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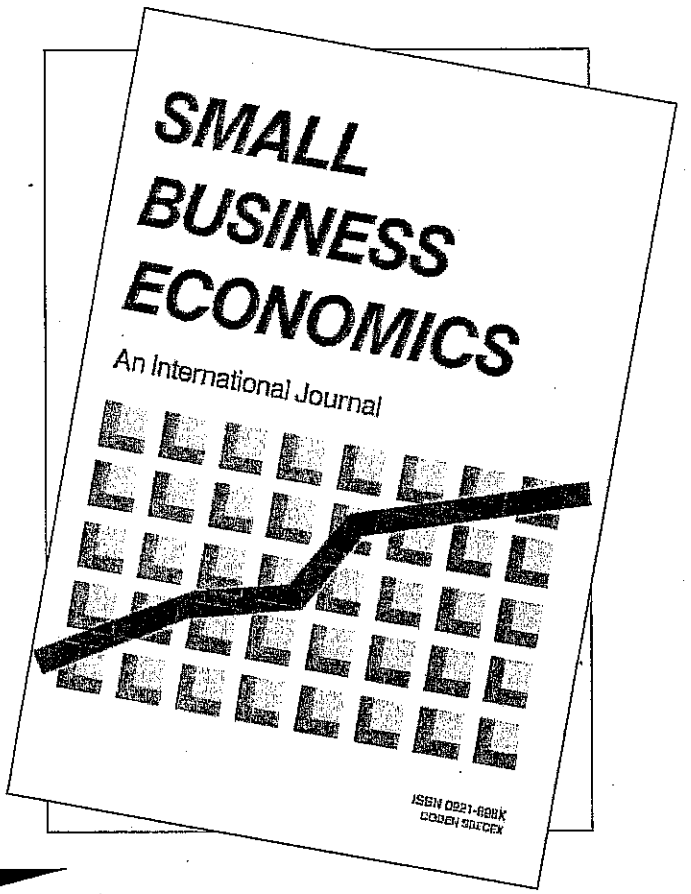

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ABSTRACT. This paper derives testable implications of the standard Cournot models and confronts these implications with real world data. Though we cannot expect that real world may be characterized by a simple static homogeneous model, it is surprising that little empirical work exists on testing the implications of this most popular model of oligopoly and non cooperative game theory.

We make use of three data sets for manufacturing industry, two of them on the firm level, one about firms grouped according to their size. The relation of the results to the predictions of the Cournot model is discussed, as well as its relation to alternative oligopoly models. We specifically focus at the question whether the implications of the oligopoly models on the performance of large versus small firms are in line with the data.

1. The plan of the paper

The paper investigates whether the most popular oligopolistic models offered by the industrial organization literature are roughly in line with the empirical data. A natural way to start is the homogenous static Cournot model. This model in which firms set quantities and markets clears through instantaneously adjusting market prices, has been for decades the most prominent model for describing the behavior of firms interacting in oligopolies. This is partly a matter of convenience, partly due to the fact that the predictions of the Cournot model are considered as plausible. However there are very few papers which really test whether the predictions of the model are replicated in real world data.

This paper confronts the predictions of the standard Cournot model with industry and firm data. Eventual deviations of the empirical data from the model will then be discussed in the light of alternative theories and extensions of the static, homogeneous model. The paper is structured as follows. In Section 2 we derive the testable implications of the static, homogenous Cournot model, Section 3 describes the data and the variables used. Section 4 makes a first informal look to find out whether the empirical profit margins are roughly consistent with the predictions of the Cournot model. Section 5 presents econometric evidence. The last section summarizes the results.

2. Testable implications of the static cournot model

The standard static Cournot model for homogeneous products assumes that n firms are independently maximizing profits by setting quantities. The market clears through instantaneous adjustment of the prices.[1] The main qualitative result is that firms enjoy a positive price cost margin. It is lower than in the monopoly case and decreases with the number of firms and the price elasticity of demand.

Consider n firms competing to supply a homogeneous good. Demand is given by $p(X)$, where p is the price, and $X = x_1 + \ldots + x_n$ is industry output. Cost are assumed to be $C_i(x_i)$, where we want to assume that marginal costs are different across firms but constant for each firm (c_i). Given a set of choices $\{x_i\}$, price adjusts to clear the market, i.e., $p = p(X)$. The Cournot equilibrium vector $\{x_i, \ldots, x_n\}$ is determined by n equations

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$\delta\pi_i/\delta x_i = 0$, which gives the first order condition $p(X) + x_i\, p'(X) = c_i$. Simply rewriting this[2] and substituting the definitions for market shares and demand elasticity gives (1).

The price cost margin of a firm i is thus given by a quotient, with the own market share, s_i, as numerator and the (absolute) market demand elasticity, ε, as denominator. If we furthermore define as aggregate price cost margin the weighted margins of the firms (using market shares as weight), we come to an equally simple formula for the industry margin. The aggregate margin of an industry is the quotient of the Herfindahl index of concentration (H) and the demand elasticity (2). We can use the logarithmic form of (1) and (2) as starting point of an empirical test of the static homogenous Cournot model (1A, B)

$$PCM_i = s_i/\varepsilon_{market} \quad (1)$$

$$PCM_{ind} = \sum s_i \cdot PCM_i = H_{ind} \cdot /\varepsilon_{market} \quad (2)$$

$$\ln PCM_i = \ln s_i - \ln \varepsilon_{market} \quad (1A)$$

$$\ln PCM_{ind} = \ln H_{ind} - \ln \varepsilon_{market} \quad (2A)$$

The Cournot model is attractive insofar as it is consistent with two stylized facts. It can explain – in contrast to competitive models – the coexistence of firms with differences in their efficiency, higher efficiency is translated into higher market shares. And the model implies positive margins for firms and the industry. Its main rival, the static homogeneous Bertrand model, implies zero profits and no differences in efficiency of firms on the market. We will therefore investigate how important profit differences are and how large profits are in the empirical data. This is not a test of the prediction of the model, however high profits and a large variance of profits[3] may indicate that the Cournot setting is more realistic than the world modeled by Bertrand.

Testing the Cournot model in the direct way as suggested by Equation (1A) or (2A) is very rare in literature. This is probably the consequence of the disappointment with studies testing the relation between profitability and concentration in cross section studies in general (see Schmalensee, 1989; Bresnahan, 1989). Indirect tests of Cournot models have been performed however in time series studies. Having sufficiently long time series on quantity and price for a specific industry, it is possible to specify a model with general conjectures about the aggressiveness of the reaction of competing firms. A coefficient of conjectural variation (usually labeled θ) in the supply relation reveals how near the firm or the market is to monopoly, Cournot or competition. We report on a paper following this approach in Section 5.5 (Aiginger *et al.*, 1995), but do not present additional own evidence here, since all the three data sets do not contain long time series.

3. Data sets, definitions and methodology

We make use of three data sets for testing the correspondence of empirical data with the Cournot model. The first is the firm data by the Austrian National Bank (balance sheets, OENB = Österreichische Nationalbank), the second comes from the industry census of the Austrian Central Statistical Office (for aggregates and grouped data which we will call "quasi firm"). A third data set is a survey by the Austrian Institute of Economic Research (WIFO-ES; Wirtschaftsforschung-Entrepreneurial Survey) and contains firms data mainly of a qualitative (categorical) type.

The firm data set OENB refers to approximately 1,500 firms in manufacturing. After eliminating outliers 1,151 firms remain for the most recent year. For a long term investigation the data set supplies a panel of about 300 firms which reported in a consistent way between 1983 and 1992.

The second data set is the Census which allows to calculate indicators for 97 industries (on the 3-digit level). It is available for 1983 and 1988, indicators constructed from the annual statistics on manufacturing (Industriestatistik and Gewerbestatistik) are also available for the years in between. A specific feature of the census is, that it reports separately about the four, eight, twelve largest firms. We used this to construct four "quasi firms" (firm groups): quasi firm one is the aggregate of the largest four firms (ranked by their value added) and is labeled as firm14, quasi firm two consists of the firms ranking from five to eight (firm58), the next firm group consists of the firms ranking from nine to twelve (firm912). The last group consists of all the other firms and is called the fringe (firmfri).

The third data set is the survey among firms (WIFO-ES). More than 1,500 firms in manufacturing are asked regularly about investment, sales, employment and business conditions and at specific occasions about structural variables. We use variables concerning cash flow, investment, sales and several qualitative characteristics of firms and markets. The questions asked in the survey are formulated in a way to mimic as closely as possible concepts, strategies and variables hailed as important in oligopoly theory. The variables in this survey are mainly categorical (see the Appendix for the wording of the questions and answer categories used in this paper). Qualitative econometric models have to be used for testing theories with these data.

Calculating price cost margins from the (quantitative) empirical data is no straightforward business. Several types of problems are involved. One is the definition of the price cost margin, the numerator can be gross or net of depreciation, the denominator can be sales, gross production or value added. Most empirical studies disregard fixed costs and assume constant marginal costs. The second type of problem is that any empirical measured profits ("accounting profits") will deviate from the economic concept ("economic profits"). This is well discussed in literature (Fisher and Gowen, 1983; Fisher, 1987) and leads to a critical attitude of many economists to empirical studies using profit data.

We use four different definitions for the PCM. For Gross Price Cost Margin we use as the numerator the value added minus payroll, this can be divided into value added or into sales (which we label as GPCMV resp GPCMS). If we deduct the capital input in the numerator (depreciation or investment) we speak about the Net Price Cost Margin, which again can be related to value added or sales (NPCMV or NPCMS). Which concept is the best is not easy to decide. From the theoretical point of view, NPCMS is the definition closest to the theoretical model in Equation (1). However, since empirical data on depreciation are either not available or at least dramatically different from any economic concept of depreciation, the theoretical difference looses importance. We will use in the regressions the gross margin relative to sales (GPCMS) and control for differences in the capital intensity by a right hand variable, this does not seem inferior to the use of a net concept as the dependent variable.

4. Market shares and margins

4.1. *The relation between market shares and margins (OENB panel data)*

We have grouped the OENB firm data ($n = 1{,}151$) into 11 industries and ranked the firms from 1 to 12 within the industries according to their size (employment). The Cournot model would imply price cost margins to decrease strictly with higher ranks.

The largest firm in each industry typically has a market share of 11.3%, the next 4 firms have shares of 6.1% to 4.9%, the 12th largest firm has typically a share of 2% (median of 11 industries, employment shares, see Table I). The remaining 100 firms in each industry share together the other half of the market. Taking Equation (1) literally, would allow us to use these shares to make a prediction about the relation between the profit margins of firms, since the elasticity will be different across industries but identical within an industry. The Cournot model and the empirical shares reported, would imply profit differences of approximately two to one between the leader and his three followers, of five to one between the leader and firm number 12 and again five to one between number 12 and the average firm in the "fringe".

Actual price cost margins do not show such a decline of profit margins for smaller (higher ranking) firms, the margins do not even decline continuously with size. The gross price cost margin (GPCMV) of the largest firms is 31.9% (median of the 11 industry leaders), that of the fringe is 29.7%. For the net concept (NPCMV), the margin of the largest firms (15.6%) is even slightly below that of the fringe (15.9). Between the first and the 12th firm in each industry there is no clear increase or decrease in the price cost margins.

4.2. *The sandwich position of the second largest firm*

One striking feature of the data is the decline of the margin between the first and the second largest

TABLE I
Market shares and PCMS in 12 leading firms
(median or arithmetic mean over 11 industries, 1991; denominator: sales, resp. value added)

Rank within industries	Market share (sales)[1]	Employment share[1]	GPCMS[1]	NPCMS[1]	GPCMS[2]	NPCMS[2]	GPCMV[1]	NPCMV[1]	GPCMV[2]	NPCMV[2]
1	18.2	11.3	11.2	5.8	11.8	5.7	33.9	17.7	31.9	15.6
2	8.2	6.1	5.6	1.0	6.1	1.2	21.6	3.7	23.2	4.4
3	5.8	4.9	7.4	3.5	10.1	6.2	27.9	13.3	29.9	17.1
4	4.7	5.2	12.4	7.4	9.9	4.7	33.9	20.3	26.5	13.6
5	4.0	4.3	10.1	3.6	4.1	1.8	30.4	10.8	23.0	10.7
6	3.4	2.5	8.7	4.9	9.8	5.2	31.2	17.6	25.2	12.6
7	3.1	3.1	12.1	8.0	10.6	5.3	32.9	21.8	31.7	17.6
8	2.7	2.5	8.0	4.1	7.9	5.4	24.9	12.7	23.7	15.8
9	2.5	2.4	11.9	7.8	12.5	8.4	36.2	23.7	36.0	20.7
10	2.5	1.5	9.2	4.9	8.2	4.6	25.6	13.6	32.9	14.5
11	2.0	2.1	10.8	7.0	10.2	5.8	35.9	23.2	31.8	17.3
12	1.7	2.2	9.0	4.3	8.2	4.6	24.1	11.4	24.4	14.1
Fringe	41.2	51.7	10.2	6.0	9.7	5.6	27.9	16.4	29.7	15.9

[1] Mean over 11 industries.
[2] Median over 11 industries (median of the 11 leaders, median of 2nd ranked firms, etc.).

firm. The gross margin relative to value added, declines by 9 percentage points, the net margin from 15.6% to 4.4% (11 points). This feature is no artifact and does not come from aggregation. In 7 out of 11 industries the net margin in the largest firm is higher than that of its closest followers.[4]

If we analyze the margins relative to sales the picture is similar. The median gross margin (GPCMS) is 11.8% for the leaders, falls down to 6.1% for the second firm and returns to 10.1% for the third placed firms. Two-digit margins are reached by the 7th, the 9th (this is the all place high) and the 11th firm. The margin of the fringe is 9.7%, well in the middle of the road.[5]

The sandwich position of the second largest firm is well known in the media branch as "the seconds' curse". In many metropolitan areas only one or two newspapers survive, and usually the second largest newspaper has low profits, while smaller papers take advantage of diversification be it in the quality spectrum or the locality. This has lead to the assertion that it is relative size (circulation as compared with the leader) and not absolute size that determines profitability.

The individual profits in the OENB set are therefore insofar in line with the Cournot model, as the largest firms have higher profits than many of its followers and than the fringe. The hierarchy is however much flatter than forecast by the Cournot model. Remember, that the static homogeneous Cournot model implies, that – for the same market price elasticity – margins are proportional to the market shares.[6] For one of the four definitions applied, the margin of the fringe is even larger than that of the largest firms.

4.3. *The evidence for "quasi-firms" (size classes)*

The Austrian Census of Manufacturing reports data on the groups of the largest 4 firms, on the firms ranked 5–8 and 9–12 and finally on the other firms for 97 industries. This allows the calculation of market shares and margins for these four groups (see Table II). The firms in the first group are considerably larger than those in the second group, they have a combined market share (measured in terms of value added) of about 30–40%. The firms ranked from 5 to 8 share typically 10–15% of the market. The next four share less than 10%, the fringe something less than 50%. Applying the Cournot prediction to these data should give a strong decline in the price cost margin especially between the group one and two, then a more moderate decline and finally again a sharp decline.

The average GPCMS for total manufacturing (mean over industries) is 10.9% for 1988. It is

TABLE II
Shares and margins of quasi firms

	Shares					GPCMS				
	All	Firm 1–4	Firm 5–8	Firm 9–12	Fringe[1]	All	Firm 1–4	Firm 5–8	Firm 9–12	Fringe[1]
1988	100	50.3	12.8	6.8	30.2	10.9	11.9	10.2	10.6	9.6
1983	100	50.6	11.9	6.4	31.2	10.0	10.2	9.9	11.4	9.8

Source: Austrian Statistical Office, Nichtlandwirtschaftliche Bereichszählung 1983, resp. 1988.
[1] All other firms.

1 percentage point higher for the largest 4 firms (11.9%), declines to 10.2% respectively 10.6% for the next two groups. In the fringe the gross margin is 9.5%. Looking into the industries reveals a very diverse picture.

- The price cost margin of the largest 4 firms (GPCMS14) is larger than that of the industry average in 57 cases (smaller in 36 industries). It is larger than that of the second group in 60 industries, larger than group 9–12 in 58 cases and larger than in the fringe in 57 industries.
- The price cost margin of the second group is larger than industry average in 38 industries and below average in 59 industries. The "seconds' curse" survives though we do not really have firm data here. The margin is larger in the second group than that of the group 9–12 in 41 industries (smaller in 53). There is a slight majority of cases in which the margin is larger than that of the fringe (46:45).
- The price cost margin of the third group is lower than industry average in 54 industries. It is larger than that of the sandwich group, the number of industries in which the margin is larger and smaller than that of the fringe is approximately equal (45:46).
- If we look into the data set for 1983 the slightly higher margins of the larger firms become even harder to see. The price cost margin (GPCMS) of the leading quasi firm is 10.2% in 1983, as compared to an average of 10%. It declines to 9.9% for the group of firms ranking 5–8, but increases to 11.4% for the number 9–12 firms. The price cost margin of the fringe is 9.8%.

4.4. *In search of Cournot industries*

The "qualitative prediction" of Cournot model is that the price cost margins decline from "quasi firm 1" to "quasi firm 4" step by step. This picture is seen only in six out of 97 industries (see Table III). Even out of these, two industries have to be dismissed as Cournot candidates since in one case (*"other metal products"*) there is no well defined market, and in another (*basic textiles, yarns*) the concentration is so high that quasi firms 3 and 4

TABLE III
Approximately Cournot industries

Code	Market share 1988				GPCMS 1988				GPCMS 1983			
	1–4	5–8	9–12	Fringe	1–4	5–8	9–12	Fringe	1–4	5–8	9–12	Fringe
334	96.5	3.5	0.0	–	6.3	3.1	2.2	–	3.7	1.1	0.0	0.0
453	58.8	15.6	9.5	16.1	19.5	11.9	5.3	3.0	5.3	14.5	2.0	2.9
480	67.8	8.6	6.2	17.4	29.3	16.9	13.5	8.0	19.2	10.9	12.6	9.9
511	83.1	11.2	3.9	1.7	18.1	14.8	10.0	7.1	3.8	1.1	5.2	12.6
539	29.1	17.1	9.5	44.4	14.7	14.2	14.0	10.7	15.1	1.4	9.1	12.7
561	63.4	15.9	7.3	13.4	18.0	16.1	9.8	8.7	16.3	4.6	9.5	10.0

334 = textile yarns; 453 = pharmaceuticals; 480 = glass products; 511 = iron and steel; 539 = other metal products; 561 = electrical engines.

are extremely small (the shares of the largest four, resp. eight firms are 96.5, and 100.0). Four industries remain as candidates: pharmaceuticals (3-digit classification: 453), electrical engines (561), iron and steel (511) and glass & glass products (480). These industries do not have too much in common (two produce differentiated products with frequent product innovations, two are mature industries). Furthermore in none of these branches the picture is replicated by the data in 1983.[7]

If we would like to find the largest possible range of Cournot industries we could define as Cournot industries those in which the margins in the aggregate of the 8 leading firms are more than 5 percentage points higher than these in the rest of the industry in 1988. According to this definition 18 industries out of 97 follow the forecast of the model.

4.5. *Variance of price cost margins across firms and industries*

The variance of the margins within and across industries is quite large. There are six industries in which the average margin is less than 5.5% (the half of industry average) and there are eight industries in which the margin exceeds 16.4% in 1988. More interesting is the intra-industry variance of the price cost margin (see Table IV). The mean of GPCMS is 6.542%, its standard deviation is 7.455. 10% of the firms have margins less than −1.457 (meaning that the loss is higher than that figure). On the other side 10% of the firms have a margin larger than 15.3%. Of course short term profits are more volatile than long term profits. Calculating average profits for 10 years (1983/92) gives a mean of 7.09% and a standard deviation of 6.44. 10% of the firms have long term profit of less than 0.82% of sales (20% less than 2.7%). On the other hand 10% of the firms have a margin higher than 15.4% over this decade.

TABLE IV
Variance of margins on the firm level. GPCMS 304 firms

Deciles	1992	1983/92
10.00	−1.457	0.821
20.00	0.739	2.694
30.00	3.256	3.893
40.00	5.071	5.045
50.00	6.719	5.322
60.00	7.819	7.725
70.00	10.092	9.653
80.00	12.124	11.717
90.00	15.296	15.399
Mean	6.542	7.088
Stand. dev	7.455	6.442

Source: OENB, subsample of firms reporting in each year for 1983 through 1992 (10.00 means the decile of firms with the lowest GPCMS; 90.00 means the decile of firms with the highest GPCMS).

The *average level* of the price cost margin is rather high. This is the case for the census data, but even more strikingly for the firm data. The margin which is defined as a gross margin (value added minus payroll into sales) is 10.9% of sales. If we assume a typical equity sales ratio of 25% we get a rate of return of 40%. The gross margin with value added as denominators is 28.4% (NPCMV; average over the 97 industries). The Cournot model would forecast a price cost margin of 10% for a industry characterized by a Herfindahl of 0.2 and a demand elasticity of 2. Relative high margins are typical for all concepts and data bases.

We have to acknowledge that the empirical margins include several components definitely considered as non profit elements by economists. There are rents due to advertising, research and development included, but also salary equivalents to the employer and his family members, provisions for future obligations (pensions, dismissal payments, etc.). Nevertheless it seems to be a safe conclusion, that median and average margins seem to be far away from zero.

The conclusion for the oligopoly model is that the large variance of the price cost margins and its high level is more in line with the predictions of a homogeneous Cournot model than with that of the homogeneous Bertrand models.

5. Regressions motivated by static Cournot models

5.1. *Relation of margins to concentration rates*

Regressing the industry margins on concentration rates should give a positive relationship. Ideally if we want to test a Cournot model we should use the Herfindahl index as a measure of concentra-

tion. Herfindahl indices are not available for the 3-digit industries. So we had to use the four firm concentration rate.

These regressions unfortunately do not give a positive relationship. The "plain vanilla regression", which regress price cost margins only on concentration gives a negative relation between margins and concentration, with coefficients near or above the significance level of 95%. There are many caveats which should be made in such simple equations and we have invested a lot of research to get rid of this implausible result (Aiginger, 1993, 1994a). To sum it up it is possible to find explanations which *lower* the implausible negative impact of concentration on profits,[8] but it is absolutely impossible to get a significant positive cross section relationship between profit margins and concentration.

On the micro level (OENB set) no indicator on concentration (CR4, 2-digit Herfindahls, number of firms, size) is significant, most have a insignificant negative sign, whether taken alone or combined with other variables (Aiginger, 1994a).

5.2. *The relation of margins to the elasticity of demand and the market shares for "quasi firms"*

The Cournot model implies that the firm's profit depends positively on their market shares (s_i) and negatively on price elasticity of demand (ELAST). If the margins are gross of depreciation, we have to control for differences in the capital sales ratio (CSR). Following literature we add the lagged dependent variable (GPCMS83) to the equation.

We estimated this relationship on the "quasi firm level". The firms ranking from 1–4 are considered as one quasi-firm, then the firms ranked 5–8 as the second, then firms ranked from 9–12 as the third firm and finally the combined fringe as the fourth. We get 348 quasi firms (97 industries times 4 groups), their market shares are the value added share of the firms in a group relative to the industry value added to which they belong (QMS).

We had to construct some indicator on the price elasticity of demand. We did this by regressing quantity in a specific industry on its relative price and the GNP (as proxy for product substitutes). Doing this in the logarithmic form we got a primitive proxy for demand elasticity. Most of the elasticities for the 97 industries had the correct sign and the majority of the coefficients in the demand equations were significant. However we multiplied ELAST by a dummy taking the value 1 if this was the case and zero otherwise to get ELASTSIG.[9] A justification for this is that observable price – output combinations are influenced by supply and demand conditions and if estimated elasticities were not different from zero, this most likely does not come from facts, but from the incomplete estimation model.

Table V shows the regressions of the margins for the quasi firms (GPCMS88) on their quasi market shares (QMS,) on elasticity of demand (ELAST). All the variables included have the correct sign and most are significant. The coeffi-

TABLE V

Cournot quasi firms (4 groups × 97 industries; 1988, coefficients, t-value in brackets)

Equation L if log	R^2	ELAST	ELASTSIG	QMS	CSR	GPCM83
1	0.25		–0.45 (1.08)	0.03 (2.63)	0.50 (4.88)	0.37 (8.46)
2L	0.50		–0.20 (1.53)	0.28 (9.20)	0.30 (2.79)	0.44 (11.46)
3	0.10	0.02 (0.12)		0.03 (2.57)	0.67 (6.16)	
4L	0.32	0.004 (0.05)		0.42 (13.22)	0.41 (3.31)	
5	0.20	–0.06 (0.44)		0.03 (2.53)		0.42 (9.54)
6L	0.49	–0.02 (0.29)		0.27 (8.89)		0.45 (11.84)
7	0.20		–0.24 (0.56)	0.03 (2.53)		0.42 (9.47)
8L	0.49		–0.23 (1.69)	0.27 (8.98)		0.44 (11.60)

Dependant variable: GPCMS88 = (S – W – M)/S · 100.
S = sales; W = wages; M = material.
QMS: Quasi-market share (value added of the firm group in percentage of industry value added).

cient of determination is between 0.20 and 0.50 which is quite high. The equations in their logarithmic form (which is called for by the theoretical model) have a higher explanatory power than the linear equations. The coefficient of the market share is significant under all modifications, though it is relatively small. A 1% increase in market share increases PCM by 0.3 percent. The persistence of profits is remarkable high (see Mueller, 1990). Capital intensity increases the price cost margin.

The price elasticity of demand influences the margin in the direction[10] forecasted by the Cournot model, if we take into account only those elasticities which were significant (ELASTSIG). The coefficient is however not significant. This is not surprising since the estimation of price elasticities of demand on the level of 3-digit industries is a hard task.

5.3. *Firm level regression*

5.3.1. *The OENB set*

The regressions on the firm level with the OENB set do not give satisfactory results (Table VI). The plain Cournot regressions give insignificant coefficients of the market shares and for the price elasticity, in the majority of the equations both have the signs opposite to that forecast by the theory. Many variations were tried, including capital intensity, lagged price cost margins, the logarithmic version, dummies for industries, sectors, etc. At this stage of the research and for this data set, we have to conclude that profits do not depend positively on market shares.

5.3.2. *The WIFO-ES*

The WIFO-ES set gives information about GPCMS in a categorical way. The dependent variable is the GPCMS in 1993, the categories are margins smaller than 4%, between 4% and 10%, or larger than 10%.[11] Ordered probit models had therefore to be used for estimating the models (see Tables VII–IX for probit models estimated with this data set).

The market shares have the expected positive impact in this data set. The coefficients are zero or negative for market shares below 20% and positive for all higher ones, with the largest coefficient in the second largest class (probit model 1). The t-ratios are significant at best at the 10% level (usually not at all), however, the picture is very robust. If we add other variables or if we aggregate the market shares into 3 groups instead of five (probit model 2), the main results do not change. The Chi-Square test confirms significance of the market share variables at the 90% level (not at the 95% level).

Especially interesting is the addition of a proxy on price elasticity (see Table VIII). Firms give an assessment on the question whether they work in a market with high or low price elasticity (for the wording of the question see Appendix). The coefficient is –0.274 for firms, which report to sell on an elastic market and +0.164 for firms in inelastic markets, the first coefficient is significant at the 1% level, the second narrowly fails signif-

TABLE VI
Cournot equations for firms (OENB-set; 1988, coefficients, t-value in brackets)

Equation L if log	R^2	ELAST	ELASTSIG	MARKET SHARE	CSR	GPCM83
1	0.02	0.47 (0.98)		–12.51 (0.89)		
2L	0.002	–0.18 (1.15)		–0.01 (0.36)		
3	0.11	0.35 (1.20)		–19.33 (1.44)	0.15 (5.75)	
4L	0.06	–0.08 (0.55)		–0.02 (0.55)	0.36 (4.02)	
5	0.30	0.21 (0.51)		–16.04 (1.35)	0.10 (4.44)	0.43 (8.69)
6L	0.11	–0.17 (1.10)		–0.01 (0.21)	0.30 (3.30)	0.18 (3.38)
7	0.30		–0.14 (0.45)	–19.27 (1.68)	0.10 (4.38)	0.43 (8.79)
8L	0.19		–0.35 (1.90)	–0.03 (0.74)	0.36 (3.46)	0.24 (4.18)

Dependant variable: GPCMS92 = (S – W – M)/S · 100.
S = sales; W = wages; M = material.
274 firms.

TABLE VII
The dependance of profits on market shares
(Qualitative firm data 1993, WIFO-ES, 1992, 1994)

Ordered profit 1.
GPCMS = f (market shares).
n = 792, log-likelihood = –861.15, restricted log-likelihood = –866.21, Chi-square = 10.13 (5).
Correct forecasts = 39.0%.

	Coefficients	t-value	p-value
MS < 10%	0.014	0.100	0.920
10 < MS < 20%	–0.054	–0.330	0.741
20 < MS < 30%	–	–	–
30 < MS < 40%	0.189	1.121	0.262
40 < MS < 50%	0.346	1.903	0.057
MS > 50%	0.215	1.478	0.139
Constant	0.385	3.075	0.002
MU	0.999	20.276	0.000

TABLE VIII
The Cournot equation for qualitative data
(Firm data 1993, WIFO-ES, 1992, 1994)

Ordered profit 2,
GPCMS = f (market shares, price elasticity).
n = 754, log-likelihood = –810.30, restricted log-likelihood = –823.99, Chi-square = 27.37 (7).
Correct forecasts = 40.7%.

	Coefficients	t-value	p-value
MS < 10%	0.048	0.326	0.744
10 < MS < 20%	–0.052	–0.316	0.752
20 < MS < 30%	–	–	–
30 < MS < 40%	0.184	1.077	0.281
40 < MS < 50%	0.351	1.922	0.055
MS > 50%	0.220	1.492	0.136
PRQ = 1	–0.274	–2.776	0.006
PRQ = 2	0.164	1.621	0.105
Constant	0.434	3.158	0.002
MU	1.028	19.935	0.000

icance at the 90% level. The model with the combined influence of market shares and price elasticity easily passes the Chi-Square test at the 99% level.

Other variables can be added to this "simple Cournot model". Adding SIZE (grouped data on the number of employees) gave a positive impact, showing that in this data set profits increase with the size (see Table IX). This is in line with the spirit of the static homogeneous Cournot model. The stability of the market (STAB, see profit model 10) is an additional strong positive variable, so is the dynamic of the market. Both indicators are favorable for collusion and enable a robust prediction in supergame models (see Aiginger, 1994a). The investment sales ratio is significant too. Dummies for different industry groups are insignificant.

5.4. *Evaluation of the firm results*

The results for the validity of the Cournot model differ between the two data sets dramatically. The OENB sample gives an unfavorable result for the Cournot model, the survey results are more in line with it. There seem to be three reasons.

The main reason is that the market shares differ between the data sets. In the OENB set market shares are calculated as firm sales divided by industry sales on the 2-digit level. The resulting market shares may be a weak proxy for actual market shares for large firms, which in fact however work across industries. But definitely they are a very poor proxy for small and medium firms, which work in much more narrow markets than those defined by 2-digit industries. The median market share of the firms calculated according to this procedure is less than 1%. The economically relevant market differs from the statistically calculated market share on this level of aggregation dramatically.

In the WIFO-ES the average firm reports a market share of 30%. Firms define here their market borders according to their own assessment and are apparently following an extremely narrow concept of their relevant market, consequently they (believe to) have high shares. Maybe the subjective evaluations of firms as to their relevant market is too narrow, the firms may underscore cross price elasticities with substitutes, but this underscoring seems smaller than the errors imposed by defining markets as broad as in the statistical approach.

The second difference lies in the price elasticities. Estimating price elasticities by empirical data needs a lot of work (ideally a system of supply and demand function, a minimum of exogenous variables significant in the specific industries). The estimation of unbiased price elasticities is a hard work for each single industry, but hopeless for a

TABLE IX
Probit models for explaining profitability differences (firm data 1993, WIFO-ES 1993, 1994, dependant variable = GPCMS)

Variables (categories)	*n*	log-likelihood	Restricted log-likelihood	Chi-square	Share of correct forecasts
1. MS (six groups)	792	–861.15	–866.21	10.13 (5)	39.0
2. MS (three groups)	792	–862.21	–866.21	8.00 (2)	38.0
3. MS (6), PRQ (3)	754	–810.30	–823.99	27.37 (7)	40.7
4. MS (3), PRQ (3)	754	–811.45	–823.99	25.09 (4)	40.8
5. MS (6), PRQ (3), EXQ (6)	751	–803.55	–820.44	33.79 (12)	42.1
6. MS (6), SIZE (4)	792	–850.06	–866.21	32.30 (8)	42.0
7. MS (6), SIZE (4), PRQ (3)	754	–802.72	–823.99	42.53 (10)	41.0
8. MS (6), GROWTH (2)	395	–426.73	–433.56	13.66 (6)	39.2
9. MS (6), GROWTH (2), PRQ (3)	380	–405.38	–416.95	23.15 (8)	44.5
10. MS (6), STAB (3), PRQ (3)	417	–446.82	–457.18	20.70 (9)	42.0
11. MS (6), PRQ (e), log (S/E)	750	–801.68	–819.27	35.20 (8)	42.7

Source: WIFO-ES 1993.
S/E = Sales per employee 1993.
For MS, PRQ, SIZE, GROWTH, STAB see Appendix.

bulk of 97 industries. Substituting this workload by a subjective assessment by firms involves problems too, but in this case the results look plausible.

The third difference is that margins depend positively on size in the WIFO-ES survey, but there is no clear structure in the OENB survey. This difference has to be investigated into. In general we have seen a change in the profitability hierarchy. In the seventies and in the eighties most studies revealed that if anything smaller firms were more profitable than larger ones. Gradually this seem to have shifted. Larger firms have learned to exhaust their potential for higher profits by restructuring. By far not to that extent predicted by the static, homogeneous Cournot model, but at least to some extent.

5.5. *The NEIO approach*

This approach tries to find out the implicit degree of conjectural variation by the estimation of a demand function and a supply relationship. The estimation does not need measured profit data, the price cost relationship is inferred from the behavior of output and prices over time. See Appelbaum (1982) for a classical paper and see Aiginger *et al.* (1995) for the estimation of the coefficients for two industrial sectors in Austria. The estimated coefficients are supporting the Cournot model insofar as they do not differ too much from the coefficient implied by the Cournot model. The estimated coefficients for the two industries investigated are however far away from the monopoly as well from the value in the competition model. A survey on the literature, see Bresnahan (1989) and Aiginger *et al.* (1995).

6. Tentative conclusions and further research

This paper confronts empirical data with the Cournot hypothesis. There are some strict implications of the static homogeneous model, and some qualitative forecasts, which are not consistent with other oligopoly models.

The data show that the Austrian manufacturing industry is rather oligopolistic. The largest 12 firms enjoy market shares of 50% or more in the majority of the 3-digit industries, in many industries the largest four firms do supply two thirds of the market demand. Measured price cost margins differ widely as to the exact definition. All margin look to be much higher than a level which we would consider as a competitive rate of return. Margins vary much across industries, but even more within industries, profit differences across firms are persistent.

These findings are comfortable for the Cournot model which predicts positive economic profits and intra-industry profit differences (if efficiency differs). The competitive model and the homogeneous, static Bertrand model would forecast low

margins, identical over branches and within industries. If we allow for product differentiation and an infinite horizon the model predictions between the Cournot model and the Bertrand model do not differ that much, and the data are less likely to discriminate between the model classes.

The empirical data show some support for the Cournot model insofar as the price cost margins of the market leaders are larger than those of the immediate followers. Secondly, the margins of the aggregate of the largest 4 firms ("quasi firm 1") are higher than those of other "quasi firms" (in fact: groups of smaller firms) and larger than in the industry average. The decline of the margins from the largest firms to the smaller ones is however much too weak in relation to the strong forecast of a proportional link between market shares and margins (for the same demand elasticity). And the weak position of the second in relation to the smaller firms is definitely not in line with the Cournot model. It is however also not in line with the Stackelberg model or with some asymmetric price model in which a group of leading firms shares a market with a price taking fringe. In relation to all these models the actual performance of the small firms is much better than predicted.

The structure emerging in the data could be explained by the following hypothesis. The largest firms are engaged in rather homogeneous markets with direct competition, the second largest firm is in a delicate position because it works in the same market but with less market power. The smaller firms can partly evade into some differentiated market segment and have definitely higher profits than predicted by the Cournot model (and those predicted for the follower, resp. the fringe in asymmetric oligopoly models).

Regressions give to some extent a conflicting evidence on the validity of the basic Cournot model. The firm data set by OENB, in which market shares and demand elasticity are calculated in a quantitative manner does not support the model. The data set which contains subjective, categorical data on market shares and price elasticity (WIFO-ES) gave encouraging results for the basic Cournot equation, the grouped data are in between.

We know, however, that there are many more determinants of profitability than market shares and elasticities. We are able to explain profitability differences on the micro and on the aggregate level among other theories by supergames stressing market growth and stability as important determinants (Aiginger, 1994a,b). We furthermore know about the deficiencies of cross section results for proving or falsifying theories and would like to extent the research with panel data and proper instruments to controll the endogeneity problem.

The data available in this paper, however, are to some extent compatible with and favorable to the basic Cournot model. The picture of relatively high profits, their variance across and within industries is consistent with the Cournot model. The evidence that market shares and price elasticities do influence margins is predicted by the Cournot model and replicated by two of our three data sets. Both these findings are more compatible with this model than with its alternatives in the theory of oligopoly like Bertrand, Stackelberg, and fringe models or with monopolistic or perfect competition.[12] The profitability of small firms, however, is definitely larger in all three data sets, than that predicted in the standard Cournot model. No declining hierarchy of profit margins parallel to market shares is to be seen in the data.

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Appendix

The questions in the entrepreneurial survey of the austrian institute of economic research (WIFO-ES)

PRQ (price elasticity of demand):
Firms were asked to chose one of the following answers

- the price is the most important determinant of sales (PRQ1)
- demand depends inter alia on the price, but other factors are important too (PRQ2)
- quality, goodwill and service are more important for sales than the price (PRQ3)

MS (market shares):
Firms were asked whether their market share on the domestic market amounted to

< 5, 5–10, 10–15, . . . , 40–45, > 50 (these groups are called MS1 to MS11)
the answers were then regrouped into 5 broader groups (MS1–MS5)
less than 10%, 10–20, 20–30, 30–40, 40–50, >50
and finally into 3 groups (MA1–MA3)
less than 20, 20–40, > 40

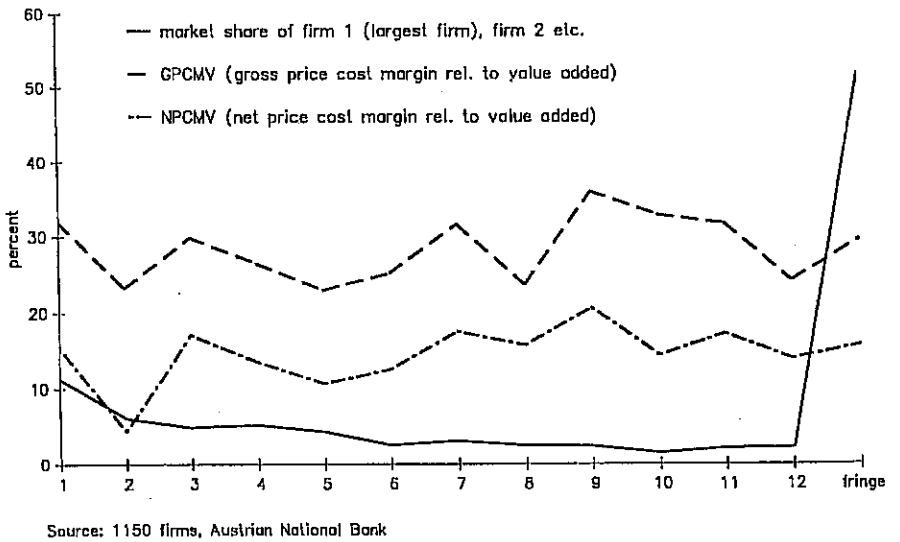
Price cost margin:
Firms were asked to choose for the cash flow to sales ratio one of the following categories

GPCMS < 0%, 0–2, 2–4, . . . , 8–10, > 10 (7 categories)
these data were regrouped into 3 categories
< 4%, 4–10, > 10%

Growth
Firms were asked whether the market for their dominant product line was growing faster/slower than industry average

Stab
Firms were asked whether the market for their dominant product line were more stable, less predictable or about average as compared to other industries

Recall:	PCM	price cost margin
	GPCM, NPCM	indicates gross, resp. net price cost margins (in the latter depreciation or investment as a proxy for depreciation is deducted in the numerator)
	PCMS, PCMV	indicates that the PCM has sales resp. the value added as its denominator



Graph 1. Price cost margins and market shares of the 12 largest firms (median of 11 industries 1991).

Notes

[1] This adjustment is not explicitly modeled. This is a popular critique of the model and an argument, why some economists assess the model as unrealistic.

[2] Shifting the second term on the left to the right, costs to the left and dividing the equation by p, gives the margin on the left side and market share divided into price elasticity on the right hand side. We add the suffix market to this elasticity to indicate that it is not the price elasticity of demand which an individual firm faces.

[3] In a homogeneous market all firms set price equal to marginal costs and have the same costs. In case of efficiency differences the most efficient firm would serve the whole market being able to set its price slightly below the marginal costs of the second most efficient potential firm. It can thus make a positive profit. Empirical data will contain only one producer. Firms actually producing cannot have different unit costs in the static Bertrand model.

[4] For gross margin this relation is only six to five. The third largest firm surpasses the second largest in 8:3 cases as far as net margins are concerned and 9:2 for gross margins.

[5] The net margin is 5.71% for the leader, this is five times as much as for the second, but lower than that of the third ranked firms, lower than the average and the fringe. The means (over the firms in the same ranks) show the same picture.

[6] For a review why profits may be higher in small firms than for large firms see Aiginger and Tichy (1991), for a listing of the prediction of the recent industrial organization literature see Aiginger (1993).

[7] In another search for Cournot industries, we screened the data for industries in which the following three criteria were met: (i) price cost margin is largest in group 1 in 1988, (ii) price cost margin in group 1 and group 2 (in the aggregate of the eight largest firms) is five percentage higher than in group 3 and group 4 (aggregate from firm 9 on) in 1988, and (iii) data in 1983 conform at least to criteria (I). If we use these criteria we get 7 "approximately Cournot industries": breweries (321, furs and related products (343), wood plates (372), printing and publishing (421/430), pharmaceuticals (453), cement (480) and electrical engines (561).

[8] Neumann had found a negative coefficient for concentration in a firm panel too, allowing for fixed effects helped to convert the negative coefficient into a positive one. Instrumenting market shares sometimes give positive coefficients, but never significant ones.

[9] Actually we tried two strategies to get rid of implausible and insignificant coefficients for some industries. First we multiplied the elasticities by their t-value (this weights them with the confidence we could have into this elasticity). The second and more successful strategy was to multiply the elasticities by a dummy, which was one if the elasticities were plausible and the coefficients were significant and zero otherwise. The justification for both procedures is that it can be expected a priori for some branches that actual price and output data revealed demand elasticities (as is well-known output – price – pairs are influenced by supply and demand conditions). If they did not reveal plausible demand elasticities then the resulting data should not be used.

[10] The higher the absolute elasticity the lower the margin. The equations in the tables show the inverse of the negatively signed elasticity, the correct sign is therefore negative too.

[11] The variable asked in the questionnaire is the cash flow in relation to sales, this concept is very near to the GPCMS. Originally the questionnaire contained 10 categories for the variable, the categories were aggregated in a way that the answers were distributed approximately equal across the new categories. See Appendix.

[12] The difference between the predictions of models tend however to become smaller if we screen dynamic models and if we allow for product differentiation. With product differentiation firms enjoy positive profits even in Bertrand models, collusion creates profits in this model too, to some extent the Bertrand model is even more favorable for collusion (this is the so-called "topsy turvy" result of industrial organization).

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