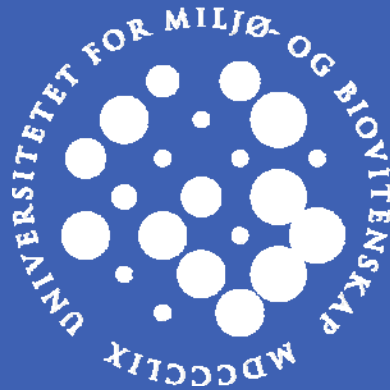


Time Regularities in Electricity Pricing: Potentials for Profitable Arbitrage; New Technologies; and Reduced Volatility?

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Halden, May 19, 2008



Efficient markets

- Spatial and inter-temporal price differentials beyond transportation and transaction costs, cost-of-carry, and risk
..... are arbitraged away

“The Law of One Price”

Electric power – no ordinary commodity

- Once produced, must be consumed
- Can only be stored in the form of another energy carrier:
- Water in the reservoir
- Hot water
- Hydrogen
-

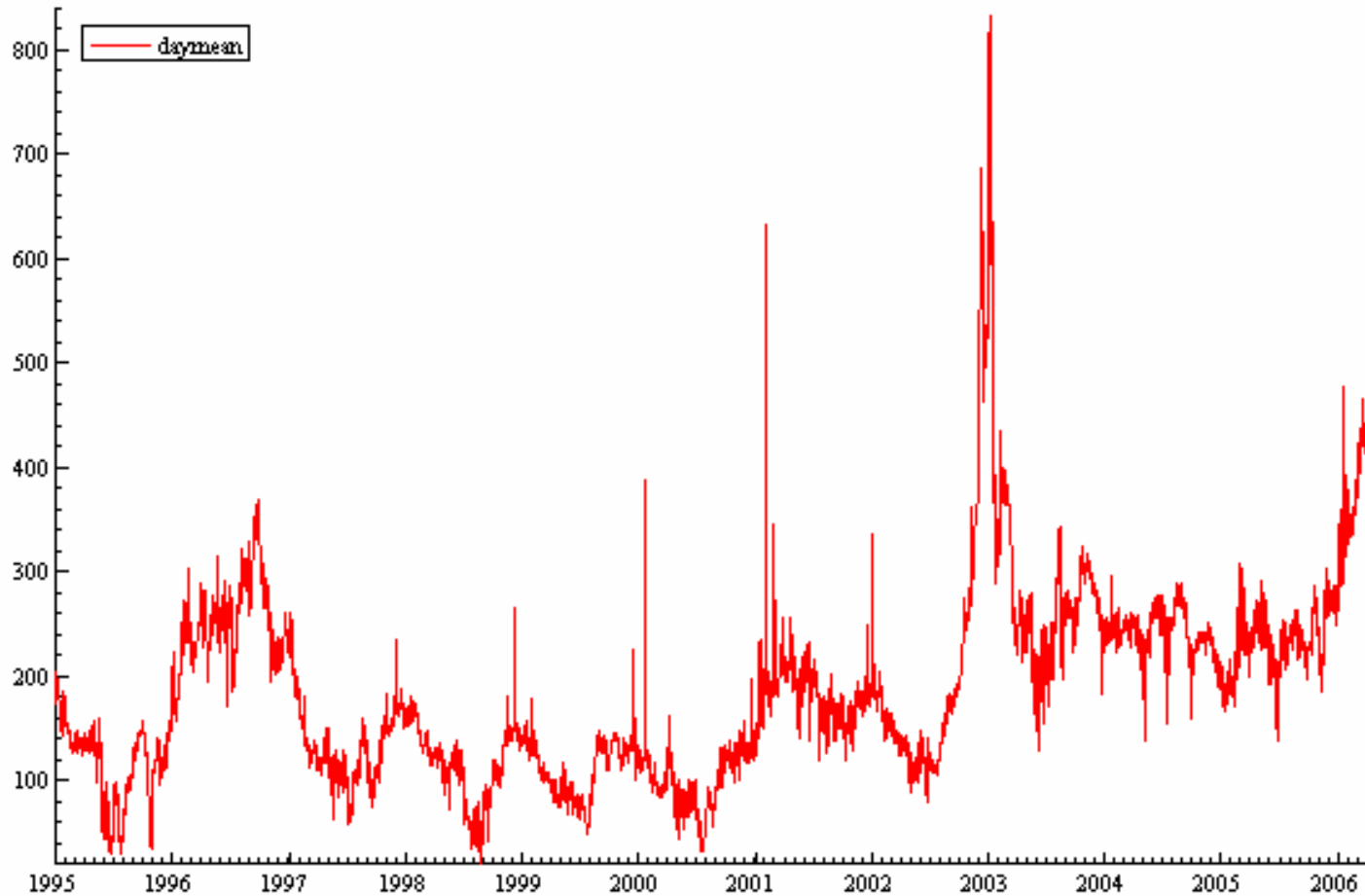
Electricity consumption: Systematic variations over time

- Shifts in demand are time systematic and partly predictable
- Season of the year
- Day of the week
- Time of the day
- Inelastic supply – shifts in demand cause great changes in price
- Price changes are partly predictable

Is the power market rational and efficient?

- Everyone knows that the electricity price Monday morning is generally higher than the price Sunday night.
- Does everyone know how much higher?
- Are the Monday and other price peaks or troughs within arbitrage limits, or is there a free lunch?
- Is the market informationally and technologically efficient?
- Are there technologies that may profit from the observed regularities?
- Should the observed regularities initiate changes in consumer behavior?

Daily electricity (spot) prices Jan 1, 1995 – Dec 31, 2006



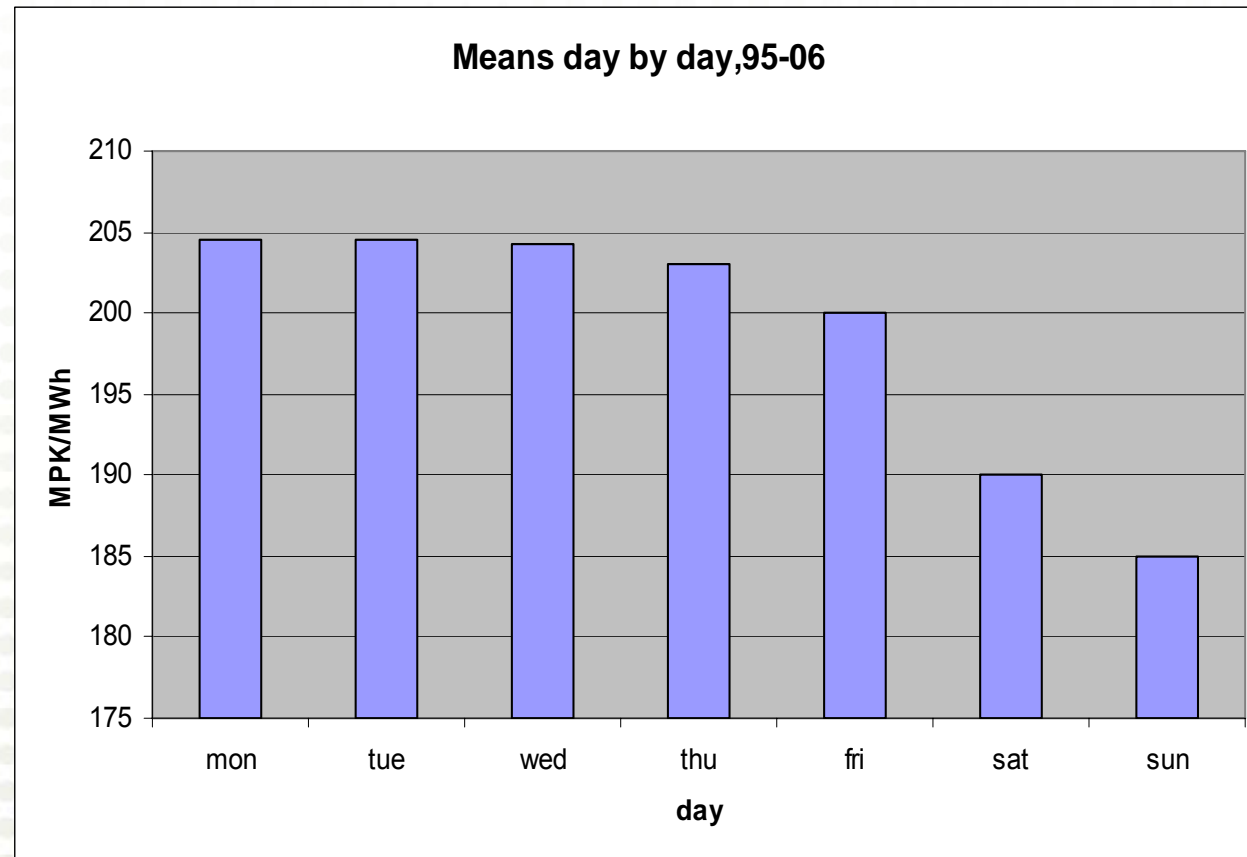
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Volatility in the power market

- Electricity prices, due to the inelastic supply, are extremely volatile
- 1995-2006: $\sigma(\text{el}) = 62\%$ vs $\sigma(\text{oil}) = 31\%$
- Part of the volatility is time systematic and predictable
- Is the volatility still excessive?
- Can the volatility be reduced?

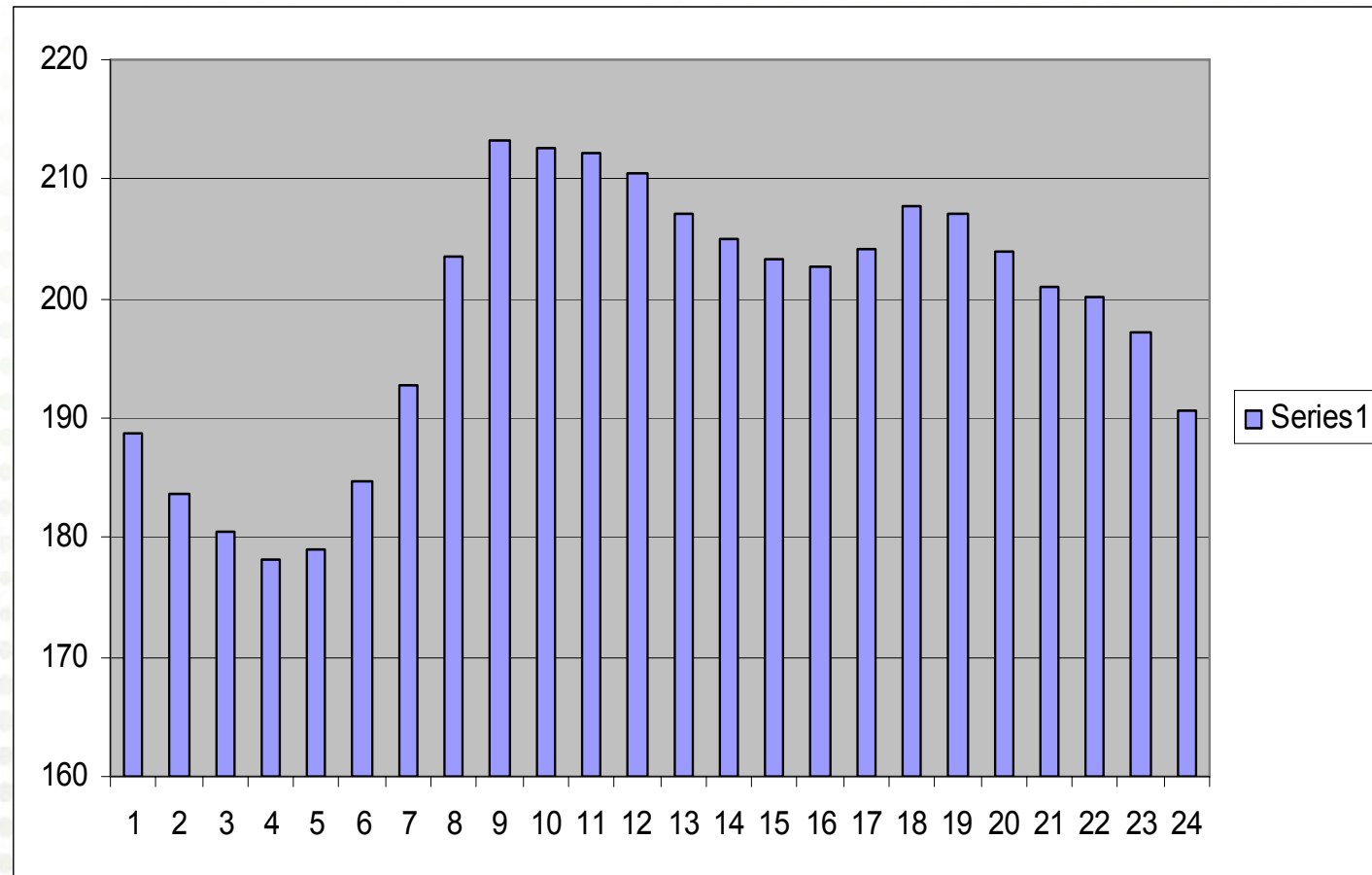
Day-of-the-week regularities



Day-of-the-week regularities

- 1995-2006:
- Sunday to Monday: +11,2% mean
- Thursday to Friday: -1,8%
- Friday to Saturday: - 6,3%

Time-of-the-day regularities



The five to nine jump

- 1995-2006:
- Five – to –nine o'clock:
- +19,1%, all days
- +27,8%, Mondays
- In 4,384 days, the price at 0500 has been higher than the price at 0900 only 204 times

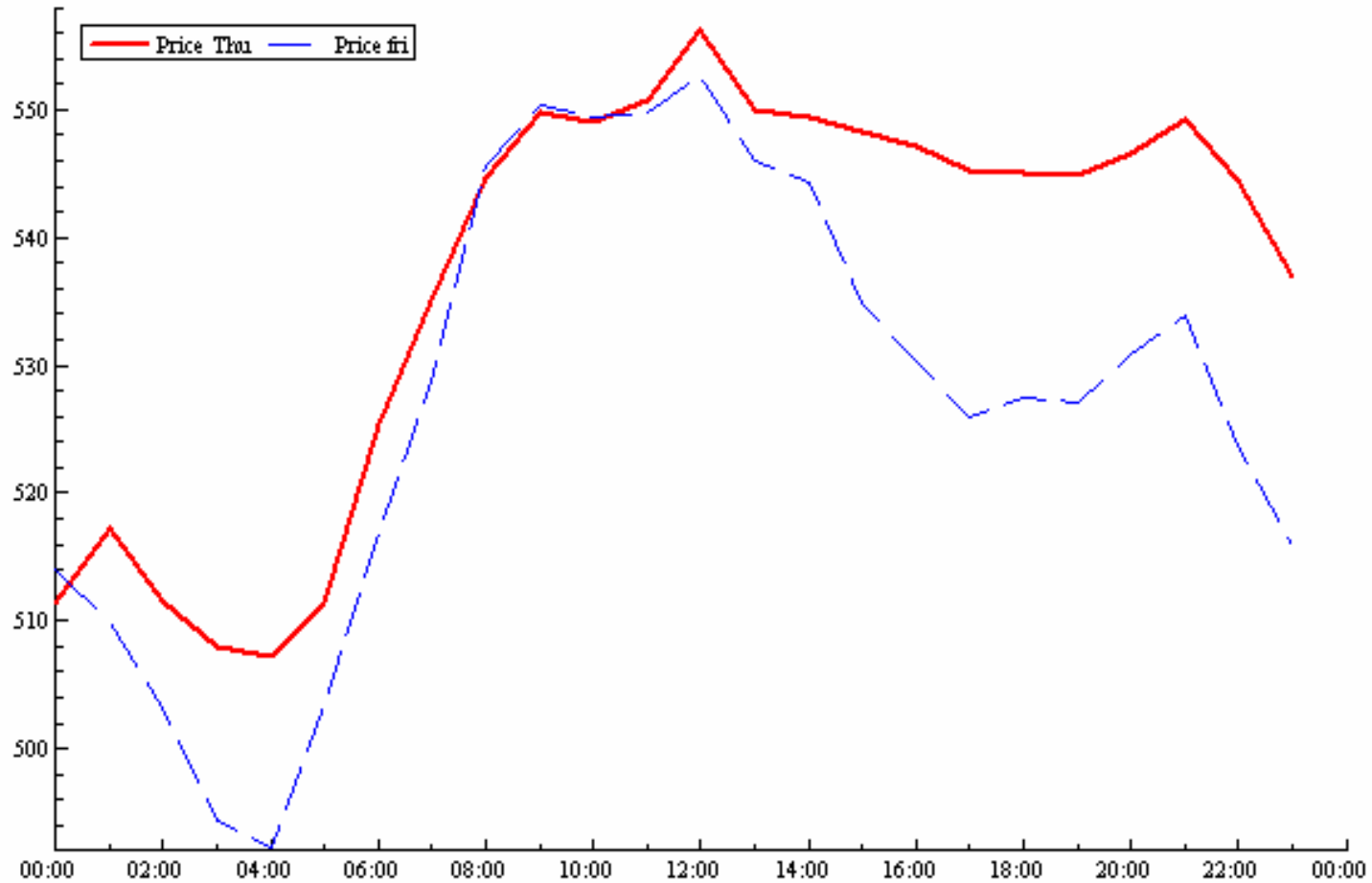
The start-of-the-week-end-effect Price changes 1995-2006 = 626 weeks

	Positive	Negative
Fridays	31,8%	68,2%
Thursdays	50,3%	49,7%

When does the week-end start?

- Friday 0900 = Thur 0900 = Wed 0900
- Friday 1500 \neq Thursday 1500
- The week end starts approx at Friday 1400. Then the price on Fri on average drops to 0,96-0,97 of the price the same time of the day on Thursday
- The week-end starts earlier now than a few years ago. A continuous process?

A randomly chosen Thursday and Friday in Sept 06



Tentative and preliminary conclusions

- Arbitrage opportunities *may* exist
- Investments in more flexible technologies both on the demand and the supply side may prove profitable
- Incentives for changed consumer behavior should be developed
- New technologies and changes in consumer behavior most likely will reduce price volatility