Limited Rationality and Strategic Interaction

The Impact of the Strategic Environment on Nominal Inertia

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Motivation

- When are the rational types decisive for the aggregate outcomes and when can boundedly rational types shape the aggregate outcomes?

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- Do the strategic environments shape/change the beliefs of the agents? Can agents have more or less rational expectations depending on the environment they are placed in?
- Haltiwanger and Waldman (1989) "inspired the experimental design". Sophisticated agents have an incentive to imitate the naive agents because of strategic complementarity.

Main Result: Where is the slow adjustment coming from?

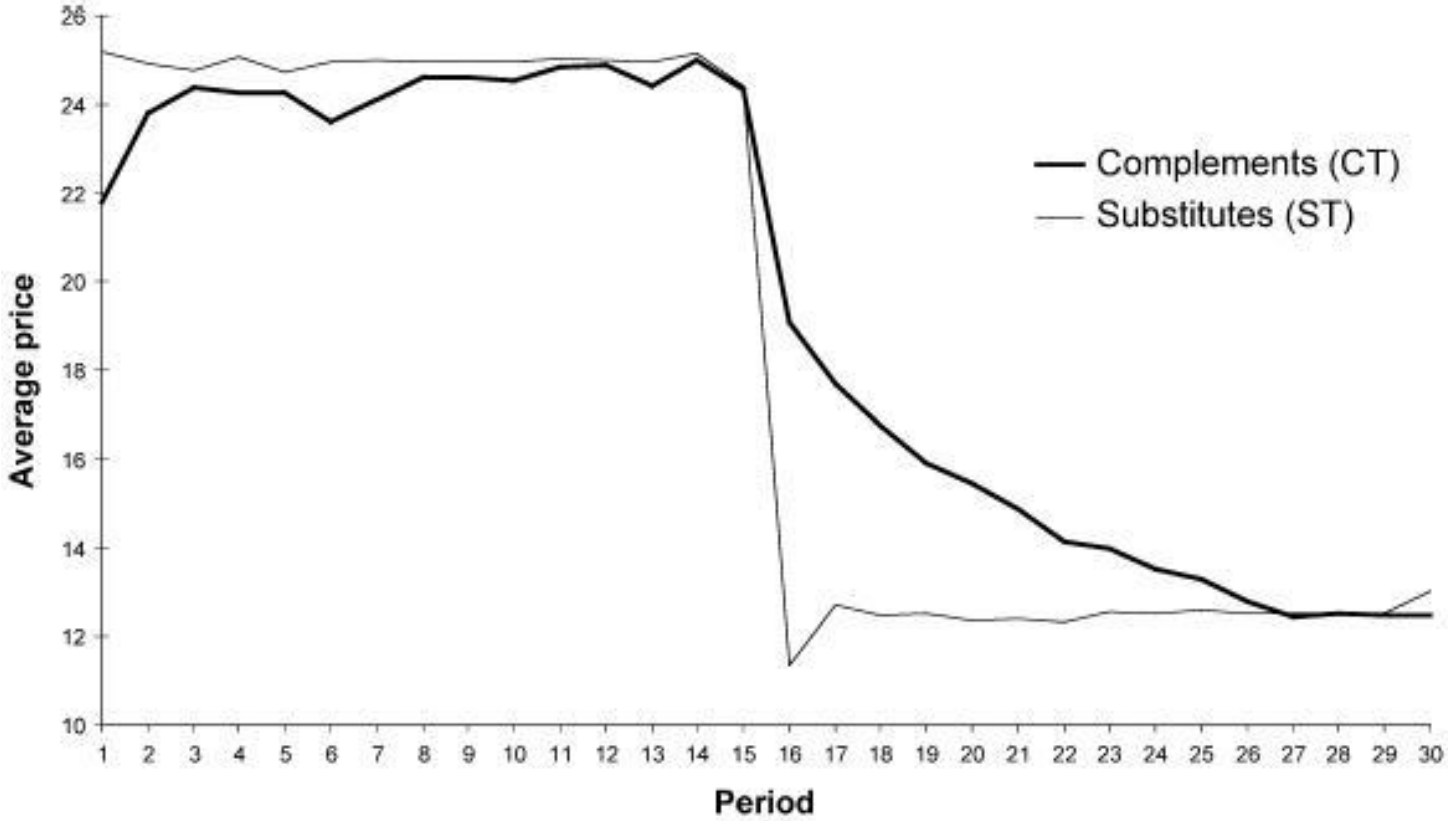

FIGURE 1.—Nominal average prices over time in the main treatments.

Outline

- Key Concepts.
- Experiment: Design and Technicalities.
- Results: Evidence for Money Illusion, and Anchoring.
- Simulations.

Key Concepts

- **Strategic complementarity (CT) (substitutability (ST))**: if the higher is the number of agents choosing a particular behavior the higher (the lower) is the return to agent *i* of choosing that behavior.
- **Money Illusion**: agents tend to take nominal income as a proxy for real income.
- **Anchoring**: the common human tendency to rely too heavily, or to "anchor", on one trait or a particular piece of information when making decisions.

Experiment: Design

- Price setting game in two versions: CT and ST.
- 4 subjects in the group.
- Two types of subjects: x and y.
- Each subject was given a payoff matrix for both types, and asked to choose a nominal price $P_i \in \{1, 2, 3, ..., 30\}$ in each round. In addition, they had to provide their expectation about $\overline{P}_{-i}$.
- At the end of each round each subject was informed about the actual value of $\overline{P}_{-i}$, and his real payoff calculated by the experimenters according to

$$v_i = v_i\left(P_i, \overline{P}_{-i}, M\right) = v_i\left(\frac{P_i}{M}, \frac{\overline{P}_{-i}}{M}, 1\right)$$

- At the end of period 15, subjects were informed that they would get different payoff tables and that the experiment would last for another 15 periods. Everything else was held unchanged.

Experiment: Subject's point of view

NOMINAL PAYOFF TABLE D1: COMPLEMENTS, POST-SHOCK, TYPE X

selling price \ Average price of other firms	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	39	78	60	34	24	19	17	16	16	16	16	17	18	19	20	20	21	21	22	23	24	25	25	26	27	28	30	31	32	33
2	20	40	117	80	43	29	23	20	18	18	17	18	19	20	21	21	21	22	23	23	24	25	26	27	28	29	30	31	32	33
3	9	17	60	156	100	52	34	26	22	20	19	19	21	22	22	22	22	23	23	24	25	25	26	27	28	29	30	31	32	34
4	5	10	26	80	195	120	60	38	29	25	22	21	23	25	24	23	23	24	24	24	25	26	26	27	28	29	31	32	33	34
5	3	6	14	34	100	234	140	69	43	32	27	24	26	28	26	25	25	25	25	25	26	26	27	28	29	30	31	32	33	34
6	2	5	10	19	43	120	273	160	77	48	36	30	32	34	30	28	27	26	26	26	27	27	27	28	29	30	32	33	34	35
7	2	4	7	13	24	52	140	312	180	86	53	39	42	45	37	32	30	29	28	28	28	28	28	29	30	31	32	33	35	36
8	2	4	6	10	16	29	60	160	351	200	95	58	62	67	49	39	34	32	30	29	29	29	29	29	31	32	33	34	35	37
9	2	3	5	8	12	19	34	69	180	390	220	103	112	120	72	52	42	36	33	32	31	30	30	30	32	33	34	35	37	38
10	1	3	5	7	10	15	23	38	77	200	429	240	260	280	129	77	55	44	39	35	33	32	32	31	33	34	35	37	38	39
11	1	3	4	6	9	12	17	26	43	86	220	468	507	546	300	138	82	58	47	41	37	35	34	33	34	36	37	39	40	41
12	1	3	4	6	8	11	14	20	29	48	95	240	260	280	585	320	146	86	61	49	43	39	36	35	37	38	40	41	42	44
13	1	3	4	6	7	10	12	16	22	32	53	103	112	120	300	624	340	155	91	65	52	45	40	38	40	41	43	44	46	48
14	1	2	4	5	7	9	11	14	18	25	36	58	62	67	129	320	663	360	163	96	68	54	47	42	44	46	48	49	51	53
15	1	2	4	5	7	8	10	13	16	20	27	39	42	45	72	138	340	702	380	172	101	71	57	49	51	53	55	57	59	61
16	1	2	4	5	6	8	10	12	14	18	22	30	32	34	49	77	146	360	741	400	181	106	74	59	62	64	66	69	71	74
17	1	2	4	5	6	8	9	11	13	16	19	24	26	28	37	52	82	155	380	780	420	189	110	78	81	84	87	91	94	97
18	1	2	3	5	6	7	9	10	12	15	17	21	23	25	30	39	55	86	163	400	819	440	198	115	120	125	130	134	139	144
19	1	2	3	5	6	7	9	10	12	14	16	19	21	22	26	32	42	58	91	172	420	858	460	206	215	224	232	241	249	258
20	1	2	3	5	6	7	8	10	11	13	15	18	19	20	24	28	34	44	61	96	181	440	897	480	500	520	540	560	580	600
21	1	2	3	4	6	7	8	10	11	13	14	17	18	19	22	25	30	36	47	65	101	189	460	936	975	1014	1053	1092	1131	1170
22	1	2	3	4	6	7	8	9	11	12	14	16	17	18	21	23	27	32	39	49	68	106	198	480	500	520	540	560	580	600
23	1	2	3	4	6	7	8	9	11	12	13	15	16	18	20	22	25	29	33	41	52	71	110	206	215	224	232	241	249	258
24	1	2	3	4	5	7	8	9	10	12	13	15	16	17	19	21	23	26	30	35	43	54	74	115	120	125	130	134	139	144
25	1	2	3	4	5	7	8	9	10	11	13	14	16	17	18	20	22	25	28	32	37	45	57	78	81	84	87	91	94	97
26	1	2	3	4	5	7	8	9	10	11	13	14	15	16	18	20	21	24	26	29	33	39	47	59	62	64	66	69	71	74
27	1	2	3	4	5	6	8	9	10	11	12	14	15	16	18	19	21	23	25	28	31	35	40	49	51	53	55	57	59	61
28	1	2	3	4	5	6	8	9	10	11	12	14	15	16	17	19	20	22	24	26	29	32	36	42	44	46	48	49	51	53
29	1	2	3	4	5	6	8	9	10	11	12	13	15	16	17	18	20	21	23	25	28	30	34	38	40	41	43	44	46	48
30	1	2	3	4	5	6	7	9	10	11	12	13	14	15	17	18	20	21	23	24	27	29	32	35	37	38	40	41	42	44

Experiment: Experimenter's point of view

TABLE A.1

BEST-REPLY FUNCTION IN THE COMPLEMENTS AND THE SUBSTITUTES TREATMENT

If the Average Price of the Other Firms, $\bar{P}_{-i}$, Is in the Range	Player i's Best Reply in the *Strategic Complements* Treatment Is Given by[a]	Player i's Best Reply in the *Strategic Substitutes* Treatment Is Given by[b]
$\frac{\bar{P}_{-i}}{M} \leq \frac{\bar{P}^*_{-i}}{M} - \frac{P^*_i}{M}$	Δ	$\frac{2P^*_i}{M} - \Delta$
$\frac{\bar{P}^*_{-i}}{M} - \frac{P^*_i}{M} \leq \frac{\bar{P}_{-i}}{M} \leq \frac{\bar{P}^*_{-i}}{M} - \Delta$	$A + \frac{\bar{P}_{-i}}{M}$	$A - \frac{\bar{P}_{-i}}{M}$
$\frac{\bar{P}^*_{-i}}{M} - \Delta \leq \frac{\bar{P}_{-i}}{M} \leq \frac{\bar{P}^*_{-i}}{M} + \Delta$	$\frac{P^*_i}{M}$	$\frac{P^*_i}{M}$
$\frac{\bar{P}^*_{-i}}{M} + \Delta \leq \frac{\bar{P}_{-i}}{M} \leq \frac{\bar{P}^*_{-i}}{M} + \frac{P^*_i}{M}$	$A + \frac{\bar{P}_{-i}}{M} - 2\Delta$	$A - \frac{\bar{P}_{-i}}{M} + 2\Delta$
$\frac{\bar{P}^*_{-i}}{M} + \frac{P^*_i}{M} \leq \frac{\bar{P}_{-i}}{M}$	$\frac{2P^*_i}{M} - \Delta$	Δ

[a]Here $A = -1/21$ if type x, $A = 3/21$ if type y, and $\Delta = 1/21$ for both types.

[b]Here $A = 23/21$ if type x, $A = 25/21$ if type y, and $\Delta = 1/21$ for both types.

$$v_i = 1 + \frac{38}{1 + \Delta^{-2}\left(P_i/M - brf\right)^2}$$

Experiment: a reading-group student's point of view

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- The above best-reply functions guarantee the existence of a **unique**, **money-neutral** (so that any real effects of exogenous, fully anticipated, nominal shock must be associated with out-of-equilibrium behavior) and **efficient** (so as to exclude collusion on a more efficient outcome which hinders adjustment toward the equilibrium) **Nash equilibrium** in both treatments.

- Equilibrium prices, real equilibrium payoffs, real payoffs along the reaction functions, the number of strictly dominated strategies, and the real income loss if players deviated from playing best reply are the same across CT and ST.

Main Result

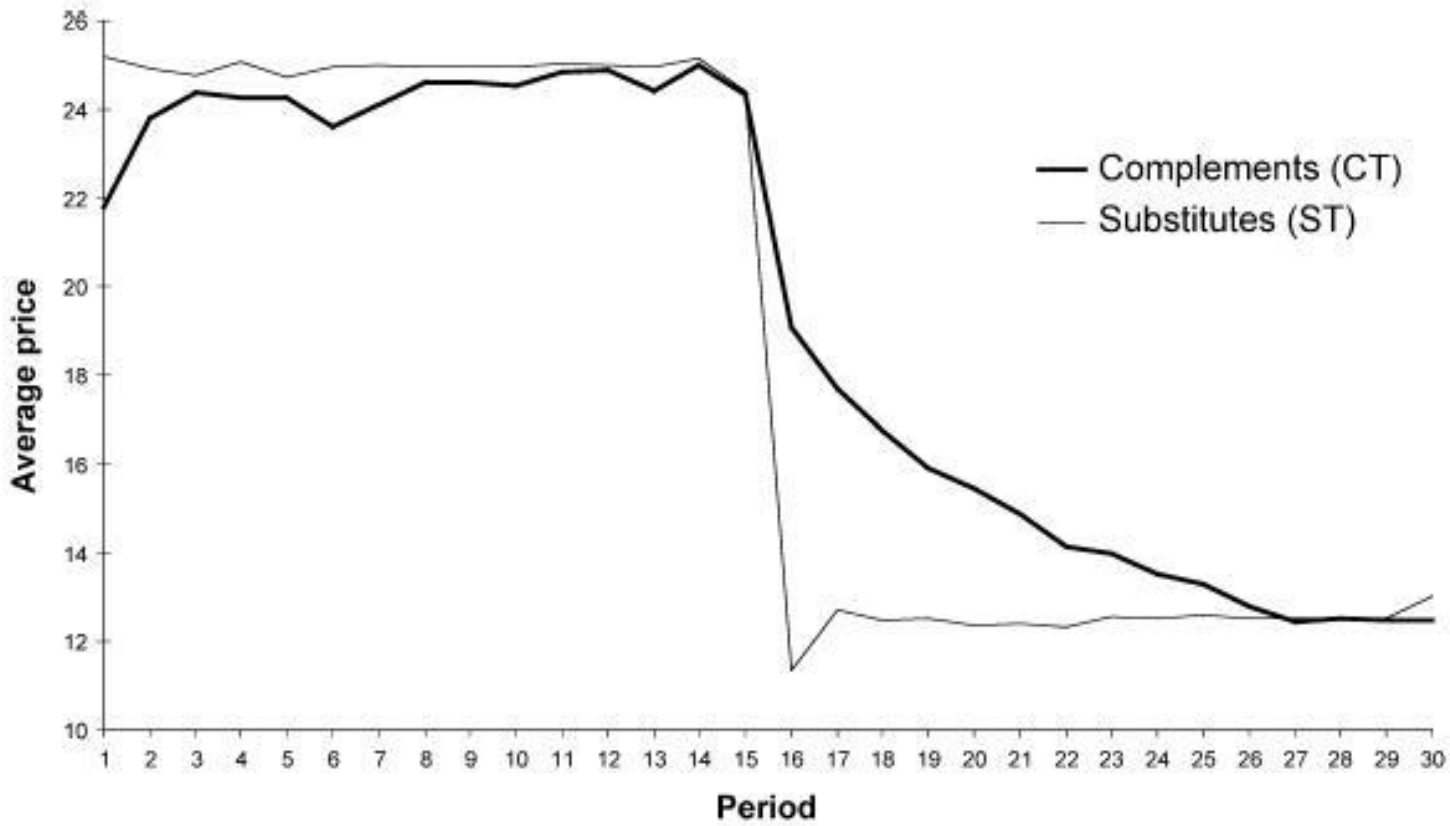

FIGURE 1.—Nominal average prices over time in the main treatments.

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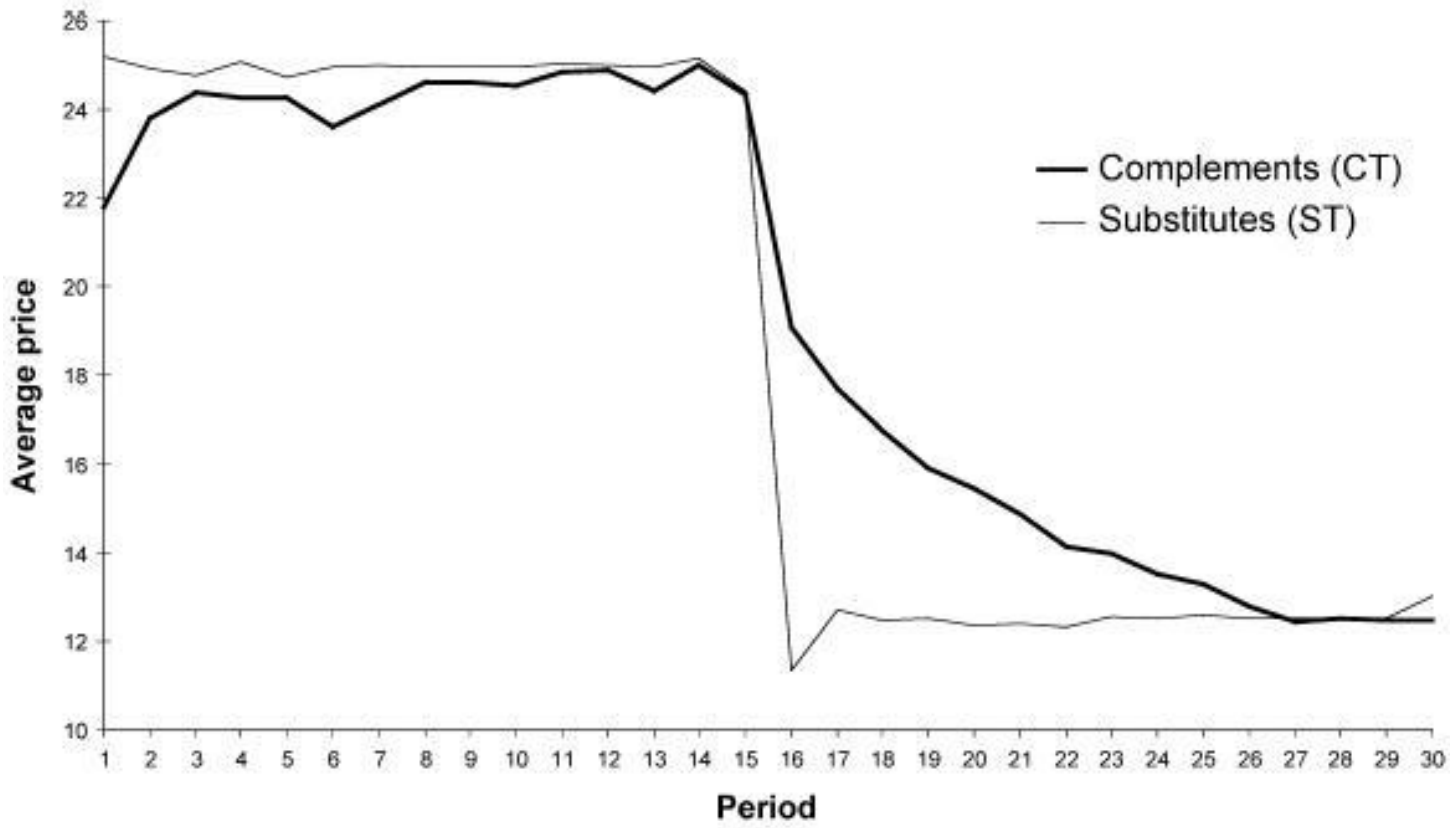

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What are the forces behind disequilibrium play in the post-shock phase of the main treatment?

Control Treatments

OVERVIEW OF TREATMENTS[a]

	Treatment Label		Representation of Payoffs: Pre-Shock Phase ($M = M_0$, 15 periods)	Representation of Payoffs: Post-Shock Phase ($M = M_1$, 15 periods)	Representation of Payoffs: Restart Phase ($M = M_1$, 10 periods)
Main treatments	CT (10 groups)		Nominal	Nominal	—
	ST (9 groups)		Nominal	Nominal	—
Control treatments	CT-real (8 groups)	CT-restart-real (4 groups)	Real	Real	Real
		CT-restart-nominal (4 groups)	Real	Real	Nominal
	ST-real (6 groups)	ST-restart-real (3 groups)	Real	Real	Real
		ST-restart-nominal (3 groups)	Real	Real	Nominal

[a]CT indicates a complements treatment; ST indicates a substitutes treatment. "Real" indicates that subjects received payoff tables in real terms while "Nominal" indicates that they received nominal payoff tables.

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Money Illusion: If nominal inertia during the post-shock phase is larger in the presence of nominal payoff tables.

Anchoring: If we observe that subjects choose nominal prices close to the pre-shock equilibrium in the post-shock phase of the control treatments.

Neither: Restart phase of CT-real and ST-real.

Evidence of Money Illusion and Anchoring

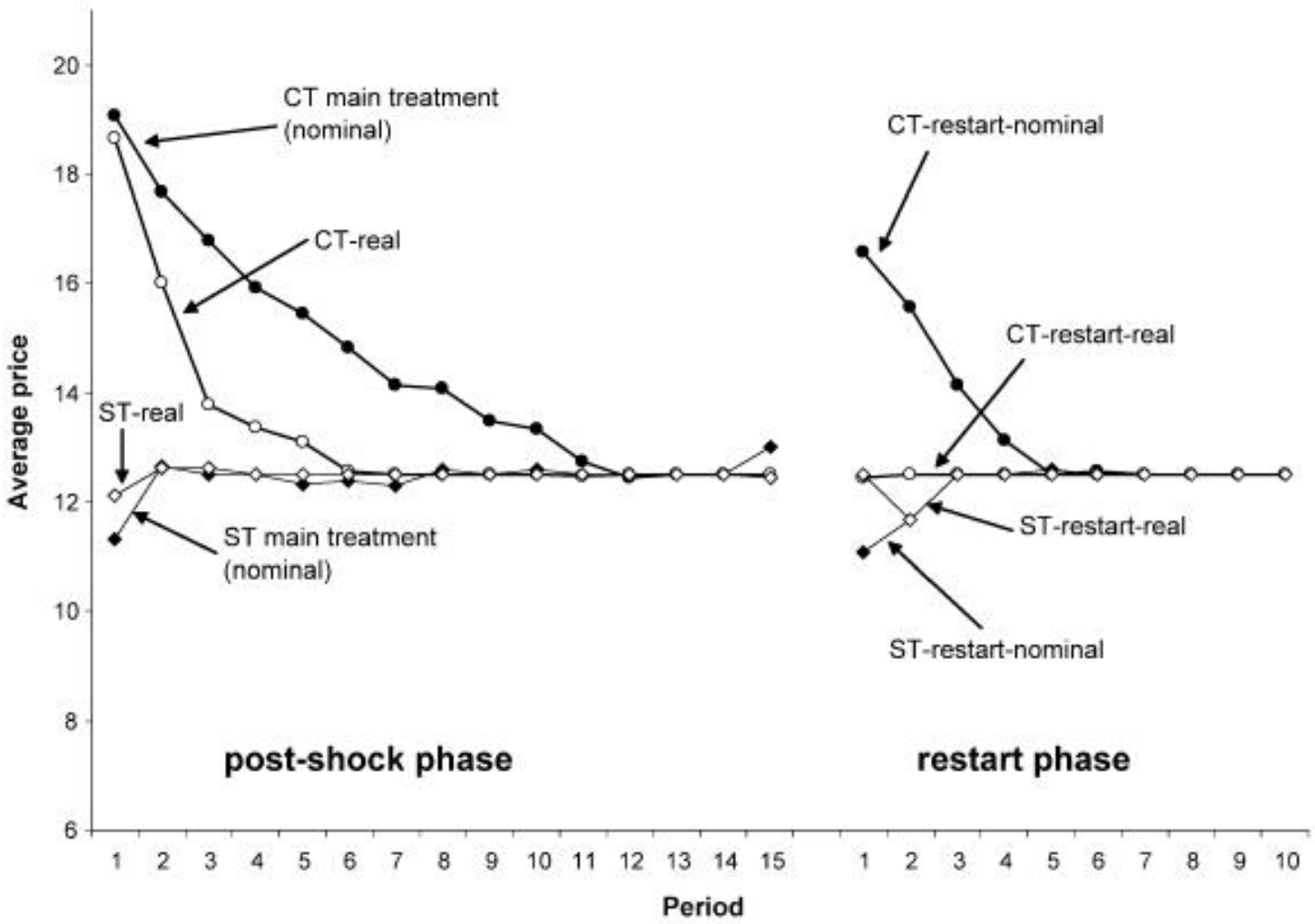


FIGURE 6A.—Average prices in the post-shock and the restart phases across treatments.

Simulations

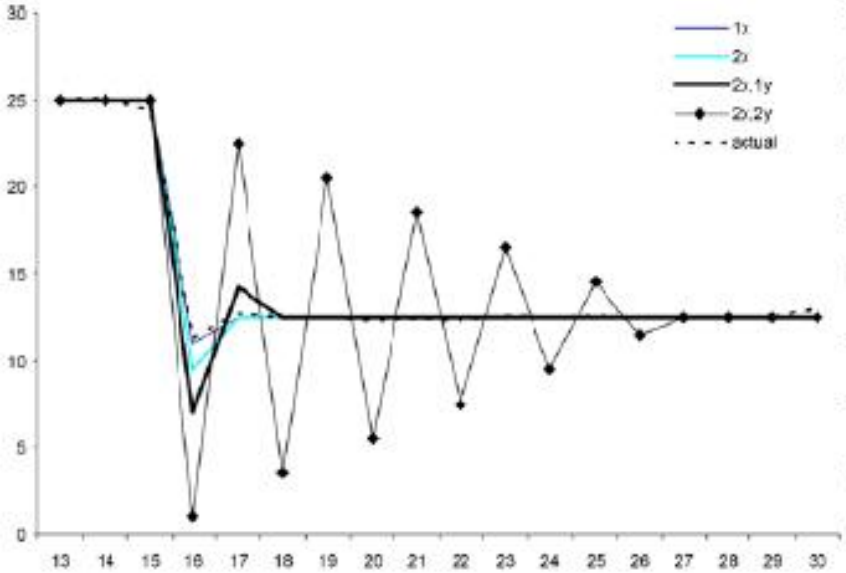


FIGURE 7A.—Simulations of price adjustment with varying numbers of adaptive players in the substitutes treatment (ST).

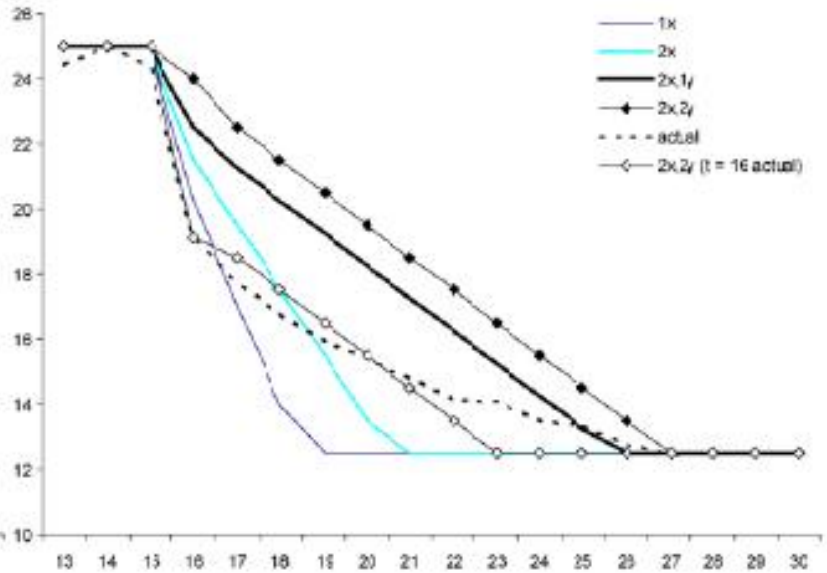
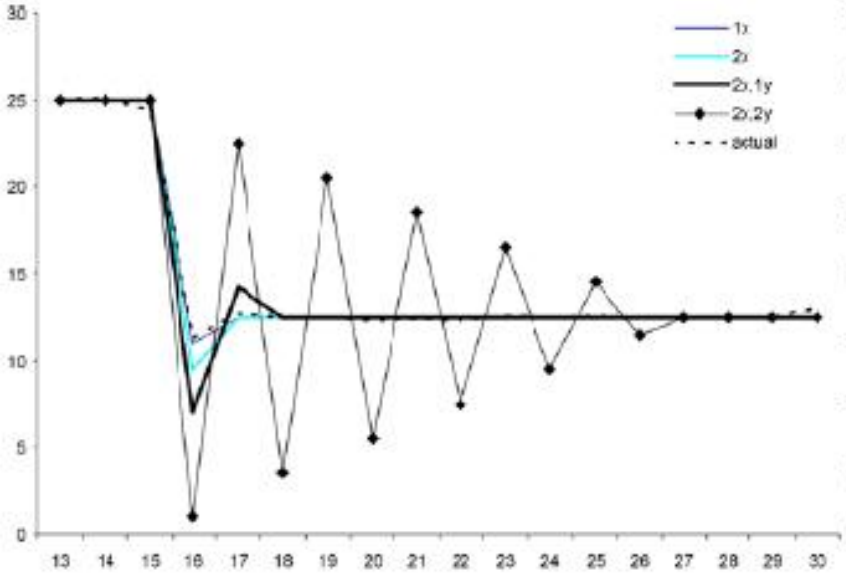


FIGURE 7B.—Simulations of price adjustment with varying numbers of adaptive players in the complements treatment (CT).

Simulations



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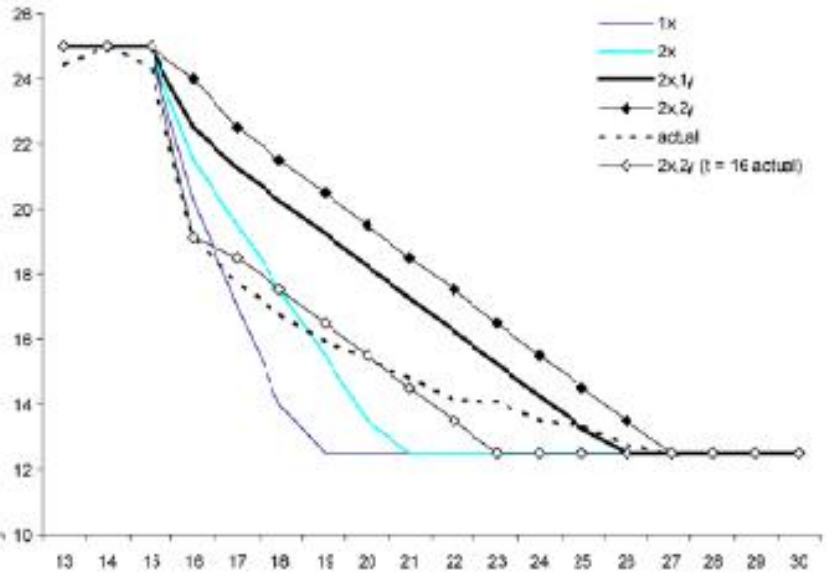

FIGURE 7B.—Simulations of price adjustment with varying numbers of adaptive players in the complements treatment (CT).

The strategic environment may change the degree of individual rationality. In particular, under substitutability people appear to be considerably more rational (49 vs. 26 percent) and also attribute more rationality to other players.

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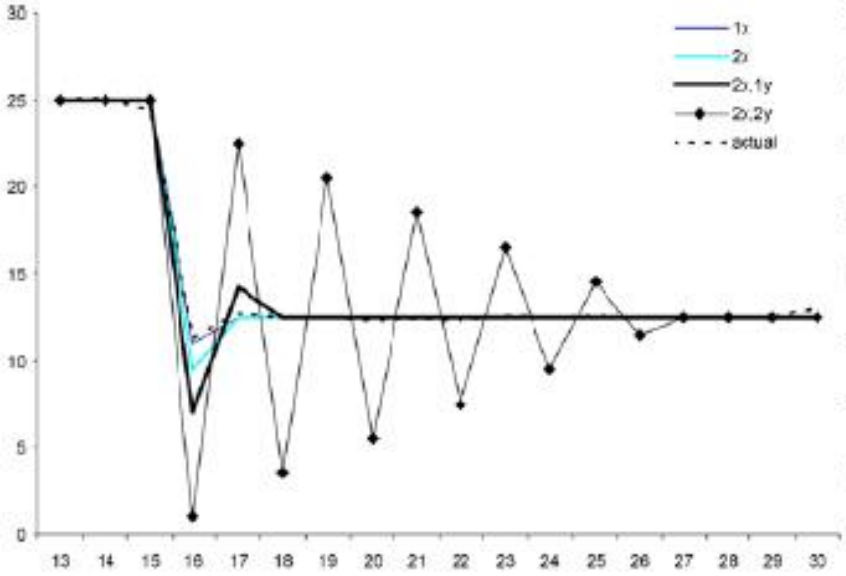

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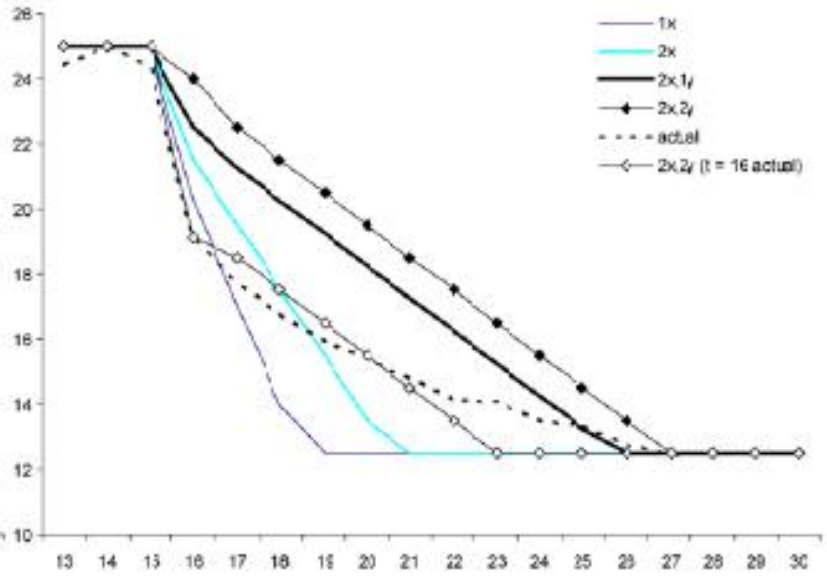

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$\Rightarrow$ Degree of rationality should not be taken exogenously.