COLLUDE, COMPETE, OR BOTH? *DEREGULATION IN THE NORWEGIAN AIRLINE INDUSTRY*[#]

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Abstract:

The purpose of this paper is to test the nature of competition concerning price and capacity setting in the Norwegian airline industry after the deregulation in 1994. Did the two airlines, SAS and Braathens, compete on prices and capacities (competition), collude on prices and capacities (collusion) or collude on prices and compete on capacities (semicollusion)? We reject the hypothesis that they achieved collusion, and we find the observed behaviour consistent with semicollusive behaviour and inconsistent with competitive behaviour.

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1. *Introduction*

The airline industry has been one prime example of an industry being deregulated. Although the findings are mixed, most agree that deregulation in this industry has in general been beneficial for society.[1] In the US – where the airline industry was deregulated already in 1978 – many effects are observed following the deregulation. Baltagi *et al.* (1998) found that it led to a substantial increase in the load factor. One possible explanation is that deregulation triggered rivalry on prices, thereby dampening the rivalry on capacities.[2] Morrison and Winston (1986, 1995) observed increased flight frequency in the period immediately following the deregulation. Deregulation in Norway in April 1994 led to a substantial decrease – not an increase – in load factor. The routes here represent one third of the Norwegian airline market. The average load factor was 61% on these routes in the period 1985-87, and dropped to 49% in the period 1994-96. The purpose of this article is to investigate in detail the nature of competition in the Norwegian airline industry in order to try to explain the Norwegian experience. In particular, our study asks whether we have had *semicollusion* in the deregulated Norwegian airline deregulation; collusion on prices and competition on capacities. This phenomenon has received increased attention lately, where several studies have suggested that collusion on prices may trigger more aggressive competition along other dimensions, such as capacity or R&D.[3]

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[1]The surveys by both Evans and Kessides (1993) and Morrison (1998) concerning US deregulation report that prices have fallen after deregulation. They do, however, also point to some elements that may conflict with competitive pricing behaviour: (1) several large airports are dominated by one airline, and (2) an increase in multimarket contact. Other empirical studies of the US deregulation include Borenstein (1989, 1990), Borenstein and Rose (1994), Brander and Zhang (1990, 1993), Evans and Kassides (1994), Hurdle *et al*. (1989) and Whinston and Collins (1992) See McGowan and Seabright (1989), Encaoua (1991), Good, Røller and Sickles (1993), Neven and Røller (1996), Marin (1995, 1998) and Røller and Sickles (1997) concerning deregulation in the European airline industry.

[2]As noted in Morrison (1998), load factor did increase more on long than short flights. The reason, according to Morrison, was that under regulation 'long-haul fares were set above cost, which led to low load factors as carriers competed with flight frequency' (p. 164).

[3]There are several studies of semi-collusion, where all of them assume collusion in the product market (either on prices or quantity) while the firms compete along other dimensions. Competition on capacity is analysed in Fershtman and Muller (1986), Osborne and Pitchik (1987), Davidson and Deneckere (1990), Matsui (1989), Fershtman and Gandal (1994) and Steen and Sørgard (1999); competition on R & D is analysed in Katz (1986),

Since the largest routes in the Norwegian airline industry are of almost equal size as the routes between many specific airports inside Europe as well as inside United States, it should be of general interest to explain the experience in Norway. The institutional setting in the Norwegian airline industry suggests that it might have been a scope for price collusion after deregulation, and we have some anecdotal evidence indicating that firms in fact have colluded on prices. However, as in many other airline studies, we do not have detailed data on prices and the share of discounted tickets, so we cannot test directly for whether this is true or not. On the other hand, we have detailed data on capacities. We have therefore formulated a theoretical model that enables us to distinguish between three different regimes by observing capacity and changes in capacity: (i) firms colluding on prices and capacities (*collusion*); (ii) firms colluding on prices and competing on capacities (*semicollusion*); (iii) firms competing on prices and capacities (*competition*).

We have found a significant increase in capacity on the duopoly routes following deregulation. This is inconsistent with collusion on both prices and capacities. Moreover, we have found that a marginal change in the demand had a larger effect on large than on small duopoly routes in the period after deregulation. This is consistent with a semicollusive regime, where the firms collude on prices and compete on capacities. It is in contrast to the U.S. experience, where prices were regulated prior to deregulation, but carriers competed on flight frequencies (Morrison, 1998). In this respect the US regulatory regime could best be described as semicollusion according to our terminology. The price competition triggered by the US deregulation apparently dampened the rivalry on capacities observed in the regulatory regime. No surprise, then, that deregulation in the US led to a substantial increase in load

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D'Aspremont and Jacquemin (1987), Kamien *et.al*. (1992) and Fershtman and Gandal (1994); competition on location is analysed in Friedman and Thisse (1993). For a survey of the literature on semi-collusion, see Fershtman and Gandal (1994) or Phlips (1995), chpts 9 and 10.

factor. In Norway, the firms were not allowed to compete on capacities in the regulated era. The lack of price competition following deregulation triggered therefore more investments in capacity and a reduction in the load factor.

In Section 2, we describe the Norwegian airline industry. In Section 3, we formulate the model. Since the model in Section 3 is very stylised, we discuss in Section 4 whether relaxation of some of the assumptions would change our predictions. To test the hypotheses derived in Section 3, we specify in Section 5 an econometric model. The empirical results are reported in Section 6, and discussed in Section 7. In Section 8 we summarise our results.

2. The Norwegian airline industry

The Norwegian airline industry has many of the features observed in other European countries. The largest routes in Norway are of almost equal size as the routes between many specific airports inside Europe as well as United States.[4] Before 1987 one single firm was given the exclusive right to have flights on each route. Both prices, the number of flights and time location were regulated. However, there are indications that the regulation had only a minor or no impact on the firm's price setting.[5] In October 1987, a second airline was permitted to have a limited number of flights for some particular routes - four flights at a maximum on each route.

[4]Not surprisingly, the number of flights between city pairs as, for example, San Francisco-Los Angeles and London-Amsterdam, are much higher than between city pairs in Norway. However, when we take into account the fact that there are several airports in each of these large cities, then the number of flights between specific airports are at the same level as the number of flights on the largest routes in Norway [see Strandenes (1990)].

[5]The regulation dates back to the 40s. Each firm had to apply to the civil aviation authorities concerning price changes, typically once every year. Then each firm could argue that they have had cost increases, an argument that the authorities would find difficult to disprove. Norman and Strandenes (1994) have calibrated the market equilibrium on the route Stockholm-Oslo prior to deregulation in 1993, and they conclude that '[i]nsofar our calibrated coefficients seem "reasonable", the regulatory constraint cannot be severe'. (p. 96) Hence, their study gives support to our conjecture that the regulation had no substantial impact on the price setting.

In April 1994, all routes, except those between the smallest airports ('kortbanenettet'), were further deregulated.[6] All domestic firms were free to enter, and they were free to set prices and to determine the time location of their flights as well as the number of flights on each route. Two Norwegian airlines, SAS and Braathens, were the active firms in the Norwegian airline industry before deregulation. They continued to be the only active airlines also after deregulation. On 24 out of 32 routes, the legal monopolist from the era of regulation continued to be a monopolist. On the remaining 8 routes, the two firms were both active after deregulation.

Prior to deregulation, both firms threatened to cut prices following deregulation. However, a study indicates that there was no price reduction on the full fare tickets in the business travellers' segment following deregulation, and only a minor increase in the share of discounted tickets.[7] The study, though, is not an empirical test. The conclusions are drawn from observing descriptive statistics.

Although we do not know with certainty whether the airlines colluded on prices, there are several reasons for why they could succeed in achieving collusive prices also after the deregulation. First, the two firms had initially almost equal market shares in the domestic market. Then it was natural to continue with the initial market sharing in the deregulated system. In fact, there were only rather minor changes in the market shares on each route as well as in the total market shares after deregulation.[8] At 24 out of the 32 city-pair routes, the initial monopoly carrier continued to be a monopolist. For the remaining eight routes, the pre-deregulation dominant firm continued to have a dominant position. On average, the

[6] In terms of passengers these smaller airports ("Kortbanenettet") represented less than 8% of the total traffic in 1997 and 1998.

[7] This is shown in Lian (1996). He finds that the share of the discounted tickets increased with 2.5 %-point from 1992 to 1994-95. According to Lian (1996) this is no dramatic change: *'a 2-3 %-point increase in discount tickets in two-three years is in line with a long term trend and imply no sudden change in this trend'* [our translation] (p. 15). The increase in the share of discounted tickets is larger in the 'leisure' segment than in the business segment [see Lian (1996), table 4.4].

dominant firm had a 13 %-points reduction in market share on these eight routes, and it had no less than 60% market share on any of the routes in the deregulated regime.[9]

Second, for those routes where both firms did have flights, there exists a system for co-ordinating prices. The firms are permitted to consult each other concerning price setting. To allow for late changes of flight schedules for normal (no rebate) tickets, from one airline to another, the airlines must have «transferable» prices. To implement such a policy, the firms are permitted to meet regularly to inform each other concerning future prices on non-rebated tickets - labelled interline tickets. Hence, there exists an institutional pre-play communication system where each firm can inform its rival about its future prices on normal tickets.

Third, the firms have signaled an aggressive response to any move by its rival. In particular, each firm matches the rival's offer. For example, prior to deregulation Braathens SAFE introduced a rebate ticket named *Billy* to match SAS' rebate ticket *Jackpot* and set a price NOK 5 below the *Jackpot* price. SAS responded immediately by reducing its *Jackpot* price by NOK 5.[10] Although the Lian (1996) study suggests that there was no price competition in the business traveler's segment following deregulation, casual observations suggest that it has been more price competition in the leisure segment, where the firms offer discounted tickets. Both Billy and Jackpot are examples of this kind of tickets. These were discounted tickets with restrictions which made them unattractive for business travelers. There are also other examples of discounted tickets with restrictions, where a firm matched the rival firm's offer. For example, in the summer of 96 both SAS and Braathens introduced 50th anniversary tickets, which also where discount tickets with restrictions. Casual

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[8]Each firm's market share changed only modestly following deregulation; Braathens SAFE increased its market share from approximately 50% in 1993 to 52% in 1995 [see Lorentzen *et al*. (1996)].
[9]The exception is the route Bodø-Tromsø, where each had two non-stop flights both before and after April 1994.

observations from the press also suggest that there has been no fierce price competition in the business segment. A representative for Braathens, the public relation manager Audun Tjomsland, said it this way:

> *'The two Norwegian firms on Norwegian routes, Braathens and SAS, are of equal size and can follow each other during a price war. A firm starting a price war will quickly be followed by the rival firm, so the firm that starts a war will have an advantage only a day or two. Accordingly, the firms are reluctant to trigger a price war' (our translation) [Bergens Tidende, 31/7/95]*

Moreover, other statements suggest that the two firms did compete intensely along other dimensions, among others capacity. For example, Braathens explained its poor result in the first quarter of 1996 in the following way:

> *'Braathens explains this [poor result] with an increased competition. The firm has increased its capacity, but it has not helped much. The growth results in an increase in employment and other costs of production (our translation) [Dagens Næringsliv, 10/5/96]*

A few months earlier, SAS had announced several new initiatives:

> *'Among the initiatives are recruitment on the ground and in the cabin, adjustment of time-scheduling of flights, an increase in capacity amounting to 400.000 seats annually, better food on business class between Norway and other countries, .. (our translation) [Bergens Tidende, 9/3/96].*

Note that none of them mention price cuts. Hence, these statements are consistent with collusion on prices and competition on capacities.

There are also some observations suggesting that it has been a large increase in capacity following deregulation.[11] One possible explanation could be that this is due to a general growth in demand. Other possibilities is that the increase in capacity might be due to changes in input prices such as reduction in the cost of purchasing aircrafts or reduction in other input prices as the price of labor and fuel. None of these reductions in input prices took

[10] A statement by a representative for Braathens SAFE suggests that this is a deliberate policy for the firms in question: 'We will match any offer by SAS within an hour, and we can not accept that SAS has cheaper rebate tickets than what we have' (our translation) [C. Fougli to Dagens Næringsliv, 20/1/94].

[11] For example, during the first year after deregulation, total capacity for routes to and from Oslo increased by 12.5 % [see Lian (1996), Table 5.2].

place in this period. Alternatively, the capacity increase might also be driven by intense rivalry on capacity triggered by collusion on prices. The lack of other apparent reasons and the observed large drop in load factor on the routes in question, from 61% prior to deregulation to 49% after deregulation, suggests at first glance that deregulation led to an intense rivalry on capacities.

We thus see that casual observations suggest that SAS and Braathens colluded on prices and competed on capacities. However, we do not know with certainty whether this is true. The question we ask is therefore: did the firms in fact compete on capacity and collude on price, or did they either collude or compete along both dimensions following deregulation? This is what we have set out to test.

3. A theoretical model

Let us consider a duopoly where firms choose both prices and capacities. Since prices are typically more flexible than capacities, we assume the following game:

Stage 1: Both firms set capacities
Stage 2: Both firms set prices

If the firms behave non-cooperatively on both stage 1 and 2, we have a game which is analysed in Kreps and Scheinkman (1983). They show that, when certain assumptions are met, the equilibrium is identical to the Cournot equilibrium. We label this the *competitive regime.* If the firms behave cooperatively on both stages, the firms behave as a cartel and thereby they attain the monopoly equilibrium concerning both price and capacity setting. We label this the *collusive regime.* A third alternative is that the firms behave cooperatively for one choice variable, and non-cooperatively for the second choice variable. As we argued, price is typically easier to change than capacity. As is well known from theory of repeated games, it is easier to collude on a choice variable that can be changed very rapidly. Hence, we find it natural to assume that the firms can collude on prices and compete on capacities.[12] We label this the *semicollusive regime.*[13]

Let us assume the following inverse demand function:

$$P = A - Q_1 - Q_2 \tag{1}$$

where P is price, Q_i quantity supplied by firm i, i=1,2, and A a parameter measuring the demand potential.[14] Furthermore, let C_S denote short run marginal cost and C_L cost per unit of installing capacity. K_i denotes capacity for firm i, where i=1,2, and $K = K_1 + K_2$. Let us consider each of the three cases.

Collusive regime (price- and capacity cartel)

Obviously, the firms have no incentives to build idle capacity. Therefore, we have that $Q_i=K_i$ for firm i. The following capacity is installed:

$$K_1^M + K_2^M \equiv K^M = \frac{A - C_S - C_L}{2}. \tag{2}$$

Then we have the following effect of a change in, interpreted as a change in the demand:

$$\frac{\partial K^M}{\partial A} = \frac{1}{2}. \tag{3}$$

[12]The fourth alternative would be capacity collusion and price competition. Then the firms could achieve the collusive outcome concerning both prices and capacities simply by setting the monopoly capacity. Hence, the outcome of this fourth alternative would be identical to the outcome in what we labelled the collusive regime.
[13]The semicollusion game we analyse here was first introduced in Fershtman and Gandal (1994).
[14]Note that we assume no product differentiation. As is well known from theory, product differentiation would have dampened competition even in a Cournot model (our competitive regime). Moreover, product differentiation would lead to a more complex sharing rule, with no longer a one-to-one relationship between relative capacity and market share in the semicollusive outcome. Although we cannot say whether this would lead to a larger or smaller difference between the semicollusive and the competitive regime, we conjecture that the overall picture would still be the same: semicollusion would still trigger an overexpansion in capacity compared to a non-cooperative (Cournot) outcome.

Competitive regime (price- and capacity competition)

As for collusion, there is no reason for the firms to install idle capacity. The following capacity is installed in equilibrium:

$$K_1^C + K_2^C \equiv K^C = \frac{2(A - C_S - C_L)}{3}. \tag{4}$$

Then we have the following effect of a change in the demand:

$$\frac{\partial K^C}{\partial A} = \frac{2}{3}. \tag{5}$$

Semicollusive regime (price collusion and capacity competition)

The firms succeed in coordinating their price setting. At stage 2, the collusive price is found by solving the following problem:

$$\sum_{i=1}^{2} \pi_i = \max_P (P - C_S)Q - K \cdot C_L, \tag{6}$$

If $K < (A - C_S)/2$, the marginal revenue exceeds the short run marginal cost when all capacity is used for production. Hence, the firms set the price so that the entire capacity is used for production. Then, the market price is $P = A - K$.

If $K \geq (A - C_S)/2$, it is optimal to set $P = (A + C_s)/2$. If so, the firms install excess capacity. Then it remains to determine the sharing rule - each firm’s quota in the market. In that case we assume that:

$$Q_i^S = \frac{K_i}{K} D(P). \tag{7}$$

Each firm’s market share is thus identical to its share of total capacity. [15] There are, at least, two reasons for a positive relationship between its own share of total capacity and its own

[15]We are implicitly assuming that market share is equal to capacity share in this specification. This is at odds with the notion of an ‘S-curve’ relationship between capacity and share, where often the airline with the greatest capacity share receives an even higher market share. Our relationship can be seen as an approximation, where

share of total sale. First, the larger the capacity the larger the probability that there is a vacant seat at the airline firm in question. Second, the larger the capacity the larger the number of flights and thereby the service frequency for the airline firm in question. More generally, when products and prices are identical it is reasonable to assume that the demand is distributed so that each firm's sale is related to its share of total supply in the market.

At stage 1, the firms set capacity non-cooperatively. Firm *i* has the following maximization problem:

$$p_i = \max_{K_i} (P - C_S) Q_i - C_L K_i \tag{8}$$

s.t. (i) $if \quad K \leq \frac{A - C_S}{2}, \ then \ Q_i = K_i \quad and \quad P = A - K$

(ii) $if \quad K > \frac{A - C_S}{2}, then \ Q_i = Q_i^S \quad and \quad P = \frac{A + C_S}{2}$

Given that $K \leq (A - C_S)/2$, we are back to the case where all capacity is used for production. Then each firm determines its sale by determining its capacity, and price is set to clear the market. Hence, the firms compete for capacity and we have an outcome analogous to the competition regime we specified previously. If $K > (A - C_S)/2$, then the firms installs more capacity than what is demanded in the market at the collusive price. From the first order conditions, we have the following total capacity in equilibrium:

$$K^S = K_1^S + K_2^S = \frac{2(A - C_S)^2}{16 C_L}. \tag{9}$$

Then we have that the firms install more capacity than what is used for production if:

we capture that on the margin an increase in own capacity, all else equal, would lead to a higher market share. Furthermore, note that the two airlines in question are of equal overall size in the Norwegian market. This suggests that there is no systematic bias in our modelling approach, since one airline is large on some routes and small on other routes and vice versa. Finally, we have checked for the effect of an asymmetric market sharing rule, see the last part of Appendix A, end we find that our theoretical results are robust to such an extension.

$$\frac{A - C_S}{2} < \frac{2(A - C_S)^2}{16C_L} \tag{10}$$

Rearranging, we find that the firms install excess capacity if $A > 4C_L + C_S$. Given that $A > 4C_L + C_S$, we have the following change in equilibrium capacity as a result of a marginal change in the demand:

$$\frac{\partial K^S}{\partial A} = \frac{A - C_S}{4C_L}\,. \tag{11}$$

Now we can use two illustrations to summarise our results so far.

[Figure 1 and 2 here]

If $P=A$, demand equals zero. Hence, production is zero at $C_S+C_L=A$. We know from the analysis that an increase in A will have a more limited effect on equilibrium capacity under collusion than under semicollusion or competition. Therefore, in Figure 1 the capacity curve is flatter in the collusive regime than in the other two regimes.

Then we can formulate our first hypothesis, which is relevant for the shift from a regulated regime - which we will interpret as a collusive regime (see Section 5) - to a deregulated regime:

Hypothesis 1: *If the nature of competition shifts from a collusive regime to either a semicollusive or a competitive regime, a positive shift in the total capacity is observed.*

If we reject the hypothesis that the nature of competition is collusion after the deregulation, the next step would be to distinguish between the two other regimes. To do so, we have to look at how total capacity is affected by a change in the demand. This is illustrated in Figure 2.

Note that the effect on total capacity by a marginal change in the demand is not affected by the market size in the competitive regime. On the other hand, in the semicollusive regime the market size matters. The larger the market size, the larger the effect on total capacity by a marginal change in the demand. Now we can formulate our second hypothesis:

Hypothesis 2: *If a marginal change in the demand has a larger effect on capacity in a large than in a small market, then the observation is consistent with a semicollusive regime and inconsistent with a competitive regime.*

To understand the distinction between the semicollusive and the competitive regime, note that an expansion of own capacity will result in a lower price in the competitive regime. This dampens the incentive to expand capacity. In the semicollusive regime, on the other hand, such a capacity expansion does not affect the price. The only - and important - effect, is that it increases the firm's market share, since its market share is determined by its share of total capacity. The larger the market size, the larger the absolute increase in sale by increasing its market share with a certain amount. Hence, a firm has stronger incentives to expand its capacity the larger the size of the market. We label this *the semicollusion effect*.

4. A discussion of the predictions

The model we have presented is quite stylised, and there are numerous questions that can be raised. Let us comment on some important issues.

First, the nature of competition in the competitive regime may differ from Cournot competition. If there is no commitment power concerning capacity setting and the firms compete on both capacities and prices, then in equilibrium we would have price equal to long run marginal costs. However, it can be shown that such a change in the definition of the competitive regime would not change our two hypotheses. A competitive regime following deregulation would result in an increase in capacity. Moreover, a marginal change in the market size has the same effect on capacity in a small and a large market if the competitive regime is in force.

Second, a capacity in excess of what is needed in the particular market does not necessarily imply that capacity is idle. It could be that the residual capacity is used for supplying another market segment. For the market in question, the first market segment can be the business segment and the second one can be the leisure/holiday segment. In Appendix *A* we have used an extended version of the model presented in Section 3 to capture the existence of two market segments, where the installation of capacity intended for the business segment results in some extra capacity to serve the leisure segment. It can easily be shown that adding a second market segment does not change any results concerning Hypothesis 1. A shift from collusion to any of the two other regimes would still result in an increase in the equilibrium capacity in the industry. Moreover, Hypothesis 2 is still valid, despite more ambiguous results concerning the distinction between the competitive and the semicollusive regime. When the competitive regime is in force, market size does not matter for the effect on capacities of a marginal change in market size. However, in the semicollusive regime the market size matters. If the price in the leisure segment is forced down to short run marginal costs, or the price in the leisure segment is unaffected by the sale of firm i in the leisure segment, then the results reported in Section 3 are still valid. However, if price is above short run marginal cost and affected by i's sale, results are now ambiguous (see Appendix A). Then an increase in market size can have a larger impact in a small than in a large market. The intuition is that the price reduction in the leisure segment following a larger sale in the leisure segment dampens the incentive to overinvest in capacity, and this may overturn the semicollusion effect we described in Section 3. If we do observe that a marginal change in the demand has a larger effect on capacity in a large than in a small market, this is consistent with semicollusion in the major market segment. On the other hand, if we find that market size does not matter we cannot distinguish between the two regimes.

Third, one may question our modelling of market size. If we stick to the linear functional form, a more general inverse demand function could be the following:

$$P = S(A - Q/B) \tag{12}$$

In Section 3, both S and B were normalised to one. The parameter A was interpreted as a proxy for market size. Alternatively, either S or B can be a proxy for market size. An increase in S would technically speaking imply that the intersection with the vertical axes would shift upwards and thereby the demand curve would become steeper. An increase in B would likewise imply that the intercept with the horizontal axis would shift outwards and thereby the demand curve would become flatter. In Appendix A we show that the semicollusion effect we found in Section 3 is still present if we interpret S as market size, but that it is not present if we interpret B as market size. However, one could argue that an increase in market size should come about as a combination of the shift in demand caused by S and B, respectively. It can be shown that a shift in A causes a parallel shift in the demand curve, which can be seen as a combination of those two effects captured by a change in S and B, respectively. Moreover, if marginal costs are lower in large than in small market, this is analogous to an upward shift in A in large markets. In line with such a line of reasoning, we find that A is the most natural choice as a proxy for market size. However, one of the alternative proxys for market size shows that we may not be able to distinguish between a competitive and a semicollusive regime by observing how a marginal change in market size affects capacity in a small and a large market, respectively.

Fourth, one may question the predictions from our model. From the analysis in Section 3, it can easily be shown that individual profits are greater under competition than under semicollusion if capacity costs are not too high.[16] Then one may ask why firms end up choosing the semicollusive regime in the first place, where the firms have to (implicit or explicit) coordinate their price setting. One reason is, as indicated, the size of the capacity cost. Another reason might be that semicollusion is a prisoner's dilemma outcome. As pointed out by Fershtman and Gandal (1994), for any given capacity the firms are always better off colluding on prices than not. So any decision not to collude on prices might not be credible. Finally, the competitive regime can be more competitive than the one we have modelled. For example, the competitive regime can be à la Bertrand rather than à la Cournot. If so, individual profits will be higher in the semicollusive than in the competitive regime. According to theory, then, both the semicollusive and the competitive regime can be equilibrium outcomes.

In all, we find that both our hypotheses are robust. However, there might be cases where we are not able to distinguish between the semicollusive and the competitive regime. A natural next step is then to examine whether we in fact are able to detect which one of the regimes that has been present in the Norwegian airline industry.

5. An econometric model

In order to test our two hypotheses regarding the effect on capacity following deregulation, we have used annual data for 11 routes for the years 1985-95 (see Appendix B for details

[16] In the semicollusive regime individual profits are $(A - C_S)^2/16$, while in the competitive regime individual profits are $(A - C_S - C_L)^2/9$. See Fershtman and Gandal (1994), who first found that semicollusive could be detrimental to individual profits.

concerning the data).[17] These routes represent between 34 and 37% of the Norwegian airline market in terms of passengers. The routes are shown in Figure 3. The development in the number of passengers and capacity are shown for four of these routes in Figure 4. Apparently, the capacity increase following deregulation is larger on the two duopoly routes then on the two monopoly routes. What we attempt to achieve in the econometric tests is to see whether differences in capacity changes between routes also hold systematically for all the duopoly routes when we control for factors as changes in size of the market and deregulation.

[Figure 3 and 4 here]

We specify two main models, one for each hypothesis:

Test of hypothesis 1*: Collusion vs. Competition/Semicollusion*

Model (I) $$CAP_{i,t} = a + b_{PAS} PAS_{i,t} + b_{REG94} REG94_t + b_{REGMON} REG94_t * MON_i + e_{i,t}$$

Test of hypothesis 2*: Competition vs. Semicollusion*

Model (II) $$CAP_{i,t} = a + b_{PAS} PAS_{i,t} + b_{REG94} REG94_t + b_{REGLARGE} REG94_t * LARGE_i + e_{i,t}$$

$CAP_{i,t}$ is capacity by routes $i=1\text{-}11$, for $t=1985\text{-}95$, $PAS_{i,t}$ is the number of passengers by routes representing the demand for airline services, $REG94_t$ the deregulation dummy defined as one for 1994 and onwards, MON_i defines whether a route is a monopoly route also after the deregulation with non-monopoly routes as the reference category. $LARGE_i$ defines the

[17] Both the monopoly and the duopoly routes are chosen according to representativity of the whole market. In particular one will find both monopoly routes that are larger then duopoly routes and visa versa. All routes

four largest routes, and $\varepsilon_{i,t}$ is an error term with standard properties. The reason for not choosing a continuous variable like passengers to represent size in model (II), is the size structure of these routes, where the four largest routes are on average four times the size of the smaller routes.[18] Furthermore, the four largest routes are very similar in size. See Table B1 in Appendix B for an overview over which routes are included, and how the $LARGE_i$ variable is defined.

In model (I) we test whether deregulation of the Norwegian airline regime led to intense rivalry. By assumption, a collusive regime was reached under regulation. The prediction from theory (Hypotheses 1) is that a shift to a semicollusive or a competitive regime results in a positive shift in total capacity. In model (I) we test this by interacting the regulation indicator variable and the monopoly variable. If this interaction terms is negative, and controlling for the increase in demand by including $PAS_{i,t}$, this implies that deregulation led to increased capacity for the routes shifting from monopoly to duopoly.

Given that we find that deregulation led to an increase in capacity, our second model tests whether deregulation led to a competitive or a semicollusive regime. If a marginal change in demand for airline services had a stronger impact on total capacity the larger the market is (Hypotheses 2), this would be consistent with a semicollusive regime and inconsistent with a competitive regime. Hence, the main variable in model (II) is thus the interaction term between the size of the market and the regulation indicator, $REG94_t *LARGE_i$, defining the impact on capacity of the four largest routes following the deregulation. Again, we control for market size and the deregulation by including the passengers and the regulation dummy also in model (II). A possible problem in model (II) is too much overlap in flights between large routes and duopoly routes; a possible difference

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connected to Oslo we use the departures from Oslo to the other cities.

[18] On average there are 23.75 flights per day on a large route, a small route have an average of 6.13 flights per day (see Table B1 in Appendix B).

between small and large routes mirrors the difference between duopoly and monopoly, rather then the difference between large and small routes. As a refinement of the test between semicollusion and a competition regime, we therefore estimate a second version of model (II) where we only include duopoly routes.

In addition to estimations using OLS we extend the analysis to include fixed effect estimation, an instrument variable technique, and control for heteroscedasticity. The interpretation of the within estimator is that differences over flights which are fixed in the data period and not captured by included variables, particular characteristics such as load factor etc., are controlled for. Demand for airline services ($PAS_{i,t}$) may well be an endogenous variable and thus a biased control variable in our equations caused by a correlation between the error term and the $\mathrm{PAS}_{i,t}$ variable. We instrument out this effect by including instruments expected to be highly correlated with demand for airline services for each route and not correlated with capacity. The included instruments are tax income to the region corresponding to each route, population in the region, and the expenditures of the municipalities in the regions (see the Appendix for details on the construction of these variables). Furthermore, we will expect that heteroscedasticity might be a problem here since increased size of the routes may lead to higher variance. Heteroscedasticity is first tested for and then corrected for by using a robust estimator with route size as the grouping variable. For all the models we estimate and report results for the OLS, the Instrument and Instrument/robust estimators.

6. Empirical results

Test of hypothesis 1: Collusion vs. Competition/Semicollusion

In Table 1 the results from estimating Model 1 with the four estimators are presented.

[Table 1 here]

The model explains well the variation in total capacity. The explanatory power is convincing, and the control variables $PAS_{i,t}$ and $REG94_t$ have the expected signs and have significant impact. When exploiting the panel structure of the data and estimating with the within estimator, we notice from column 2 that the results from the OLS estimator carries over. Further, since the variance may increase as a function of route size, we used a Cook-Weisberg test for heteroscedasticity. The H_0 of constant variance is rejected for the OLS specification and a robust estimator utilized to estimate the variance-covariance matrix. Further, since *PAS* is expected to be an endogenous variable, the 2SLS instrument estimator was used. All three estimators, *i.e.*, OLS, 2SLS and 2SLS/robust, show very similar results supporting our general specification.

The most important result from Table 1 is that the interaction term $REG94_t*MON_i$ is negative and has a significant impact. This shows that deregulation led to increased capacity for the routes shifting from monopoly to duopoly routes in excess of the increased demand for airline services (the reference groups). Hence, deregulation led to more intense rivalry. However, we cannot use these results to conclude whether the post-regulation regime is a competitive or semicollusive regime. Hence, now we turn to our second model to test hypothesis 2.

Test of hypothesis 2: Competition vs. Semicollusion

Table 2 presents results from estimating Model (II) for all 11 routes where the aim now is to distinguish between semicollusion and competition.

[Table 2 here]

The within estimator provides support for the OLS results also for this model. The same test for heteroscedasticity was undertaken and a constant variance rejected. Hence, a robust estimator was used. Further, the 2SLS estimator was used since $PAS_{i,t}$ is expected to be endogenous. The four specifications show a very a similar and stable pattern in explaining the variation in total capacity. The control variables have the expected signs and are significantly different from zero.

The interaction term between the variable for deregulation, $REG94_t$, and the size of the market, $LARGE_i$, is positive and has a significant impact. It shows that market size matters for the Norwegian airlines' investment in total capacity following a deregulation: Capacity is more sensitive to changes in demand in a large than in a small market. Hence, we are able to distinguish between a semicollusive and competitive regime. Since investment in total capacity following deregulation is predicted from theory to be dependent on market size only when semicollusion characterises the relationship among firms, our results reject a competitive regime.

The four largest routes are all duopoly routes. In order to ensure that the positive relationship between market size and investment in capacity found in model (II) is *not* driven by routes going from monopoly to duopoly (a deregulation effect), but rather is a "pure" size effect, we now estimate model (II) only for the duopoly routes. These results are presented in Table 3.

[Table 3 here]

The results of Model (II), now only for the duopoly routes are parallel to what we found when estimating Model (II) for all routes. Even though the size effect is less significant now

– with the exception of the fixed effect estimator where it is not significant at conventional levels -we still find size to have a positive effect on capacity; the interaction term $REG94_t$ $*LARGE_i$ is positive in all three models in Table 3.[19] The effect is significant at all conventional levels for the IV-specification. Moreover, the significance level is within 10 percent in both remaining cases (10 percent for the OLS and 7 percent for the IV/robust regressions, respectively).[20] Hence, even when we only include the duopoly routes we can reject the competitive regime. We found that our results are consistent with a semicollusion regime.

Since both model I and II have capacity on the left hand side another alternative would have been to test our two hypotheses simultaneously, rather then in sequence. We have chosen the formulated test sequence because it links more directly to the two hypotheses this way. However, we have undertaken estimations where we include both effects within the same equation, the main result still holds, in particular we find that the size effect on the duopoly routes comes in significantly.[21]

7. Discussion of the results

Could there be other possible explanations for our empirical findings? Let us here discuss some other factors and whether they can explain our results.

First, one could argue that it is incorrect to assume a collusive outcome in the regulatory regime. Although we have argued that prices were at a collusive level in the regulatory regime, capacity may not have been at a collusive level. Since the airline companies had to apply to authorities when increasing prices, typically by arguing that they

[19]For the fixed effect estimator the sign of the parameters points in the right direction. Since we are limiting the variation in the data dramatically using the within estimator for only the duopoly routes it is probably to ask too much of the data to expect it to be significant.

[20]An additional explanation for the lower significance in these models, might be that we have considerable fewer observations and thereby less variance.

have had cost increases, the regulation would be a de facto rate-of-return regulation. As is well known, such a regulatory regime may well result in overinvestment in capacity. However, this cannot explain our finding that we have large investment in capacity following deregulation. On the contrary, excess capacity in the regulatory regime is a factor that potentially could make it impossible to detect a shift to a semicollusive or competitive regime following deregulation. Since this is a bias *against* finding support for a semicollusive regime, our results are even more robust.

Second, even without entry the threat of entry under deregulation could have caused capacity to rise even for monopoly markets. The reason would be that the incumbent firm installs capacity to deter entry, as first shown in Dixit (1980). This effect biases our estimates against finding support for our non-collusion hypothesis. Then, as above, it is even more convincing when we find support for our hypothesis that capacity is higher in duopoly than in monopoly markets.

Third, as is evident from the data, market shares are asymmetric. Typically, on each route the incumbent firm has a larger number of passengers than the entrant. On some routes SAS is the incumbent firm, while on other routes Braathens is the incumbent firm. One possible explanation would be brand loyalty. At a given price and identical capacity, a majority of the customers prefer the incumbent firm. This may be captured by the market sharing rule:

$$Q_1^S = \left(\frac{bK_1}{bK_1 + K_2}\right)D(P), Q_2^S = \left(\frac{K_2}{bK_1 + K_2}\right)D(P), \qquad (13)$$

where $b > 1$. Then the market sharing rule is in favour of firm 1. In Appendix A we show that such an asymmetric market sharing rule does not affect our predictions from theory. In particular, the semicollusion effect is still present.

[21] The results are available on request to the authors.

Fourth, one could argue that we should take into account sales in the leisure segment, the second market segment, in our empirical testing. As noted in Section 3, the firms might try to sell the extra capacity in the leisure segment, thereby reducing the number of idle seats. If this is the case, $PAS_{i,t}$ will become higher than it otherwise would have been. If this effect is important, the specification used will also be biased since we are controlling for market size using all passengers. Hence, if there are more passengers due to lower prices in the leisure segment $CAP_{i,t}$ t would be biased upwards, and our test is biased in favour of finding a lesser or no capacity increase after the deregulation. Again, it implies that our results are even more robust.

Fifth, lack of price competition may not be the result of collusion on prices. It could be that the firms responded to deregulation by differentiating their products, thereby dampening competition. For example, we could have departure-time differentiation. If that is true, we would expect a continuation of the collusive outcome following deregulation. In contrast, we find strong support for a non-collusive outcome following deregulation. Moreover, in another paper we find a tendency of local clustering of flight departures in this industry in question following deregulation (see Salvanes, Steen and Sørgard, 1997). There is a tendency of pairwise flights, especially in the business segment (morning and afternoon). We observe more flights, but at the same time the increase in the consumers' departure time choice is very limited. Therefore, we have no reason to believe that the lack of price competition can be due to endogenous product differentiation.

8. Some concluding remarks

The purpose of this paper has been to test the effect of the deregulation in the Norwegian airline industry in 1994. Did the two established firms, SAS and Braathens, compete after deregulation? If yes, did they compete on capacity, on price, or both? We have found that the observed changes in capacities are consistent with a semicollusive regime, where the firms collude on prices and compete on capacities, and not consistent with a competitive regime where they compete along both dimensions. Although the phrase semicollusion is seldom used, we find numerous examples of this phenomenon.[22]

We have argued that the institutional setting in this particular industry partly explains why they could succeed in achieving collusive prices. First, prior to deregulation each firm had a market share of approximately 50%. It made it natural to try to continue the initial market sharing in the deregulated system rather than trigger price competition. Second, in the deregulated system the firms are permitted to consult each other regularly concerning price setting for full fare tickets, to make it possible with passengers' late changes of flights schedule from one airline to another. Third, several years before deregulation the second carrier were permitted a limited number of flights for a few particular routes where the first carrier had a legal monopoly. Each firm was then quite familiar with the rival's behavioural pattern, and the transition from regulation to deregulation became a very smooth process.

As noted, the experience in Norway is along some dimensions in contrast to the experience in the US. While deregulation led to intense rivalry on capacities, lack of price competition and a lower load factor in Norway, the opposite was to a large extent true in the US. In our opinion, this contrast highlights the role of the initial regulatory regime and institutional setting. While in Norway the airlines could neither compete on prices nor on capacities, the airlines in the US could compete on capacities. They did so, and the result was a low load factor in the US in the regulatory regime. There were thus potentials for cost

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[22]Price collusion led to intense rivalry on advertising in the American cigarette industry [see Scherer (1980), p. 388-389], the installing of excess capacity in the German [see Scherer (1980), p. 370] as well as the US cement industry [see Scherer and Ross (1990), p. 674], and to excess capacity in ocean shipping [see Scherer and Ross (1990), p. 674]. The existence of cartels in the domestic Japanese market, where quotas were allocated according to relative capacity, led to excess capacity in many Japanese industries during the 50s and 60s [see Matsui (1989)]. The price cartel in the Norwegian cement market led to the instalment of excess capacity in the Norwegian cement industry in the 50s and 60s, which showed up as a large increase in exports [see Steen and Sørgard (1999)].

reductions due to better capacity utilization in the US airline industry, while in Norway such a potential for efficiency was clearly more limited. Moreover, the institutional setting in the transition from a regulated to a deregulated regime is crucial for whether we do observe rivalry on prices or not. In Norway, as explained above, the institutional setting supported the two active firm's effort to continue its market sharing and avoid any rivalry on prices. Unfortunately, this triggered intense rivalry on capacities. The contrast between Norway and the US thus illustrates the importance of price competition following deregulation. It might dampen non-price competition and thereby reduce costs, which can add to the traditional welfare gain from a reduction in the dead weight loss associated with lower prices. This said, a welfare gain might have taken place as a consequence in Norway since increased capacity also can be viewed as increased "service quality" such as reductions in passengers' schedule delay etc. In fact, two-thirds of the welfare gained increase in the US was from increased flight frequency and not fare reductions (Morrison and Winston, 1986).

Appendix A – Alternative assumptions

Two market segments

Let us consider a market with two separate segments, interpreted as the business segment (*B*) and the leisure segment (*L*) in our airline industry setting. Let D^i and P^i denote the demand and price in segment *i*, where $i=B,L$. We apply the inverse demand function in (1) for the business segment, while we assume the following inverse demand function in the leisure segment:

$$P^L = AM - NQ^L \tag{A.1}$$

where Q^L is total sale in the leisure segment. If $M=N=1$, then the two market segment are identical. To capture the fact that the willingness to pay and the price elasticity is higher in the leisure segment than in the business segment, we expect both $M < 1$ and $N < 1$.

A firm installs capacity K_i to serve the business segment. However, for each unit of capacity installed to serve the business segment, it has some idle capacity *t* which it can use to serve the leisure segment. In addition, in the semicollusive regime it can use part of the excess capacity to serve the leisure segment. We assume that a fraction *u* of the excess capacity is used in the leisure segment, where $u < 1$. To simplify, let us assume that C_S is normalized to zero. The rules of the game are as specified in Section 3. Then firm *i* have the following maximization problem in the semicollusive regime:

$$p_i = \max_{K_i} P^B Q_i^B + P^L Q_i^L - C_L K_i \tag{A.2}$$

s.t. (1) *If* $P^L = C_S = 0$ *then* $Q_i^L = \dfrac{AM}{2B}$ *and*

(1.1) $Q_i^B = K_i$ *and* $P^B = A - K$ *if* $K \le \frac{A - C_S}{2}$, *and*

(1.2) $Q_i^B = D^B \frac{K_i}{K}$ *and* $P^B = \frac{A + C_S}{2}$ *if* $K > \frac{A - C_S}{2}$

(2) *If* $C_S + C_L > P^L \ge C_S$, *then* $Q_i^L = tK_i + u[K_i - Q_i^B]$, *and*

(2.1) $Q_i^B = K_i$ *and* $P^B = A - K$ *if* $K \le \frac{A}{2}$

(2.2) $Q_i^B = D^B \frac{K_i}{K}$ *and* $P^B = A/2$ *if* $K > \frac{A}{2}$

Case (1) is analogous to the case analysed in Section 3. There is no profits in the leisure segment, and the maximization problem is reduced to the one specified in (6), with short run marginal costs normalized to zero.

In case (2), each firm earns gross profits from serving the leisure segment. We can solve for the equilibrium capacities. For example, if we assume that $M=N=t=1$, then we have the following individual capacity:

$$K_i^S = \frac{(2u+6)A - 2C_L + \sqrt{(48 - 12u + 4u^2)a^2 - (24C_L + 8uC_L)a + 4C_L^2}}{48} \tag{A.3}$$

We are interested in the sign of $\frac{\partial^2 K_i^S}{\partial^2 A}$, *i.e.*, how market size affects the relationship between capacity and a change in market size. It can be shown that the sign of $\frac{\partial^2 K_i^S}{\partial^2 A}$ depends on the parameter values. For example, for each combination of M, N, t and C_L, there is a critical value of u which ensures that $\frac{\partial^2 K_i^S}{\partial^2 A} = 0$. In Table *A1* we have shown examples of the critical value of u.

Table A1. Critical values of u for t=1 and C_L=1/4.

	M = N					
	1	0.5	0.25	0.12	0.06	0.03
u^*	0.33	0.5	0.66	0.8	0.89	0.94

For $u < u^*$, $\frac{\partial^2 K_i^S}{\partial^2 A} > 0$, and the opposite is true for $u > u^*$.

Let us now assume that the competitive regime is in force. Then there is no gain from installing excess capacity in the business segment. Each firm's maximization problem is then the following:

$$p_i = \max_{K_i} P^B K_i + P^L t K_i - C_L K_i \tag{A.4}$$

Then it can be shown that firm i installs the following capacity:

$$K_i^S = \frac{A(1+Mt) - C_L}{3(1+Nt^2)} \tag{A.5}$$

Then it can easily be seen that $\frac{\partial^2 K_i^S}{\partial^2 A} = 0$.

Modeling of market size

Let us return to the case of one market segment. If we apply the inverse demand function in (12), we have the following individual capacity in the semicollusive regime:

$$K_i^S = \frac{B(AS - C_S)^2}{16SC_L} \tag{A.6}$$

Then we have the following comparative statics concerning B and S:

$$\frac{\partial K_i^S}{\partial B} = \frac{(AS - C_S)^2}{16SC_L}, \quad \frac{\partial^2 K_i^S}{\partial^2 B} = 0 \text{ and } \frac{\partial K_i^S}{\partial S} = \frac{B(AS - C_S)(AS + C_S)}{16S^2 C_L}, \quad \frac{\partial^2 K_i^S}{\partial^2 S} = \frac{BC_S^2}{8C_L S^3} \tag{A.7}$$

Then we see that the effect on capacity by a marginal change in B is unaffected by the initial size of B, while the effect on capacity by a marginal change in S is increasing in the initial size of S.

Asymmetric market sharing rule

Given the market sharing rule in (13), we have the following equilibrium capacities and sale in the semicollusive outcome:

$$K_1^S = K_2^S = \frac{b(A - C_S)^2}{4C_L(b+1)^2}, \text{ and } Q_1^S = \frac{b(A - C_S)}{2(b+1)}, \ Q_2^S = \frac{A - C_S}{2(b+1)} \tag{A.8}$$

We see that the asymmetry in the market sharing rule results in asymmetric sale, but identical capacity. The effect of a marginal change in market size on an individual firm's capacity is then the following:

$$\frac{\partial K_i^S}{\partial A} = \frac{b(A - C_S)}{2C_L(b+1)^2} \tag{A.9}$$

Then we see that the semicollusive effect is present: The lager the market size, the larger the effect on capacity of a marginal increase in market size.

Appendix B - Data definitions and data sources

Capacity and passenger figures

The calculation of capacity on each route is based on departures, flight schedules and information on air carriers in the "Books of Norwegian flight schedules" from 1985 to 1995. Passenger figures on route-level are provided by the Norwegian Civil Aviation Authority.

In order to calculate the capacity on each route, the number of weekly departures are counted for the two air carriers BU and SAS. The capacity for each air carrier is then calculated by multiplying the number of departures by the capacity of the particular plane used. The sum of the capacity for each air carrier is the total capacity for the route. For the calculation of monthly capacity, the weekly capacity is multiplied by a factor 26/6 to reflect the fact that there are more than 4 weeks in a month. The annual capacity is then aggregated using the monthly figures. All non-stop departures are included. The analysed routes are shown in Table B1:

Table B1: The analysed routes, number of departures and competition status

City-pair Number	**City-pair Codes**	**City-pair Names**	**Non-stop Departures 1995**	**Competition status***	**Definition** $LARGE_{it}$
1	FBU-TRD	Oslo - Trondheim	27	D	1
2	FBU-BOO	Oslo - Bodø	7	D	0
3	FBU-TOS	Oslo - Tromsø	9	D	0
4	FBU-BGO	Oslo - Bergen	24	D	1
5	FBU-STV	Oslo - Stavanger	24	D	1
6	BGO-STV	Bergen - Stavanger	20	D	1
7	TRD-AES	Trondheim - Ålesund	4	M	0
8	FBU-KRS	Oslo - Kristiansand	7	M	0
9	FBU-AES	Oslo -Ålesund	6	M	0
10	FBU-HAU	Oslo - Haugesund	8	M	0
11**	FBU-MOL	Oslo - Molde	5	M	0
12**	FBU-KSU	Oslo - Kristiansund	3	M	0

*/ D = Duopoly, M = Monopoly

**/ <u>*Routes 11 and 12*</u>

On the routes from Oslo to Molde and from Oslo to Kristiansund, Braathens SAFE has monopoly. From 1985 to 1991 these two routes were basically one route; first the air carriers flew to Molde and then to Kristiansund. From 1991, Braathens SAFE has increased the number of non-stop flights to Kristiansund considerably. Since only non-stop flights are included in the analysis, and the fact that the figures we use to represent the passenger variable includes all passengers, the capacity and passenger figures are not comparable over time when looking at the individual routes (11 and 12). We have adjusted for this effect in the following way:

- the numbers of passengers are summarised for fbu-mol and fbu-ksu for each year
- from 1985 to 1991 only the capacity numbers for fbu-mol are used. From 1991 on, the capacities also for the route fbu-ksu are included.

Hence, route 11 and 12 are aggregated, leaving us with 11 city-pair routes to be analysed.

Demand Instruments

The demand instruments used in this study are collected from “The Norwegian Social Science Data Service, “The Municipal Database” and are as follows:

- Population in total, collected from the “census of population”.
- Gross Expenditures in total, collected from municipal accounts at the municipal level. Chapter 1, item 000-599 until 1991, and chapter 1 item 01-59 from 1991.
- Taxes, collected from the municipal accounts; chapter 1.900 until 1991, and chapter 1.800, from 1991.

In order to be able to use the figures in the analysis, the numbers are aggregated to regions corresponding to the city-pairs. The basis for the aggregation is the classification of municipals explained below, where closeness in terms of commuting area around each airport are used as the aggregation criterion. The figures from each municipal that is located in the airport region are aggregated. Using these airport region figures we then aggregate into 11 city-pair regions.

Classification of Municipals

The classification of municipals is based on “*The Norwegian Official Statistics, Standard for Municipal Classification - 1994*”, and “*Regional classification in the general equilibrium model, MISMOD*”, WP 63/1990, Centre for Applied Research, by Frode Steen. Municipals are categorised and given a centrality code which indicates the commuting possibilities (closeness) between the airport area and the municipal. Dependent on the size of the nearby cities, the municipals are given centrality codes. For the largest cities; Oslo, Bergen, Trondheim, Stavanger and Kristiansand, centrality code “3” indicates good commuting possibilities and short distance in time to the airport (which always are located within, or very close to its city municipal). For the airports located in the smaller cities; Haugesund, Ålesund, Molde, Kristiansund, Bodø and Tromsø, the centrality code “2” indicates good commuting possibilities. Hence, the classification used here is based on these codes, where all relevant (close) municipals are attributed to one of the 11 airports included in our 11 city-pairs. Then these 11 regions are aggregated into city-pair variables. Table B2 summarises the municipals, and their airport region codes.

Table B2: The municipals' airport region codes

Air-port Code *	Mun-icipal No	Municipal Name	Air-port Code *	Mun-icipal No	Municipal Name	Air-port Code *	Mun-icipal No	Municipal Name	Air-port Code *	Mun-icipal No	Municipal Name
1	104	Moss	1	533	Lunner	3	1120	Klepp	6	1532	Giske
1	123	Spydeberg	1	534	Gran	3	1121	Time	6	1534	Haram
1	124	Askim	1	602	Drammen	3	1122	Gjesdal	7	1502	Molde
1	135	Råde	1	604	Kongsberg	3	1124	Sola	7	1535	Vestnes
1	136	Rygge	1	605	Ringerike	3	1127	Randaberg	7	1543	Nesset
1	137	Våler	1	612	Hole	3	1129	Forsand	7	1547	Aukra
1	138	Hobøl	1	623	Modum	3	1130	Strand	7	1548	Fræna
1	211	Vestby	1	624	Øvre Eiker	3	1141	Finnøy	7	1551	Eide
1	213	Ski	1	625	Nedre Eiker	3	1142	Rennesøy	8	1503	Kristiansund
1	214	Ås	1	626	Lier	3	1145	Bokn	8	1554	Averøy
1	215	Frogn	1	627	Røyken	4	1106	Haugesund	8	1556	Frei
1	216	Nesodden	1	628	Hurum	4	1146	Tysvær	8	1557	Gjemnes
1	217	Oppegård	1	702	Holmestrand	4	1149	Karmøy	8	1572	Tustna
1	219	Bærum	1	711	Svelvik	5	1201	Bergen	9	1601	Trondheim
1	220	Asker	1	713	Sande	5	1241	Fusa	9	1624	Rissa
1	221	Aurskog-Høland	1	714	Hof	5	1242	Samnan-ger	9	1638	Orkdal
1	226	Sørum	2	904	Grimstad	5	1243	Os	9	1648	Midtre Gauldal
1	227	Fet	2	926	Lillesand	5	1245	Sund	9	1653	Melhus
1	228	Rælingen	2	935	Iveland	5	1246	Fjell	9	1657	Skaun
1	229	Enebakk	2	937	Evje og Hornnes	5	1247	Askøy	9	1662	Klæbu
1	230	Lørenskog	2	1001	Kristiansand	5	1251	Vaksdal	9	1663	Malvik
1	231	Skedsmo	2	1002	Mandal	5	1253	Osterøy	9	1664	Selbu
1	233	Nittedal	2	1014	Vennesla	5	1256	Meland	9	1714	Stjørdal
1	234	Gjerdrum	2	1017	Songdalen	5	1259	Øygarden	9	1719	Levanger
1	235	Ullensaker	2	1018	Søgne	5	1260	Radøy	10	1804	Bodø
1	236	Nes	2	1021	Marnardal	5	1263	Lindås	10	1840	Saltdal
1	237	Eidsvoll	2	1027	Audnedal	6	1504	Ålesund	10	1841	Fauske
1	238	Nannestad	2	1029	Lindesnes	6	1517	Hareid	11	1902	Tromsø
1	239	Hurdal	3	1102	Sandnes	6	1523	Ørskog	11	1933	Balsfjord
1	301	Oslo	3	1103	Stavanger	6	1528	Sykkylven	11	1936	Karlsøy
1	419	Sør-Odal	3	1114	Bjerkreim	6	1529	Skodje			
1	532	Jevnaker	3	1119	Hå	6	1531	Sula			

*/ Airport region codes used in the table translate to airports as follows:

1 - Oslo	5 - Bergen	9 - Trondheim
2 - Kristiansand	6 - Ålesund	10 - Bodø
3 - Stavanger	7 - Molde	11 - Tromsø
4 - Haugesund	8 - Kristiansund	

Figure 1: Market size and total capacity

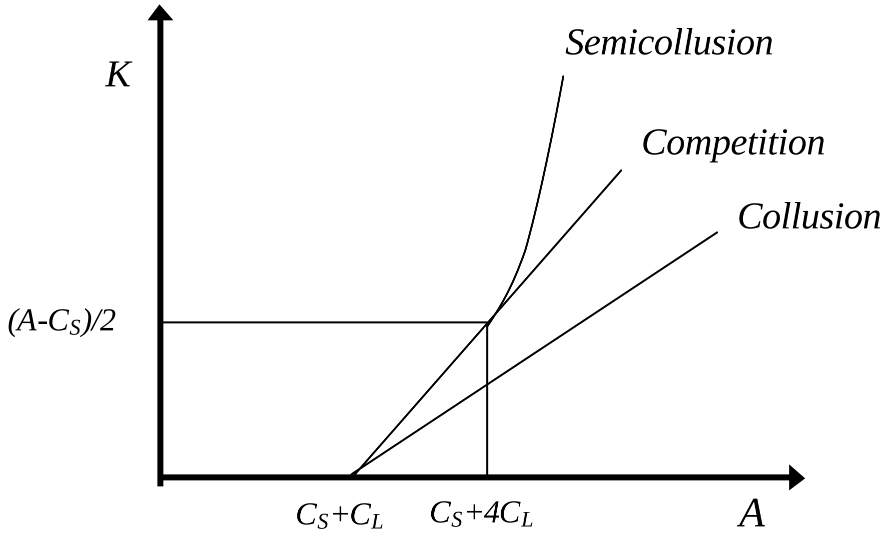


Figure 2: Market size and the effect on total capacity by changes in demand

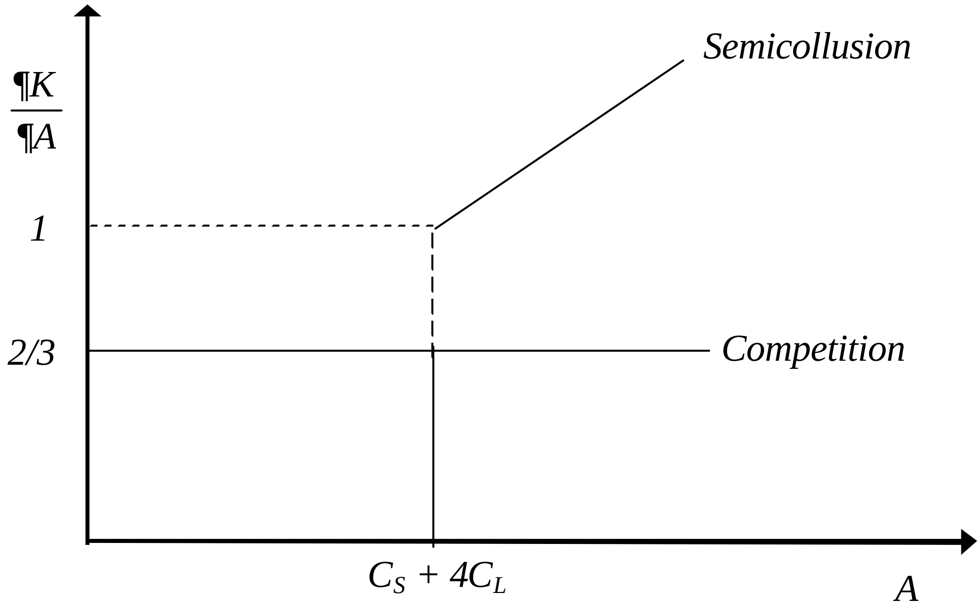


Table 1: Results for Model (I).

Variable	Model (I), OLS		Fixed Effects (I)		Model (I), Instrument		Model (I), Instrument/robust	
	Param.	St.error	Param.	St.error	Param.	St.error	Param.	St.error
PAS	1.828*	0.056	2.12*	0.167	1.55*	0.083	1.54*	0.165
REG94	89051*	24727	65308*	24291	136299*	28738	137730*	52326
*REG94*MON*	-82560*	34373	-76035*	28753	-145487*	39772	-147393*	55618
Constant	10.57*	12322	-52988*	29489	47570*	16588	49011*	28412
Cook-Weisb.	Chi2(1)=14.84							
$\bar{R}^2$	0.92		0.92		0.91		0.82	
# OBS	121		121		121		121	
Root MSE	74351		74351		81600		81913	

*/ Indicates significantly different from 0 at the 5 percent level.

Table 2: Results for Model (II), using all routes.

Variable	Model (II), OLS		Fixed Effects (II)		Model (II), Instrument		Model (II), Instrument/robust	
	Param.	St.error	Param.	St.error	Param.	St.error	Param.	St.error
PAS	1.77*	0.057	2.15*	0.177	1.56*	0.078	1.56*	0.143
REG94	6941*	20747	8652*	17989	-1720	22073	-1720	21526
*REG94*LARGE*	131361*	36260	56471*	31688	196048*	41094	196048*	74867
Constant	8134*	12322	-56968*	31348	46042*	15619	46042*	26188
Cook-Weisb.	Chi(1)=18.77							
$\bar{R}^2$	0.93		0.95		0.92		0.92	
# OBS	56712		56712		121		121	
Root MSE	72219		56712		76635		76535	

*/ Indicates significantly different from 0 at the 5 percent level.

Table 3: Results for Model (II), using only the duopoly routes.

Variable	Model (II), OLS		Fixed Effects (II)		Model (II), Instrument		Model (II), Instrument/robust	
	Param.	St.error	Param.	St.error	Param.	St.error	Param.	St.error
PAS	1.85*	0.1001	2.11*	0.25	1.3222*	0.188	0.3478*	1.282
REG94	23114	48653	43106	43106	-13372	59216	60680	1843427
*REG94*LARGE*	104340**	62370	8945	53295	237651*	83242	102885**	5.615
Constant	-13754*	28013	-78155	61576	116695	490223	94268	330302
Cook-Weisb.	Chi(1)=15.21							
$\bar{R}^2$	0.89		0.93		0.84			0.85
# OBS	66		66		66			66
Root MSE	92916		74443		110000			110000

*/ Indicates significantly different from 0 at the 5 percent level.
**/ Indicates significantly different from 0 at the 5 percent level.

Figure 3. Market structure in 1995 on the 12 domestic routes

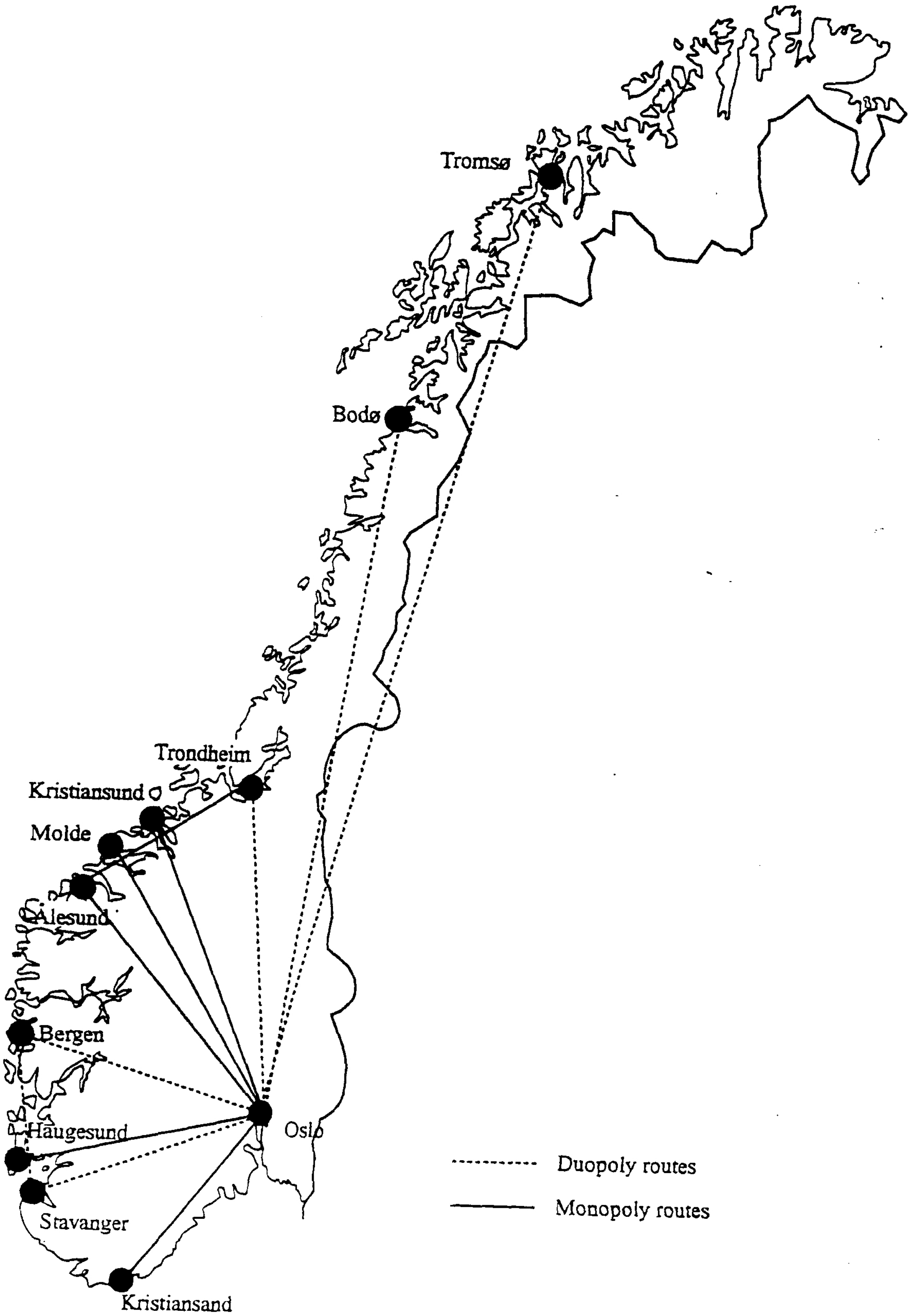
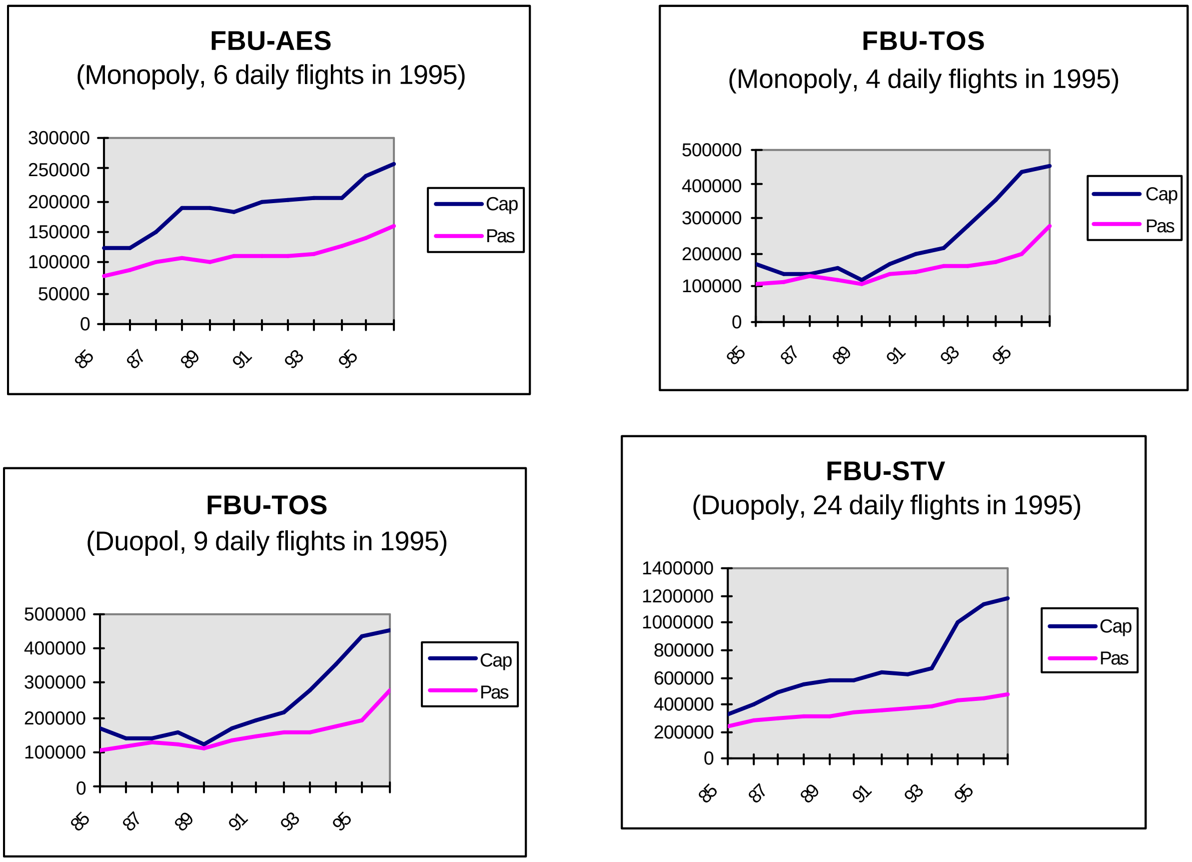


Figure 4. Capacity and number of passengers 1985-96 on four routes



References

Baltagi, B. H., J. M. Griffin and S. R. Vadali, 1998, Excess Capacity: A Permanent Characteristic of US Airlines?, *Journal of Applied Econometrics*, 13, 645-657.

Borenstein, S., 1989, Hubs and High Fares: Dominance and Market Power in the US Airline Industry, *Rand Journal of Economics*, 20, 344-365.

Borenstein, S., 1990, Airline Mergers, Airport Dominance and Market Power, *American Economic Review*, 80, 400.404.

Borenstein, S. and N. L. Rose, 1994, Competition and Price Dispersion in the US Airline Industry, *Journal of Political Economy,* 102, 653-683.

Brander, J. A. and A. Zhang, 1990, Market Conduct in the Airline Industry: An Empirical Investigation, *Rand Journal of Economics*, 21, 567-583.

Brander, J. A. and A. Zhang, 1993, Dynamic Oligopoly Behaviour in the Airline Industry, *International Journal of Industrial Organization*, 11, 407-436.

D'Aspremont, C., and A. Jacquemin, 1987, 'Cooperative and Noncooperative R&D in Duopoly with Spillovers', *American Economic Review*, 78, 1133-1137.

Davidson, C. and R. Deneckere, 1986, 'Long-Term Competition in Capacity, Short-Run Competition in Price, and the Cournot Model', *Rand Journal of Economics*, 17, 404-415.

Davidson, C. and R. Deneckere, 1990, 'Excess Capacity and Collusion', *International Economic Review*, 31, 521-541.

Dixit, A., 1980, 'The Role of Investment in Entry Deterrence', *The Economic Journal*, 90, 95-106.

Encaoua, D., 1991, Liberalizing European Airlines: Cost and Factor Productivity Evidence', *International Journal of Industrial Organization,* 9, 109-124.

Evans, W. N. and I. Kessides, 1993, Structure, Conduct and Performance in the Deregulated Airline Industry, *Southern Economic Journal*, 59, 450-467.

Evans, W. N. and I. Kessides, 1994, 'Living by the "Golden Rule": Multimarket Contact in the US Airline Industry', *Quarterly Journal of Economics*, 109, 341-366.

Fershtman, C. and N. Gandal, 1994, Disadvantageous Semicollusion, *International Journal of Industrial Organization*, 12, 141-154.

Fershtman, C. and E. Muller, 1986, 'Capital Investment and Price Agreement in Semicollusive Markets', *Rand Journal of Economics*, 17, 214-226.

Friedman, J. M. and J.-F. Thisse, 1993, 'Partial Collusion Fosters Minimum Product Differentiation', *Rand Journal of Economics*, 24, 631-645.

Good, D., L-H. Røller and R. C. Sickles, 1993, ‘US Airline Deregulation: Implications for European Transport’, *Economic Journal*, 103, 1028-1041.

Hurdle, G. J., R. L. Johnson, A. S. Joskow, G. J. Werden and M. A. Williams, 1989, ‘Concentration, Potential Entry, and Performance in the Airline Industry’, *Journal of Industrial Economics*, 38, 119-139.

Kamien, M., E. Muller and I. Zang, 1992, ‘Research Joint Ventures and R & D Cartels’, *American Economic Review*, 82, 1293-1306.

Katz, M., 1986, ‘An Analysis of Cooperative Research and Development’, *Rand Journal of Economics*, 17, 527-543.

Kreps, D. and J. Scheinkman, 1983, Quantity Precommitment and Bertrand Competition yield Cournot outcome, *Bell Journal of Economics*, 14, 326-337.

Lian, J. I., 1996, ‘Økt luftfartskonkurranse?’(An increase in airline competition?), TØI-rapport nr. 322/1996, Transportøkonomisk Institutt, Oslo.

Marin, P., 1995, ‘Competition in European Aviation: Pricing Policy and market Structure’, *Journal of Industrial Economics*, 43, 141-159.

Marin, P., 1998, ‘Productivity Differences in the Airline Industry: Partial Deregulation versus Short Run Protection’, *International Journal of Industrial Organization*, 16, 395-414.

Matsui, A., 1989, ‘Consumer-Benefited Cartels under Strategic Capital Investment Competition’, *International Journal of Industrial Organization*, 7, 451-470.

McGowan, F. and P. Seabright, 1989, ‘Deregulating European Airlines’, *Economic Policy*, 9, 284-344.

Morrison, S., 1998. ‘The Airline Industry’, in L. L. Duetsch (ed), *Industry Studies*, Sharpe, New York.

Morrison, S. and C. Whinston, 1986, *‘The Economic Effect of the Airline Industry’*, Washington, DC, Brookings Institution.

Neven, D. J. and L.-H. Røller, 1996, ‘Rent Sharing in the European Airline Industry’, *European Economic Review*, 40, 933-940.

Norman, V. D. and S. P. Strandenes, 1994, ‘Deregulation of Scandinavian Airlines: A Case Study of the Oslo-Stockholm Route’, in P. Krugman and A. Smith (eds.), *Empirical Studies of Strategic Trade Policy*, The University of Chicago Press, Chicago.

Osborne, M. and C. Pitchik, 1987, ‘Cartels, Profits and Excess Capacity’, *International Economic Review*, 28, 413-428.

Phlips, L., 1995, *Competition Policy - A Game-theoretic Perspective*, Cambridge University Press, London.

Røller, L.-H. and R. C. Sickles, 1997, 'Capacity and Product Market Competition: Measuring Market Power in a "Fat-Cat" Industry', unpublished manuscript, Humboldt University.

Salvanes, K. G., F. Steen and L. Sørgard, 1997, 'Hotelling in the Air? Flight Departures in Norway', Discussion paper 19/97, Department of Economics, Norwegian School of Economics and Business Administration.

Scherer, F., 1980, *Industrial Market Structure and Economic Performance*, Houghton-Mifflin, Boston, MA.

Scherer, F. and D. Ross, 1990, *Industrial Market Structure and Economic Performance*, Houghton-Mifflin, Boston, MA.

Steen, F. and L. Sørgard, 1999, 'Semicollusion in the Norwegian Cement Market', *European Economic Review*, 43, 1775-1796.

Strandenes, S. P., 1990, 'Regulering og konkurranse i skandinavisk luftfart' (Regulation and Competition in Scandinavian Airline Industry), chapter 4 in L. Sørgard (ed.), *Næringsøkonomi - 13 norske bransjestudier (Industrial Economics - 13 Norwegian Industry Studies)*, Bedriftsøkonomens Forlag.

Whinston, M. D. and S. C. Collins, 1992, 'Entry, Contestability, and Deregulated Markets: An Event Study of People Express', *Rand Journal of Economics*, 23, 445-462.