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4 Deregulation of Scandinavian Airlines: A Case Study of the Oslo–Stockholm Route

Victor D. Norman and Siri P. Strandenes

As part of the 1992 program, the national preferences inherent in the airline policies of most EC countries will gradually be abandoned. This will be accompanied by general deregulation of air services within the European Community, although the extent and nature of deregulation remains uncertain. The Scandinavian countries are likely to match such a program, whether or not Sweden and Norway become part of the internal market. The purpose of the present paper is to assess the possible welfare effects for the Scandinavian countries of deregulation. We restrict the analysis to inter-Scandinavian routes and use the Oslo–Stockholm route as a case study.

The Oslo–Stockholm leg is suitable for several reasons. First, it is at present a virtual Scandinavian Airlines (SAS) monopoly. Finnair has one flight in each direction per day, but as this is an Oslo-Stockholm-Helsinki flight, a majority of the passengers have Helsinki as point of origin or destination. Aeroflot also has connecting flights, but only on a daily basis. The remaining flights—on the average nine per day—are all SAS flights, giving SAS 90–95 percent of the market. Moreover, the SAS monopoly is not a natural one—it is a direct consequence of the consortium agreement between the three Scandinavian governments, which reserves flights between the Scandinavian countries for SAS. Thus, deregulation is likely to have an impact on the route. Second, the traffic is large enough to make entry likely if permitted. Third, the route can

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be studied in isolation, as neither Oslo nor Stockholm are natural transfer points for passengers from the other city.

In the paper, we analyze the effects of deregulation using a numerical simulation model in which consumer demand for air transportation depends both on price and flight frequency and in which there is oligopolistic interaction between airlines. The route is initially considered as a pure SAS monopoly (i.e., we ignore the Finnair and Aeroflot flights), so the model parameters are found by calibrating the model to initial data and first-order conditions for a profit-maximizing monopolist. We use the model to simulate the effects of entry, assuming that a many-firm equilibrium will be perfectly symmetric (i.e., firms will have equal numbers of flights and charge the same price). The oligopoly equilibrium is assumed to reflect a Bertrand equilibrium in prices and a Cournot equilibrium in the number of flights. Methodologically, the study is related to recent simulation studies of trade and trade policy under imperfect competition—see, e.g., Smith and Venables (1986), Baldwin and Krugman (1987), Baldwin and Flam (1989), and the surveys in Helpman and Krugman (1989) and Norman (1989).

We know of no comparable simulation studies of air transportation. Prior to the 1978 deregulation of air services in the United States, however, Douglas and Miller (1974) did a careful study of the effects of regulation, using an approach with points of similarity to our study. They modeled city-pair markets as Cournot oligopolies and studied the effects of nonprice competition (competition in capacity offered) given publicly regulated airfares. They found, not surprisingly, that nonprice competition eliminates pure rents (through overcapacity). In an extension, they also looked at the trade-off between frequency and price, using queuing theory.

Other relevant studies are Jordan (1970) and DeVaney (1975). DeVaney looked at the effects of entry given alternative assumptions regarding scheduling decisions. Jordan looked at airline regulation as an endogenous regulatory regime.

Finally, the present study builds on the experience of deregulation in the United States. For a summary of the U.S. experience and a discussion of the issues involved in European deregulation, see McGowan and Seabright (1989) and Strandenes (1987).

4.1 The Simulation Model

4.1.1 Demand

To study the route, we use a highly stylized model of the demand for air transportation. Suppose the consumer can choose among n flights per day, equally spaced over the time interval $(0,T)$. Thus, the time interval between flights is $I = T/n$. Suppose that a potential passenger has a gross value, v, associated with the flight and that he has a desired departure time, z. His net value

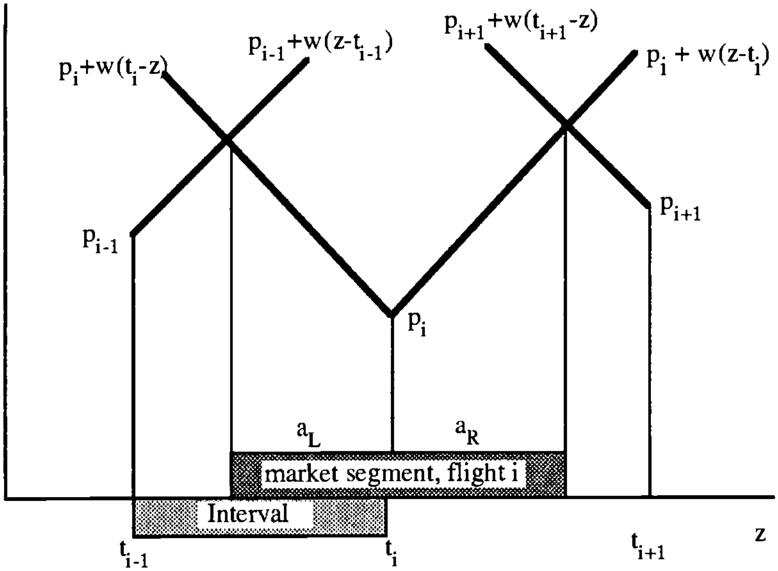

Fig. 4.1 Flight market segment

is assumed to be the value of the flight less the opportunity cost of the time difference between his desired departure time and the actual departure time of his flight, i.e., $(v - w\,|t - z|)$, where w is his unit opportunity cost of time. His consumer surplus is the net value less the price of the ticket.

We assume that the distribution of desired departure times is uniform over the time interval $(0,T)$ and independent of the distribution of gross values across potential passengers.[1] Let $N(v)$ denote the cumulative density function over gross values, so $N(v)$ can be interpreted as the number of passengers with gross values $\geq v$. The density of consumers with values $\geq v$ at a particular desired departure time is then simply $N(v)/T$.

Within this demand framework, consider the demand for flight number i, with departure time t_i and ticket price p_i. Figure 4.1 may be useful. Flight i competes with neighboring flights, $i - 1$ and $i + 1$, with departures times $t_{i-1} = t_i - I$. A passenger will choose flight i if the price plus the imputed waiting-time cost is lower for that flight than for neighboring flights. Passengers with $z < t_{i-1}$ will always (in a symmetric equilibrium) prefer flight $i - 1$, and passengers with $z > t_{i+1}$ will always prefer flight $i + 1$, so we need only consider potential passengers with $t_{i-1} \leq z \leq t_{i+1}$. Those with $t_{i-1} \leq z \leq t_i$ will prefer

1. If the distribution of desired departure times is nonuniform, an appropriate transformation of the time axis can always be used to make it uniform. Such an interpretation will, however, imply that the opportunity cost of time will vary with the time of day and proportionally with the density of traffic.

flight i if and only if $p_i + w(t_i - z) < p_{i-1} + w(z - t_{i-1})$. Thus, flight i will capture all potential passengers with desired departure times between $t_i - a_L$ and t_i, where a_L is given by

$$p_i + w\,a_L = p_{i-1} + w\,(I - a_L),$$

i.e., by

(1) $$a_L = \frac{I}{2} + \frac{p_{i-1} - p_i}{2w}.$$

Similarly, flight i will capture all potential passengers with desired departure times between t_i and $t_i + a_R$, where a_R is given by

(2) $$a_R = \frac{I}{2} + \frac{p_{i+1} - p_i}{2w}.$$

Thus, the market segment for flight i will be potential passengers with desired departure times, $t_{i-1} - a_L < z < t_i + a_R$. A potential passenger with a particular desired departure time within this interval will actually purchase a ticket if the gross flight value exceeds the price plus the waiting-time cost. The demand for flight i will therefore be

(3) $$x_i = \frac{1}{T}\int_{p_i}^{p_i+wa_L} N(v)dv + \frac{1}{T}\int_{p_i}^{p_i+wa_R} N(v)dv,$$

or, using averages as approximations,

(4) $$x_i \approx \frac{1}{T}\left[a_L N\!\left(p_i + w\,\frac{a_L}{2}\right) + a_R N\!\left(p_i + w\,\frac{a_R}{2}\right)\right].$$

Restricting ourselves to symmetric cases, where $p_{i-1} = p_{i+1} = p_c$, say, we have

(5) $$a_L = a_R = \frac{I}{2} + \frac{p_C - p_i}{2w,}$$

which gives the demand function

(6) $$x_i = \frac{1}{T}\left(I + \frac{p_C - p_i}{w}\right) N\!\left(p_i + w\!\left(\frac{I}{4} + \frac{p_C - p_i}{4w}\right)\right).$$

In a fully symmetric equilibrium, where $p_i = p_C = p$, this reduces to, using $I = (T/n)$,

(7) $$x_i = \frac{N\!\left(p + wT/4n\right)}{n}.$$

4.1.2 The Market Game

In the market, there are a number of identical airlines—i.e., airlines with identical cost functions and equal numbers of flights. The flights are scheduled in such a way that no airline has neighboring flights (except, of course, in the monopoly case).[2] The market game is assumed to be a simultaneous Bertrand pricing game and Cournot capacity game: The firms set prices assuming that the prices of competing airlines are fixed and decide on the number of flights assuming that the number of competing flights is given.

One could, perhaps, argue that the market should be modeled as a two-stage game, in which the airlines in stage 1 decide on the number of departures (as a Cournot game) and in stage 2 decide on prices (as a Bertrand game). In a later version of the paper, we may do that. It should be noted, however, that there is nothing in the technology or the institutional arrangements that suggests that capacities must be decided prior to pricing decisions—airlines have great flexibility, even in the short term, with respect to prices, capacities, and schedules. Thus, a simultaneous price/quantity framework seems as reasonable as a two-stage game.

Firm j has n_j departures, selling x_j seats on each flight, at price p_j. Its profits are therefore

$$\pi_j = n_j p_j x_j - b(x_j, n_j), \tag{8}$$

where $b(x,n)$ is the total cost associated with n flights with x passengers per flight. Taking the prices of competing (neighboring) flights as given and taking the number of departures of other airlines as given, the firm chooses price and schedules departures so as to maximize (8). The first-order conditions are

$$\frac{\partial \pi_j}{\partial p_j} = n_j\left[x_j + \left(p_j - \frac{b_x}{n_j}\right)\frac{\partial x_j}{\partial p_j}\right] = 0, \tag{9}$$

$$\frac{\partial \pi_j}{\partial n_j} = p_j x_j + n_j\left(p_j - \frac{b_x}{n_j}\right)\frac{\partial x_j}{\partial n_j} - b_n = 0, \tag{10}$$

where b_x and b_n denote partial derivatives. The derivatives $(\partial x_j/\partial p_j)$ and $(\partial x_j/\partial n_j)$ are obtained from the demand function (6): the (Bertrand) price derivative of demand for a particular flight offered by company j is

$$\frac{\partial x_j}{\partial p_j} = \frac{N}{wT} + \frac{1}{T}(I + \frac{p_c - p_j}{w})\, N'[1 - \frac{1}{4}]. \tag{11}$$

2. Note that we do not go into the complex issue of optimum scheduling, beyond observing that any scheduling equilibrium (if it exists) must involve alternating departures. In particular, we do not look at the issue of Hotelling-type clustering. It is not clear, from the experience of U.S. deregulation, that competition leads to clustering over and beyond what follows from peak-hour demand, but the issue deserves careful analysis. For a discussion, see McGowan and Seabright (1989).

In a symmetric equilibrium, with $p_j = p_C = p$, this can be written as

$$\frac{\partial x_j}{\partial p_j} = -\frac{N}{wT}\left(1 - w\frac{3}{4}I\frac{N'}{N}\right), \tag{12}$$

or

$$\frac{\partial x_j}{\partial p_j} = -\frac{N}{wT}\left[1 - \left(\frac{3/4wI}{p + 1/4wI}\right)\left(\frac{N'v}{N}\right)\right], \tag{13}$$

where the elasticity $[(N'v)/N]$ is evaluated at $v = [p + w(I/4)]$; i.e., at the effective cost of the trip to the average passenger. We treat the elasticity $[(N'v)/N]$ as a constant, $-e$. Using this, and recalling that $x_j = (N/n)$ and $I = (T/n)$, the price elasticity can be written as

$$\frac{\partial x_j}{\partial p_j}\frac{P_j}{x_j} = -\left[1 + \left(\frac{3/4wI}{p + 1/4\,wI}\right)e\right]\left(\frac{p}{wI}\right). \tag{14}$$

This reflects two price effects. One is the loss of market segment when the price is raised: passengers indifferent between our flight and a neighboring flight will choose the latter when our price increases. The other is the loss of passengers initially indifferent between traveling and not traveling.

The (Cournot) elasticity of demand per flight with respect to the number of flights is found in a similar way. It is most easily found from the symmetric demand function (7), keeping in mind that $n = \sum n_i$. It gives

$$\frac{\partial x_j}{\partial n_j} = -\frac{N}{n^2}\left[1 + \left(\frac{wT}{4n}\right)\frac{N'}{N}\right]. \tag{15}$$

But we know that $(T/n) = I$. Using this, $x_j = (N/n)$, and $v = [p + w(I/4)]$, (15) can be written in elasticity form as

$$\frac{\partial x_j}{\partial n_j}\frac{n_j}{x_j} = -\frac{n_j}{n}\left[1 - \left(\frac{wI/4}{p + wI/4}\right)e\right]. \tag{16}$$

Again, this reflects two forces. One is the direct effect of spreading a given total number of passengers across more flights: A one percent increase in the number of flights will, for a given total number of passengers, mean one percent fewer passengers per flight. The other is the indirect effect through the effective cost of traveling: More flights mean less waiting time and thus lower total travel costs. This indirect effect thus contributes to larger total demand and will dampen—and possibly reverse—the direct effect.

Substituting the elasticities (14) and (16) into the first-order conditions (9) and (10), we find the Bertrand/Cournot equilibrium in prices and departures when (9) and (10) hold for all firms simultaneously.

4.2 Data and Calibration

The model is parameterized through what is now the standard procedure for numerical imperfect-competition models: A few key parameters are set exogenously; the rest are found by calibrating the model to actual data for some base period. In our case, we set the price elasticities of demand and the marginal passenger costs exogenously and find the remaining parameters by calibrating the model to 1989 data for demand and prices and estimates of marginal and total costs.

4.2.1 Demand and Prices

In the numerical implementation, we distinguish between Euroclass (full fare) and tourist (discount fare) passengers. SAS provided data for a representative week (in September 1989) on the number of passengers in each direction and in each class for each day of the week. From the SAS timetable we have data on the number of flights and the aircraft used (mostly DC9; on two daily flights in each direction MD80 or the slightly larger MD87). On the basis of this information we have constructed a "representative" day of the week with nine flights in each direction, each carrying 52 Euroclass and 21 tourist class passengers.

We do not have data on actual prices paid, but we know the full fare (NOK 1,260, or $177, one way). We assume that 80 percent of the Euroclass passengers pay the full fare, while the remainder travel on discounts averaging 50 percent. For the tourist-class passengers, we have—arbitrarily—set the average discount at 50 percent. In computing average prices for the two classes, we have also deducted 7.5 percent for travel agency commissions, assuming (if the tickets are sold directly by SAS) that the commission reflects real costs associated with sales and ticketing. The prices are converted to dollars using the official SAS exchange rate of NOK 7.11 per dollar.

4.2.2 Costs

We do not have data for actual costs for the Oslo-Stockholm route,[3] so we have had to rely on ad hoc estimates and cost data reported in the literature. Marginal passengers costs are likely to be quite low. Safety regulations fix the minimum crew, and this minimum is usually sufficient even for a full plane. Fuel consumption depends on the weight of the plane, but the number of passengers has little impact on the total weight. The most important passenger-related costs are therefore catering expenses (very small on a short flight) and airport fees. In the base-case simulations reported in this paper, we arbitrarily set marginal passenger cost at $25. In the sensitivity analyses, we will see how the results are affected if instead marginal passenger costs are $20 or $30.

3. We asked SAS for cost data, but the company found such information to be too sensitive to give out.

As for the total cost per flight, there are several studies which give relevant data. We rely on two sources. Oster and McKey (1984) report actual 1982 costs for a 200-mile flight for three airlines—Southern, United, and Piedmont—using a Boeing 737, i.e., a plane very similar to the DC9 used by SAS and a distance very close to Oslo–Stockholm (249 miles). McGowan and Seabright (1989) report representative costs per available seat miles (ASM) for different planes. They also report, based on official industry sources, costs per tonkilometers performed for different airlines and a breakdown of those costs. Based on these, we make three alternative estimates, shown in table 4.1, of total costs for a representative Oslo-Stockholm flight.

The first alternative is based on the average direct cost per ASM for three of the planes reported in McGowan and Seabright—DC9–10, Boeing 737–200, and Boeing 737–300. None of these are used on the route today (SAS uses larger, newer versions of the DC9), but they should be representative of planes which could be used. We convert this into total cost per ASM using the actual SAS figures for direct costs as a percentage of total costs, then multiply by the distance (249 miles) and the number of seats (110) to get a total cost estimate. As the reported figures are for 1988, we add an arbitrary 5 percent to account for cost increases since then. This procedure gives a cost estimate of $3,241.

The second alternative is based on the McGowan and Seabright figure of $1.69 for SAS 1987 total costs per tonkilometer. It should be noted that the SAS figure is very much higher than the corresponding figures for other airlines. For U.S. airlines, they report costs of $0.68–$0.89, and for the two other European airlines in their sample (Alitalia and British Airways), the costs are

Table 4.1 **Alternative Total Cost Estimates**

	Estimate
Based on 1988 direct costs per available seat miles (ASM)	
Direct costs per ASM (¢)	4.26[a]
Indirect SAS costs (% of total costs)	62.2
Estimated total costs per ASM (¢)	11.27
Estimated total costs, 110 seats, 249 miles ($)	3,087
Adjusted for 5 percent cost increase since 1988 ($)	3,241
Based on 1987 costs per tonkilometers performed	
Average SAS cost per tonkilometer ($)	1.67
Estimated tonkilometers, 73 passengers, 100 kilos, 249 miles	2.945
Estimated total costs, 73 passengers, 249 miles ($)	4.918
Adjusted for 10 percent cost increase since 1987 ($)	5.409
Based on 1982 costs for United	
Total United costs, 200 miles, Boeing 737 ($)	3.600
Adjusted to 249 miles ($)	4.482
Adjusted for 35 percent cost increase since 1982	6.051

Sources: McGowan and Seabright (1989); Oster and McKey (1984).

[a]For 125 seats: obtained as average of values for DC 9-10 (92 seats, 5.92¢ per ASM), Boeing 737-200 (133 seats, 3.92¢ per ASM), and Boeing 737-300 (149 seats, 2.94¢ per ASM).

\$0.80 and \$0.83, respectively. To some extent the difference can be explained by the shorter hauls of the SAS network. Still, the figures may suggest that the SAS figures include costs not directly related to air transportation or that there is substantial inefficiency in SAS operations. We convert the SAS costs per tonkilometer to total costs for the route by using the actual (average) number of passengers and assuming an average weight (including baggage) of 100 kilos per passenger. Adding an arbitrary 10 percent to account for cost increases since 1987, this method yields a total cost estimate of \$5,409.

The third method is based on the actual 1982 total cost figures for U.S. airlines reported by Oster and McKey. This was before the full effects of U.S. deregulation had been felt; significantly, their figures show that the established carrier (United) had very much higher costs than the other two. We use the United figure, assume that costs rise proportionally with distance, and add 35 percent for cost increases since 1982. That gives a total cost estimate as high as \$6,051.

Of the three estimates, it is likely that the first is an underestimate and the last is an overestimate. The first method is likely to lead to an underestimate because (a) the aircraft used represent an older and cheaper generation than the planes actually used by SAS and (b) costs per ASM are lower for long than for short hauls, and the Oslo–Stockholm route is probably shorter than the average route for which these aircraft are used. The third method is likely to overestimate because (a) the 1982 United costs were much higher than the costs of the other carriers and (b) costs do not, as we have assumed, rise proportionally with distance.

In the simulations, we take a total cost of \$4,800 as our base case. This is close to the average (\$4,900) of the estimates obtained from the three alternative approaches. Because of the divergence, however, we also calibrate and simulate the model for the higher cost figures of \$5,800 and \$6,800. The last of these is included, even though it is outside the cost range indicated in table 4.1, because SAS—in a public reaction to an earlier draft of this paper—indicated that its actual costs for the route are that high.[4]

4.2.3 Calibration

Knowing prices, departures, passengers per flight, and costs, the remaining unknowns are the demand function parameters (the elasticities of the $N(v)$ functions and the shadow wage rates). The demand-side parameters are calibrated to satisfy the first-order conditions for a profit-maximizing monopolist. There are three relevant conditions: the marginal revenue = marginal cost conditions for the pricing of Euroclass and tourist class seats, respectively, and the condition that the monopolist have a profit-maximizing number of flights. The

4. SAS stated that our estimate of \$4,800 was 30 percent below the actual costs of the company for the Oslo–Stockholm route, i.e., that actual costs are around \$6,800. We suspect, however, that such a figure includes allocated fixed costs for the SAS system as a whole.

first two conditions determine the price elasticity of demand for a particular flight, equal to the ratio of price to (price − marginal cost); with a marginal cost of \$25, the implied price elasticities are, respectively, 1.2 and 1.5 for Euro- and tourist class. From equation (14), we see that given the price elasticity, we can solve for e or w as function of the other. The optimum condition with respect to the number of flights involves passengers per flight, prices, marginal passenger costs, and the marginal cost per flight—all of which we know. In addition, it involves e and w for each of the two classes. All told, therefore, we have three equations to solve for e and w in each of the two classes. The missing equation is obtained by assuming that the shadow wage for tourist-class passengers is 40 percent of the Euroclass shadow wage. Using this and solving the full set of equations, we get shadow wages of \$57 in the Euroclass segment and \$23 in tourist class, and elasticities of the $N(v)$ functions of 1.36 and 1.67, respectively. The full set of data and calibrated parameter values for the base case is shown in table 4.2.

4.3 Simulation Results

We use the model to simulate the effects of entry. An oligopoly equilibrium is assumed to be perfectly symmetric, so SAS and new entrants will have equal numbers of flights and charge the same price. We do not try to analyze entry barriers (fixed costs or artificial barriers) but simply look at equilibria with different numbers of firms. In the calculations, we take account of integer constraints on the number of flights offered by each carrier, so the number of flights is determined by the maximum number of flights per carrier consistent with positive marginal profitability of new flights. We also take into account capacity constraints on each flight. We, arbitrarily, assume that the average load factor cannot exceed 80 percent and include a shadow price of capacity in the pricing equation to account for this constraint. In all the oligopoly cases, the capacity constraint is binding.

Table 4.2 Data Set and Calibrated Coefficients

	Total	Euro class	Tourist Class
Stylized data			
Number of flights	9		
Passengers per flight	73	52	21
Price (\$)		148	74
Marginal passenger cost (\$)	25		
Total cost per flight (\$)	4,800		
Calibrated coefficients			
Price elasticity of demand		1.20	1.51
Marginal cost per flight (\$)	2,975		
Shadow wage (\$ per hour)		57	23
Elasticity ($-(N'v)/N$)		1.36	1.67

Table 4.3 **Summary of Results**

	SAS Monopoly	Duopoly	Three-firm Oligopoly	Four-firm Oligopoly
Consumer gains				
Number of flights	9	12	15	16
Change in average price (%)		−29.7	−39.5	−42.1
Change in number of passengers (%)		60.7	100.9	114.3
Change in consumer surplus ($ per day)		38,143	55,748	61,047
Change in consumer surplus (% of initial consumer expenditure)		45.8	67.0	73.3
Producer losses				
Change in SAS profits ($ per day)		−24,050	−32,200	−34,923
Change in foreign airline profits ($ per day)		16,000	15,700	15,382
Sum of producer losses ($ per day)		8,050	16,500	19,540
Welfare changes (% of total initial consumer expenditure)				
World		36.1	47.1	49.9
Scandinavia		16.9	28.3	31.4
Norway		14.7	22.4	24.7
Sweden		10.5	16.9	18.7
Denmark		−8.3	−11.1	−12.0

The main results are shown in table 4.3. The welfare effects for Scandinavia are calculated assuming that 50 percent of the passengers on the route are Norwegians and 50 percent Swedes and using the ownership shares in SAS (Norway and Denmark 2/7 each, Sweden 3/7). It is assumed that new entrants are from outside Scandinavia.

As we can see, the simulations indicate very substantial gains from entry—particularly from entry by one firm (giving a consumer gain of 45.8 percent and an efficiency gain of 36.1 percent of initial consumer expenditure). The simulations also indicate significant profit shifts, however: More than half of the net gain will accrue to the new entrant, so if the new firm is non-Scandinavian, more than half the net gain will "leak out."

4.3.1 Sensitivity: Bertrand versus Cournot

To see whether our assumption that the oligopoly equilibrium involves Bertrand price competition is important, we also simulate the effects of entry assuming Cournot competition in the number of seats offered on each flight. A comparison of the Bertrand and Cournot duopoly solutions is given in table 4.4.

As is seen, the simulated equilibria are virtually identical, except as regards the degree of price discrimination between Euroclass and tourist-class passengers: As should be expected, Cournot competition (being less aggressive than Bertrand) involves greater price discrimination; consequently, the relative price of Euroclass tickets falls more in the case of Bertrand than in the Cournot case.

Table 4.4 **Cournot versus Bertrand Duopoly**

	Bertrand Duopoly	Cournot Duopoly
Consumer gains		
Number of flights	12	12
Change in average price (%)	−29.7	−29.6
Change in Euroclass price (%)	−37.2	−36.8
Change in tourist-class price (%)	−1.7	−3.7
Change in number of passengers (%)	60.7	60.7
Change in consumer surplus ($ per day)	38,143	37,939
Change in consumer surplus (% of initial consumer expenditure)	45.8	45.6
Producer losses		
Change in SAS profits ($ per day)	−24,050	−24,015
Change in foreign airline profits ($ per day)	16,000	16,035
Sum of producer losses ($ per day)	8,050	7,979
Welfare changes (% of total initial consumer expenditure)		
World	36.1	36.0
Scandinavia	16.9	16.7
Norway	14.7	14.5
Sweden	10.5	10.4
Denmark	−8.3	−8.2

4.3.2 Sensitivity: Cost Parameters

To see how sensitive the results are with respect to our cost estimates, for the duopoly cases, we also simulate the effects assuming higher total costs and higher marginal passenger costs. For total costs, the base case is total costs of $4,800 per flight (at the initial load factor); as alternatives, we also look at total costs of $5,800 and $6,800. For marginal passenger costs, we assume $20 and $30 as alternatives to the base-case assumption of $25. The results are shown in table 4.5. As is seen, the general conclusions are not very sensitive to the underlying cost assumptions.

4.3.3 Sensitivity: Initial Regulation

The last simulation experiment we carry out relates to the initial equilibrium for the route. We assume that SAS initially behaves as an unregulated monopolist. In fact, SAS is subject to government regulation, in the sense that both prices and schedules have to be approved by Norwegian and Swedish authorities. It is unclear whether, or to what extent, regulation is binding. Insofar as our calibrated coefficients seem "reasonable," the regulatory constraints cannot be severe.

To see how important initial regulation may be, however, we also calibrate the model assuming binding regulatory constraints on SAS initially. Specifically, we have assumed a 10 percent wedge between marginal revenue and marginal cost both with respect to pricing and frequency—in other words,

Table 4.5 Sensitivity Analysis: Total and Marginal Cost

Total Cost ($)		Marginal Passenger Cost ($) 20	25	30
4,800	Departures	14	12	12
	Price change (%)	−35.8	−29.7	−30.3
	Consumer surplus change (%)	62.5	45.8	44.8
	World welfare change (%)	49.0	36.1	33.1
	Scandinavian welfare change (%)	31.7	16.9	14.9
5,800	Departures	12	10	10
	Price change (%)	−26.9	−19.4	−19.4
	Consumer surplus change (%)	46.9	28.6	28.6
	World welfare change (%)	39.2	25.1	24.2
	Scandinavian welfare change (%)	24.4	8.2	7.7
6,800	Departures	10	10	8
	Price change (%)	−18.5	−18.3	−8.9
	Consumer surplus change (%)	27.9	27.6	8.8
	World welfare change (%)	25.3	24.3	10.2
	Scandinavian welfare change (%)	13.4	12.7	−3.7

Note: Changes in consumer surplus and welfare are expressed as percentages of initial consumer expenditures.

regulation forces SAS to offer so many more seats on each flight, and so many more departures, that marginal revenue is uniformly 10 percent below marginal cost. The implication is that the initial average price is some 15 percent below the monopoly price, and SAS initially would have liked to offer only seven departures per day (compared to the actual figure of nine departures).

The results are shown in table 4.6. Note again the robustness of the general results: The effects of competition will be very similar whether the initial equilibrium is interpreted as one of regulated or unregulated monopoly.

4.3.4 Other Sensitivity Tests

We have also carried out two other sensitivity tests. Details of those tests will not be reported here, but let us point out the general conclusions. One test concerns initial prices. In the experiments reported above, the model is calibrated to an average discount fare of 50 percent of the Euroclass fare. Alternatively, we have carried out calibration and simulations assuming an average discount fare of 30 percent. The corresponding simulations give slightly *higher* welfare gains from competition. The reason is that a lower initial tourist-class fare implies a higher elasticity of demand in the tourist-class segment and thus a large efficiency loss from monopoly.

The other sensitivity test concerns the form of the demand function. Instead of assuming a loglinear $N(v)$ function, we have calibrated the model and carried out simulation experiments using a linear $N(v)$ function. By itself, a linear function would reduce the value of extra flights and should therefore give

Table 4.6 **Importance of Initial Regulation**

	Initially Unregulated			Initially Regulated		
	Total	Euroclass	Tourist class	Total	Euroclass	Tourist class
Calibrated coefficients						
e (elasticity of $N(v)$)		1.36	1.67		1.30	1.56
w (shadow wage)		57	23		45	18
Unregulated monopoly compared to Initial equilibrium						
Price change (%)				15.5	16.2	12.7
Demand change (%)				−18.6	−18.8	−18.3
Consumer surplus change (%)				−16.6	−17.2	−13.5
Scandinavian welfare change (%)				−11.8		
Duopoly compared to initial equilibrium						
Price change (%)	−29.7	−37.2	−1.7	−30.8	−38.6	−0.5
Demand change (%)	60.7	82.5	6.9	60.7	83.8	3.7
Consumer surplus change (%)	45.8	54.2	4.5	46.4	55.3	2.5
Scandinavian welfare change (%)	16.9			16.6		

Note: Changes in consumer surplus and welfare are expressed as percentages of initial consumer expenditure.

smaller efficiency gains from competition. That is offset by the calibration procedure, however. Since the model has to support the actual, initial number of flights, a functional form which gives lower value to extra flights must give higher calibrated opportunity time costs. It is not *a priori* clear, therefore, how the choice of functional form would affect the simulated efficiency gains. In fact, it hardly matters: The order of magnitude of the welfare gains are the same for the loglinear and linear functions.

4.4 Conclusions and Extensions

The analysis indicates that there would be very significant effects of entry into the Oslo–Stockholm market. Prices could fall dramatically, and there could be some (more modest) increase in flight frequency. Consumer gains would, not surprisingly, outweigh SAS losses. Moreover, and perhaps more surprisingly, even though there would be a significant shift of profits from SAS to new entrants, the net welfare effect on Scandinavia would be positive and significant even if the entrants came from outside Scandinavia.

The analysis also indicates that these conclusions are robust, both with respect to the average and marginal costs of the firms and to the nature of the market game. In particular, it does not seem to matter greatly whether a future oligopoly equilibrium involves price or quantity competition.

The reason the two equilibria are virtually identical is that the capacity constraint on each flight is binding in all our simulated equilibria. That suggests that it may be worthwhile to incorporate optimum choice of aircraft (size) into the simulations. That is one natural extension of our work.

Another natural extension is to look at entry and exit games. We have not looked at the likelihood of entry at all. To see whether deregulation *will* make new firms enter, one should analyze the optimum behavior of SAS vis-à-vis potential entrants and look at the welfare implications of such behavior. Nor have we looked at the sustainability of an oligopolistic equilibrium. Given the U.S. deregulation experience, it would be worthwhile to study strategic interaction between firms in a setting where each knows that exit is an option. Our simulation model seems suitable to such experiments. To carry them out, however, we would need estimates of fixed costs associated with maintaining the route.

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