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Max Planck Institute for Research on Collective Goods, Kurt-Schumacher-Str. 10, D-53113 Bonn
http://www.coll.mpg.de

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How Much Collusion?
A Meta-Analysis On Oligopoly Experiments

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I. Research Question

Richness can be embarrassing. Oligopoly has been among the first topics in experimental economics, starting as early as 1959 (Hoggatt 1959; Selten and Sauermann 1959). In the meantime, a total of 154 experimental papers has been published[1]. Many of them report on more than one experiment, so that there is data on much more than 500 different parameter constellations[2]. There is a number of survey articles (Friedman 1969; Plott 1982; Plott 1989; Davis and Holt 1993; Holt 1995; Lupi and Sbriglia 2003; Huck, Normann et al. 2004; Suetens 2004; Suetens and Potters 2005). But the latest comprehensive survey is a decade old. Moreover, it does not make the findings comparable across publications. This is undertaken in the present meta-study. It uses a simple question to turn the richness of the material into a boon: how much collusion have the respective experimenters found? More than one would normatively want? And more than game theory would expect?

Specifically, this study not only compares what experimenters have set out to test. In order to test subjects on their respective research question, they had to specify a whole array of other parameters, like product characteristics, market size, the shape of supply and demand, the strategic variable, the duration of the game, communication protocols, the information environment, and trading institutions. That way they have generated a rich body of data that has remained untapped thus far. This meta-study makes this data available.

This richness of the data has a third advantage. The sample is large enough to make many interaction effects significant. The most important ones are presented here.

Actually, these questions are not only helpful in generating order. They are also decisive for the main users of oligopoly experiments: the antitrust authorities. There are two main ways how these authorities may put experimental findings to productive use. Even in legal orders as dedicated to antitrust enforcement as the US, the European Community or Germany, administrative resources are limited. Knowing which factors facilitate collusion most helps these authorities detect instances of collusion.

Yet the relevance is not confined to administrative policy. Getting the expected degree of collusion right also matters in doctrinal terms. Both in the US[3] and in Europe,[4] merger control intervenes if the fact that a previously independent commercial entity disappears from the market makes “tacit collusion“ substantially more likely. The behavioural evidence helps antitrust authorities in their ensuing predictive task. For them, understanding interaction effects is particu-

1 For references see the list at the end of this paper.

2 For the reasons laid out in section II, this study covers 510 independent observations.

3 Department of Justice, Federal Trade Commission, Antitrust Division, 1992 Horizontal Merger Guidelines of September 10, 1992, 57 FR 41552, Section 2.1.

4 Court of First Instance, 6 June 2002, *Airtours plc v Commission of the European Communities*, European Court Reports 2002 II 2585, at para. 60; Guidelines on the Assessment of Horizontal Mergers under the Council Regulation on the Control of Concentrations between Undertakings, OJ 2004 C 31/5, para. 22, 39, 41

larly relevant. They have to find out whether the co-presence of two or more factors makes it more or less likely that collusion happens.

The remainder of this article is organised as follows. Section II specifies the methodology. Section III presents the evidence on product characteristics. Section IV addresses market structure, section V supply and demand, section VI seller characteristics, section VII seller interaction, section VIII the information environment, and section IX buyer activity. Section X concludes.

II. Methodology

Individual experimental papers often excel in sophistication. They for instance offer complex theoretical models for explaining the data. Recently, a wealth of learning theories has been used for the purpose (see in particular Sherman 1969; Shubik, Wolf et al. 1971; Cox and Walker 1998; Nagel and Vriend 1999b; Nagel and Vriend 1999a; Rassenti, Reynolds et al. 2000; Capra, Goeree et al. 2002; Offerman, Potters et al. 2002; Anderhub, Güth et al. 2003; Bosch-Domènech and Vriend 2003; Altavilla, Luini et al. 2005). Others present demanding statistical models (e.g. Daughety and Forsythe 1987; Benson and Faminow 1988; Davis, Reilly et al. 2003; Davis and Wilson 2005). Most papers give graphical information on time series. None of this works for a study that aims at being as encompassing as possible. The reason is simple. Many publications do not offer the data one would need for the purpose.

One information, however, is hardly ever missing: which has been the effect of the respective treatment on the strategic variable of the oligopolists (which is normally either price or quantity)? Specifically, in the large majority of papers, this information is given per instance of interaction. If the author has not done so anyhow, it is easy to calculate the mean for all rounds of interaction. Of course, duration matters. In a typical experiment, there is a pronounced change from the initial rounds over the middle of the game towards end effects (Selten and Stoecker 1986). If one adds many more rounds, the characteristic picture may reverse (Alger 1987). But duration varies so profoundly from experiment to experiment that only comparing aggregates is feasible. Since the number of rounds from which the mean is taken is always reported, one may control the result for total duration.

Absolute price or quantity is not meaningful across experiments. One needs a standardised benchmark. Actually, in oligopoly games there are three such benchmarks: the Walrasian and the collusive benchmarks always exist. In the standard Bertrand situation, the Walrasian and the Nash benchmark coincide (Bertrand 1883). But when marginal cost is not constant, or when firms compete in quantity, to name only the two most important reasons, the Nash equilibrium predicts a different outcome. Typically, it is between the Walrasian and the collusive expectations. This makes for the following picture.

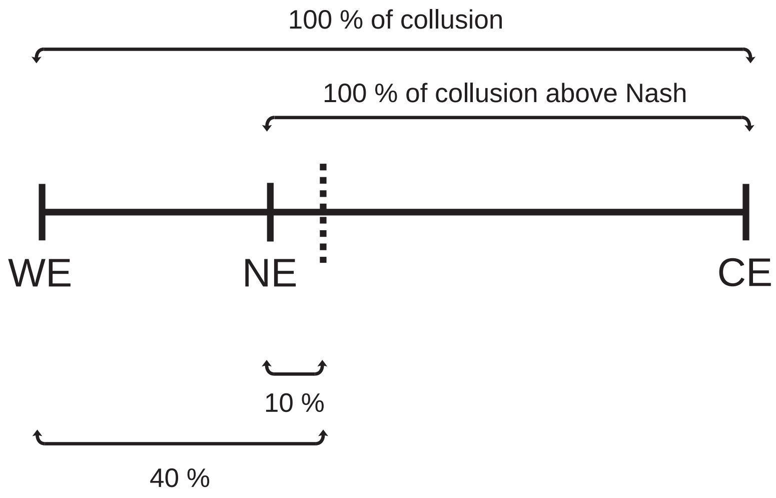

Figure 1
Normalized Benchmarks

The distance between the Walrasian equilibrium WE and the collusive equilibrium CE is defined as 100% of collusion. The dashed line is an example for the reported value of the strategic variable, say price. In the example, this value lies 40% above the Walrasian level. This index is reported as CW. However, compared to the Nash equilibrium, there is only 10% collusion. This is due to the fact that the span for calculating this index only covers the distance between the Nash equilibrium NE and the collusive equilibrium CE. It is reported as CN.

Of course, the reported value may be below the Nash equilibrium. In that case, the degree of collusion above Nash is indicated by a negative number. The distance to the left of the Nash equilibrium point is expressed as a fraction of the distance between NE and CE. Sometimes the reported value is even below WE. In that case, also the distance from WE to the left is expressed as a fraction of the distance between WE and CE, and it carries a negative sign. If the strategic variable is quantity, a small number means a high degree of collusion. To capture this, the reported quantity is normalised by how much it lies below, not above the Walrasian expectation.

There is one study in the literature following a similar approach. It compares experiments on Cournot games, and investigates how the number of sellers in the market matters (Huck, Normann et al. 2004). This study has introduced a different index. For all papers included in that meta-study, it calculates

$$\frac{\overline{Q}}{Q_N}$$

It thus expresses mean quantity from the experiment as a fraction of the respective Nash expectation. This is a less reliable measure. It is sensitive to arbitrary changes in the level of Q_N. This becomes patent in experiments that use an identical relative specification of demand and supply, but shift the level of the Walrasian equilibrium from experiment to experiment. Experimenters sometimes have done so in order to exclude parameter learning (for an example see Isaac, Ramey et al. 1984)[5]. Moreover, this index generates high values if Q_N is very small, and low values if Q_N is very high in absolute terms. And it cannot be calculated if an experimenter has normalised $Q_N = 0$. For three reasons, this index is nonetheless calculated wherever possible. It is reported as NN. First it makes comparisons easier with the (small) set of papers in the literature that presents this index. Occasionally the CN index suffers from a mirror problem. If the Nash equilibrium is close to the collusive equilibrium, this index grows very large. In the experiments covered by this study, however, this is a rare event. Most importantly, however, there are several treatment variables where the NN index is significant, while the CN index is not.

60 of the 510 experiments covered in this study use a stranger design. In every round, subjects are rematched. Behaviourally speaking, this is not the same as one-shot interaction. From round 2 on, subjects come with the expectations built in previous rounds. But it at least is as good an approximation as is feasible with the experimental method. In the remaining 460 experiments, however, interaction is repeated. As is known from the folk theorem, this leads to multiple Nash equilibria if there is uncertainty about the end of the game (Aumann and Shapley 1994). Of course, the data on repetition effects is reported here. However, for calculating the Nash benchmark, repetition is ignored. The benchmark is always taken from the one-shot game.

The large majority of the experiments covered in this study use a computer to simulate the opposite market side. This computer is programmed as a non-strategic actor. It simply represents the demand curve. Equilibrium analysis becomes much more demanding if there are strategic actors on both sides of the market. In order to make the data comparable across treatments, this element of the situation is ignored when calculating the Nash equilibrium in the minority of experiments with human buyers. The benchmark is always exclusively taken from the interaction between sellers, i.e. assuming passive buyers.

The number of papers which themselves calculate one of the three indices is very small (see e.g. Cason and Davis 1995). But generating them is straightforward if the benchmarks and the means are reported. This, however, is often not the case. Whenever possible, these calculations have been done in preparation of this meta-study. Often this meant optimisation calculus. If the Walrasian benchmark was missing, often the industry demand and supply functions had to be constructed from firm functions, or directly from the cost functions. Occasionally, the reported values had to be weighted for calculating the means, for instance if discrete outcomes had different frequencies. The data bank behind this paper specifies which parameters could not be taken directly from the respective paper, and it explains which kind of judgement has been exercised in so doing, if necessary. It is publicly available.

Following the theory of induced valuation (Smith 1976), in the Seventies and Eighties, many experimenters have given their subjects step functions for supply and demand. Determining the

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5 Take the following simple example: in the first experiment, WE = 0, CE = 100, NE = 50, experimental data 40. In this case, the index is 40/50 = 0,8. Now shift the scale by 100, leaving relative positions unaffected. Now WE = 100, CE = 200, NE = 150, experimental data 140. Now the index is 140/150 = 0,9333.

Walrasian equilibrium is straightforward with step functions. It is the point where the two step functions cross. Calculating the collusive equilibrium requires trial and error, but is doable. However, since these functions are characterised by discontinuities, there is often no Nash equilibrium in pure strategies. Calculating the mixed equilibria is theoretically possible, but it is a formidable task (Holt and Solis-Soberon 1992). If the authors themselves have done so, and if they have come up with a single equilibrium, the expected value is taken as the Nash benchmark. But the effort for doing so for all the remaining papers with step functions would have been prohibitive. Instead, it is only checked whether there is a Nash equilibrium in pure strategies (at or directly above the Walrasian equilibrium). If this is not the case, the two indices relying on the Nash equilibrium are left blank. This is the main, but not the only reason why it has not been possible for all papers to calculate all three indices. The databank specifies which indices are missing, and for which reason. In the presentation of the results, for each index the composition of the sample is presented separately.

47 papers have a pertinent topic, but are not included in this meta-study. There are different reasons for excluding them. Most frequently, in the paper there are only graphs, but no exact numbers for calculating the means. In other cases, it is not possible to calculate the benchmarks, for instance because a step function is only presented graphically and measurement scales cannot be reconstructed from the graph. Sometimes, the research question is too far away, for instance if the experimenters have given their subjects so little information that it is meaningless to talk about collusion. Finally, some papers do not give summary statistics, but exclusively regressions, and the model is such that the data relevant for this comparative paper cannot be reconstructed. Also, experiments on spatial competition are excluded.

The data is presented the following way. The main effect of each treatment variable is calculated three times. The first calculation covers all experiments with the respective feature. It is called the *gross* data. Some papers do not report the standard variable. They for instance do not indicate industry profit, or the necessary elements for calculating it, when sellers are asymmetric. In such cases, the best available proxy is taken for calculating the indices.[6] Other papers do not give data for all rounds of repetition, but only for some of them. Such somehow unusual data is excluded from the second calculation. It is called *ordinary coverage*. Finally, the effect is calculated a third time with data taken only from those experiments where this was a treatment variable. This is called the *treatment* data.

All effects are tested for significance by way of ANOVA. That way, interaction effects can be analysed as well. The samples are relatively large. However, variance might not always be homogeneous in subsamples. Moreover, the number of cases in each subsample is not always balanced. For both reasons, ANOVA results might not be fully reliable (see Hays 1994:10.20). Therefore, as a double-check, the main effects are also tested with a non parametric test.[7] If the independent variable is dichotomous, a Mann Whitney U Test is used. If the independent vari-

6 The respective proxy is specified in the data bank.
7 Reinhard Selten had suggested to do so.

able has more than two categories, a Kruskal Wallis test is applied (as suggested by Bortz 2005:287). In most cases, the p-values are similar. Not so rarely, the non parametric test even yields a smaller p-value than the ANOVA.

In order to save space, insignificant findings are not presented. Weakly significant findings ($p<0,1$) are reported where the result seems sufficiently relevant. The *treatment* data, however, is always reported. This is justified since experimenters themselves had to check for significance. The results of the non parametric test are only presented if the ANOVA has yielded a significant result.

III. Dependence of Collusion on Product Characteristics

1. Homogeneity vs. Heterogeneity of Goods

If products are (imperfect) substitutes, producers each have their own niche. There is some competitive pressure, but competition is monopolistic (Chamberlin 1933). Consequently, sellers should do better if there is heterogeneity of products. This expectation is borne out if one compares experimental data to the Walrasian equilibrium. In such markets sellers typically charge different prices, and they sell different quantities. Therefore the strategic variable is not a good indicator of collusion. Wherever possible, it is replaced by industry profit.[8]

gross	CW	CW (SD)	CW NOS	CW ANOVA	CW Mann-Whitney
homogeneous	30,0403023	40,1702612	419	0	0
heterogeneous	67,4634146	26,0427925	91		
ordinary coverage	OC CW	OC CW (SD)	OC CW NOS	OC CW ANOVA	
homogeneous	18,4556962	30,8799469	237	0,001	0
heterogeneous	42,1052632	21,7967753	19		
treatment	T CW	T CW (SD)	T CW NOS	T CW ANOVA	
homogeneous	42,8	38,317098	5	0,003	0,058
heterogeneous	79,7647059	22,2779397	34		

Table 1
Homogeneity: Normalized Deviation from the Walrasian Equilibrium
(Legend: CW: Normalized Deviation from the Walrasian Equilibrium
SD: Standard Deviation
NOS: Number of Observations
ANOVA: Univariate Analysis of Variance
OC: sample reduced to experiments with Ordinary Coverage
T: sample reduced to experiments where homogeneity was a Treatment variable)

8 For details see the databank.

Provided cost structures are similar, if products are heterogeneous, game theory expects an outcome above the competitive equilibrium for each of the products; there is much less competitive pressure after all. The empirical picture is not very clear. The only weakly significant result is on the NN index in the gross sample. There is collusion in both types of markets, but it is much stronger with homogeneous products. The treatment data from the CN index is insignificant, but points into the same direction. However, the treatment data on the NN index has the opposite result. This result too, however, is insignificant.

treatment	T CN	T CN (SD)	T CN NOS	T CN ANOVA	T CN Mann Whitney
homogeneous	-0,4	70,9175578	5	0,875	0,855
heterogeneous	-6,67647059	84,1667611	34		

Table 2

Homogeneity: Normalized Deviation from the Nash Equilibrium

(Index: CN: Normalized Deviation from the Nash Equlibrium
data from gross and ordinary coverage samples insignificant)

gross	NN	NN (SD)	NN NOS	NN ANOVA	NN Mann-Whitney
homogeneous	50,6590164	229,032508	305	0,098	0,492
heterogeneous	8,65853659	21,4713243	82		
treatment	T NN	T NN (SD)	T NN NOS	T NN ANOVA	
homogeneous	2,6	19,1911438	5	0,491	0,823
heterogeneous	10,2352941	23,3433643	34		

Table 3

Homogeneity: Proportional Deviation from the Nash Equilibrium

(Legend: NN: Proportional Deviation from the Nash Equilibrium
data from ordinary coverage sample insignificant)

A look at interaction effects clears the picture. When products are homogeneous, there is a certain positive deviation from the Nash expectation if subjects are rematched every round. If they have a fixed partner, the result is slightly below the Nash expectation. The pattern dramatically changes if products are heterogeneous. Now strangers end up far below the Nash expectation, whereas partners are somewhat above. If products are homogeneous, the distinction between simultaneous and sequential play has little effect on deviations from the Nash equilibrium. However with heterogeneity, in simultaneous interaction there is a small positive deviation from the Nash benchmark, whereas in sequential interaction the outcome is far below. If products are homogeneous and supply is constant, there is a small degree of collusion. If the supply curve has a positive slope, the deviation from the Nash equilibrium is negative. The pattern dramatically reverses if products are heterogeneous. Now subjects fall below the Nash expectation if gains from collusion are large. They end up high above the Nash benchmark if gains from collusion are small.

If products are homogeneous and sellers are symmetric, there is less collusion than the Nash equilibrium predicts. The opposite is true when sellers are asymmetric. This totally changes if products are heterogeneous. Now seller symmetry yields a positive deviation from the Nash benchmark, whereas seller asymmetry pushes sellers far below the Nash prediction. Finally if products are homogeneous and capacity is unconstrained, sellers achieve a small surplus over the Nash expectation. The opposite is true if capacity is constrained. The picture reverses if products are heterogeneous. Now unconstrained capacity leads to a result below Nash, whereas constrained capacity induces subjects to collude at a level far above the Nash benchmark.

partner/stranger	partner	partner (SD)	partner NOS	partner/stranger Sig.
homogeneous	-5,19548872	83,8680868	266	0,05786161
heterogeneous	3,04938272	65,5322251	81	
	stranger	stranger (SD)	stranger NOS	
homogeneous	11,7291667	35,5460382	48	
heterogeneous	-36,5555556	122,054405	9	
sequence	simultaneous	simultaneous (SD)	simultaneous NOS	sequence Sig.
homogeneous	-3,83773585	83,4581646	265	0
heterogeneous	8,63095238	59,4431549	84	
	sequential	sequential (SD)	sequential NOS	
homogeneous	4,04081633	44,1606722	49	
heterogeneous	-134,5	116,135696	6	
surplus	symmetric	symmetric (SD)	symmetric NOS	surplus Sig.
homogeneous	-4,9	61,5540413	90	0,04078703
heterogeneous	52	29,2711462	6	
	consumer	consumer (SD)	consumer NOS	
homogeneous	6,39	50,5182976	200	
heterogeneous	-4,69047619	73,8901784	84	
symmetry	symmetric	symmetric (SD)	symmetric NOS	symmetry Sig.
homogeneous	-5,59911894	89,9633288	227	0,00614978
heterogeneous	13,2459016	40,4753652	61	
	asymmetric	asymmetric (SD)	asymmetric NOS	
homogeneous	5,1954023	33,8546273	87	
heterogeneous	-30,6896552	110,065598	29	
capacity	unconstrained	unconstrained (SD)	unconstrained NOS	capacity Sig.
homogeneous	5,79545455	48,9326439	176	0,00084469
heterogeneous	-14,2769231	80,5259096	65	
	constrained	constrained (SD)	constrained NOS	
homogeneous	-13,326087	104,207203	138	
heterogeneous	33,84	27,8652711	25	

Table 4
Homogeneity: Interaction Effects
(normalized deviation from the Nash equilibrium)

2. Effect of Introducing Fixed Costs

All three benchmarks for this study are taken from the one-shot situation. On the short run, for rational actors only marginal, and hence variable cost should matter. However, subjects interact over multiple rounds, and if there is a fixed cost it matters for the payment they expect from the experimenter. One should therefore expect that subjects trade at a price further away from the Walrasian equilibrium if there is a fixed cost. This expectation holds true in the data from the gross sample. In line with this, with no fixed cost, the normalised mean deviation from the Nash equilibrium is negative. If there is a fixed cost, the mean deviation becomes positive. Apparently, subjects do not decide in a purely forward-looking manner.

gross	CW	CW (SD)	CW NOS	CW ANOVA	CW Mann-Whitney
no fixed cost	32,2363184	36,2569986	408	0	0
fixed cost	58,4285714	53,5142452	102		

Table 5
Fixed Cost: Normalized Deviation from the Walrasian Equilibrium
(data on ordinary coverage insignificant; no treatment data available)

gross	CN	CN (SD)	CN NOS	CN ANOVA	CN Mann-Whitney
no fixed cost	-6,76489028	77,7691586	319	0,022	0
fixed cost	14,7882353	73,6943647	85		

Table 6
Fixed Cost: Normalized Deviation from the Nash Equilibrium
(data on ordinary coverage insignificant; no treatment data available
data on NN index from gross and ordinary coverage samples insignificant, from treatment sample not available)

3. Effect of Constrained Capacity

If sellers compete in price, if products are homogeneous, and if marginal cost is constant, the mere presence of a second seller suffices to force the competitive equilibrium on the sellers. This is in essence the result of (Bertrand 1883). In the literature, this result is typically referred to as the “Bertrand paradox“ (e.g. Tirole 1988:210). Among the many attempts to dissolve the paradox, the first had been to introduce capacity constraints (Edgeworth 1897). Theory then expects positive profits. The experimental data stands in harsh opposition to the expectation. If capacity is constrained, collusion plummets with respect to all three indices.

gross	CW	CW (SD)	CW NOS	CW ANOVA	CW Mann-Whitney
unconstrained	54,0912698	38,9772076	252	0	0
constrained	16,8590308	32,7397548	227		
ordinary coverage	OC CW	OC CW (SD)	OC CW NOS	OC CW ANOVA	
unconstrained	42,5	24,2806826	98	0	0
constrained	6,38607595	26,1501604	158		

Table 7
Capacity: Normalized Deviation from the Walrasian Equilibrium
(no treatment data available)

gross	CN	CN (SD)	CN NOS	CN ANOVA	CN Mann-Whitney
unconstrained	0,38174274	59,6220345	241	0,41	0,769
constrained	-6,09202454	97,9236166	163		
ordinary coverage	OC CN	OC CN (SD)	OC CN NOS	OC CN ANOVA	
unconstrained	5,64516129	33,9112157	93	0,028	0
constrained	-20,2340426	107,531583	94		

Table 8
Capacity: Normalized Deviation from the Nash Equilibrium
(no treatment data available)

gross	NN	NN (SD)	NN NOS	NN ANOVA	NN Mann-Whitney
unconstrained	58,1631799	252,777783	239	0,044	0,421
constrained	15,2702703	70,1011509	148		
ordinary coverage	OC NN	OC NN (SD)	OC NN NOS	OC NN ANOVA	
unconstrained	130,43956	396,327031	91	0,004	0,001
constrained	5,625	74,1055961	88		

Table 9
Capacity: Proportional Deviation from the Nash Equilibrium
(no treatment data available)

Interaction effects make it possible to say more about the underlying forces. Most graphic is the interaction with market size. In duopoly, the constraint only has a small (negative) effect on the deviation from the Walrasian equilibrium. The effect becomes a bit more pronounced in triopoly, and is strong in larger markets. In asymmetric markets, the negative effect of a capacity constraint on deviations from the Walrasian equilibrium is much more pronounced than in symmetric markets. Likewise, the negative effect is stronger in sequential than in simultaneous interaction. Collusion in homogeneous markets is dampened much more by a capacity constraint than when subjects trade in substitutes. Finally, a capacity constraint reduces collusion with all specifications of ex ante information, but the reduction is much stronger with reduced ex ante information.

size	size 2	size 2 (SD)	size 2 NOS	size Sig.
unconstrained	62,5733333	40,6232232	150	0,07080032
constrained	59,1538462	22,3712842	13	
	size 3	size 3 (SD)	size 3 NOS	
unconstrained	48,8484848	32,913828	33	
constrained	38,2826087	35,8029565	46	
	size 4	size 4 (SD)	size 4 NOS	
unconstrained	40,53125	36,5892496	32	
constrained	7,04545455	28,6812237	110	
ex ante information	reduced ex ante	reduced ex ante (SD)	reduced ex ante NOS	ex ante Sig.
unconstrained	71,56	45,9547604	25	0
constrained	7,20792079	25,3957937	101	
	partial ex ante	partial ex ante (SD)	partial ex ante NOS	
unconstrained	44,5	24,63737	52	
constrained	29,6578947	38,2532643	38	
	full ex ante	full ex ante (SD)	full ex ante NOS	
unconstrained	57,738255	41,5450579	149	
constrained	28,7741935	36,0820451	31	
symmetry	symmetry	symmetry (SD)	symmetry NOS	symmetry Sig.
unconstrained	50,345	40,3647437	200	0,00131709
constrained	19,573913	36,7657499	115	
	asymmetry	asymmetry (SD)	asymmetry NOS	
unconstrained	68,5	29,2014638	52	
constrained	14,0714286	27,90483	112	
homogeneity	homogeneous	homogeneous (SD)	homogeneous NOS	homogeneity Sig.
unconstrained	48,3903743	41,2493403	187	
constrained	13,7	31,2028477	210	0
	heterogeneous	heterogeneous (SD)	heterogeneous NOS	
unconstrained	70,4923077	25,3975411	65	
constrained	55,8823529	25,9540034	17	

Table 10
Capacity: Interaction Effects
(deviations from the Walrasian equilibrium)

4. Effect of Advance Production

Theory expects a similar outcome if sellers ultimately compete in price, but have a chance to precommit on quantity. They then play a game of two stages that yields results similar to quantity competition, i.e. a price substantially above the expectation of the Bertrand model (Kreps and Scheinkman 1983; but see Davidson and Deneckere 1986). If subjects must produce a perishable commodity in advance, this is a way to implement the setting in the laboratory. Here, results are less impressive than with capacity constraints. The only result significant at the 5% level is in the treatment sample, and with respect to the NN index. As with capacity constraints, however, collusion is reduced, not increased by the manipulation. Qualitatively, the treatment sample reaches the same result with respect to the CN index, but it is only weakly significant.

treatment	T CW	T CW (SD)	T CW NOS	T CW A-NOVA	T CW Mann Whitney
no advance production	42,3333333	26,5847701	9	0,15124064	0,118
advance production	22,75	31,7722721	12		

Table 11
Advance Production: Normalized Deviation from the Walrasian Equilibrium
(data from gross and ordinary coverage samples insignificant)

treatment	T CN	T CN (SD)	T CN NOS	T CN ANOVA	T CN Mann Whitney
no advance production	4	30,1454806	9	0,08337275	0,088
advance production	-29,75	48,6698058	12		

Table 12
Advance Production: Normalized Deviation from the Nash Equilibrium
(all other data insignificant)

treatment	T NN	T NN (SD)	T NN NOS	T NN ANOVA	T NN Mann Whitney
no advance production	3,66666667	8,51469318	9	0,04223725	0,025
advance production	-5,25	9,80839158	12		

Table 13
Advance Production: Proportional Deviation from the Nash Equilibrium
(all other data insignificant)

5. Collusion when Process Innovation is Possible

Do subjects collude more if they have a chance for a process innovation that reduces cost for them, but not for their competitors? There is no significant data with respect to the Nash equilibrium. With respect to the Walrasian equilibrium, the effect is significant and pronounced. The opportunity to invest in cost reduction leads to substantially more collusion. The fact that there is no significance in the sample reduced to experiments with ordinary coverage has a simple explanation. From 26 experiments with a chance to innovate only two are in the reduced sample.

gross	CW	CW (SD)	CW NOS	CW ANOVA	CW Mann-Whitney
no innovation	34,9359823	36,5078226	453	0,001	0,159
innovation	62,7692308	81,8873898	26		

Table 14
Innovation: Normalized Deviation from the Walrasian Equilibrium
(data from ordinary coverage sample insignificant, no treatment data on this index
data on CN and NN indices insignificant, no treatment data on these indices)

IV. Dependence of Collusion on Market Characteristics

1. Effect of Market Size

Most independent variables in this data set are dichotomous or categorical. One of the major exceptions is market size. One may wonder whether, in a strict sense, this is a cardinal variable. But it at any rate is ordinal, which makes a linear regression meaningful. With respect to deviations from the Walrasian equilibrium, it is highly significant, and it has the expected result. The larger the market, the smaller the degree of collusion. With respect to deviations from the Nash equilibrium, only the NN index leads to a significant result, and only if one reduces the sample to experiments that explicitly tested for market size. The effect is also negative, but much less so than with the Walrasian equilibrium. In the treatment data, the effect of size on the CN index is even smaller, but still negative. This result, however, is not significant.

gross	CW B	CW B SD	**CW Beta**	CW Sig.
	-4,42037497	0,61463467	-0,31277205	0
	CW Const	CW Const SD		CW Const Sig
	53,7129887	2,97988296		0
	CW R^2	CW adj.R^2		
	0,09782636	0,09593501		
ordinary coverage	OC CW B	OC CW B SD	**OC CW Beta**	OC CW Sig.
	-2,19592089	0,53092697	-0,2511955	0
	OC CW Const	OC CW Const SD		OC CW Const Sig
	30,5386279	3,12131327		0
	OC CW R^2	OC CW adj.R^2		
	0,063	0,059		
treatment	T CW B	T CW B SD	**T CW Beta**	T CW Sig.
	-4,40960208	1,08323964	-0,35091268	0
	T CW Const	T CW Const SD		T CW Const Sig
	59,636808	4,9777975		0
	T CW R^2	T CW adj.R^2		
	0,123	0,116		

Table 15
Market Size
Normalized Deviation from the Walrasian Equilibrium: Regression
(Legend: CW: Normalized Deviation from the Walrasian Equilibrium
SD: Standard Deviation
NOS: Numbers of Observations
B: B Value
Beta: normalized B Value
Sig: Significance Level
Const: Constante
R^2: R Square
adj. R^2: adjusted R Square
OC: sample reduced to experiments with Ordinary Coverage
T: sample reduced to experiments where homogeneity was a Treatment variable)

treatment	T CN B	T CN B SD	**T CN Beta**	T CN Sig.
	-2,40376305	2,5122409	-0,09386209	0,34089841
	T CN Const	T CN Const SD		T CN Const Sig
	17,3645249	11,5099233		0,13444788
	T CN R^2	T CN adj.R^2		

Table 16
Market Size
Normalized Deviation from the Nash Equilibrium: Regression
(Legend: CN: Proportional Deviation from the Nash Equilibrium
data from the gross and ordinary coverage samples insignificant)

treatment	T NN B	T NN B SD	**T NN Beta**	T NN Sig.
	-4,98615508	2,57577325	-0,19480297	0,05586649
	T NN Const	T NN Const SD		T NN Const Sig
	52,5256509	11,9103942		0
	T NN R^2	T NN adj.R^2		
	0,0379482	0,02782134		

Table 17
Market Size
Proportional Deviation from the Nash Equilibrium: Regression
(Legend: NN: Proportional Deviation from the Nash Equlibrium
all regressions on CN index, and regressions on NN index based on gross and ordinary coverage samples insignificant)

"Four are few, and six are many", game theorists say (Selten 1973). "Two are few, and four are many", experimentalists claim (Huck, Normann et al. 2004). It therefore makes sense to also look at outcomes for individual market sizes. If one looks at the gross data, and at the deviation from the Walrasian equilibrium, theory seems to get it right. While the degree of collusion in quadropoly is much smaller than in triopoly, it again goes up to almost the level of triopoly in a market of five. In markets of 6,7 and 8, the deviation is much smaller. However, the picture is far from clear. In markets of 10 and 16, the deviation is again remarkable.

The CN index supports the experimentalist view. There is a positive deviation in duopoly and triopoly, and a negative deviation in markets of 4 and 5. However, that finding too is not totally beyond doubt. There are small positive deviations from the Nash prediction in markets of 10 and 22.

	CW	CW (SD)	CW NOS	CW ANO-VA	CW Kruskal-Wallis
size 2	62,3006135	39,4430571	163	0	0
size 3	42,6962025	34,8061866	79		
size 4	14,5915493	33,5766626	142		
size 5	37,95	30,7989662	20		
size 6	18,0540541	28,2527737	37		
size 7	1	13,7840488	6		
size 8	14,9473684	25,9325486	19		
size 10	26	.	1		
size 11	8,5	1,73205081	4		
size 16	38	32,5269119	2		
size 22	6,75	29,0789156	4		
size 25	-11	14,1421356	2		

Table 18
Individual Market Size
Normalized Deviation from the Walrasian Equilibrium
(gross data only; ordinary coverage data and treatment data is also significant at the 0,000 level, and shows the same qualitative picture)

	NN	NN (SD)	NN NOS	NN ANOVA	NN Kruskal-Wallis
size 2	31,4240506	143,836438	158	0,021	0,003
size 3	65,8636364	234,862637	66		
size 4	26,53	160,645004	100		
size 5	-4,3125	12,3758838	16		
size 6	260,4375	620,428881	16		
size 7	-13,6666667	13,2035349	3		
size 8	11,7333333	21,7139411	15		
size 10	2	.	1		
size 11	-3,5	1,91485422	4		
size 16	-6	0	2		
size 22	-0,25	2,21735578	4		
size 25	-6	4,24264069	2		

Table 19
Individual Market Size
Proportional Deviation from the Nash Equilibrium
(gross data only; CN index is insignificant)

2. Symmetry vs. Asymmetry of Sellers

In the view of antitrust authorities, when assessing the opportunities for tacit collusion, symmetry is a crucial factor.[9] The experimental evidence is more nuanced. This might be due to the fact that symmetry facilitates imitation, which increases competitive pressure. In the gross sample, asymmetry has little effect on the deviation from the Walrasian equilibrium. It is stronger if one reduces the sample to experiments with ordinary coverage, but it almost disappears in those experiments that explicitly tested for symmetry (and is not significant). The deviation from the Nash equilibrium is much clearer, and in line with what antitrust authorities think. But it is (in ordinary coverage only weakly) significant only with respect to the NN index. The CN index is weakly significant only for the experiments that had symmetry as a treatment variable.

gross	CW	CW (SD)	CW NOS	CW ANOVA	CW Mann-Whitney
symmetry	39,1111111	41,7554722	315	0,0465909	0,015
asymmetry	31,3292683	37,9801546	164		
ordinary coverage	OC CW	OC CW (SD)	OC CW NOS	OC CW ANOVA	
symmetry	27,2484472	32,8722967	161	0	0
asymmetry	8,28421053	22,8434371	95		
treatment	T CW	T CW (SD)	T CW NOS	T CW ANOVA	
symmetry	72,2222222	25,1713085	18	0,90811584	0,752
asymmetry	71,2631579	30,4681351	38		

Table 20
Symmetry: Normalized Deviation from the Walrasian Equilibrium

treatment	T CN	T CN (SD)	T CN NOS	T CN ANOVA	T CN Mann Whitney
symmetry	18,7727273	68,5405211	22	0,09588123	0,047
asymmetry	-19,5476191	93,8460604	42		

Table 21
Symmetry: Normalized Deviation from the Nash Equilibrium
(data from gross and ordinary coverage samples insignificant)

9 Department of Justice, Federal Trade Commission, Antitrust Division, 1992 Horizontal Merger Guidelines of September 10, 1992, 57 FR 41552, Section 2.11; ECJ of First Instance Case T-102/96, Gencor v Commission, [1999] ECR II-753, paragraph 222; EC Commission Decision 92/553/EC in Case IV/M.190 — Nestlé/Perrier, OJ L 356, 5.12.1992, p. 1, points 63-123.

gross	NN	NN (SD)	NN NOS	NN ANOVA	NN Mann-Whitney
symmetry	55,3498233	236,903865	283	0,03062506	0,026
asymmetry	4,77884615	27,2756361	104		
ordinary coverage	OC NN	OC NN (SD)	OC NN NOS	OC NN ANOVA	
symmetry	92,4592593	334,671632	135	0,06154268	0,002
asymmetry	-2,65909091	7,72173972	44		
treatment	T NN	T NN (SD)	T NN NOS	T NN ANOVA	
symmetry	44,3888889	79,4859506	18	0,02969758	0,176
asymmetry	8,81578947	40,2511408	38		

Table 22
Symmetry: Proportional Deviation from the Nash Equilibrium

Again, interaction effects help to understand the somewhat mixed evidence. It is particularly interesting to test for interactions with market size. Asymmetry increases collusion in markets of 2 and 3, but reduces it in larger markets. Moreover, symmetry hurts if gains from collusion are small, but it helps if there is a larger pie.

size	size 2	size 2 (SD)	size 2 NOS	size Sig.
symmetry	59,3082707	42,1597216	133	0,00060183
asymmetry	75,5666667	19,4221405	30	
	size 3	size 3 (SD)	size 3 NOS	
symmetry	33,4418605	29,2023338	43	
asymmetry	53,75	38,0213286	36	
	size 4	size 4 (SD)	size 4 NOS	
symmetry	18,626506	37,6708177	83	
asymmetry	8,91525424	26,0452445	59	
	size 5	size 5 (SD)	size 5 NOS	
symmetry	51	33,4932829	11	
asymmetry	22	18,1727818	9	
surplus	producer surplus	producer surplus (SD)	producer surplus NOS	surplus Sig.
symmetry	-18,375	38,9539563	8	0,00137745
asymmetry	25,1176471	30,7284118	17	
	symmetric surplus	symmetric surplus (SD)	symmetric surplus NOS	
symmetry	27,6981132	33,1364193	106	
asymmetry	3,34615385	17,7153996	26	
	consumer surplus	consumer surplus (SD)	consumer surplus NOS	
symmetry	48,5103093	43,0939737	194	
asymmetry	38,214876	39,3086518	121	

Table 23
Symmetry: Interaction Effects
(normalized deviation from the Walrasian equilibrium)

3. fect of Power Asymmetries among Sellers

Symmetry addresses relative gains from collusion, whereas power says something about bargaining weights when it comes to (implicit) negotiations about how to split these gains. In experiments, power is typically implemented by giving some, but not all sellers inframarginal units. These sellers then can exert influence on their competitors by withholding supply.[10]

The effect of power on deviations from the Walrasian equilibrium is insignificant throughout, as is the effect on proportional deviations from the Nash equilibrium. However, the effect on the CN index is highly significant. The effect is not surprising. If some sellers have power, this pushes the equilibrium far below the Nash prediction.

treatment	T CW	T CW (SD)	T CW NOS	T CW ANOVA	T CW Mann Whitney
no power	56,8571429	28,3162413	7	0,13489024	0,241
power	71,8461539	14,9935884	13		

Table 24
Power: Normalized Deviation from the Walrasian Equilibrium
(data from the gross and ordinary coverage samples insignificant)

gross	CN	CN (SD)	CN NOS	CN ANOVA	CN Mann-Whitney
no power	4,58933333	49,6103738	375	0	0,023
power	-90,4137931	211,052552	29		
ordinary coverage	OC CN	OC CN (SD)	OC CN NOS	OC CN ANOVA	
no power	-0,62857143	32,9936303	175	0	0,363
power	-105,583333	285,93593	12		
treatment	T CN	T CN (SD)	T CN NOS	T CN ANOVA	
no power	18,2857143	21,2423656	7	0,21427761	0,485
power	-38,8461539	114,962201	13		

Table 25
Power: Normalized Deviation from the Nash Equilibrium

treatment	T NN	T NN (SD)	T NN NOS	T NN ANOVA	T NN Mann Whitney
no power	5,57142857	5,38074167	7	0,77904285	0,485
power	4,30769231	10,9497688	13		

Table 26
Power: Proportional Deviation from the Nash Equilibrium
(data from the gross and ordinary coverage samples insignificant)

10 Of course, this also generate asymmetry among sellers. But asymmetry is the wider category. It in particular also covers mere cost asymmetry.

V. Dependence of Collusion on Demand and Supply Characteristics

1. Effect of Demand Characteristics

From a theoretical perspective, the shape of the demand curve matters since it is the upper bound of the bargaining range. Most experiments use a linear demand curve with negative slope. Frequently, there is also a step function that could be approximated by such a linear curve. Occasionally more complicated, e.g. quadratic, specifications are used. All this is presented here as demand decreasing in quantity. It is opposed to constant demand. In such a box design, it would in principle be possible for the sellers to appropriate the entire consumer rent.

The effect of this manipulation on the deviation from the Walrasian equilibrium is significant only if one reduces the sample to experiments with ordinary coverage. It has the expected direction. Collusion is much higher if demand is constant. Likewise, the mean deviation from the Nash equilibrium is negative, both measured by the CN and the NN index, if demand decreases in quantity. It is positive with constant demand.

ordinary coverage	OC CW	OC CW (SD)	OC CW NOS	OC CW ANOVA	OC CW Mann Whitney
constant demand	38,8979592	22,79825	49	0	0
decreasing demand	15,4852941	31,0628598	204		

Table 27
Demand: Normalized Deviation from the Walrasian Equilibrium
(data from the gross sample insignificant, no treatment data available)

ordinary coverage	OC CN	OC CN (SD)	OC CN NOS	OC CN ANOVA	OC CN Mann Whitney
constant demand	20,6818182	19,0321304	44	0,00672669	0
decreasing demand	-17,1214286	90,6806768	140		

Table 28
Demand: Normalized Deviation from the Nash Equilibrium
(data from the gross sample insignificant, no treatment data available)

gross	NN	NN (SD)	NN NOS	NN ANOVA	NN Mann-Whitney
constant demand	234,923077	501,455953	52	0	0
decreasing demand	11,9329268	56,1681215	328		
ordinary coverage	OC NN	OC NN (SD)	OC NN NOS	OC NN ANOVA	
constant demand	288,214286	545,357101	42	0	0
decreasing demand	1,74626866	60,2104938	134		

Table 29
Demand: Proportional Deviation from the Nash Equilibrium
(no treatment data available)

2. Effect of Supply Characteristics

In practice, supply curves often have negative slope. There are, however, no experiments that have tested such a market. In most experiments, marginal cost and hence supply is constant. In many others, marginal cost increases in quantity, meaning that supply decreases in quantity. From a theoretical perspective, the supply curve is the lower bound of the bargaining range. If supply decreases in quantity, sellers have less to gain from collusion. This expectation is borne out by all data in all samples and with respect to all indices.

gross	CW	CW (SD)	CW NOS	CW ANOVA	CW Mann-Whitney
constant supply	53,4411765	39,2385579	272	0	0
decreasing supply	14,01	30,7082216	200		
ordinary coverage	OC CW	OC CW (SD)	OC CW NOS	OC CW A-NOVA	
constant supply	42,4680851	23,9787998	94	0	0
decreasing supply	6,74842767	26,8179443	159		
treatment	T CW	T CW (SD)	T CW NOS	T CW ANO-VA	
constant supply	72,3333333	19,8051111	12	0	0
decreasing supply	17,1785714	39,1086365	28		

Table 30
Supply: Normalized Deviation from the Walrasian Equilibrium

ordinary coverage	OC CN	OC CN (SD)	OC CN NOS	OC CN A-NOVA	CN Mann Whitney
constant supply	8,23595506	26,2877531	89	0,00797099	0
decreasing supply	-23,3684211	108,161823	95		
treatment	T CN	T CN (SD)	T CN NOS	T CN ANOVA	
constant supply	59,0833333	36,807752	12	0	0
decreasing supply	-3,16666667	30,6483854	18		

Table 31
Supply: Normalized Deviation from the Nash Equilibrium
(data from the gross sample insignificant)

gross	NN	NN (SD)	NN NOS	NN ANOVA	NN Mann-Whitney
constant supply	59,3474904	243,925716	259	0,01911447	0
decreasing supply	6,27272727	64,8458428	121		
ordinary coverage	OC NN	OC NN (SD)	OC NN NOS	OC NN ANOVA	
constant supply	137,103448	404,165089	87	0,0027215	0
decreasing supply	4,61797753	73,8609728	89		
treatment	T NN	T NN (SD)	T NN NOS	T NN ANOVA	
constant supply	94	100,08451	12	0,00063051	0
decreasing supply	2,72222222	13,813061	18		

Table 32
Supply: Proportional Deviation from the Nash Equilibrium

3. Dependence of Collusion on the Distribution of the Surplus

While demand and supply say something about the upper and lower bound of the bargaining range, surplus directly measures how much sellers have to gain from collusion. If most of the surplus is with producers anyhow, gains from collusion are small. If, in the Walrasian equilibrium, the distribution of the surplus is symmetric, collusion pays more. It is most profitable if, under perfect competition, most of the surplus would go to consumers. As the data shows, subjects are highly sensitive to this with respect to all three indices. The treatment data is insignificant, which is probably due to small sample size. It however consistently points into the same direction.

gross	CW	CW (SD)	CW NOS	CW ANOVA	CW Kruskal-Wallis
producer surplus	11,2	38,7405903	25	0	0
symmetric surplus	22,9015152	32,1636701	132		
consumer surplus	44,5555556	41,9180949	315		
ordinary coverage	OC CW	OC CW (SD)	OC CW NOS	OC CW ANOVA	
producer surplus	0,55	35,0690672	20	0,00358389	0,008
symmetric surplus	18,0485437	32,0873131	103		
consumer surplus	24,5769231	28,313545	130		
treatment	T CW	T CW (SD)	T CW NOS	T CW ANOVA	
producer surplus	-0,64285714	36,6639776	14	0,85851372	0,865
symmetric surplus	2,5	16,2326831	6		
consumer surplus	4,27586207	23,5719212	29		

Table 33
Surplus: Normalized Deviation from the Walrasian Equilibrium

gross	CN	CN (SD)	CN NOS	CN ANOVA	CN Kruskal-Wallis
producer surplus	-84,0952381	215,527702	21	0	0,003
symmetric surplus	-1,34375	61,5337012	96		
consumer surplus	3,11267606	58,4937674	284		
ordinary coverage	OC CN	OC CN (SD)	OC CN NOS	OC CN ANOVA	
producer surplus	-113,5625	240,771252	16	0	0
symmetric surplus	8,23287671	25,4288335	73		
consumer surplus	-2,85263158	30,9852293	95		
treatment	T CN	T CN (SD)	T CN NOS	T CN ANOVA	
producer surplus	-141,454546	288,010196	11	0,29050078	0,034
symmetric surplus	2,5	16,2326831	6		
consumer surplus	4,8	18,8069136	5		

Table 34
Surplus: Normalized Deviation from the Nash Equilibrium

gross	NN	NN (SD)	NN NOS	NN ANOVA	NN Kruskal-Wallis
producer surplus	-26,0476191	53,5504213	21	0	0
symmetric surplus	158,071429	410,884054	84		
consumer surplus	12,36	44,7012533	275		
ordinary coverage	OC NN	OC NN (SD)	OC NN NOS	OC NN ANOVA	
producer surplus	-34,9375	58,8687452	16	0	0
symmetric surplus	199,030769	459,373281	65		
consumer surplus	-0,41052632	11,9764794	95		
treatment	T NN	T NN (SD)	T NN NOS	T NN ANOVA	
producer surplus	-48	67,690472	11	0,10540691	0,083
symmetric surplus	-1	5,65685425	6		
consumer surplus	-0,4	2,07364414	5		

Table 35
Surplus: Proportional Deviation from the Nash Equilibrium

VI. Dependence of Collusion on Seller Characteristics

One of the standard defences of the rational choice approach is this: well yes, not everybody behaves like *homo oeconomicus*. But if you give them some chance to practise, they will (cf. e.g. Friedman 1953). The experimental evidence is at best mixed. If measured against the Walrasian equilibrium, experienced subjects collude less. This may be read as evidence for the learning expectation. But if one compares behaviour to the Nash equilibrium, experienced subjects collude substantially more. Apparently, they learn to collude, not to play Nash. One might object that the benchmark is taken from one shot interaction. In line with the folk theorem, collusion is an equilibrium in the repeated game with uncertain duration (Aumann and Shapley 1994). If that were the reason, however, one would have to see a strong interaction effect with the treatment variable partner versus stranger design. This is not the case. Both with the CN and the NN index, the interaction effect is insignificant (p=0,933 in both cases).

gross	CW	CW (SD)	CW NOS	CW ANOVA	CW Mann-Whitney
no experience	38,1138614	41,3056982	404	0,03701152	0,022
experience	27,4666667	35,7106742	75		
treatment	T CW	T CW (SD)	T CW NOS	T CW ANOVA	
no experience	26,9122807	38,9960074	57	0,61063109	0,735
experience	30,6981132	38,695351	53		

Table 36
Experience: Normalized Deviation from the Walrasian Equilibrium
(data from the ordinary coverage sample insignificant)

gross	CN	CN (SD)	CN NOS	CN ANOVA	CN Mann-Whitney
no experience	-4,85344828	81,6491321	348	0,08925335	0,059
experience	14,0714286	38,1546409	56		
treatment	T CN	T CN (SD)	T CN NOS	T CN ANOVA	
no experience	4,825	53,2184118	40	0,26124052	0,475
experience	17,2972973	42,341774	37		

Table 37
Experience: Normalized Deviation from the Nash Equilibrium
(data from the ordinary coverage sample insignificant)

gross	NN	NN (SD)	NN NOS	NN ANOVA	NN Mann-Whitney
no experience	32,505988	178,492835	334	0,02504473	0,005
experience	100,075472	318,645502	53		
ordinary coverage	OC NN	OC NN (SD)	OC NN NOS	OC NN ANOVA	
no experience	51,5324675	256,367031	154	0,04667632	0,115
experience	177,16	452,596737	25		
treatment	T NN	T NN (SD)	T NN NOS	T NN ANOVA	
no experience	27,55	63,2114685	40	0,85198341	0,527
experience	25,1081081	49,8240146	37		

Table 38
Experience: Proportional Deviation from the Nash Equilibrium

VII. Role of Seller Interaction in Explaining Collusion

1. Dependence on the Strategic Variable

If sellers compete in price, if the product is homogeneous, and if marginal cost is constant, the Bertrand model expects the competitive equilibrium (Bertrand 1883). If they compete in quantity, a deviation from the Walrasian equilibrium is expected, the larger the smaller the market (Cournot 1838). These expectations are only partly borne out by the experimental evidence. There is indeed a larger deviation from the competitive equilibrium if quantity is the strategic variable. If they compete in quantity, sellers end up close to or even below the Nash equilibrium. But if they compete in price, the market outcome is high above the Nash prediction.

gross	CW	CW (SD)	CW NOS	CW ANOVA	CW Mann-Whitney
quantity	49,4251969	31,1895179	127	0	0
price	30,3579882	36,7079129	338		
ordinary coverage	OC CW	OC CW (SD)	OC CW NOS	OC CW ANOVA	
quantity	37,9090909	26,4599901	44	0	0
price	16,6220096	30,7376569	209		
treatment	T CW	T CW (SD)	T CW NOS	T CW ANOVA	
quantity	57,7619048	23,5688455	21	0,48151018	0,743
price	51,3636364	34,2463699	22		

Table 39
Strategic Variable: Normalized Deviation from the Walrasian Equilibrium

treatment	T CN	T CN (SD)	T CN NOS	T CN ANOVA	T CN Mann Whitney
quantity	-21,952381	56,2463121	21	0,00856131	0,006
price	18,1818182	37,6369074	22		

Table 40
Strategic Variable: Normalized Deviation from the Nash Equilibrium
(data from the gross and the ordinary coverage samples insignificant)

gross	NN	NN (SD)	NN NOS	NN ANOVA	NN Mann-Whitney
quantity	-1,2519685	16,2529453	127	0,00321872	0
price	65,1048387	251,755322	248		
ordinary coverage	OC NN	OC NN (SD)	OC NN NOS	OC NN ANOVA	
quantity	-3,38636364	10,9123696	44	0,05595721	0,003
price	94,8863636	338,062613	132		
treatment	T NN	T NN (SD)	T NN NOS	T NN ANOVA	
quantity	-5,28571429	13,5319727	21	0,0242377	0,001
price	20,5	48,7136922	22		

Table 41
Strategic Variable: Proportional Deviation from the Nash Equilibrium

Specifically when sellers compete in price, game theoretic models make a difference between constant and increasing marginal cost (Allen and Hellwig 1986b; Allen and Hellwig 1986a). If this is relevant for the behaviour of experimental subjects, there would have to be an interaction effect between the strategic variable and the distinction between constant and increasing supply. If measured with the CN or the NN index, this is not the case (p=0,767 and 0,104 respectively). If measured with the CW index, there is indeed an interaction effect. But it points into the opposite direction. If marginal cost increases, collusion decreases, instead of increasing, as theory predicts.

	constant	constant (SD)	constant NOS	supply Sig.
quantity	55,1666667	30,83018	90	0,00232913
price	50,7777778	31,4432781	171	
	decreasing	decreasing (SD)	decreasing NOS	
quantity	35,3823529	28,9346334	34	
price	9,61349693	29,5284598	163	

Table 42
Strategic Variable – Supply Interaction
(normalized deviation from the Walrasian equilibrium)

2. Simultaneous vs. Sequential Interaction

If sellers interact sequentially (and if products are homogeneous), theory predicts a smaller deviation from the Walrasian equilibrium if they compete in quantity (Stackelberg 1934). If they compete in price and marginal cost is constant, there should be no deviation from the Walrasian equilibrium. The evidence that does not distinguish between strategic variables does not support these predictions. Sequential interaction increases the deviation from the Walrasian equilibrium, whereas from the theoretical perspective it could at most have been immaterial. The CN and the NN indices do not yield significant results.

gross	CW	CW (SD)	CW NOS	CW ANOVA	CW Mann-Whitney
simultaneous	35,0047506	36,6532656	421	0,03624041	0,419
sequential	46,9137931	61,7917511	58		
ordinary coverage	OC CW	OC CW (SD)	OC CW NOS	OC CW ANOVA	
simultaneous	18,7161572	30,4039002	229	0,02388349	0,097
sequential	32,8888889	32,7100706	27		
treatment	T CW	T CW (SD)	T CW NOS	T CW ANOVA	
simultaneous	66	26,8374738	9	0,72587447	0,760
sequential	69,125	17,3354165	16		

Table 43
Sequence: Normalized Deviation from the Walrasian Equilibrium

treatment	T CN	T CN (SD)	T CN NOS	T CN ANOVA	T CN Mann Whitney
simultaneous	14,2222222	20,8553217	9	0,15505034	0,462
sequential	-37,0625	102,540703	16		

Table 44
Sequence: Normalized Deviation from the Nash Equilibrium
(data from the gross and the ordinary coverage samples insignificant)

treatment	T NN	T NN (SD)	T NN NOS	T NN ANOVA	T NN Mann Whitney
simultaneous	3,44444444	4,21637021	9	0,44874205	0,691
sequential	1,125	8,39742024	16		

Table 45
Sequence: Proportional Deviation from the Nash Equilibrium
(data from the gross and the ordinary coverage samples insignificant)

If one looks at interaction effects, theory does not fare better. Here, the CN index is significant. But in quantity competition, there is a negative deviation from the Nash equilibrium if interaction is simultaneous. The deviation becomes positive if interaction is sequential. The negative effect of sequential play is even stronger in price competition. Apparently subjects dislike the opportunity for asymmetric gains inherent in sequential interaction.

	quantity	quantity (SD)	quantity NOS	strategic variable Sig.
simultaneous	-6,37962963	56,0348219	108	0,04859943
sequential	11,2105263	29,6771123	19	
	price	price (SD)	price NOS	
simultaneous	1,78991597	87,1664467	238	
sequential	-29,6666667	78,42684	27	

Table 46
Sequence – Strategic Variable Interaction
(normalised deviation from the Nash equilibrium)

3. Duration of the Interaction between Sellers

Strictly speaking, theory does not predict that longer duration means more collusion. If subjects are informed about the exact duration, via backwards induction, the prisoner's dilemma from the one-shot game is re-established (Selten 1978). If the end is uncertain, according to the folk theorem, there are multiple equilibria (Aumann and Shapley 1994). However, if one allows for a small deviation from strict rationality, and if the discount factor is not too large, a longer shadow of the future makes collusion more attractive (see e.g. Fudenberg and Tirole 1991:146-150). This expectation is at best weakly supported by the experimental evidence. If one restricts the sample to experiments with ordinary coverage, a linear regression yields a significant result for the CW and the NN indices. It indeed supports the view that longer duration increases collusion. One should, however, be aware of a qualification. Time series evidence demonstrates that collusion may go down again if the game is repeated very many times (Alger 1987).

gross	CW B	CW B SD	**CW Beta**	CW Sig.
	0,20048684	0,11456625	0,08988223	0,0809402
	CW Const	CW Const SD		CW Const Sig
	38,3053538	3,5195464		0
	CW R^2	CW adj.R^2		
	0,00807882	0,00544073		
ordinary coverage	OC CW B	OC CW B SD	**OC CW Beta**	OC CW Sig.
	0,45946574	0,13504525	0,24908425	0,00082811
	OC CW Const	OC CW Const SD		OC CW Const Sig
	16,2235714	3,46183856		0
	OC CW R^2	OC CW adj.R^2		
	0,06204296	0,05668321		
treatment	T CW B	T CW B SD	**T CW Beta**	T CW Sig.
	-0,29934652	0,30796074	-0,14832808	0,33660159
	T CW Const	T CW Const SD		T CW Const Sig
	63,8339001	7,47471927		0
	T CW R^2	T CW adj.R^2		
	0,02200122	-0,00128447		

Table 47

Duration: Normalized Deviation from the Walrasian Equilibrium: Regression

treatment	T CN B	T CN B SD	**T CN Beta**	T CN Sig.
	1,23323459	0,90890613	0,20492099	0,18208216
	T CN Const	T CN Const SD		T CN Const Sig
	-40,9577591	22,0606634		0,07039197
	T CN R^2	T CN adj.R^2		
	0,04199261	0,01918291		

Table 48

Duration: Normalized Deviation from the Nash Equilibrium: Regression

(estimates from gross and ordinary coverage samples insignificant)

gross	NN B	NN B SD	**NN Beta**	NN Sig.
	0,994591	0,58728859	0,08700595	0,09118278
	NN Const	NN Const SD		NN Const Sig
	18,0101709	18,0418708		0,31880353
	NN R^2	NN adj.R^2		
	0,00757004	0,0049306		
ordinary coverage	OC NN B	OC NN B SD	**OC NN Beta**	OC NN Sig.
	4,47582732	1,36914249	0,23990213	0,00129911
	OC NN Const	OC NN Const SD		OC NN Const Sig
	-20,4405987	35,0974968		0,5610504
	OC NN R^2	OC NN adj.R^2		
	0,05755303	0,05216762		
treatment	T NN B	T NN B SD	**T NN Beta**	T NN Sig.
	0,7784434	0,39897747	0,28827953	0,05773736
	T NN Const	T NN Const SD		T NN Const Sig
	-9,81206372	9,6838468		0,3167472
	T NN R^2	T NN adj.R^2		
	0,08310509	0,06127426		

Table 49

Duration: Proportional Deviation from the Nash Equilibrium: Regression

4. Partner vs. Stranger Design

It is more interesting, and more relevant, to compare experiments that had a fixed partner design with others that rematched subjects from round to round. On average, the latter manipulation increases collusion with respect to all three indices.

gross	CW	CW (SD)	CW NOS	CW ANOVA	CW Mann-Whitney
partner	34,5250597	42,0143085	419	0,006	0,001
stranger	49,8666667	25,682195	60		
ordinary coverage	OC CW	OC CW (SD)	OC CW NOS	OC CW ANOVA	
partner	16,7882883	30,6395664	222	0	0
stranger	42,5588235	22,2794799	34		
treatment	T CW	T CW (SD)	T CW NOS	T CW ANOVA	
partner	61,8421053	21,5748391	19	0,853	0,811
stranger	60,5	23,2797631	20		

Table 50
Partner vs. Stranger Design
Normalized Deviation from the Walrasian Equilibrium

ordinary coverage	OC CN	OC CN (SD)	OC CN NOS	OC CN ANOVA	CN Mann Whit-ney
partner	-11,8846154	87,1616194	156	0,086	0
stranger	15,3870968	22,8599758	31		
treatment	T CN	T CN (SD)	T CN NOS	T CN ANOVA	
partner	-8,89473684	70,2178315	19	0,656	0,440
stranger	-20,05	84,0829634	20		

Table 51
Partner vs. Stranger Design
Normalized Deviation from the Nash Equilibrium
(gross data insignificant)

gross	NN	NN (SD)	NN NOS	NN ANOVA	NN Mann-Whitney
partner	24,0684524	151,842804	336	0	0
stranger	158,313725	389,258448	51		
ordinary coverage	OC NN	OC NN (SD)	OC NN NOS	OC NN ANOVA	
partner	30,5666667	219,584581	150	0	0
stranger	268,275862	491,13243	29		
treatment	T NN	T NN (SD)	T NN NOS	T NN ANOVA	
partner	13,2631579	42,6872894	19	0,523	0,704
stranger	6,35	21,4089873	20		

Table 52
Partner vs. Stranger Design
Proportional Deviation from the Nash Equilibrium

These are surprising findings, both compared to the theoretical prediction, and to the findings in those experiments that had the distinction between partner and stranger design as a treatment variable. From the already mentioned folk theorem it follows that theory makes no clear prediction for the repeated game (Aumann and Shapley 1994). But one result is beyond doubt. In one-shot interaction, there is no collusive equilibrium. (Bertrand 1883) and (Cournot 1838) agree on this. It is equally remarkable that in the subsample with experiments that explicitly tested for the effect, the distinction between the partner and the stranger design is insignificant for all three indices.

For understanding these findings, it is helpful to look at interaction effects. In duopoly markets, shifting from partner to stranger design slightly reduces collusion. The larger the market, however, the stronger the positive effect of a stranger design on the degree of collusion. Moreover, the effect of stranger interaction on collusion is sensitive to information. With poor ex ante information or feedback, strangers collude more than partners. With full ex ante or feedback information, the effect reverses.

size	size 2	size 2 (SD)	size 2 NOS	size Sig.
partner	64,21875	42,6758405	128	0,00531679
stranger	55,2857143	23,3535127	35	
	size 3	size 3 (SD)	size 3 NOS	
partner	42,4782609	34,2192794	69	
stranger	44,2	40,6114379	10	
	size 4	size 4 (SD)	size 4 NOS	
partner	12,9111111	33,4133914	135	
stranger	47	16,4519502	7	
ex ante information	reduced ex ante	reduced ex ante (SD)	reduced ex ante NOS	ex ante Sig.
partner	18,1166667	39,8512325	120	0,04375676
stranger	57,1666667	9,66264284	6	
	partial ex ante	partial ex ante (SD)	partial ex ante NOS	
partner	37,9047619	32,7132923	84	
stranger	42,8333333	13,9773627	6	
	full ex ante	full ex ante (SD)	full ex ante NOS	
partner	53,8106061	46,1180253	132	
stranger	49,8333333	28,0025328	48	
feedback	reduced feedback	reduced feedback (SD)	reduced feedback NOS	feedback Sig.
partner	2,53521127	28,2402099	71	0,00692665
stranger	48,6666667	21,825062	3	
	partial feedback	partial feedback (SD)	partial feedback NOS	
partner	36,0593607	36,9249318	219	
stranger	52,3793103	23,7793635	29	
	full feedback	full feedback (SD)	full feedback NOS	
partner	59,12	52,0599862	75	
stranger	47,3928571	28,3957995	28	

Table 53
Partner vs. Stranger Design: Interaction Effects
(normalized deviation from the Walrasian equilibrium)

This explanation is corroborated if one checks the distribution of market sizes in the subsample that has explicitly tested the stranger versus the partner design. 33 experiments had a duopoly market, 6 a quadropoly. 27 had full, 12 partial ex ante information, none reduced information. 18 had full and 18 partial, and only 3 reduced feedback. In the subsample, treatment variables are thus overrepresented that dampen the effect of a stranger design on collusion.

5. Effect of Communication on Collusion

In game theoretic terms, competition puts sellers into a prisoner's dilemma.[11] If they have a chance to talk before play, from a theoretical perspective this is just irrelevant “cheap talk“ (for background and alternative models see Crawford 1998). Indeed, the main effect is not significant with respect to the CW and the NN indices. Only the CN index shows what common sense would expect: communication increases collusion.

treatment	T CW	T CW (SD)	T CW NOS	T CW ANOVA	T CW Mann Whitney
no communication	47,5555556	125,966376	9	0,80658175	0,042
communication	57,6153846	63,1948554	13		

Table 54
Communication: Normalized Deviation from the Walrasian Equilibrium
(data from gross and ordinary coverage samples insignificant)

gross	CN	CN (SD)	CN NOS	CN ANOVA	CN Mann-Whitney
no communication	-4,99171271	80,3984705	362	0,0349576	0,006
communication	21,5714286	35,1374603	42		
treatment	T CN	T CN (SD)	T CN NOS	T CN ANOVA	
no communication	3,11111111	21,1509128	9	0,003486	0,003
communication	45	33,4713808	13		

Table 55
Communication: Normalized Deviation from the Nash Equilibrium
(data from ordinary coverage sample insignificant)

treatment	T NN	T NN (SD)	T NN NOS	T NN ANOVA	T NN Mann Whitney
no communication	29,875	65,9641407	8	0,19233194	0,051
communication	116,9	170,040159	10		

Table 56
Communication: Proportional Deviation from the Nash Equilibrium
(data from gross and ordinary coverage samples insignificant)

11 Strictly speaking, this only holds if marginal cost increases. But if the supply curve differs from this, the parties still face a dilemma.

However, if one looks at interaction effects, the picture changes dramatically. Many of them are significant, and they matter in practical terms. In a duopoly, collusion, expressed as the deviation from the Walrasian equilibrium, is even slightly reduced. In triopoly, however, collusion jumps up. If sellers compete in price, communication reduces collusion. If they compete in quantity, communication strongly increases collusion. Inexperienced subjects slightly suffer from communication. Experienced subjects may dramatically increase collusion if they are allowed to talk. In simultaneous interaction, communication strongly increases collusion. In sequential interaction, the opposite is true. Finally with poor ex ante information, communication strongly reduces collusion, whereas with more ex ante information the opposite holds true, in particular with partial ex ante information. With poor and with full feedback, communication increases collusion. With partial feedback, collusion is reduced.

market size	size 2	size 2 (SD)	size 2 NOS	market size Sig
no communication	52,7755102	18,2314578	49	0,0291289
communication	22,75	28,1469359	4	
	size 3	size 3 (SD)	size 3 NOS	
no communication	19,173913	29,7071344	23	
communication	52	14,1421356	2	
	size 4	size 4 (SD)	size 4 NOS	
no communication	10,9032258	32,1024395	93	
communication	7,46153846	19,504766	13	
strategic variable	quantity	quantity (SD)	quantity NOS	strategic variable Sig.
no communication	46,6052632	31,3782571	114	0,0009569
communication	74,1538462	14,3052796	13	
	price	price (SD	price NOS	
no communication	74,1538462	14,3052796	13	
communication	17,24	27,2752635	25	
experience	no experience	no experience (SD)	no experience NOS	experience Sig.
no communication	38,3288043	40,3590566	368	0,00539321
communication	35,9166667	50,597219	36	
	experience	experience (SD)	experience NOS	
no communication	23,5217391	34,4005851	69	
communication	72,8333333	9,74508423	6	
sequence	simultaneous	simultaneous (SD)	simulataneous N	sequence Sig.
no communication	33,9287532	36,738458	393	0,00130297
communication	50,1071429	32,3892292	28	
	sequential	sequential (SD)	sequential NOS	
no communication	54,4090909	58,1326943	44	
communication	23,3571429	69,1059467	14	
ex ante information	ex ante reduced	ex ante reduced (SD)	ex ante reduced NOS	*ex ante Sig.
no communication	21,3333333	41,1579446	114	0,03125792
communication	7,08333333	20,322215	12	
	ex ante partial	ex ante partial (SD)	ex ante partial NOS	
no communication	33,9480519	31,2426396	77	
communication	63,6153846	22,2917715	13	

	ex ante full	ex ante full (SD)	ex ante full NOS	
no communication	52,1197605	39,6774347	167	
communication	60,8461538	66,9450598	13	
feedback information	reduced feedback	reduced feedback (SD)	reduced feedback NOS	*feedback Sig.
no communication	4,15942029	29,7744577	69	0,0173197
communication	7,8	25,2922913	5	
	partial feedback	partial feedback (SD)	partial feedback NOS	
no communication	39,650655	36,1609494	229	
communication	17,6842105	27,166263	19	
	full feedback	full feedback (SD)	full feedback NOS	
no communication	53,9354839	43,9032549	93	
communication	74,5	69,9082732	10	

Table 57
Communication: Interaction Effects
(normalized deviation from the Walrasian equilibrium)

6. Option to Agree

While mere communication should be irrelevant, at least in standard settings, from a theoretical perspective the possibility to conclude an enforceable agreement should make all the difference. Against this backdrop, the experimental evidence is somewhat disappointing. Some of the indices are insignificant in some compositions of the sample. The significant results in the gross sample, especially with respect to the CW index, are far from impressive.

gross	CW	CW (SD)	CW NOS	CW ANOVA	CW Mann-Whitney
no agreement	35,6111111	39,5691423	450	0,07618281	0,277
agreement	49,4137931	53,7603925	29		
treatment	T CW	T CW (SD)	T CW NOS	T CW ANOVA	
no agreement	43,4444444	126,973532	9	0,59879067	0,021
agreement	71,25	76,5501703	8		

Table 58
Agreement: Normalized Deviation from the Walrasian Equilibrium
(data from the ordinary coverage sample insignificant)

gross	CN	CN (SD)	CN NOS	CN ANOVA	CN Mann-Whitney
no agreement	-4,44	79,5724605	375	0,03875631	0,001
agreement	26,3448276	24,6783246	29		
treatment	T CN	T CN (SD)	T CN NOS	T CN ANOVA	
no agreement	11,6666667	47,2678538	9	0,10095232	0,016
agreement	43,25	20,2607996	8		

Table 59
Agreement: Normalized Deviation from the Nash Equilibrium
(data from the ordinary coverage sample insignificant)

treatment	T NN	T NN (SD)	T NN NOS	T NN ANOVA	T NN Mann Whitney
no agreement	43,625	79,2679678	8	0,13445532	0,079
agreement	182	225,985619	5		

Table 60
Agreement: Proportional Deviation from the Nash Equilibrium
(data from the gross and ordinary coverage samples insignificant)

As with communication, the many significant interaction effects are of greater interest. In duopoly, agreement matters most. In triopoly it still increases collusion remarkably. In quadropoly, however, the chance to agree even reduces collusion, as measured with the CW index. If buyers are simulated by a price taking computer, the effect of an opportunity to agree on collusion is much stronger than with human buyers. The chance to agree strongly increases collusion if sellers compete in quantity; it reduces collusion if they compete in price. Experienced subjects make much better use of the opportunity to conclude an agreement. If interaction is simultaneous, the opportunity to agree helps. If interaction is sequential, it hurts. If sellers are symmetric, agreement has a strong positive effect on collusion. Asymmetry dampens the effect strongly. If capacity is unconstrained, the effect of a chance to agree on collusion is much stronger than with constrained capacity. Finally, the effect of an agreement opportunity is sensitive to the information environment. If ex ante information is reduced, collusion even decreases. If ex ante information is partial, the effect is mildly positive. It is strongly positive with full ex ante information. Full feedback has a similar effect. However, in feedback, the chance to agree has a negative effect in the partial, not in the reduced specification.

market size	size 2	size 2 (SD)	size 2 NOS	size Sig
no agreement	60,7484277	36,766793	159	0,00052927
agreement	124	87,2505969	4	
	size 3	size 3 (SD)	size 3 NOS	
no agreement	37,8059701	34,9550529	67	
agreement	70	17,3310022	12	
	size 4	size 4 (SD)	size 4 NOS	
no agreement	15,3100775	34,6488633	129	
agreement	7,46153846	19,504766	13	
computer/human buyer	computer	computer (SD)	computer NOS	computer/human buyer Sig.
no agreement	41,3007916	38,7223091	379	0,0079757
agreement	88,3571429	49,0174335	14	
	human	human (SD)	human NOS	
no agreement	5,23943662	28,9000567	71	
agreement	13,0666667	24,8437019	15	
strategic variable	quantity	quantity (SD)	quantity NOS	stratvar Sig.
no agreement	46,6034483	31,1199305	116	0,00066389
agreement	79,1818182	7,31871822	11	
	price	price (SD	price NOS	
no agreement	31,1180124	37,0472257	322	
agreement	15,0625	25,2941858	16	

experience	no experience	no experience (SD)	no experience NOS	experience Sig.
no agreement	37,6754617	40,1549605	379	0,03623788
agreement	44,76	56,6092454	25	
	experience	experience (SD)	experience NOS	
no agreement	24,5915493	34,4912318	71	
agreement	78,5	5,44671155	4	
sequence	simultaneous	simultaneous (SD)	simultaneous NOS	sequence Sig.
no agreement	33,7054455	36,5721676	404	0
agreement	65,8823529	22,8333154	17	
	sequential	sequential (SD)	sequential NOS	
no agreement	52,3478261	57,6642456	46	
agreement	26,0833333	74,7364562	12	
symmetry	symmetric	symmetric (SD)	symmetric NOS	symmetry Sig.
no agreement	38,0614887	40,1913375	309	0,01223149
agreement	93,1666667	80,0834981	6	
	asymmetric	asymmetric (SD)	asymmetric NOS	
no agreement	30,2411348	37,7548295	141	
agreement	38	39,5290457	23	
capacity	unconstrained	unconstrained (SD)	unconstrained NOS	capacity Sig.
no agreement	52,8299595	37,0413337	247	0,01611412
agreement	116,4	77,4486927	5	
	constrained	constrained (SD)	constrained NOS	
no agreement	14,6600985	31,7120044	203	
agreement	35,4583333	36,008428	24	
ex ante informa-tion	ex ante re-duced	ex ante reduced (SD)	ex ante reduced NOS	ex ante Sig.
no agreement	21,3333333	41,1579446	114	0
agreement	7,08333333	20,322215	12	
	ex ante partial	ex ante partial (SD)	ex ante partial NOS	
no agreement	34,2948718	31,1898706	78	
agreement	63,8333333	23,2685247	12	
	ex ante full	ex ante full (SD)	ex ante full NOS	
no agreement	50,9314286	39,4796017	175	
agreement	116,4	77,4486927	5	
feedback informa-tion	reduced feedback	reduced feedback (SD)	reduced feedback NOS	feedback Sig.
no agreement	6,44871795	30,7755374	78	0
agreement	12	.	1	
	partial feed-back	partial feedback (SD)	partial feedback NOS	
no agreement	38,942623	35,5777244	244	
agreement	13,1428571	25,7797092	14	
	full feedback	full feedback (SD)	full feedback NOS	
no agreement	52,9278351	43,524717	97	
agreement	88,3571429	49,0174335	14	

Table 61
Agreement: Interaction Effects
(normalized deviation from the Walrasian equilibrium)

VIII. Dependence of Collusion on the Information Environment

1. Role of Ex Ante Information

From the very first oligopoly experiments on, experimenters have manipulated the information they have given their subjects, both in advance and as feedback to their choices in previous rounds (e.g. Fouraker and Siegel 1963). The effect of ex ante information on deviations from the Walrasian equilibrium is straightforward. The better subjects are informed, the more they collude. The effect on deviations from the Nash equilibrium is less clear. The only significant finding is in the sample reduced to experiments with ordinary coverage, and with respect to the NN index. Collusion increases from reduced to full ex ante information, but it is lowest with partial ex ante information.

The distinction between full and partial ex ante information is net. If subjects are fully informed, they are able to calculate their competitors' profits. With partial information, they are only able to anticipate their own profit. The reduced information category is less strictly defined. It encompasses all situations where subjects receive yet less information. Often this means that they have no full knowledge of demand. Sometimes, there is cost uncertainty.[12]

gross	CW	CW (SD)	CW NOS	CW ANOVA	CW Kruskal-Wallis
reduced ex ante information	19,9761905	39,8162709	126	0	0
partial ex ante information	38,2333333	31,7886454	90		
full ex ante information	52,75	42,0183353	180		
ordinary coverage	OC CW	OC CW (SD)	OC CW NOS	OC CW ANOVA	
reduced ex ante information	7,90588235	28,3026263	85	0	0
partial ex ante information	22,6428571	28,8273426	42		
full ex ante information	36,8064516	30,2328877	62		
treatment	T CW	T CW (SD)	T CW NOS	T CW ANOVA	
reduced ex ante information	-4,4	32,9787811	10	0,00313307	0,002
partial ex ante information	31,5	27,6973439	8		
full ex ante information	42,2307692	28,8968102	13		

Table 62
Ex ante Information: Normalized Deviation from the Walrasian Equilibrium

treatment	T CN	T CN (SD)	T CN NOS	T CN ANOVA	T CN Kruskal Wallis
reduced ex ante information	-26,2	75,3713768	10	0,64802787	0,628
partial ex ante information	-17,875	24,82762	8		
full ex ante information	-5,38461539	45,2797572	13		

Table 63
Ex ante Information: Normalized Deviation from the Nash Equilibrium
(data from the gross and ordinary coverage samples insignificant)

12 Details are specified in the databank.

ordinary coverage	OC NN	OC NN (SD)	OC NN NOS	OC NN ANO-VA	NN Kruskal Wallis
reduced ex ante infor-mation	36,2051282	104,676238	39	0,05581643	0,143
partial ex ante informa-tion	5,80952381	32,7304126	42		
full ex ante information	124,727273	384,742986	55		
treatment	T NN	T NN (SD)	T NN NOS	T NN ANOVA	
reduced ex ante infor-mation	11,3	49,073754	10	0,69951372	0,585
partial ex ante informa-tion	-0,25	18,3595051	8		
full ex ante information	19,0769231	62,9542976	13		

Table 64
Ex ante Information: Proportional Deviation from the Nash Equilibrium
(data from the gross sample insignificant)

The picture becomes much clearer if one looks at interaction effects. For markets of different size, ex ante information matters differently. In duopoly, collusion is highest with reduced information. It is lowest with partial information. Collusion with full information is slightly above collusion with partial information. The shape of the interaction curve is reversed with triopoly and quadropoly. Here collusion is lowest with reduced ex ante information, and highest with partial information. There is also a net difference between competition in quantity and in price. With reduced ex ante information, collusion is much higher if subjects compete in price. This reverses with partial and full information. Now the deviation from the Walrasian equilibrium is higher with competition in quantity.

Communication yields a similar pattern. If subjects are allowed to communicate, but severely lack information, they collude less than if they are better informed. With partial or full information, however, communication strongly increases collusion. If they are allowed to conclude an agreement, the pattern is in principle the same. However, partial information has a less pronounced impact on collusion if agreements are permitted. The situation is comparable with fixed cost. If ex ante information is reduced, fixed cost leads to less collusion than without fixed cost. With partial or full information, however, there is more collusion in fixed cost treatments. With asymmetry, the only noticeable difference is in full ex ante information environments. With this much information, subjects collude much more, whereas the level of collusion is about the same with reduced and partial information. If capacity is unconstrained, reduced ex ante information leads to very high collusion. Collusion is lowest with partial information, and somewhere in the middle with full information. Collusion with constrained capacity is almost the exact opposite. Finally, with homogeneous products, ex ante information has the standard effect. The effect reverses, however, if products are substitutes.

size	size 2	size 2 (SD)	size 2 NOS	size Sig.
reduced	78,2	27,3406494	10	0,05778036
partial	60	23,1372715	19	
full	63,661157	42,0875187	121	
	size 3	size 3 (SD)	size 3 NOS	
reduced	41	49,6329384	15	
partial	49,5517241	26,6439302	29	
full	37,3333333	33,3439064	30	
	size 4	size 4 (SD)	size 4 NOS	
reduced	9,61643836	32,544683	73	
partial	30,6	33,3441386	20	
full	18,6	36,2014207	15	
strategic vari-able	quantity	quantity (SD)	quantity NOS	strategic variable Sig.
reduced	-16,3333333	41,4568048	6	0
partial	52,2105263	26,7340838	38	
full	55,4358974	25,6927853	78	
	price	price (SD)	price NOS	
reduced	21,907563	39,1732336	119	
partial	28,0192308	31,5118965	52	
full	46,7826087	32,9591242	92	
communication	no communica-tion	no communication (SD)	no communication NOS	communication Sig.
reduced	21,3333333	41,1579446	114	0,03125792
partial	33,9480519	31,2426396	77	
full	52,1197605	39,6774347	167	
	communication	communication (SD)	communication NOS	
reduced	7,08333333	20,322215	12	
partial	63,6153846	22,2917715	13	
full	60,8461538	66,9450598	13	
agreement	no agreement	no agreement (SD)	no agreement NOS	agreement Sig.
reduced	21,3333333	41,1579446	114	0
partial	34,2948718	31,1898706	78	
full	50,9314286	39,4796017	175	
	agreement	agreement (SD)	agreement NOS	
reduced	7,08333333	20,322215	12	
partial	63,8333333	23,2685247	12	
full	116,4	77,4486927	5	
fixed cost	no fixed cost	no fixed cost (SD)	no fixed cost NOS	fixed cost Sig.
reduced	21,7672414	40,9543453	116	0,00079336
partial	33,4324324	31,5885713	74	
full	47,6842105	31,2845139	152	
	fixed cost	fixed cost (SD)	fixed cost NOS	
reduced	-0,8	8,12130258	10	
partial	60,4375	22,3605866	16	
full	80,25	72,818712	28	
symmetry	symmetry	symmetry (SD)	symmetry NOS	symmetry Sig.
reduced	21,5689655	39,3295175	58	0,04003939
partial	39,372549	32,3276728	51	
full	49,2913907	44,1783641	151	
	asymmetry	asymmetry (SD)	asymmetry NOS	
reduced	18,6176471	40,4685356	68	
partial	36,7435897	31,42637	39	

full	70,7586207	20,7547846	29	
capacity	unconstrained	unconstrained (SD)	unconstrained NOS	capacity Sig.
reduced	71,56	45,9547604	25	0
partial	44,5	24,63737	52	
full	57,738255	41,5450579	149	
	constrained	constrained (SD)	constrained NOS	
reduced	7,20792079	25,3957937	101	
partial	29,6578947	38,2532643	38	
full	28,7741935	36,0820451	31	
homogeneity	homogeneous	homogeneous (SD)	homogeneous NOS	homogeneity Sig.
reduced	6,8	27,5294947	105	0
partial	32,5324675	30,6545199	77	
full	49,722973	44,4867665	148	
	heterogeneous	heterogeneous (SD)	heterogeneous NOS	
reduced	85,8571429	22,3299926	21	
partial	72	9,97496867	13	
full	66,75	23,7459674	32	

Table 65
Ex ante Information: Interaction Effects
(normalized deviation from the Walrasian equilibrium)

2. Role of Feedback

At the aggregate level, ex ante and feedback information have similar effects. The deviation from the Walrasian equilibrium is smallest if feedback is reduced. It increases with partial feedback, and it is highest with full feedback. As with ex ante information, the aggregate effect on deviations from the Nash equilibrium is less obvious. The only weakly significant result is in the ordinary coverage sample. It is the same as with the Walrasian equilibrium.

The distinction between partial and full is the same as with ex ante information. Feedback is full if subjects know their competitors' profits. It is partial if they only know their own profit. Again the category of reduced feedback is less strictly defined. It encompasses all situations where subjects get even less feedback.

gross	CW	CW (SD)	CW NOS	CW ANOVA	CW Kruskal-Wallis
reduced feedback	6,51898734	30,5839998	79	0	0
partial feedback	37,5426357	35,5630657	258		
full feedback	57,3963964	45,5725753	111		
ordinary coverage	OC CW	OC CW (SD)	OC CW NOS	OC CW ANO-VA	
reduced feedback	-0,57894737	23,274716	57	0	0
partial feedback	22,4015748	31,2651893	127		
full feedback	40,4150943	25,5150287	53		
treatment	T CW	T CW (SD)	T CW NOS	T CW ANOVA	
reduced feedback	5,33333333	58,7934237	6	0,1014702	0,238
partial feedback	40,0285714	38,6678813	35		
full feedback	43,7368421	31,2940216	19		

Table 66
Feedback: Normalized Deviation from the Walrasian Equilibrium

treatment	T CN	T CN (SD)	T CN NOS	T CN ANOVA	T CN Mann Whitney
reduced feedback	-85,6666667	77,6908403	6	0,57446048	0,009
partial feedback	-19,7142857	171,490623	35		
full feedback	-27,4736842	76,9670697	19		

Table 67
Feedback: Normalized Deviation from the Nash Equilibrium
(data from the gross and ordinary coverage samples insignificant)

ordinary coverage	OC NN	OC NN (SD)	OC NN NOS	OC NN ANOVA	NN Kruskal Wallis
reduced feedback	-2,66666667	4,9244289	9	0,08515388	0,022
partial feedback	46,4867257	252,181876	113		
full feedback	156,108696	413,03711	46		
treatment	T NN	T NN (SD)	T NN NOS	T NN ANOVA	
reduced feedback	-27,8333333	30,6099113	6	0,56795273	0,021
partial feedback	-6,0625	41,6505722	32		
full feedback	-3,66666667	64,9823505	18		

Table 68
Feedback: Proportional Deviation from the Nash Equilibrium
(data from the gross sample insignificant)

As with ex ante information, feedback is mainly relevant through its interaction with other treatment variables. If buyers are human, going from reduced to partial feedback has a much smaller effect on collusion. If subjects are allowed to communicate, the effect of partial feedback is small, but the effect of full feedback is very large. The opposite is true if subjects cannot communicate. This pattern is even more pronounced if they are allowed to conclude an agreement. In a stranger design feedback is almost irrelevant. From this it follows that subjects use feedback mainly as a tool for backing collusion, not as one for learning how to interact. If interaction is simultaneous, feedback has the standard effects. In sequential interaction, however, collusion is high with reduced and with full feedback, and it is low with partial feedback.

If there is no fixed cost, feedback has the usual effects. With fixed cost, however, collusion is much higher with reduced and with full feedback. Although results are only weakly significant, it is also interesting to look at the interaction with surplus. If gains from collusion are high since most of the surplus is with consumers, feedback has the standard effects. With a symmetric distribution of the surplus between sellers and buyers, going from partial to full feedback no longer increases collusion. If most of the surplus is with producers anyhow, collusion even drops if one goes from partial to full feedback. Finally, if products are homogeneous, feedback has the usual effects. With substitutes, however, collusion goes down if one goes from partial to full feedback.

computer/human buyer	computer	computer (SD)	computer NOS	computer/human buyer Sig.
reduced	11,3589744	36,5257567	39	0,04509921
partial	42,462963	34,0491918	216	
full	57,3963964	45,5725753	111	
	human	human (SD)	human NOS	
reduced	1,8	22,9035883	40	
partial	12,2380952	32,6300845	42	
full	0	0	0	
communication	no communica-tion	no communication (SD)	no communication NOS	communication Sig.
reduced	6,43243243	31,0527969	74	0,00488638
partial	39,1213389	35,7197002	239	
full	53,9354839	43,9032549	93	
	communication	communication (SD)	communication NOS	
reduced	7,8	25,2922913	5	
partial	17,6842105	27,166263	19	
full	75,2777778	51,0222622	18	
agreement	no agreement	no agreement (SD)	no agreement NOS	agreement Sig.
reduced	6,44871795	30,7755374	78	0
partial	38,942623	35,5777244	244	
full	52,9278351	43,524717	97	
	agreement	agreement (SD)	agreement NOS	
reduced	12	.	1	
partial	13,1428571	25,7797092	14	
full	88,3571429	49,0174335	14	
partner/stranger	partner	partner (SD)	partner NOS	partner/stranger Sig.
reduced	4,85526316	29,7696507	76	0,004767
partial	35,6637555	36,3951937	229	
full	60,7710843	49,7477357	83	
	stranger	stranger (SD)	stranger NOS	
reduced	48,6666667	21,825062	3	
partial	52,3793103	23,7793635	29	
full	47,3928571	28,3957995	28	
sequence	simultaneous	simultaneous (SD)	simultaneous NOS	sequence Sig.
reduced	5,20779221	29,8418364	77	0
partial	39,965368	35,74619	231	
full	51,4390244	28,1609561	82	
	sequential	sequential (SD)	sequential NOS	
reduced	57	7,07106781	2	
partial	16,8148148	26,4488433	27	
full	74,2413793	73,9399637	29	
fixed cost	no fixed cost	no fixed cost (SD)	no fixed cost NOS	fixed cost Sig.
reduced	6,11538462	30,5694784	78	0,01127443
partial	36,5829384	36,3891205	211	
full	50,3555556	28,1880966	90	
	fixed cost	fixed cost (SD)	fixed cost NOS	
reduced	38	.	1	
partial	41,8510638	31,586306	47	
full	87,5714286	81,9008983	21	
surplus	producer	producer (SD)	producer NOS	surplus Sig.
reduced	6,75	29,0789156	4	0,06648389
partial	15,7	53,1560595	10	

full	-2	15,5563492	2	
	symmetric	symmetric (SD)	symmetric NOS	
reduced	2,64102564	26,6916971	39	
partial	31,8701299	31,8864559	77	
full	29,125	23,5962568	16	
	consumer	consumer (SD)	consumer NOS	
reduced	10,6944444	34,6969076	36	
partial	41,374269	35,3614984	171	
full	64,4444444	46,6943471	90	
capacity	unconstrained	unconstrained (SD)	unconstrained NOS	capacity Sig.
reduced	24,0909091	49,451905	11	0,04256421
partial	53,6241611	29,4896859	149	
full	60,9659091	48,3346688	88	
	constrained	constrained (SD)	constrained NOS	
reduced	3,67647059	25,7887174	68	
partial	15,559633	31,1984185	109	
full	43,7391304	29,9927527	23	
homogeneity	homogeneous	homogeneous (SD)	homogeneous NOS	homogeneity Sig.
reduced	2,67123288	27,9285073	73	
partial	30,793578	32,8133747	218	0
full	53,3291139	52,0031364	79	
	heterogeneous	heterogeneous (SD)	heterogeneous NOS	
reduced	53,3333333	22,6686274	6	
partial	74,325	26,4772641	40	
full	67,4375	20,4654508	32	

Table 69
Feedback: Interaction Effects
(normalized deviation from the Walrasian equilibrium)

3. Neutral vs. Market Frame

In oligopoly experiments, it is standard to tell subjects that they are sellers in a market. Some experimenters wondered whether the explicit frame has an impact on the degree of collusion. This is indeed the case, but in a surprising direction. If subjects are given the underlying game in a neutral frame, cooperation (collusion) rates go up substantially.

gross	CW	CW (SD)	CW NOS	CW ANOVA	CW Mann-Whitney
market frame	35,8543046	40,9771246	453	0,0182041	0,004
neutral frame	57,2380952	24,9116534	21		
ordinary coverage	OC CW	OC CW (SD)	OC CW NOS	OC CW ANOVA	
market frame	18,814346	30,5160302	237	0	0
neutral frame	50,0714286	22,1062619	14		

Table 70
Frame: Normalized Deviation from the Walrasian Equilibrium
(no treatment data available)

gross	CN	CN (SD)	CN NOS	CN ANOVA	CN Mann-Whitney
market frame	-4,07651715	78,9314347	379	0,05460168	0,004
neutral frame	29,3809524	39,0556989	21		

Table 71
Frame: Normalized Deviation from the Nash Equilibrium
(data from the ordinary coverage sample insignificant, no treatment data available all data on the NN index insignificant, no treatment data on that index)

IX. Sensitivity of Collusion to Buyer Activity

1. Computer vs. Human Buyers

Oligopoly experiments are designed to learn more about the behaviour of sellers. This explains that buyers are usually replaced by a computer. This computer is programmed as a non-strategic actor. It simply represents the demand curve. This apparently innocent way of saving experimental resources, and of gaining full control over the opposite market side, has a dramatic influence on collusion. When subjects know that they are playing against human buyers, collusion rates plummet.

gross	CW	CW (SD)	CW NOS	CW ANOVA	CW Mann-Whitney
computer buyer	42,9770992	40,0226592	393	0	0
human buyer	6,60465116	28,256089	86		
ordinary coverage	OC CW	OC CW (SD)	OC CW NOS	OC CW ANOVA	
computer buyer	27,1491713	29,8063167	181	0	0
human buyer	3,46666667	26,957591	75		

Table 72
Human vs. Computer Buyers: Normalized Deviation from the Walrasian Equilibrium
(no treatment data available, data on CN and NN index insignificant)

2. Sensitivity of Collusion to the Trading Institution

Trading institutions matter. This is one of the most robust findings from the experimental literature on oligopoly (see only Ketcham, Smith et al. 1984). In essence, this is a statement about the kind and the degree of buyer influence. The majority of oligopoly experiments uses the posted offer institution. Each seller is free to post a price. Buyers shop around, or efficient rationing does the shopping for them. This rule makes buyers almost passive. Consequently, collusion is highest. The effect becomes even stronger in the “posted Diamond“ treatment.[13] This treatment is meant to test the model by (Diamond 1971). This is implemented by making shopping costly for buyers. All other trading institutions yield collusion rates far below this level. If participants at both sides of the market have an opportunity to submit a sealed bid, there is still a small amount of collusion. If they negotiate individually, collusion is already close to zero. In a double auction, average collusion falls below the Walrasian prediction. Under this rule, every higher bid by a buyer replaces all previous lower bids. Likewise every lower bid by a seller replaces all previous higher ones.

gross	CW	CW (SD)	CW NOS	CW ANOVA	CW Kruskal-Wallis
other trading institution	9,1875	29,200956	16	0	0
posted	48,6666667	38,414253	339		
posted Diamond	45,1875	24,6339028	16		
sealed bid	4,52941176	29,1099589	17		
negotiation	1,28571429	11,5653898	14		
double auction	-0,06493506	26,19579	77		
ordinary coverage	OC CW	OC CW (SD)	OC CW NOS	OC CW ANOVA	
other trading institution	2,625	39,9032312	8	0	0
posted	35,4485294	24,447622	136		
posted Diamond	39	31,0207304	8		
sealed bid	4,52941176	29,1099589	17		
negotiation	1,28571429	11,5653898	14		
double auction	-1,02739726	26,5015579	73		
treatment	T CW	T CW (SD)	T CW NOS	T CW ANOVA	
other trading institution	13,1666667	12,576433	6	0,00116815	0,015
posted	18,2380952	19,0050119	21		
posted Diamond	56,75	22,3960562	4		
sealed bid	4,52941176	29,1099589	17		
negotiation	1,33333333	18,3393929	3		
double auction	3,66666667	18,8439709	15		

Table 73
Trading Institution: Normalized Deviation from the Walrasian Equilibrium

gross	CN	CN (SD)	CN NOS	CN ANOVA	CN Kruskal-Wallis
other trading institution	-139,2	307,809754	10	0	0,008
posted	2,66043614	63,6344538	321		
posted Diamond	3,92857143	44,8492591	14		
negotiation	-4,07692308	10,4360077	13		
double auction	-7,93478261	28,7992301	46		
ordinary coverage	OC CN	OC CN (SD)	OC CN NOS	OC CN ANOVA	
other trading institution	-249	366,561318	6	0	0,003
posted	4,55462185	33,8645601	119		
posted Diamond	8,5	5,71839138	6		
negotiation	-4,07692308	10,4360077	13		

13 Except for the CW index in the gross sample, where it is slightly below the value for ordinary posted offer experiments, and far above all the results for all other trading institutions.

double auction	-9,8372093	28,7409864	43		
treatment	T CN	T CN (SD)	T CN NOS	T CN ANOVA	
posted	2,61538462	33,0493027	13	0,01841942	0,022
posted Diamond	55,5	22,6936114	4		
negotiation	-9	5,65685425	2		
double auction	-26,1428571	51,6540691	7		

Table 74
Trading Institution: Normalized Deviation from the Nash Equilibrium

gross	NN	NN (SD)	NN NOS	NN ANOVA	NN Kruskal-Wallis
other trading institution	-85,3333333	73,9963963	6	0	0
posted	38,9903846	173,147159	312		
posted Diamond	271,25	613,814576	16		
negotiation	-1,61538462	7,03015483	13		
double auction	4,725	43,3814255	40		
ordinary coverage	OC NN	OC NN (SD)	OC NN NOS	OC NN ANOVA	
other trading institution	-85,3333333	73,9963963	6	0	0,011
posted	76,6869565	273,718429	115		
posted Diamond	488	836,420776	8		
negotiation	-1,61538462	7,03015483	13		
double auction	4,72972973	45,1470736	37		
treatment	T NN	T NN (SD)	T NN NOS	T NN ANOVA	
posted	56,9230769	154,47139	13	0,91419845	0,094
posted Diamond	63	26,0895892	4		
negotiation	-1,5	0,70710678	2		
double auction	33,4285714	104,485816	7		

Table 75
Trading Institution: Proprotional Deviation from the Nash Equilibrium

3. Collusion under Conditions of Demand Inertia

In reality, demand is hardly ever perfectly elastic. Buyers hold to their buying habits as long as a competing offer is not clearly more attractive in qualitative terms, or substantially cheaper. Experimenters have tested markets with such demand inertia. The result is as one would expect. Market outcomes are further away from both the Walrasian and the Nash predictions.

ordinary coverage	OC CW	OC CW (SD)	OC CW NOS	OC CW ANOVA	CW Mann Whit-ney
no demand inertia	17,0877193	30,4451732	228	0	0
demand inertia	45,6428571	21,6798495	28		
treatment	T CW	T CW (SD)	T CW NOS	T CW ANOVA	
no demand inertia	34	11,8039541	4	0,28745551	0,141
demand inertia	45,2666667	20,2006032	30		

Table 76
Demand Inertia: Normalized Deviation from the Walrasian Equilibrium
(data from gross sample insignificant)

ordinary coverage	OC CN	OC CN (SD)	OC CN NOS	OC CN ANOVA	CN Mann Whit-ney
no demand inertia	-11,2981366	86,0650077	161	0,09737016	0,001
demand inertia	17	19,3845299	26		
treatment	T CN	T CN (SD)	T CN NOS	T CN ANOVA	
no demand inertia	-16,25	46,5429909	4	0,06294287	0,347
demand inertia	10,75	22,7899019	28		

Table 77
Demand Inertia: Normalized Deviation from the Nash Equilibrium
(data from gross sample insignificant)

gross	NN	NN (SD)	NN NOS	NN ANOVA	NN Mann-Whitney
no demand inertia	31,2165242	164,653693	351	0,00144229	0
demand inertia	144,555556	420,534112	36		
ordinary coverage	OC NN	OC NN (SD)	OC NN NOS	OC NN ANOVA	
no demand inertia	49,8476821	243,190865	151	0,04129457	0
demand inertia	172,785714	474,662637	28		
treatment	T NN	T NN (SD)	T NN NOS	T NN ANOVA	
no demand inertia	44	0	2	0,7102944	0,777
demand inertia	172,035714	474,71032	28		

Table 78
Demand Inertia: Proportional Deviation from the Nash Equilibrium

X. Conclusion

Experimental research on oligopoly is rich, but it is not complete. There is one main effect that has not been tested: increasing returns to scale, or a supply curve with a negative slope. Also, nobody has ever given up the implicit assumption that barriers to entry are prohibitively high. Since both is frequent in practice, it would be worthwhile testing.

There are many more white marks on the map when it comes to the interaction between several parameters characterising an oligopoly market. This study makes them visible in two different dimensions. The first one is straightforward. To the best of our knowledge, quite a number of combinations of features have simply not been studied. Among the lacunae are the following: there is no experiment testing substitutes in a double auction or with human buyers. Nobody has explored the effect of a positive fixed cost in a double auction or in a stranger design. There is much less research on constant demand, compared to demand decreasing in quantity. Among the missing combinations is again the double auction, asymmetry, reduced feedback or a chance to conclude an agreement. Supply decreasing in quantity has not been studied in a stranger design. There is relatively little work on markets where the majority of the surplus is with producers. This has not been studied in a market of two, with a stranger design, with substitutes or with sequential interaction.

Nobody has given strangers a chance to communicate or to conclude an agreement. The opportunity to agree has also not been tested in markets of a larger size than four, if there is advance production, or if the majority of the surplus is with producers. There is no study testing full ex ante information in a double auction. Partial ex ante information has not been combined with sequential interaction or with negotiation. Human buyers have not been introduced in experiments using a stranger design, giving subjects full feedback, leaving capacity unconstrained, or differentiating products. In many contexts the double auction has not been used. There is no study imposing it in duopoly or triopoly markets. Subjects have never received full ex ante information. There has been no demand inertia. Products have always been homogeneous. No seller has had power. Experimenters have always used a fixed partner design. Capacity has always been constrained.

It has been one of the purpose of this study to make data on interaction effects available, although no experimenter has explicitly tested for them. This, however, only works if, in this meta study, the effects are significant. For reasons of space, not all of them could be reported. But many of the potential interaction effects are simply not significant. From a policy perspective, it for instance would be desirable to know more about the effect of experience on the likelihood that firms will beat the Nash equilibrium. Although a crosstable shows that there is data on many combinations, only one of the effects is significant. If one of the subjects has power, experience pushes collusion high above the Nash equilibrium.

	no power	no power (SD)	no power NOS	power Sig.
no experience	3,19626168	51,1824138	321	0,012
experience	12,8703704	38,3317427	54	
	power	power (SD)	power NOS	
no experience	-100,555556	215,453785	27	
experience	46,5	3,53553391	2	

Table 79
Experience – Power: Interaction Effect
(normalized deviation from the Nash equilibrium)

A closer look at the data demonstrates why further research on interaction effects is a desideratum. In the critical cell, the effect is based on just two observations. It has only become significant since the impact of experience is dramatic. This implies that explicit tests of interaction effects should be able to establish many more of them. This study, and the data bank behind it, may help experimenters build expectations about the direction of the interaction effects, and where they are particularly likely to be found.

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