

Structural versus Behavioral Measures in the Deregulation of Electricity Markets:

**An Experimental Investigation Guided by Theory and
Policy Concerns**

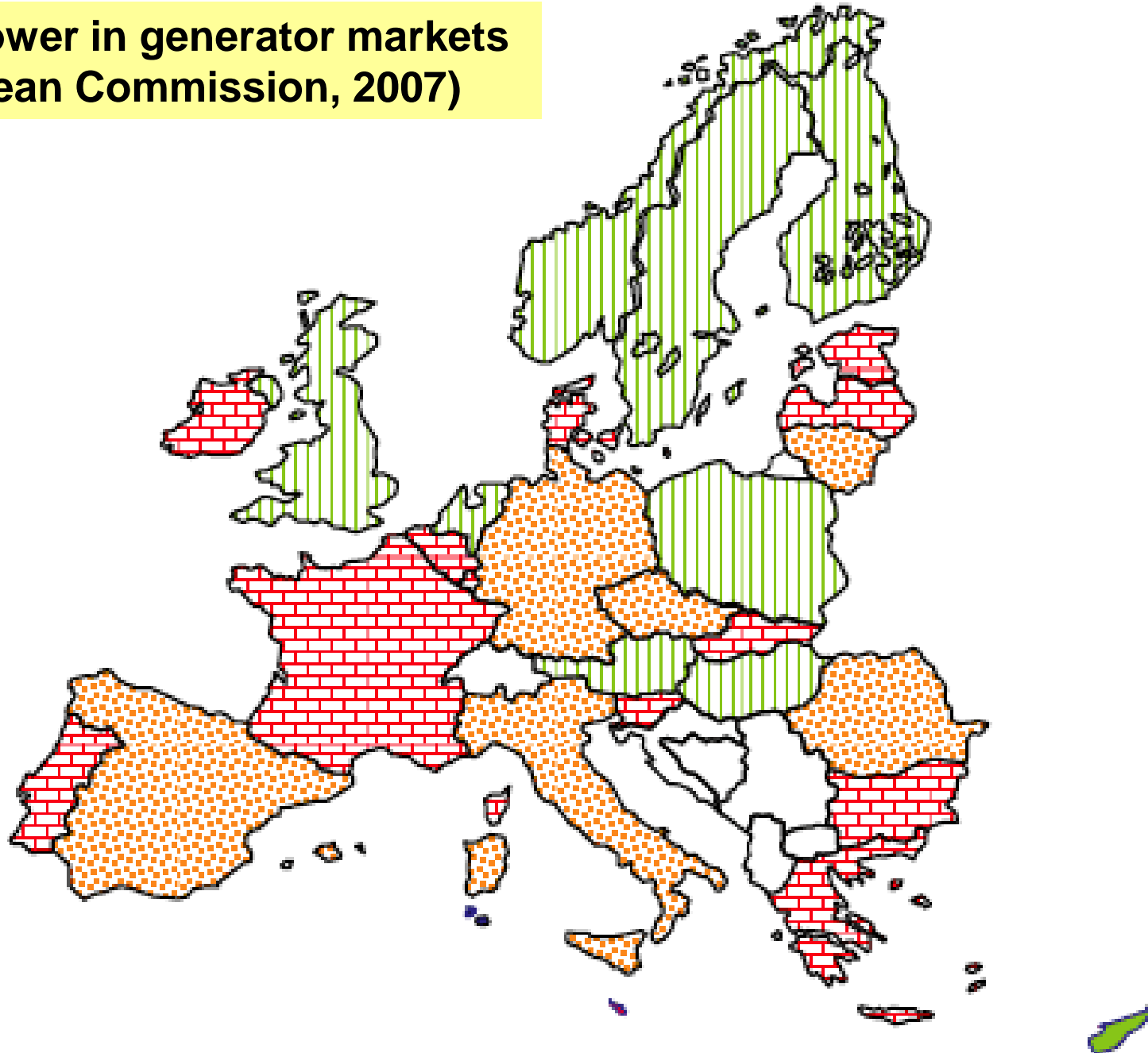
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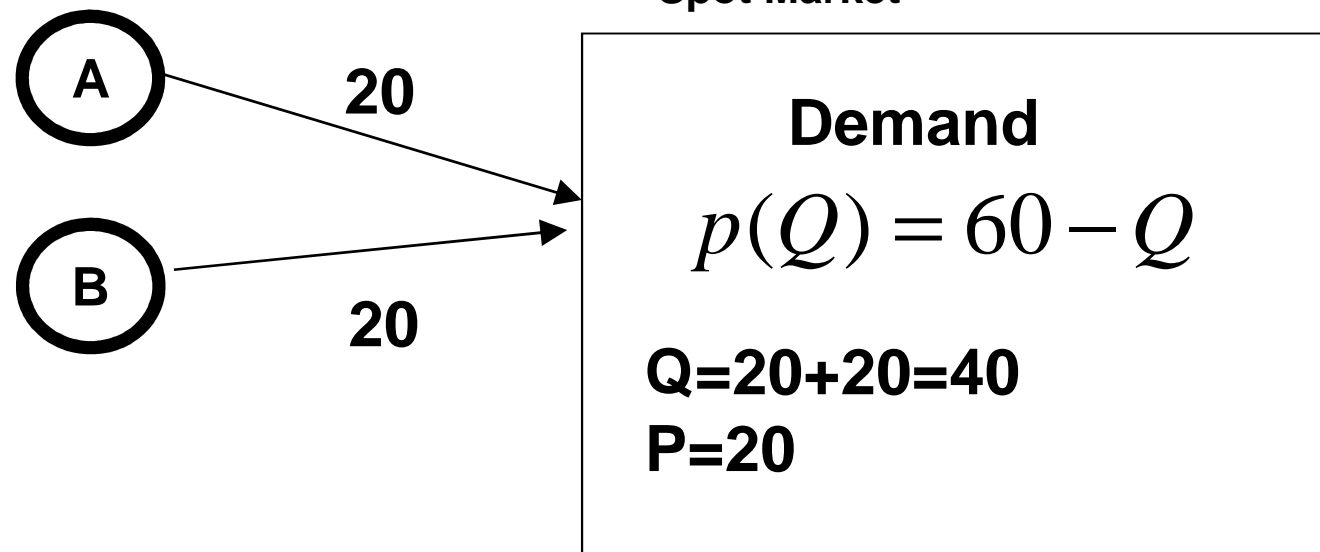
Loyola de Palacio

**Market power in generator markets
(European Commission, 2007)**



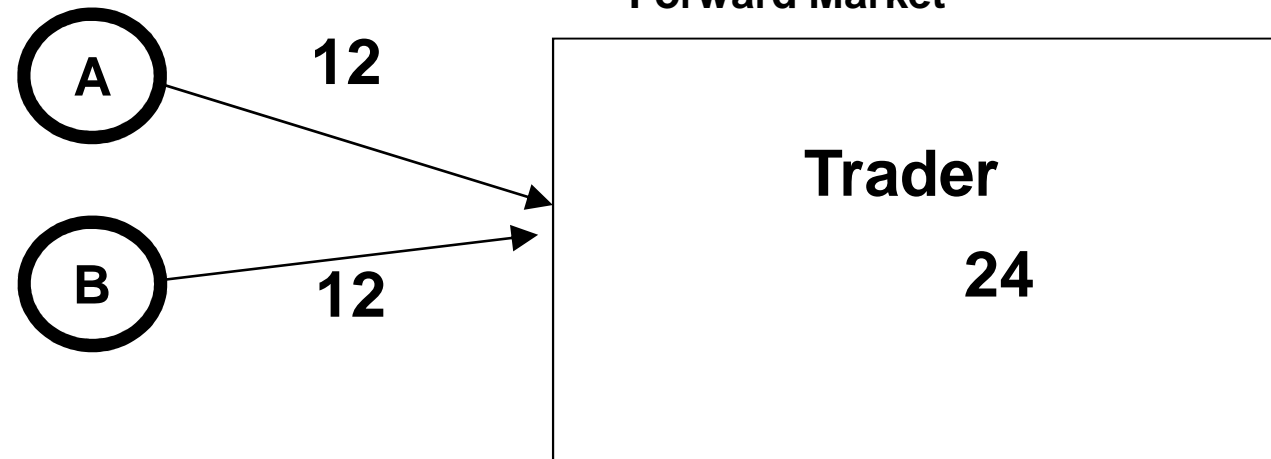
Week 5

Friday

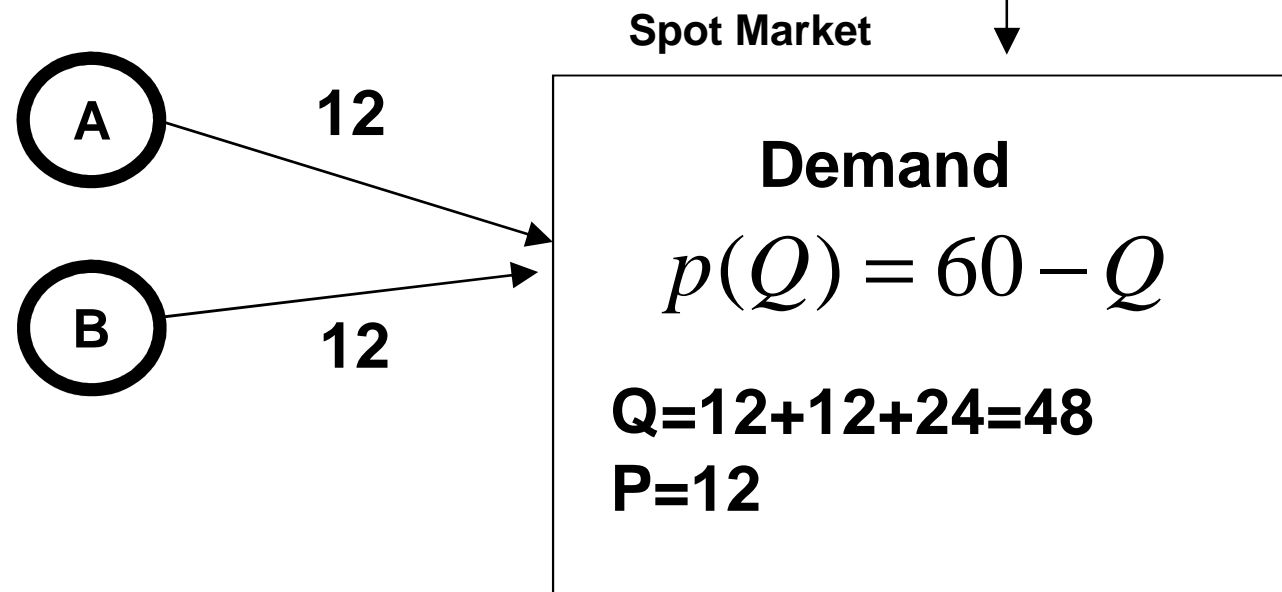


Week 5

Monday

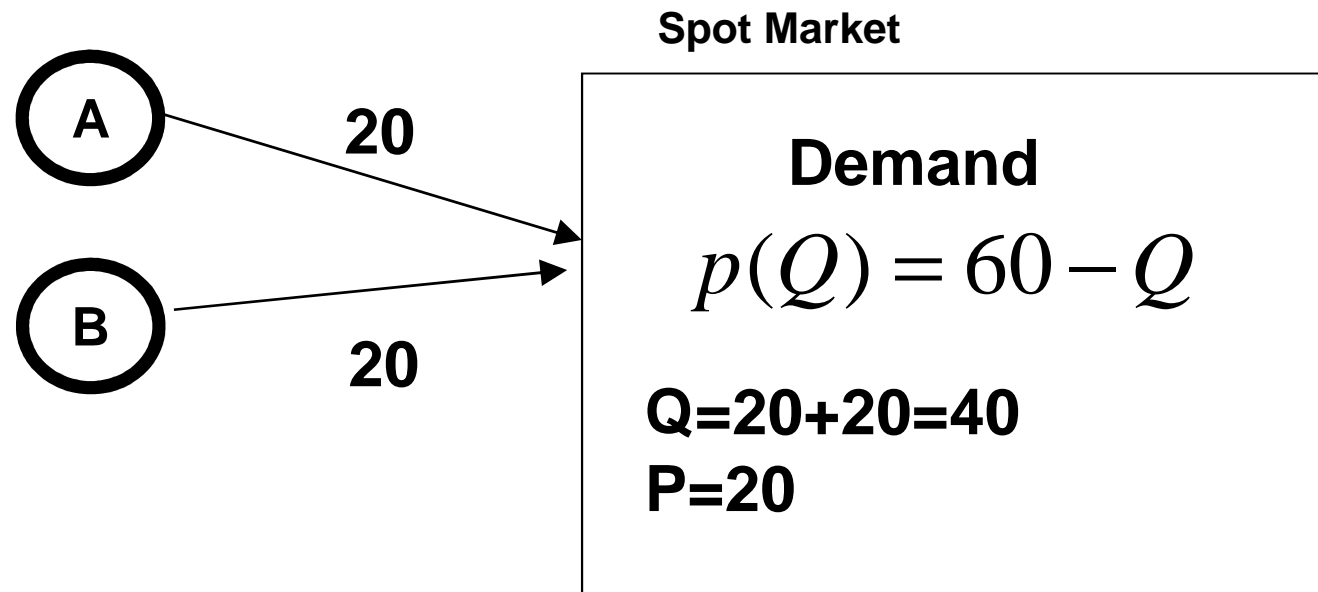


Friday



Week 5

Friday



Would this make a difference?

1. What has economic theory to say?

?

2. Can we trust economic theory?

?

3. Would this be a **significant & important** difference?

?

Demand Schedule $p[q_1 + q_2] = 60 - q_1 - q_2$

q_i Total Production (Forward + Spot)

f_i Production sold in Forward Market

$(q_i - f_i)$ Production sold in Spot Market

Spot Market Profit Function

$$\pi_1 = \underbrace{(60 - q_1 - q_2)}_{\text{Price}} \underbrace{(q_1 - f_1)}_{\text{Spot Market Production}}$$

First Order Conditions

$$60 - 2q_1 - q_2 + f_1 = 0 \iff$$

$$2q_1 = 60 - q_2 + f_1$$

$$\text{Reaction function } 2q_1 = 60 - q_2 + 15$$

$$f_1 = 0 \text{ \& } f_2 = 0$$

$$q_1 = q_2 = 20$$

$$p = 20$$

$$\pi_1 = \pi_2 = \text{\textcircled{€ 400}}$$

$$f_1 = 15 \text{ \& } f_2 = 0$$

$$q_1 = 30$$

$$q_2 = 15$$

Stackleberg equilibrium!

$$p = 15$$

$$\pi_1 = \text{\textcircled{€ 450}}$$

$$\pi_2 = \text{\textcircled{€ 225}}$$

$$f_1 = 15 \text{ \& } f_2 = 15$$

$$q_1 = q_2 = 25$$

$$p = 10$$

$$\pi_1 = \pi_2 = \text{\textcircled{€ 250}}$$

Nash-Equilibrium

$$f_1 = 12 \text{ \& } f_2 = 12$$

$$q_1 = q_2 = 24$$

$$p = 12$$

$$\pi_1 = \pi_2 = 288$$

Would this make a difference?

1. What has economic theory to say?

YES: Allaz & Villa (1993)

2. Can we trust economic theory?

?

3. Would this be a **significant & important** difference?

?

“2 are few and 4 are many” Huck et al. (JEBO 2004)

	2 Firms	3 Firms	4 Firms
Without Forward Market	M2 92.7%	M3 102.7%	M4 102.9%

“2 are few and 4 are many” Huck et al. (JEBO 2004)

	2 Firms	3 Firms	4 Firms
Without Forward Market	M2 92.7%	M3 102.7%	M4 102.9%
With Forward Market	M2F 80%? 100%?	M3F 92%? 110%?	—

Experiment

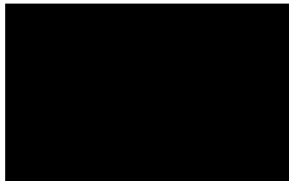
- Number of firms: 2, 3 & 4
- Demand schedule: $p(Q) = \text{Max}(0, 2000 - 27Q)$
- Costs: Steeply increasing marginal costs (Newbery, EER 2002).

$$\mathbf{c}_{M_2}[\mathbf{q}] = \frac{8}{27} \mathbf{q}^3 + \frac{2}{3} \mathbf{q}^2 + \frac{1}{3} \mathbf{q}$$

$$\mathbf{c}_{M_3}[\mathbf{q}] = \frac{18}{27} \mathbf{q}^3 + \mathbf{q}^2 + \frac{1}{3} \mathbf{q}$$

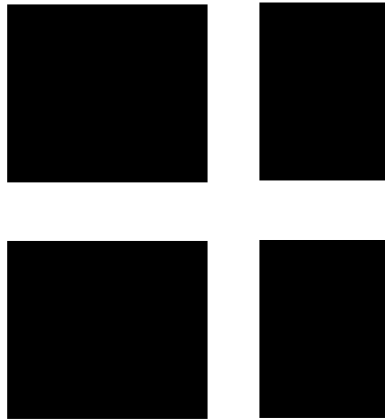
$$\mathbf{c}_{M_4}[\mathbf{q}] = \frac{32}{27} \mathbf{q}^3 + \frac{4}{3} \mathbf{q}^2 + \frac{\mathbf{q}}{3}$$

M2



M3

M2



M3

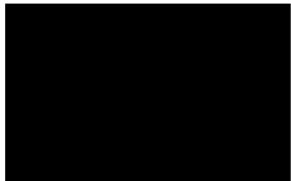
M2



M3



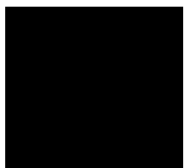
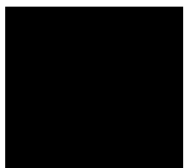
M2



M3



M3



M4

M2



M3



M3



M4

$$c_{M_2}[\mathbf{q}] = \frac{8}{27} \mathbf{q}^3 + \frac{2}{3} \mathbf{q}^2 + \frac{1}{3} \mathbf{q}$$

$$c_{M_3}[\mathbf{q}] = \frac{18}{27} \mathbf{q}^3 + \mathbf{q}^2 + \frac{1}{3} \mathbf{q}$$

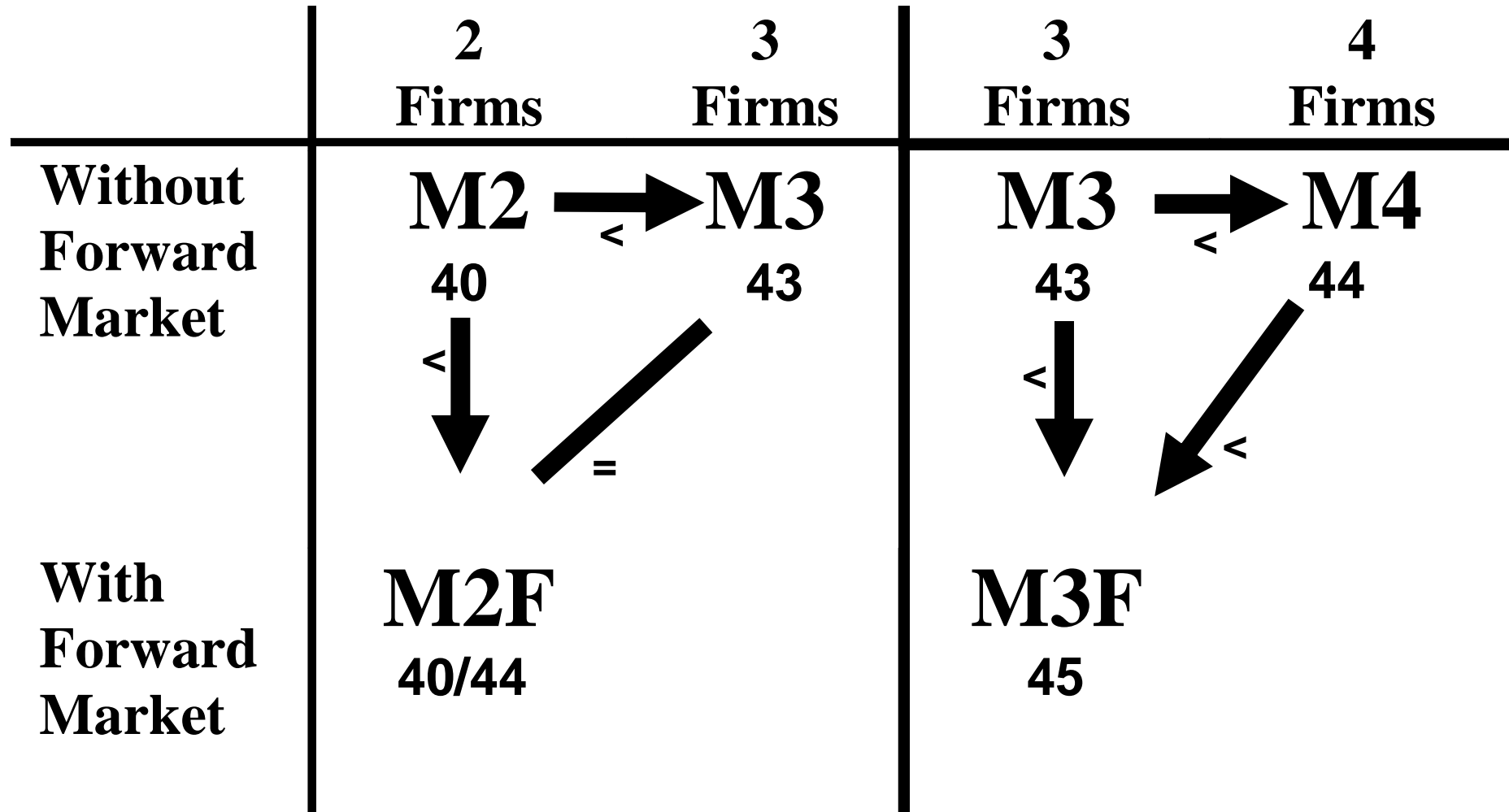
$$c_{M_4}[\mathbf{q}] = \frac{32}{27} \mathbf{q}^3 + \frac{4}{3} \mathbf{q}^2 + \frac{\mathbf{q}}{3}$$

$$c_{M_4}'\left[\frac{3}{4} \mathbf{q}\right] = c_{M_3}'[\mathbf{q}] = c_{M_2}'\left[\frac{3}{2} \mathbf{q}\right]$$

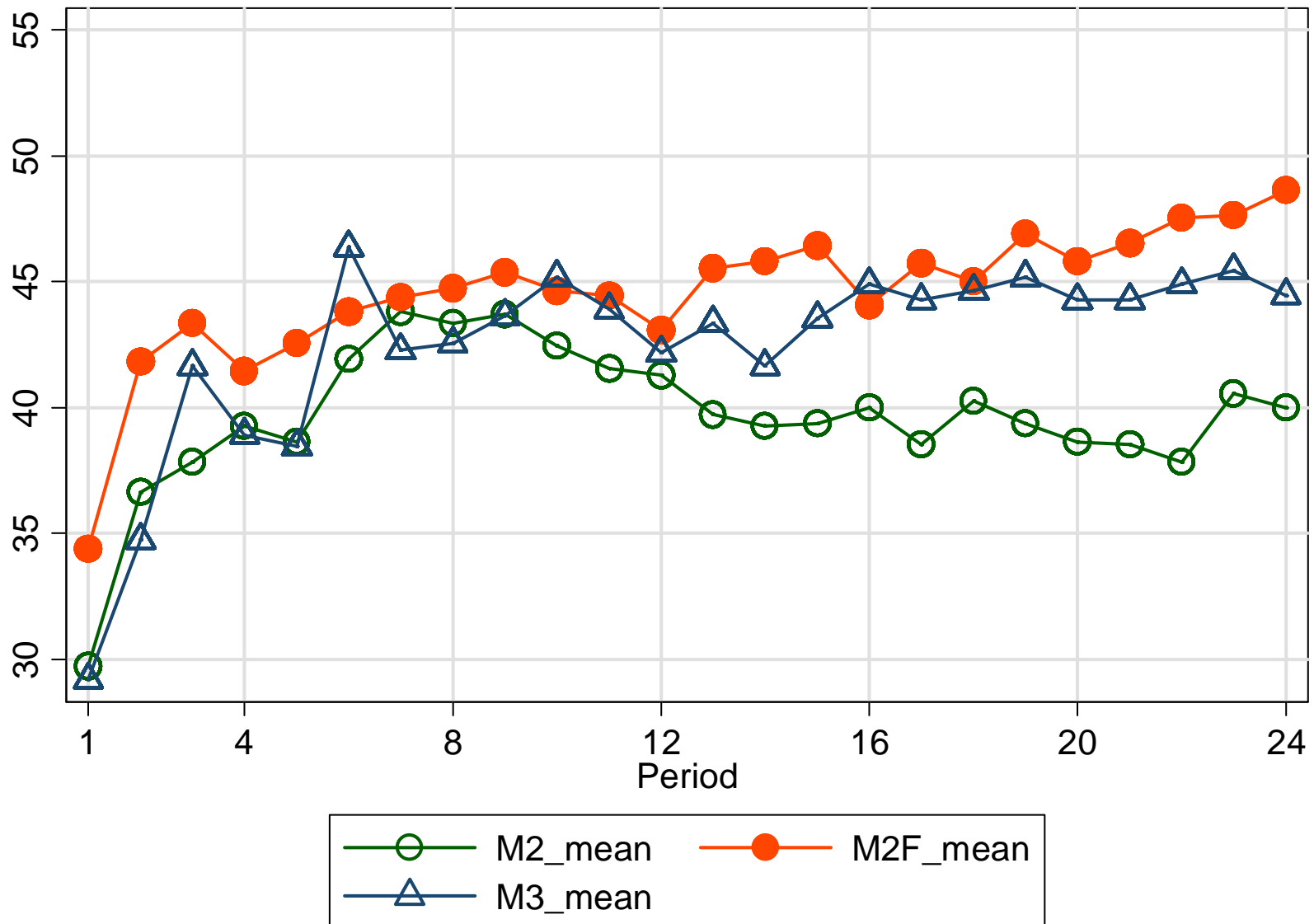
$$\Leftrightarrow c_{M_4}'[\mathbf{q}] > c_{M_3}'[\mathbf{q}] > c_{M_2}'[\mathbf{q}]$$

- Ran sessions in
 - October 2009, December 2009, April 2010
 - October 2010 as a robustness test
- 11 independent groups for each treatment
- In total 198 subjects
 - Prague business school, the economic institute and the Prague technical school
- Average Earning 350CKZ/hour = €14/hour
 - PPP: €20/hour
 - Minimum: 330 CKZ
 - Maximum: 1080 CKZ

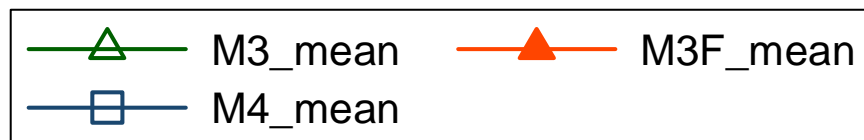
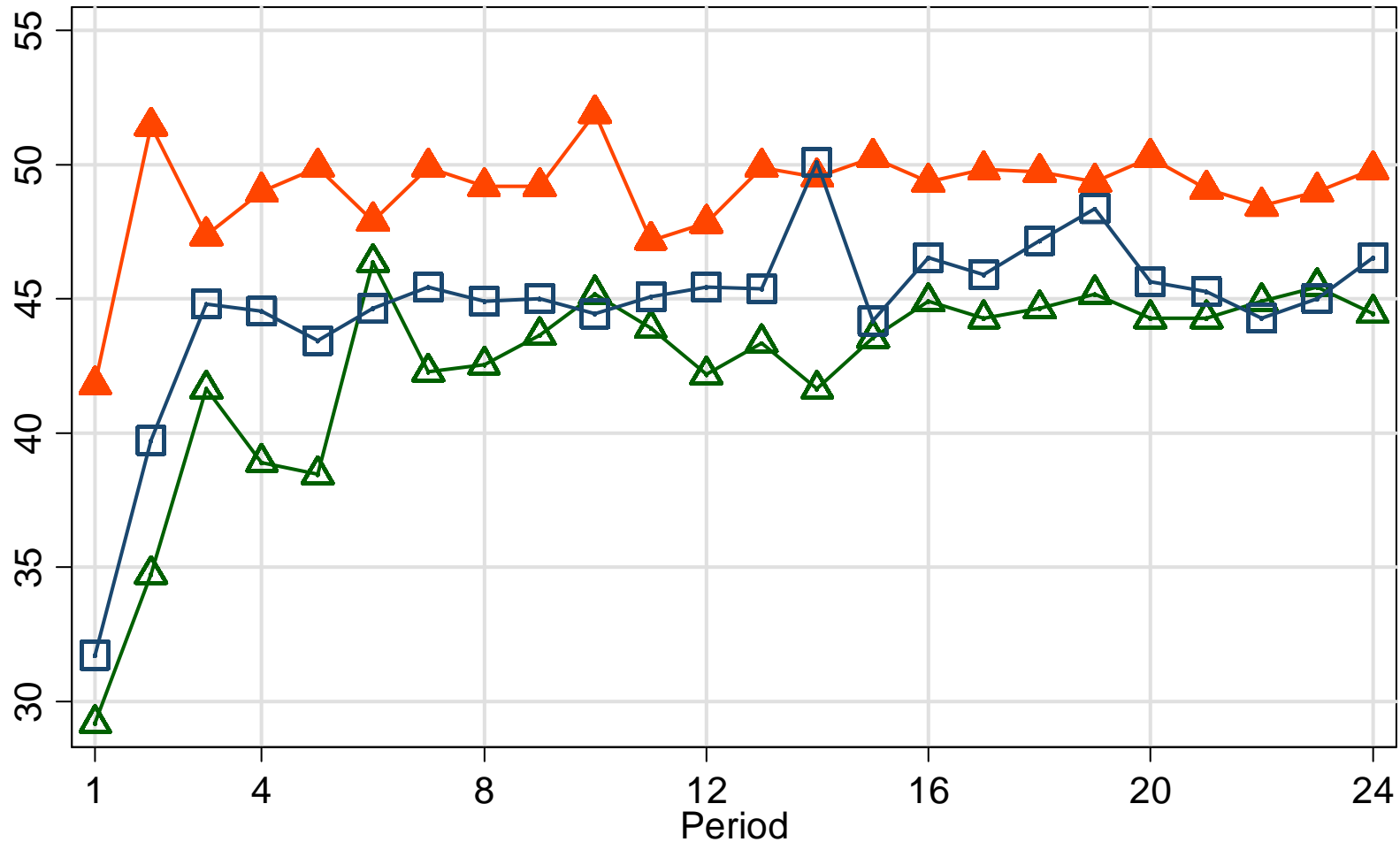
Theoretical predictions (following Allaz & Villa, 1993)



M2, M2F, M3



M3, M3F, M4



Averages

Standard errors based on groups (N=11)

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

Would this make a difference?

1. What has economic theory to say?

YES: Allaz & Villa (1993)

2. Can we trust economic theory?

**Yes, but the effect is stronger than predicted:
“2 are many and so are 3”**

3. Would this be a **significant & important** difference?

?

Results

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

Diagram illustrating the results of a market transition from "Without Forward Market" to "With Forward Market". The diagram is divided into two main sections: "Without Forward Market" and "With Forward Market".

Without Forward Market:

- 2 Firms: M2 (39.4, (1.51))
- 3 Firms: M3 (44.1, (1.26))
- 3 Firms: M3 (44.1, (1.26))
- 4 Firms: M4 (46.1, (1.01))

 Arrows indicate transitions: M2 → M3 (with <), M3 → M4 (with <), and a downward arrow from M2 (with <).

With Forward Market:

- 2 Firms: M2F (46.1, (2.12))
- 3 Firms: M3F (49.4, (0.64))

 Arrows indicate transitions: M2F → M3F (with <), and a downward arrow from M2F (with <).

Results

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

*** \rightarrow $<$ (M2 to M3, M3 to M4)
 *** \downarrow $<$ (M2 to M2F, M3 to M3F)
 *** \swarrow $<$ (M3 to M2F, M4 to M3F)
 $\tilde{p}=0.24$ (M2 to M3F)

Would this make a difference?

1. What has economic theory to say?

YES: Allaz & Villa (1993)

2. Can we trust economic theory?

**Yes, but the effect is stronger than predicted:
“2 are many and so are 3”**

3. Would this be a **significant & important** difference?

**Yes.
Especially important with 3 players**

4. Are these results robust for experienced players?

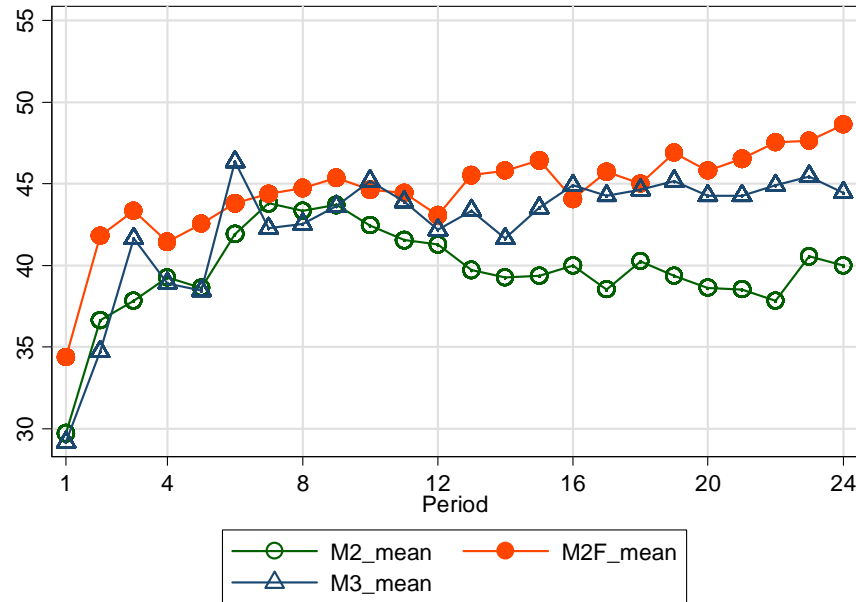
Are these results robust for experienced players?

Ferreira, Kujal & Rassenti, 2009

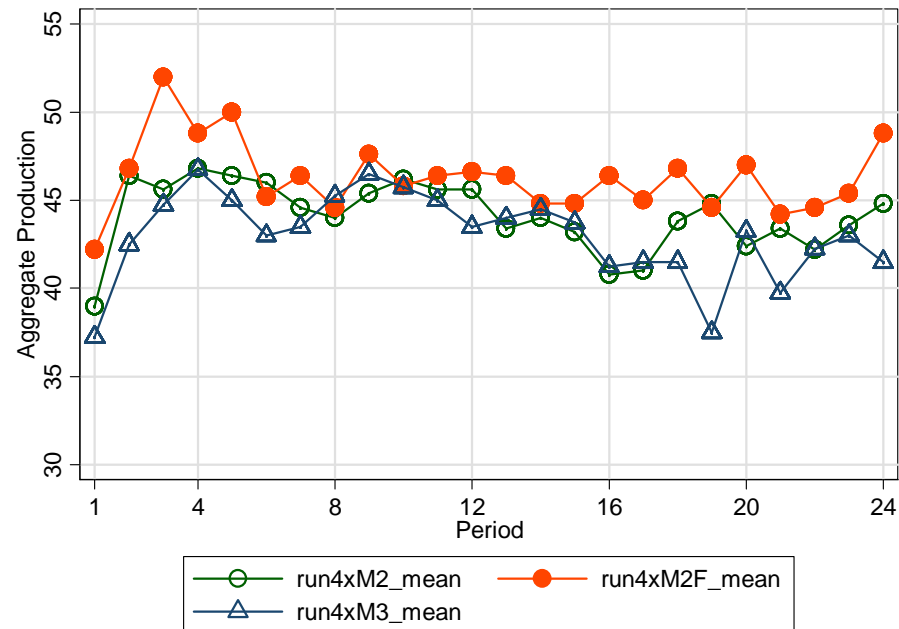
Forward Market	Observed		
	Predicted	Inexperienced	Experienced
2 firms	85.7	85.6	62.5
4 firms	89.1	99.9	76.8

Inexperienced

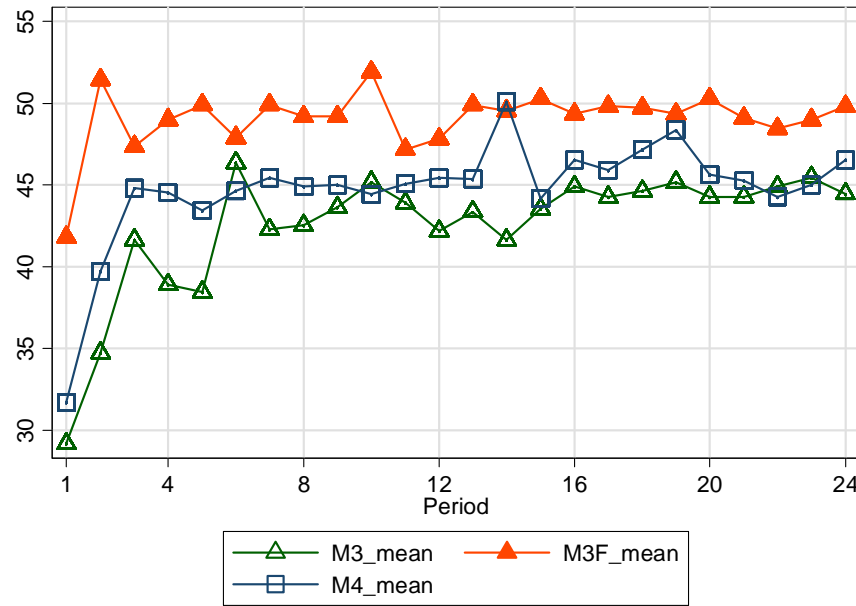
M2, M2F, M3



Experienced

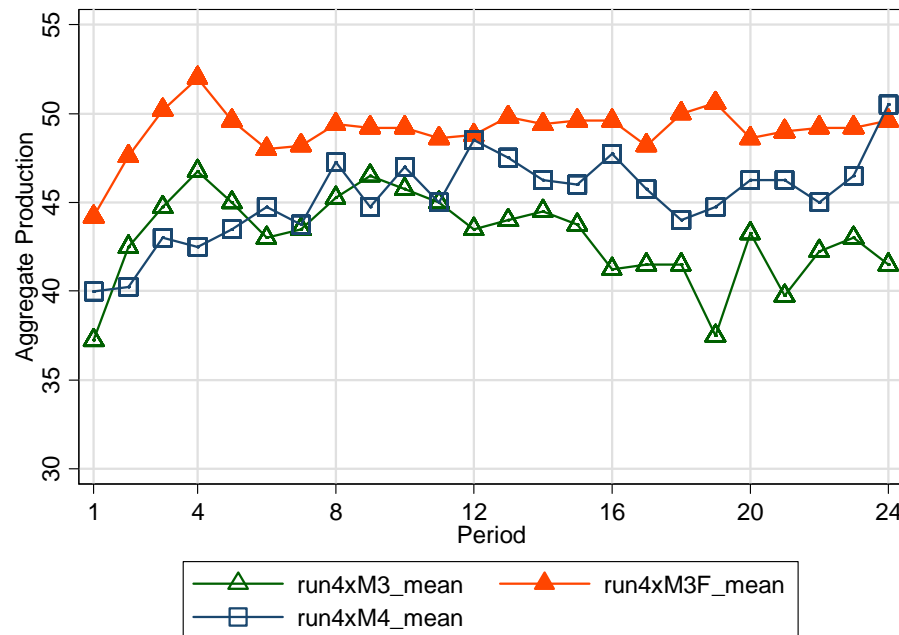


Inexperienced



M3, M3F, M4

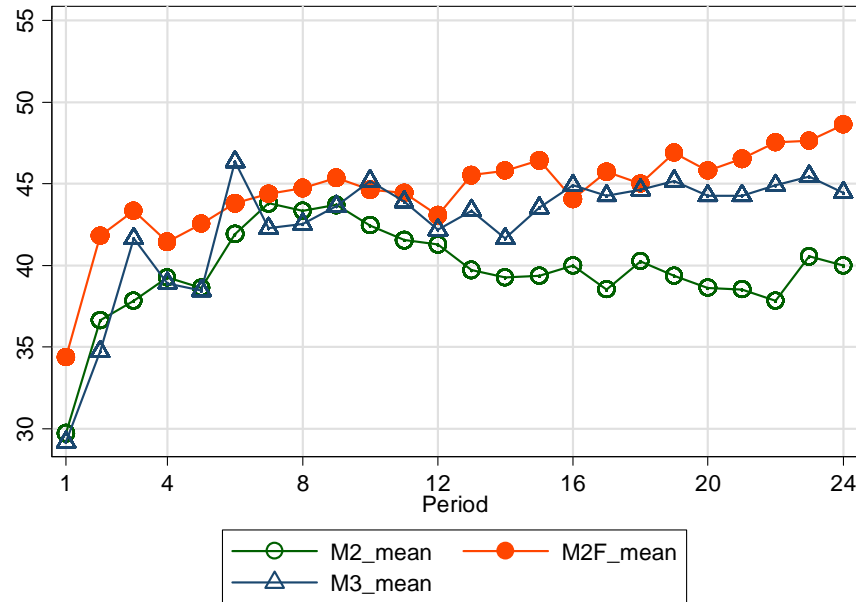
Experienced



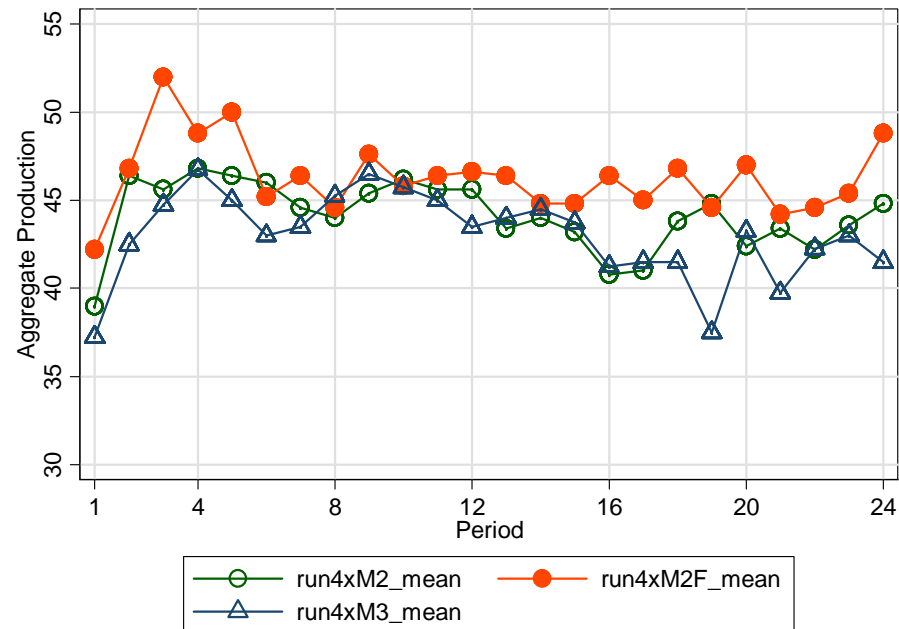
	M2	M2F	M3	M3F	M4
run123 (Inexperienced)	39.3 (1.5)	46.3 (2.0)	44.2 (1.2)	49.6 (0.6)	46.2 (1.0)
run4 (Experienced)	43.1 (1.5)	45.7 (2.4)	42.0 (1.6)	50.9 (0.2)	46.4 (0.9)
Difference					
Significance (two-sided test)					

Inexperienced

M2, M2F, M3

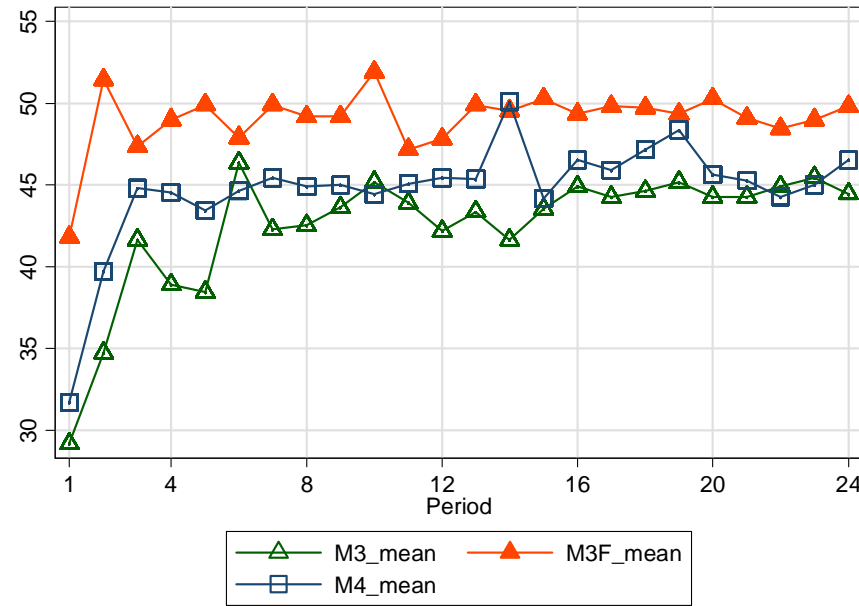


Experienced

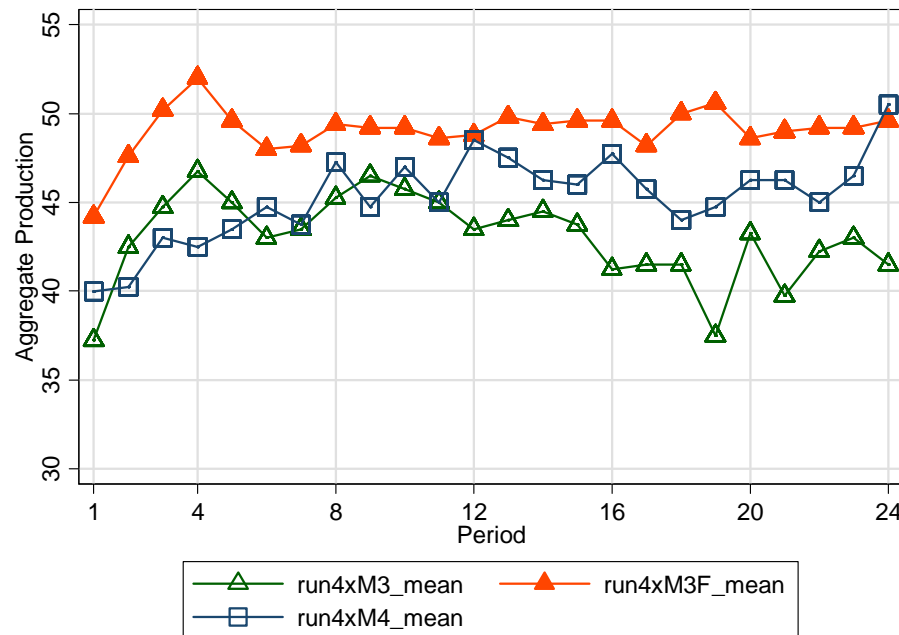


Inexperienced

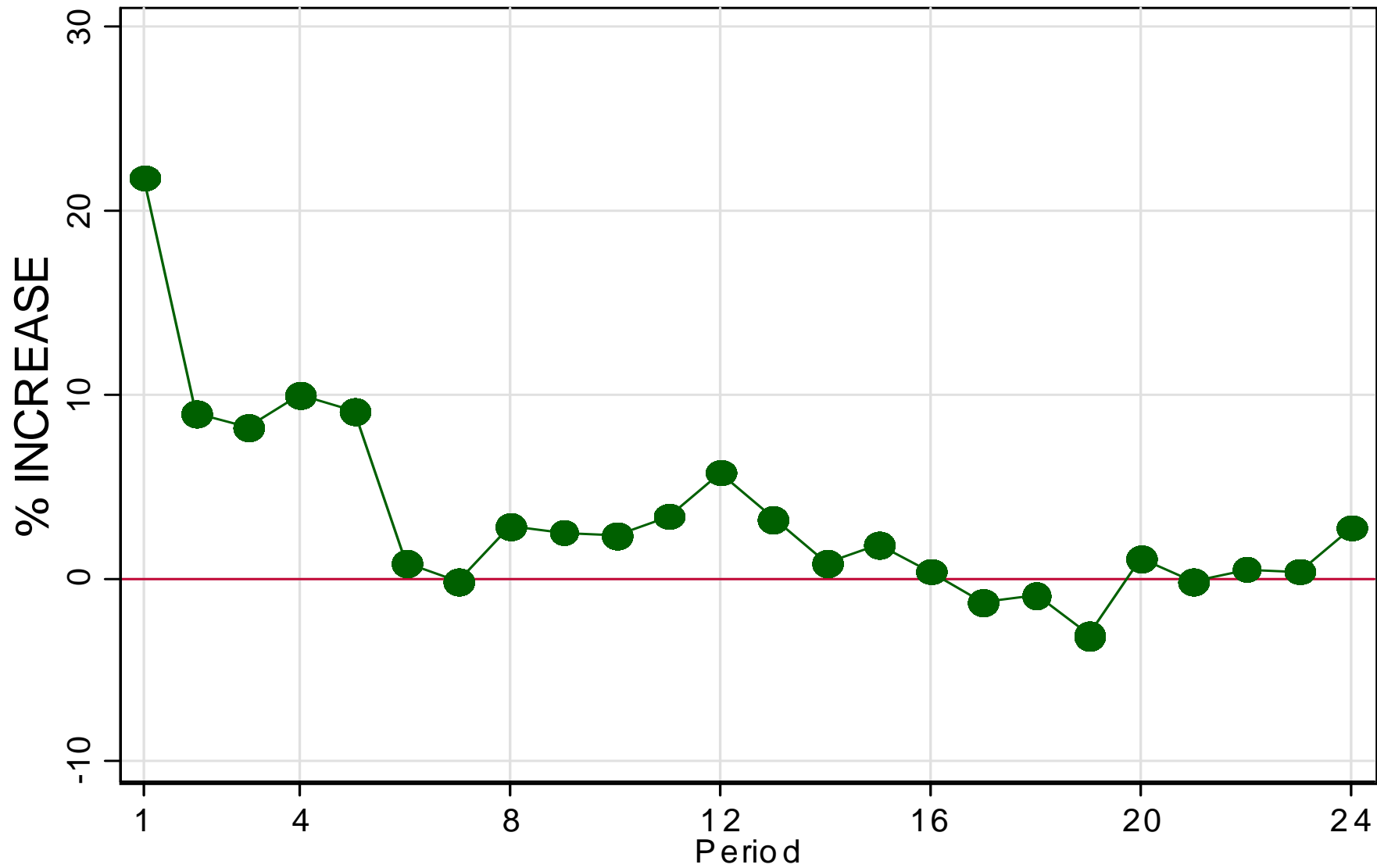
M3, M3F, M4



Experienced



Increase in production by Experienced Subjects



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