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An experimental study of investment incentives mechanisms in the electricity industry

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On incentives to invest

- Inefficient investment in generating capacities
  - The "resource adequacy" problem [De Vries (2004)]
  - The problem of peaking capacities
- Inadequate market price signals
  - Short term spot market prices
    - Not high enough to cover operating and capital investment costs
    - Too volatile to secure revenues
  - Long term forward market prices
    - Too low to generate new investments
    - In markets not liquid enough
  - "Missing money" problem [Cramton and Stoft (2006), Joskow(2006)]
- Uncertainty about future regulation

On market design issues

- What « rules of the game » in wholesale markets to generate efficient incentives to invest?
  - Administrative rules
    - Tendering (France, Germany, Portugal Directive 2005/89/CE)
    - Public procurement through bilateral contracts (Norway, Sweden)
    - Public procurement through ownership (Sweeden, Finland)
  - Market mechanisms
    - Capacity payments (UK Pool, Spain, Argentina, Peru, Chili, Colombia, NZ, Italy)
    - Capacity obligation with exchangeable rights (PJM, NY, New England)
    - Forward Capacity contracts (New England, USA)
      - Joskow (2006) Cramton, Stoft (2006)
    - Reliability option (not yet applied).
      - Vasquez et al. (2006), Oren (2005)

Research question

- How "Energy-only" market and "Forward Capacity Market" mechanisms perform in terms of private incentives to invest in peak load capacities?
  - "Energy-only" mechanism (All Market, AM) relies on market price signals to generate investments
  - "Forward Capacity Market" mechanism (FCM) relies on a dedicated reserve market for generation capacities

Method

- Experimental Two-by-two treatment

Market mechanism Market structure	Energy only markets (AM)	Forward Capacity Market (FCM)
Symmetric (Sym)	1 session 20 observations	6 sessions 89 observations
Asymmetric (ASym)	4 sessions 88 observations	3 sessions 45 observations

- Experienced subjects, 3 hours sessions, REGATE software

Experimental design

- Market structure

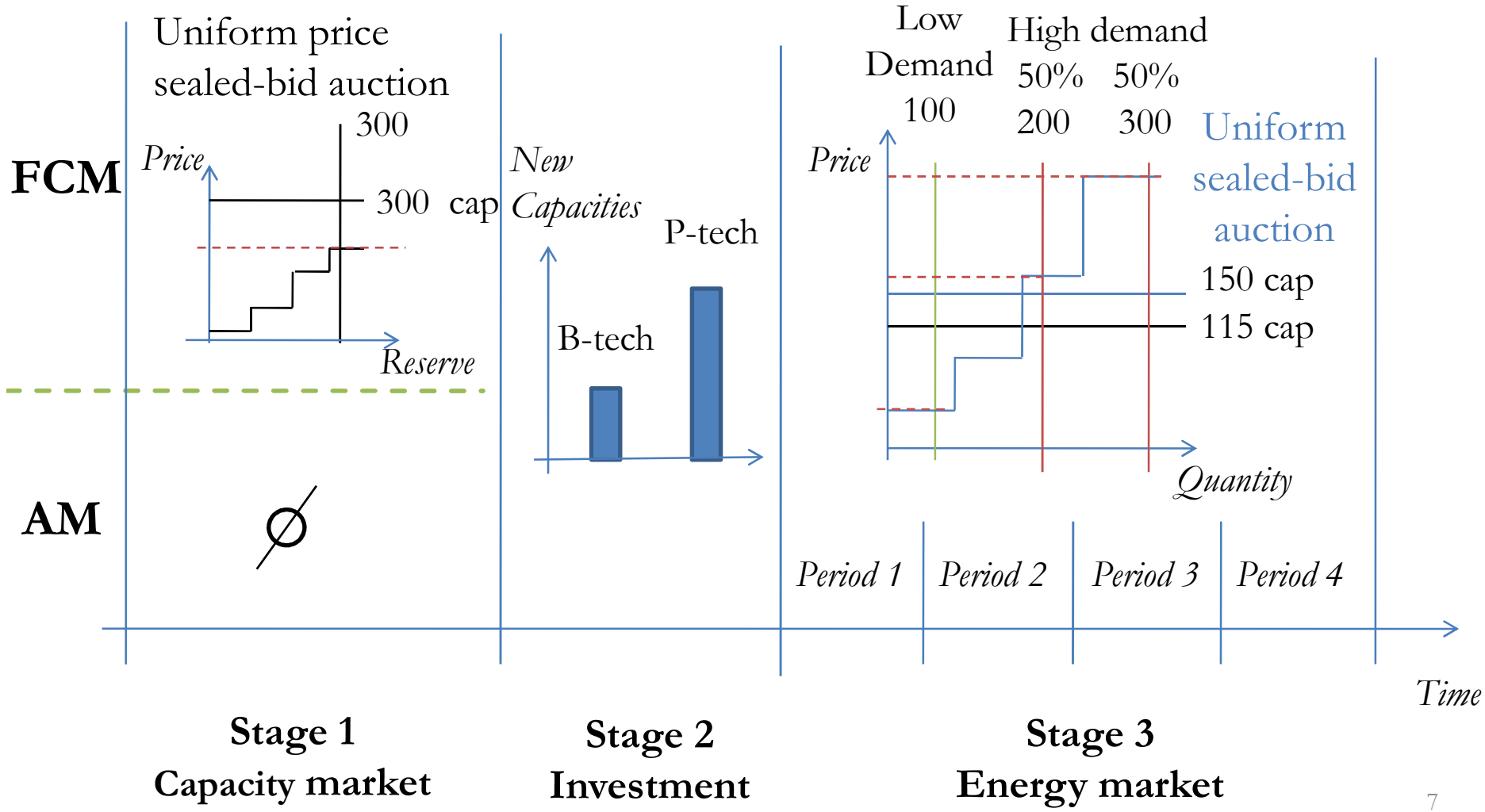
	Sym		ASym	
Generators	Base load	Peak load	Base load	Peak load
G1	30	10	120	40
G2	30	10	0	0
G3	30	10	0	0
G4	30	10	0	0

- Investment technologies

	Baseload B-Technology	Peak-load P- Technology
Fixed cost	300	100
Unit cost	$a_b q + b_b q^2$ $avec\ a_b = 0\ et\ b_b = 0{,}1$	$a_p q + b_p q^2$ $avec\ a_p = 80\ et\ b_p = 0{,}15$
Marginal cost	$2b_b q$	$2b_p q$

Experimental design

- Market mechanisms



Theoretical benchmark

- Closed-loop equilibria of the dynamic game

	FCM Sym	FCM ASym	AM Sym	AM ASym
Low Demand	100	100	---	---
Peak Demand	300	300	---	---
Total capacity	300	300	199	199
Total production in Base	100	100	100	100
Total production in Peak	200	200	199	199
Total Production in Extra Peak	300	300	199	199
Base Price	5	20	5	20
Peak Price	106	106	150	150
Extra peak Price	113.5	115	150	150
Commitment Subject 1	**75**	**195**		
Commitment Subject 2	**75**	**35**		
Commitment Subject 3	**75**	**35**		
Commitment Subject 4	**75**	**35**		
Investment Subject 1	75 (peak)	35(peak)	10(peak)	10(peak)
Investment Subject 2	75 (peak)	35(peak)	9(peak)	9(peak)
Investment Subject 3	75 (peak)	35(peak)	9(peak)	9(peak)
Investment Subject 4	75 (peak)	35(peak)	9(peak)	9(peak)

Results

Stage 1. Capacity market in the FCM treatment

- Result 1. Total commitment in capacities
- Result 2. Individual commitment
- Result 3. Capacity market prices

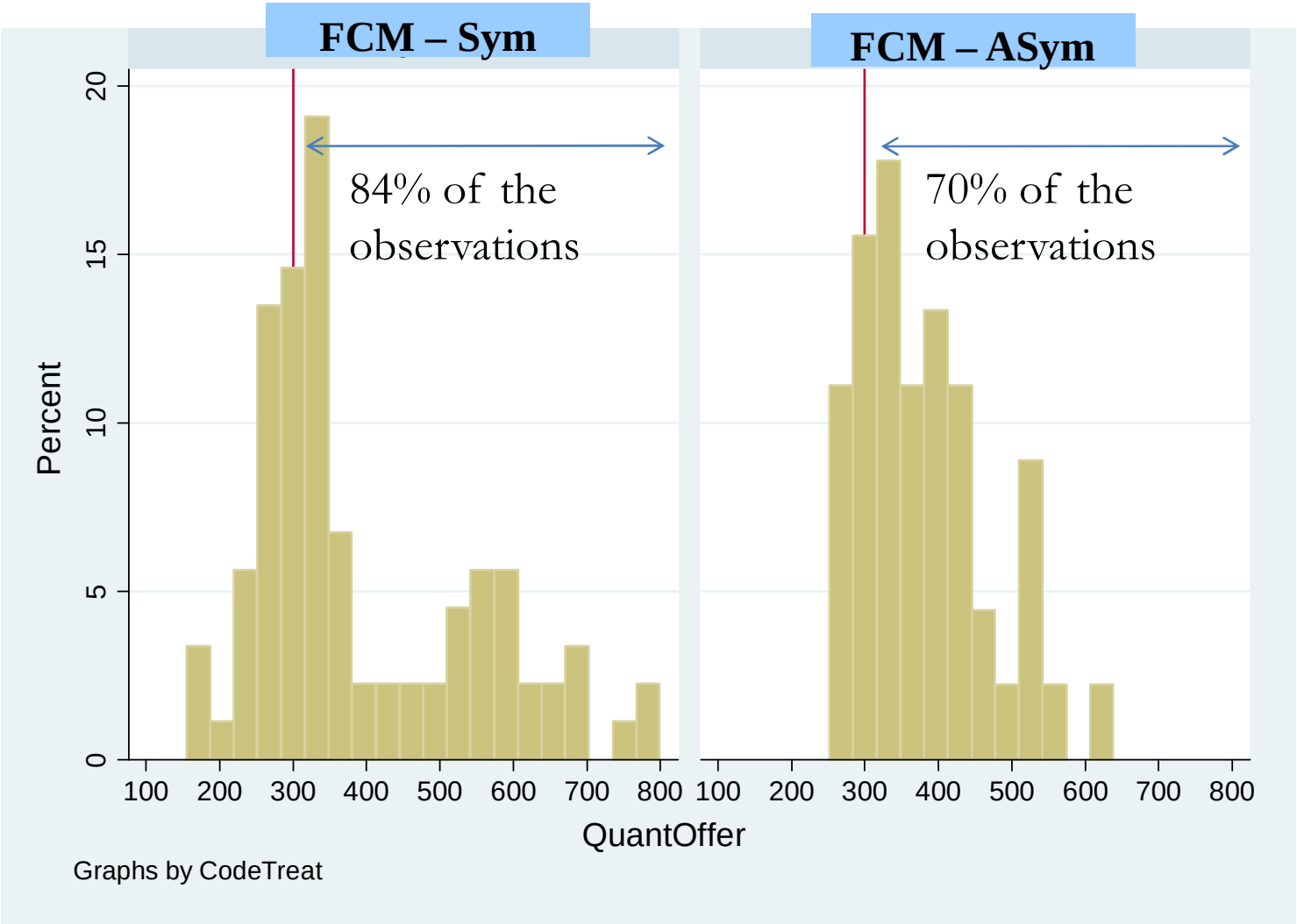
Stage 2. Investments

- Result 4. Level of investment
- Result 5. Technology choices

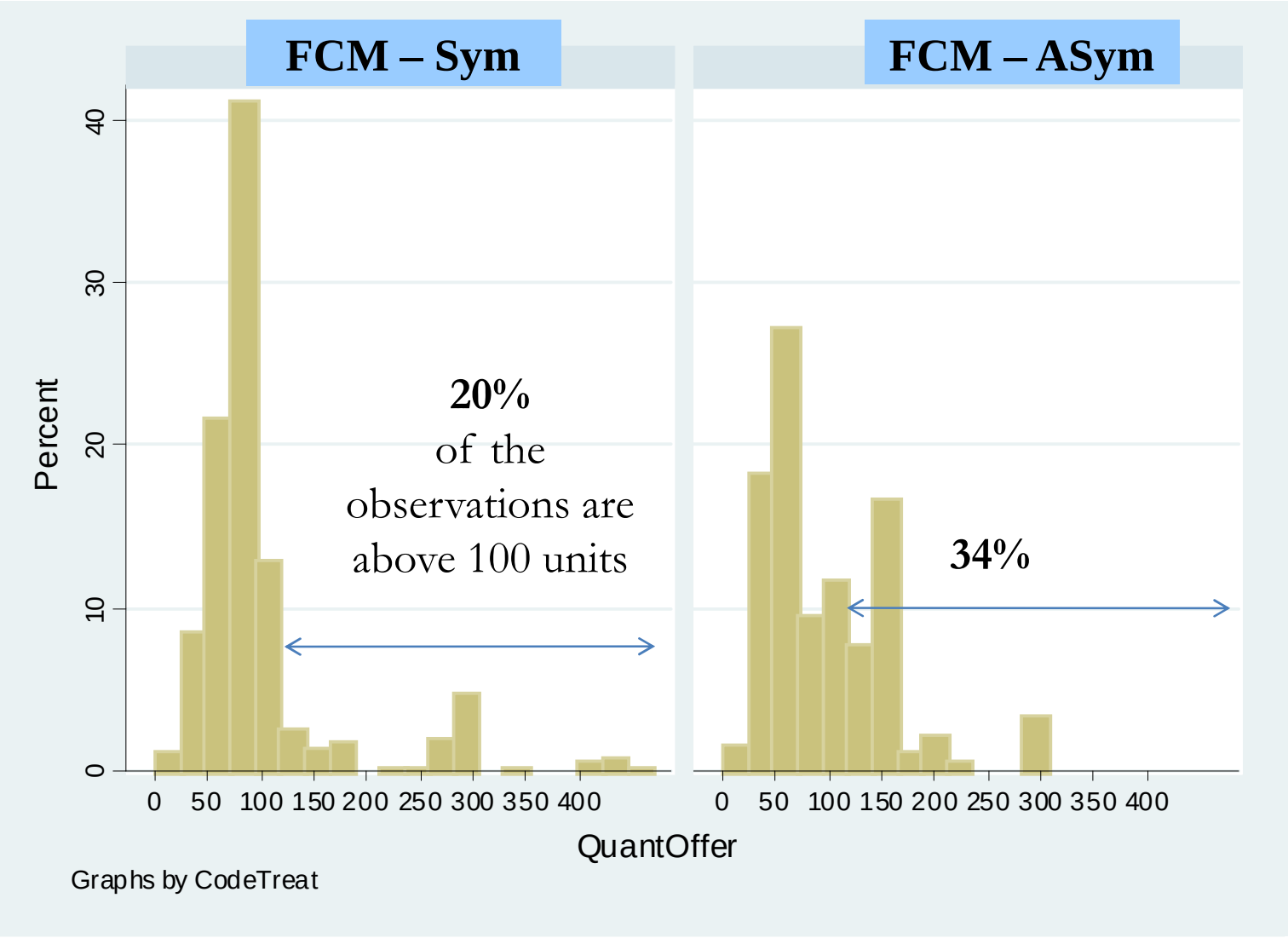
Stage 3. Energy market

- Result 6. Energy market prices

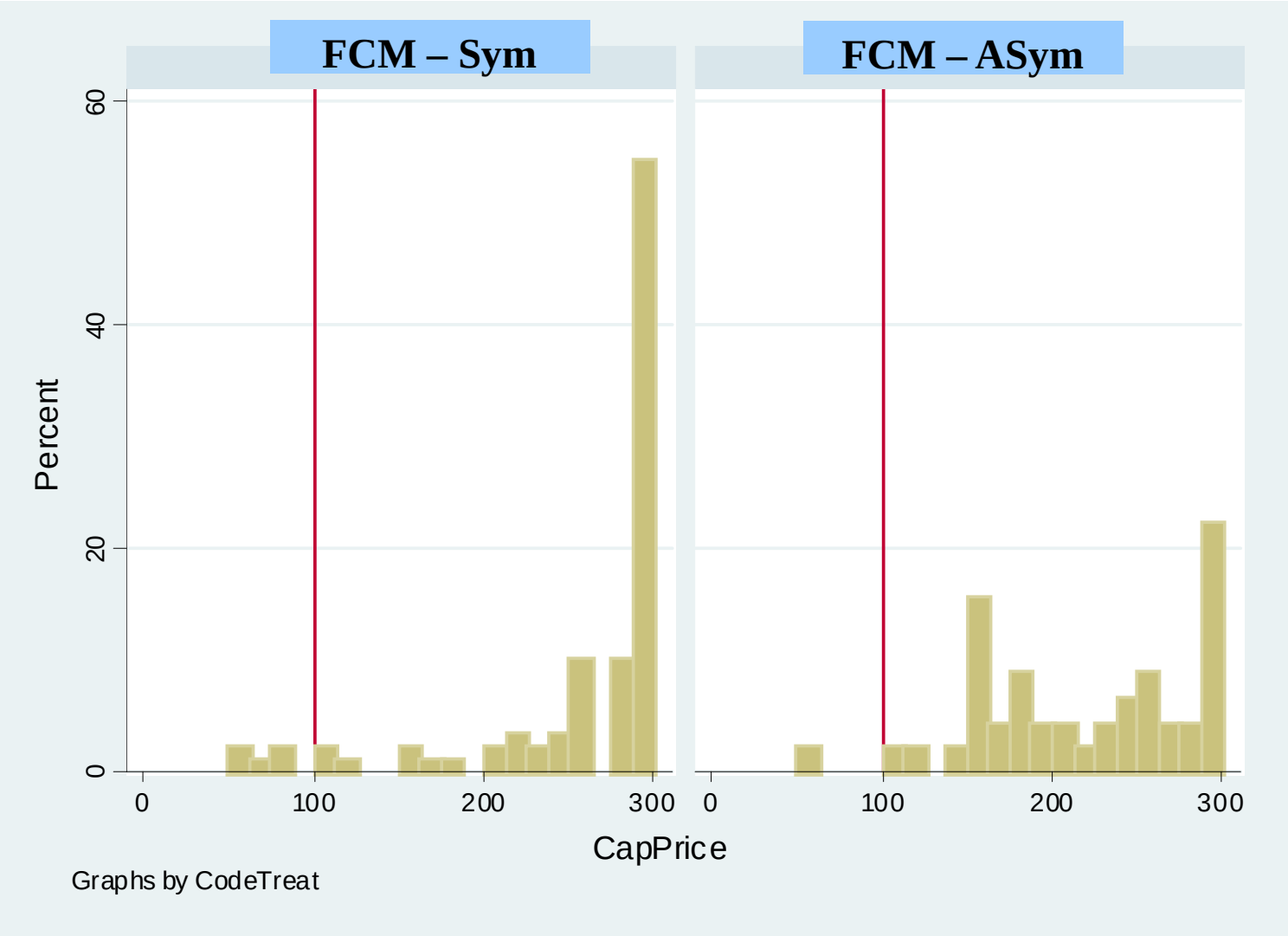
Result 1. The total generation capacity offered in the market is above the demand level.



Result 2. Producers seem to coordinate their individual offers on ¼ of the total demand (FCM-Sym).



Result 3. Reserve market prices are significantly above the expected competitive price (100) .



Result 4. Using the FCM mechanism leads to the sufficient level of investment

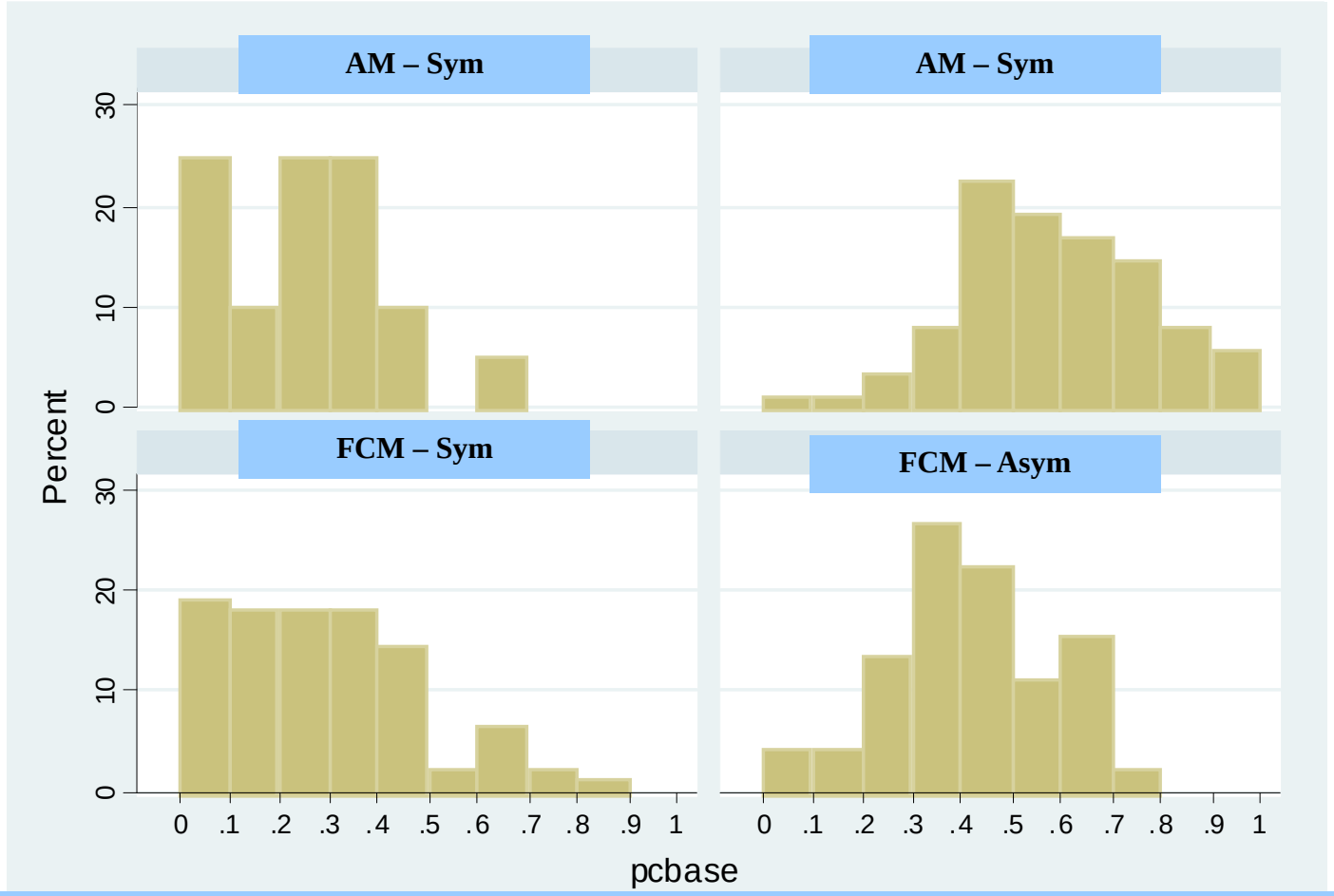
- Statistically significant underinvestment under the AM treatment

Frequency of failures to cover the levels of demand in energy market periods

	Low Demand	High Demand	Extra-high Demand
FCM-ASym	0%	0%	**13%**
FCM-Sym	0%	0%	**29%**
AM-ASym	0%	0%	**44%**
AM-Sym	0%	**15%**	**100%**

Result 5. Investments are not optimal in technologies

Producers invest in base load plants although they should only invest in peak load



Proportion of base load investments over total investment

Result 6. The FCM design leads to a significant reduction in market prices in peaking period

	Low demand	High demand	Extra high demand
AM Sym	**44.1** (14.5) *40*	**191.3** (77.9) *15*	**244.8** (27) *25*
AM ASym	**30.7** (33.5) *177*	**142.2** (84.2) *87*	**235.5** (33.7) *91*
FCM Sym	**26.9** (23.3) *178*	**86.2** (36.5) *97*	**136** (18.5) *81*
FCM ASym	**25.9** (27) *90*	**86.7** (29) *43*	**127.2** (20) *47*

Discussion

- Empirical evidence support the performance of the FCM
- Market design concerns: Strategic behaviors in the capacity market
  - Coordination of individual decisions on capacities: long term effect of collusion and market power
  - The effect of the price cap: What level? Steady or to be adapted over time? If adapted, how ? With what effect on individual and collective expectations? If no price cap, what alternative rule? How much are we (society) ready to pay to solve the resource adequacy problem? For how long?
- Investment issues : Choice of technology? Pattern of investment over time ?

Result 4. Using the FCM mechanism leads to the sufficient level of investment