overestimate the volatility of nuclear output.

- No import elasticity (average net imports are 7% of turnover)
  → we will overestimate the ability to influence the price.

- No transmission constraints (we can only replicate the system price)
  → we will underestimate the ability to influence the price.

- No forward contracts
  → we will overestimate the incentives to influence the price.

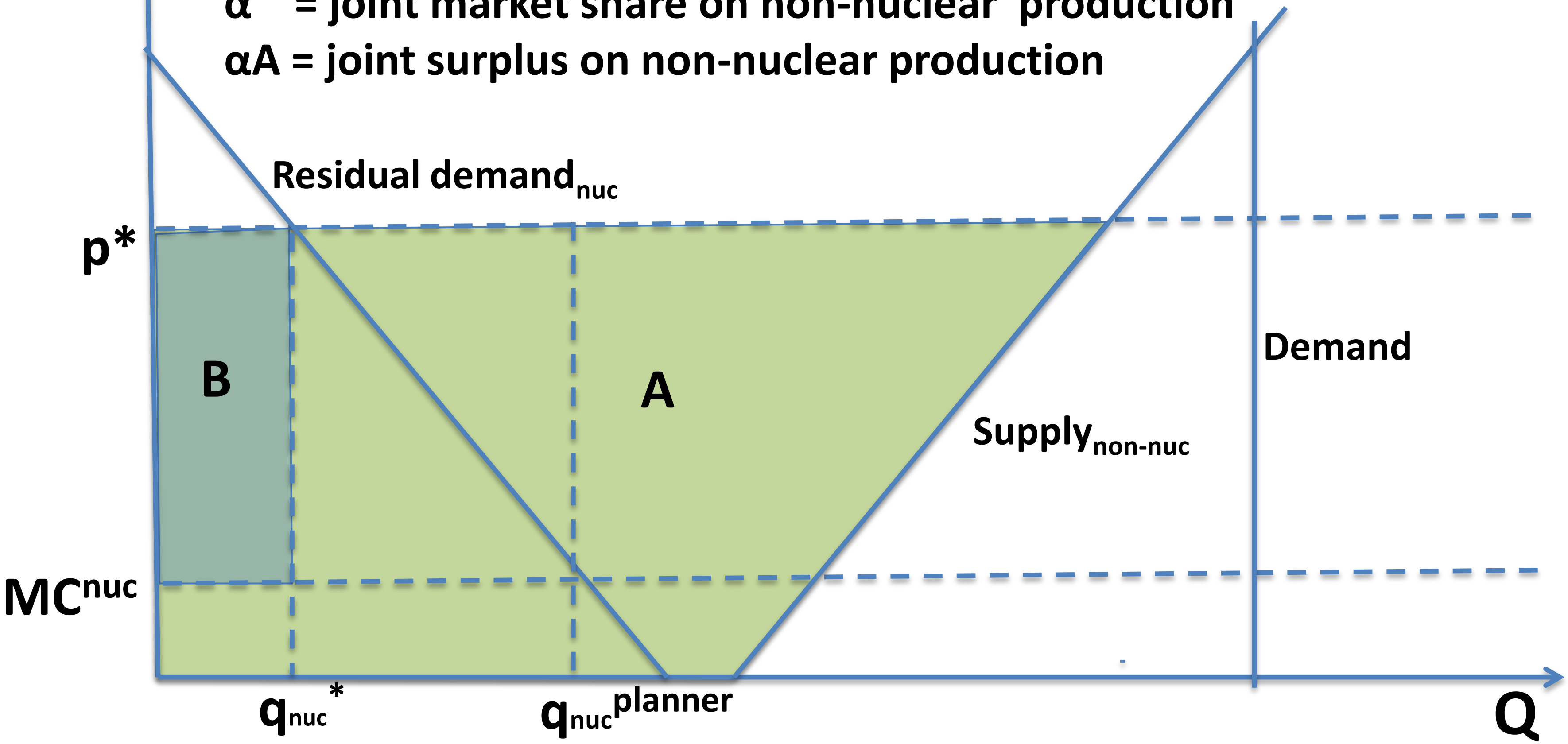
Optimal nuclear production under semi-collusion

$$\max_{q_{nuc}} \quad \text{joint producer surplus} = B + \alpha A$$

B = joint surplus on nuclear production

α = joint market share on non-nuclear production

αA = joint surplus on non-nuclear production



Optimal nuclear production under Cournot

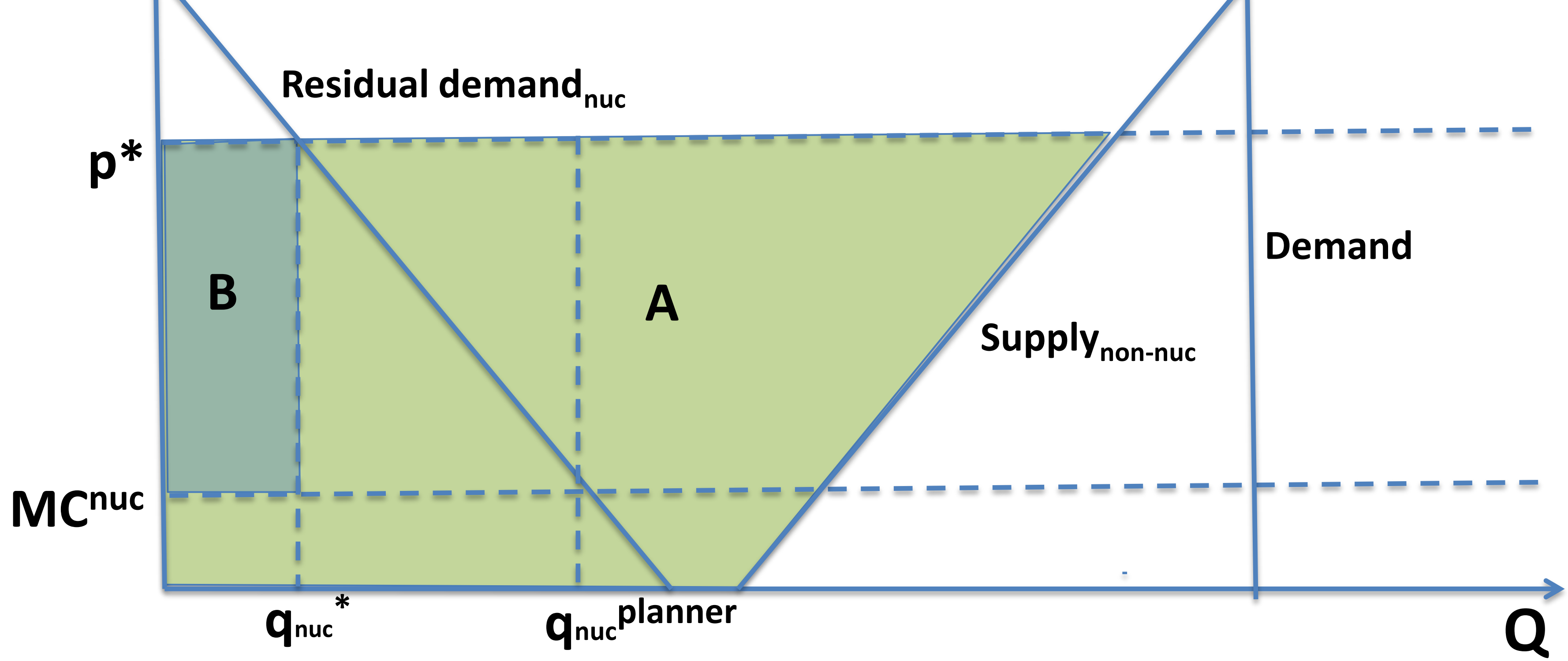
$$\max_{q_{nuc}} \quad \text{Majority owner producer surplus} = \theta B + \alpha A$$

θ = Majority owner´s ownership share in nuclear plant

θB = Majority owner´s surplus from nuclear plant

α = Majority owner´s market share on non-nuclear production

αA = Majority owner´s surplus on non-nuclear production



Results

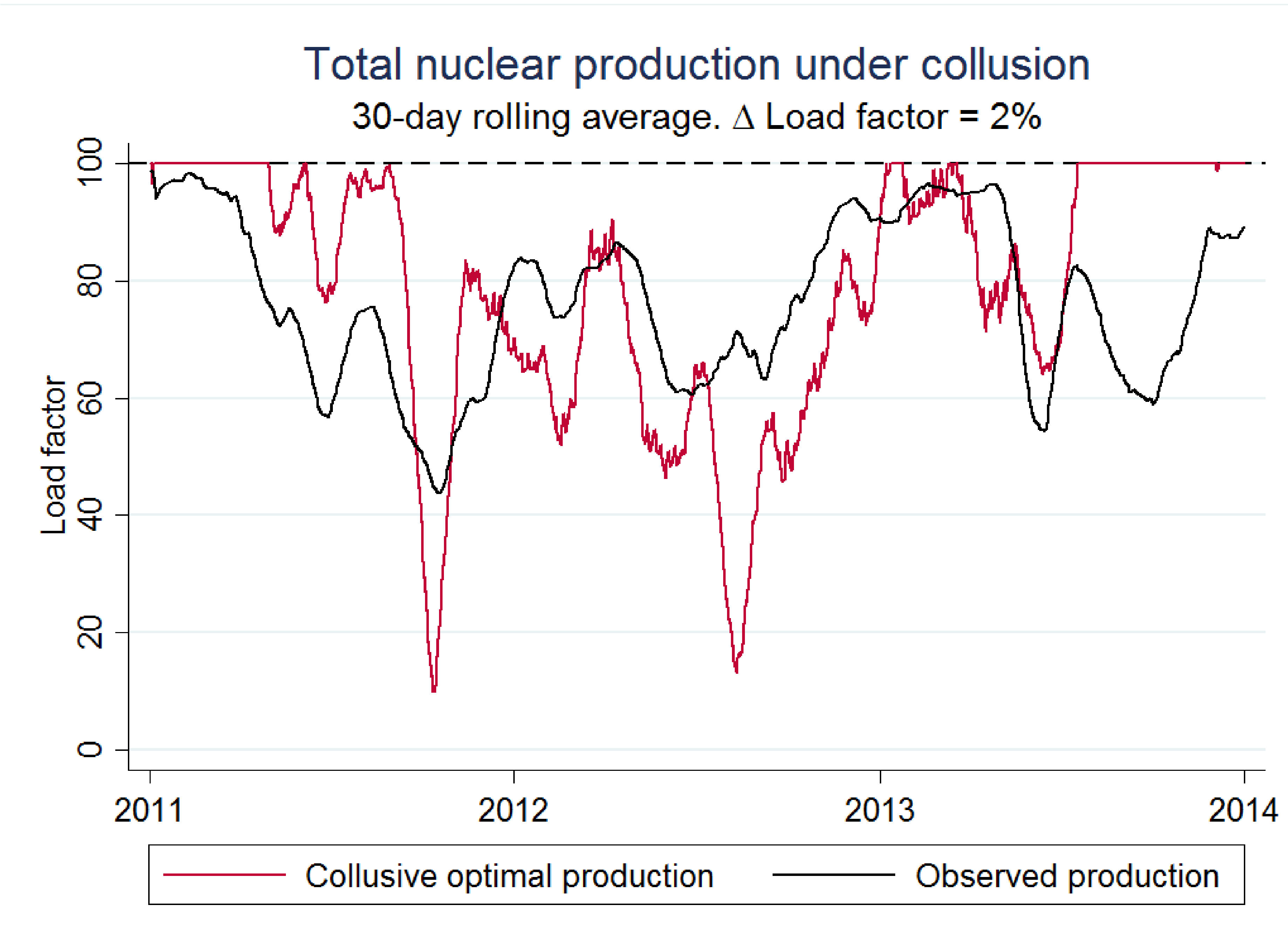
- The model of semi-collusion yields an average load factor of 78%, which (almost) coincides with data. However, much higher volatility than in data.

  Cournot average load factor is 95%, planner´s load factor is 98%.

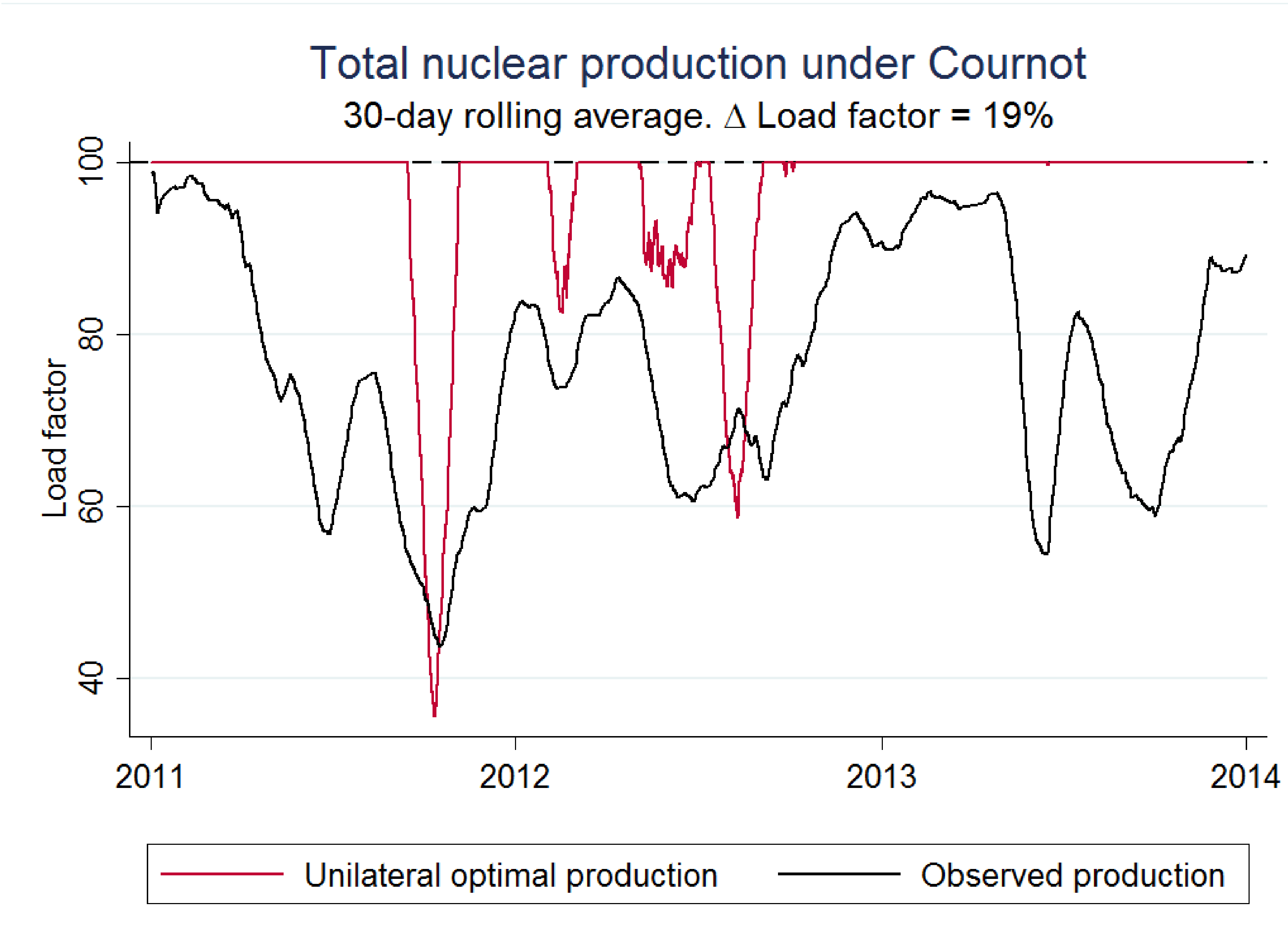
- Under a social planner, prices would have decreased by on average 12%.

- There is need for side payments to E.ON. However, E.ON is a large player in the German electricity market and will benefit from price increases through trade with the Nordic region. E.ON and Vattenfall also engage in other types of cooperation that could facilitate transfers.

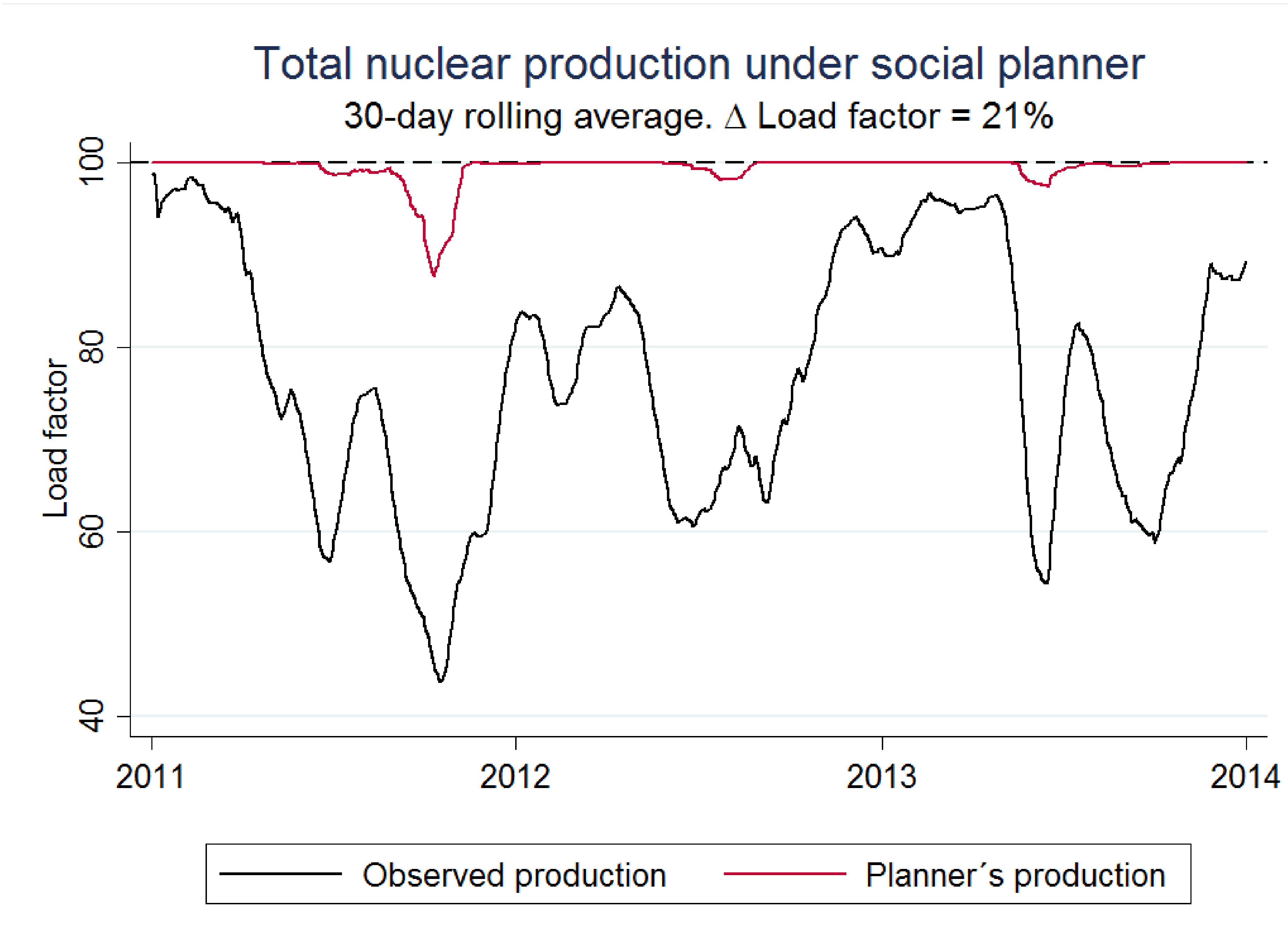
- Results are not so sensitive to the choice of marginal cost – but sensitive to the producers´ market share on non-nuclear production. If producers only own nuclear and nothing else, no model will generate incentives to exercise market power.



Total nuclear production under collusion
30-day rolling average. Δ Load factor = 2%
Load factor
0
20
40
60
80
100
2011
2012
2013
2014
Collusive optimal production
Observed production



Total nuclear production under Cournot
30-day rolling average. Δ Load factor = 19%
Load factor
100
80
60
40
2011
2012
2013
2014
Unilateral optimal production
Observed production



Total nuclear production under social planner
30-day rolling average. Δ Load factor = 21%
Load factor
100
80
60
40
2011
2012
2013
2014
Observed production
Planner´s production

Discussion

- We have shown that there are economic incentives to withdraw nuclear capacity in order to increase the spot price.
- Unilateral incentives to withdraw capacity are largely negligible, while a model of semi-collusion replicates data relatively well.
- Effect on short-term allocative efficiency is not so large due to an inelastic demand.
- However, nuclear production will be replaced by expensive fossil-based thermal plants so there is an effect on productive efficiency (and also emissions, if neglecting EU ETS effects).
- Large redistribution of welfare from consumers to producers.

THE END

THANK YOU FOR LISTENING!