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Competition in the Bergen taxi market
Model simulations

By

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FOREWORD

This is the second report from the project on competition in the taxi market.

As is well known from the literature, efficient competition in taxi markets is not easily achieved. When there is one call centre only, which may be operated on a cooperative basis by the taxi owners, one will not see functioning price competition. Free entry for new taxi owners into the market does not alter this. Prices will establish themselves at a level above optimal and taxis will wait longer than optimal between trips. Efficient price competition seems to require more call centres in each geographical market. The matching process allocating vacant taxis to waiting customers may exhibit economies of scale. Hence, the relative size of call centres, measured by the number of associated taxis, probably influences the competitive setting in the market. These economies of scale arise when customers expect that the waiting time will be shorter if they order a taxi from a large call centre.

In this second report from the project we build a simulation model and simulate the effects on occupancy rates for taxis, revenue and gross margin related to the size of call centres in a market of approximately the same size as the Bergen taxi market. The model results confirm that customers favor the larger call centre in a setting where the larger centre operates 75 per cent of the taxis in the market. A marketing strategy aiming to increase the recognition by customers for the smaller operator will, if it succeeds in making customers choose the smaller call centre, be highly beneficial for this call centre. However, this result should be seen more as an underlining of the importance of customers' valuation of a shorter waiting time than an assessment of the potential for success of such a marketing strategy. Competition in the fixed-contract market also reflects the relative size of the call centres. The model simulations assuming the relative sizes of the two largest call centres currently operating in the Bergen taxi market illustrates this. The smaller of these operators gains the most by winning large fixed contracts, but its lesser ability to meet the contract requirements limits its capacity to compete for such contracts.

The simulation model is developed by Hong Cai who also performed the model simulations and wrote this report. Hong Cai is currently a master student at the Norwegian School of Economics working under our supervision, and the work reported here is also part of her master thesis. . In addition, Professor Ingolf Ståhl of Stockholm School of Economics has given valuable advice on developing the model using the General Purpose Simulation System (GPSS) developed by him.

Bergen 21st November 2011

Rolf J Brunstad | Kurt Jörnsten | Siri Pettersen Strandenes

Abstract

By building up simulation models using WEBGPSS language, this report provides an investigation on the taxi business in Bergen, Norway, in the perspective of a large market participant, Norgestaxi. The author gives suggestions for Norgestaxi to improve its operation based on the simulation results. The suggestions are given from six aspects, including: (1) the optimal size of taxi fleet; (2) the impacts of improved recognition and market share; (3) the impact of assigning a separated airport division; (4) an investigation of hypothetical scale of market participants; (5) the impact of more fixed contract customers; (6) the impact of market growth.

CONTENT

1. INTRODUCTION

The purpose of this report is to study the competition in the Bergen taxi market using a simulation method. The modeling language is WEBGPSS[1]. WebGPSS is a stream-lined version of GPSS, the General Purpose Simulation System, which is a discrete time simulation language.

Based on the result of the simulation, we aim to provide information for Norgestaxi on effect of potential changes in their operations. There are six main objectives we try to attain through the simulations in this report.

Objective 1: to test the scale for Norgestaxi as the basis for the decision-making regarding the adjustment of the number of taxicabs in Norgestaxi.

Objective 2: to investigate how a marketing campaign by Norgestaxi would affect the operation result and the competition in the industry.

Objective 3: to explore whether Norgestaxi should assign a number of taxicabs specifically for the airport customers.

Objective 4: to investigate the cases when Norgestaxi and its largest competitor, Bergen Taxi have a similar number of taxi cabs.

Objective 5: to test the effects caused by the different shares of fixed contracts between the two firms.

Objective 6: to see how the market growth in the future affects the operation in this industry.

The next section introduces the assumptions of the basic simulation model. Section 3 explores the six objectives using different models and presents the results of the simulation. A conclusion is provided in the end.

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[1] http://webgpss.com

2. The Basic Simulation Model Setting

In the basic simulation it is assumed that there are only two taxi companies in Bergen, one is bigger and one is smaller (Company A and B, representing Bergen Taxi and Norgestaxi respectively). For the convenience of model setting and analysis, the size of both companies is scaled down by 5.67 times. Bergen Taxi is scaled down from 448 to 79 taxicabs (448/5.67=79) while Norgestaxi is scaled down from 142 to 25 taxicabs (142/5.67=25). The model is run 180 times for both companies. This represents 180 days (i.e., a half year). When reporting the results the figures are scaled back to the existing number of taxis in each company.

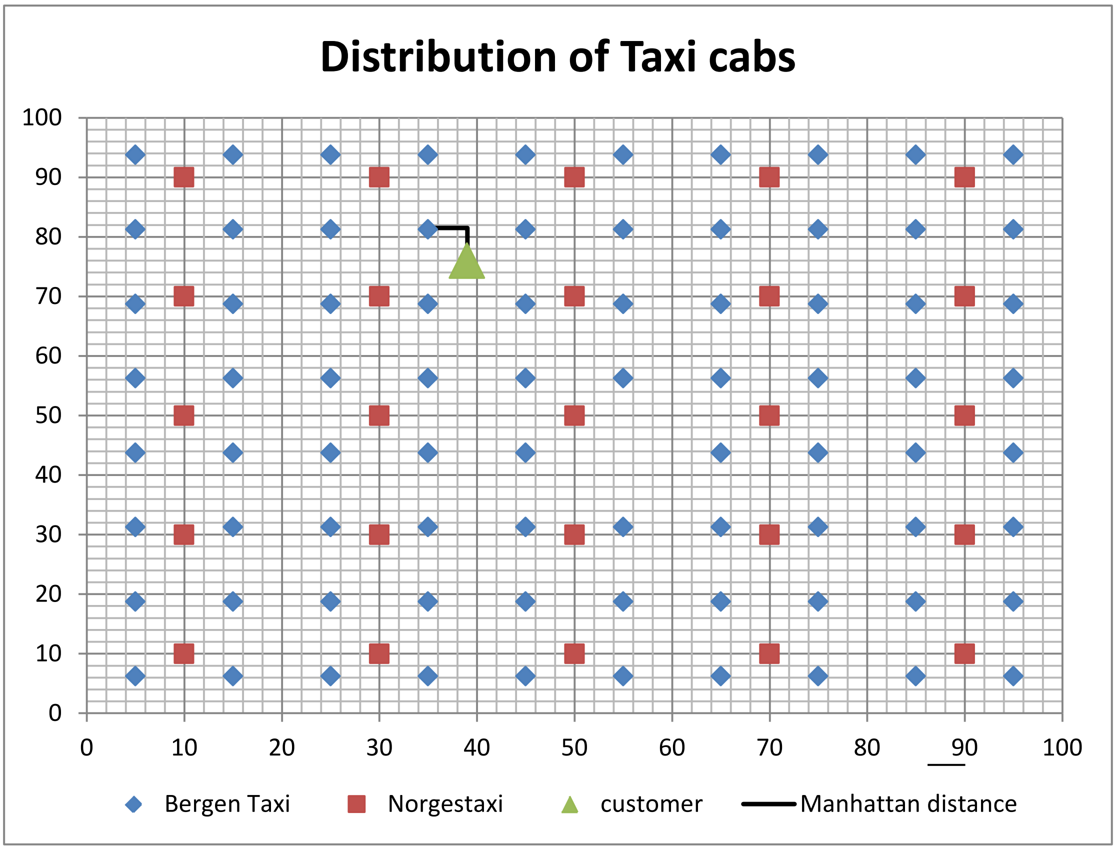

Figure 1： The allocation of taxi cabs in the basic case and an example of the Manhattan distance

The framework of the simulation model can be summarized as follows. The city is assumed to be a square. At the beginning of each day, the taxicabs of both companies are evenly distributed. In the basic model, the allocation of taxicab of Norgestaxi is a 5*5 matrix while that of Bergen Taxi is an 8*10 matrix, as is shown in Figure 1.

The customers will arrive in the system according to a certain pattern further

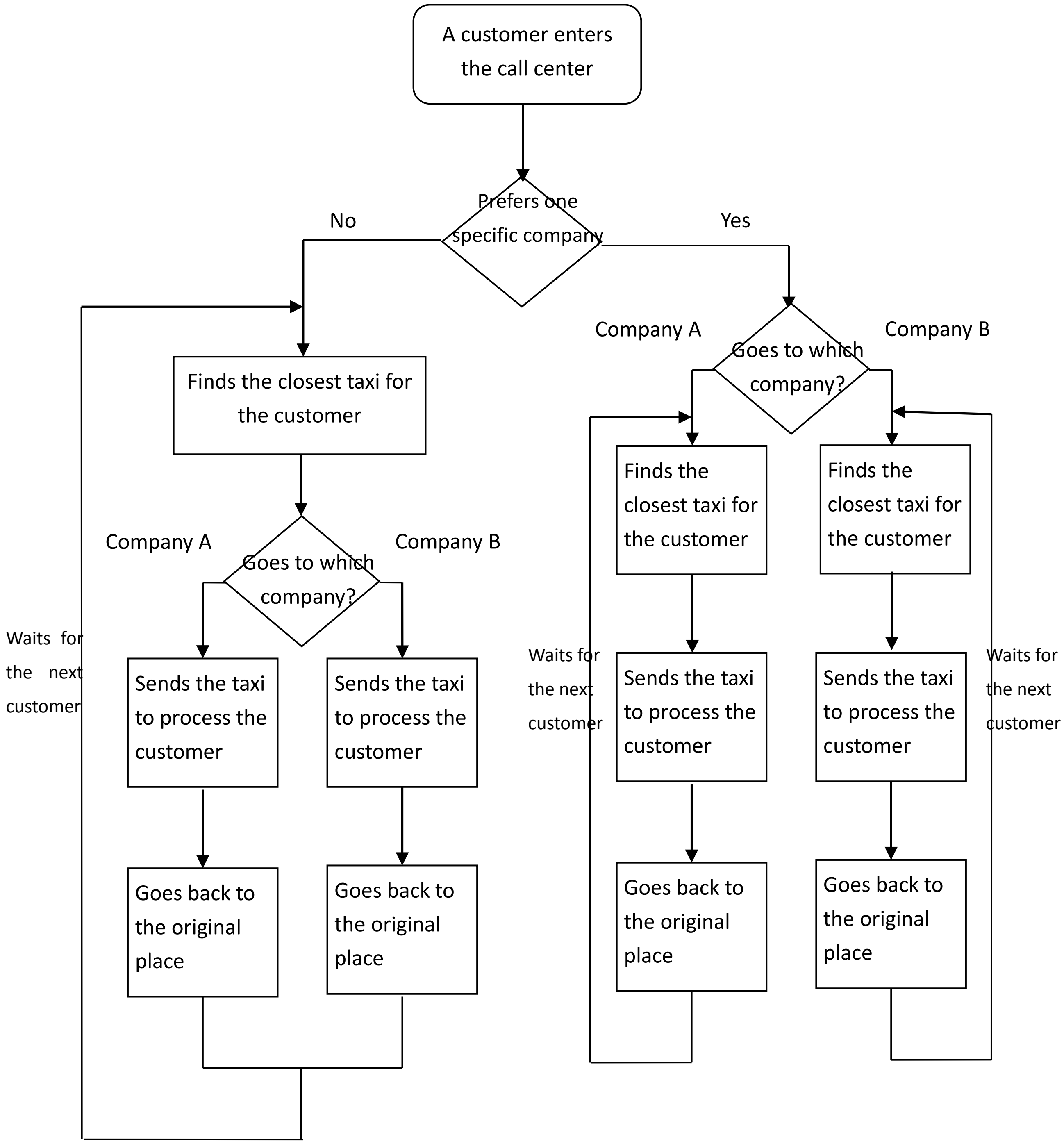

Figure 2: The process of simulation

explained in the assumption 2 below. If one customer prefers one of the taxi companies, the system will assign the taxi closest to the customer within the designated taxi company to pick up the customer. Otherwise, the system will calculate the distance between the customer and the taxicab for both companies and the taxi which is closest to the customer will pick up the customer. After serving the customers, the taxi will go back to its original place. See Figure 1

Here some important assumptions are introduced in the basic model.

Assumption 1: All the taxicabs are running 24 hours a day.

Assumption 2: The total number of customers is exogenously given. The customers will arrive in the system at any point with equal chance. The model follows the rules of "first-come, first-served". The customers who get into system first will be processed first.

In this model we assume a dynamic customer demand. The customer demand fluctuates with time. The table below shows the interval of the customers' arrival in a day. In the simulation, this arrival pattern also obeys the negative exponential distribution.

Time	0 a.m. – 6 a.m.	6 a.m. - 3 p.m.	3 p.m.-0 a.m.
Number of customers per hour	53.6	57.1	53.1
Interval (minute)	1.12	1.05	1.13

Table 1: The Interval of the Customers' Arrival

Assumption 3: In models where customers do not have a preference over the taxi companies. They will get onto the first taxi that comes to them. (The distance between the taxi and the customer will be calculated based on "the Manhattan distance[2]" in the model.) However, in the case when two taxicabs have equal distances to a customer, the customer is assumed to go for the taxi of the bigger

[2] The distance between two points in a grid based on a strictly horizontal and/or vertical path (that is, along the grid lines).The Manhattan distance is the simple sum of the horizontal and vertical components.

company, Bergen Taxi.

Assumption 4: The time of one trip for a customer trip will follow a normal distribution with the average time of 20 min (one way), estimated variance 5[3]. The earning of one trip for a taxi also follows a normal distribution with the average earning of 255 NOK, variance 15, which is based on the data given by Norgestaxi.

The above assumptions apply to the taxicabs in both companies.

Assumption 5: The total cost of running a taxicab is comprised of 3 parts: the cost of using a taxicab per day, the wage cost and the payment for the telephone service.

- The cost of introducing a new taxi is about 300,000 NOK with 50,000NOK as a residual value and should be depreciated over 3 years. Thus, the cost of using a taxi is about 228 NOK[4] per day.

- The wage cost is in total 58.5% of the gross income, which includes the wages and the social cost. Hence, the wage costs vary with the gross income in the different simulations.

  The first two cost components are assumed to be the same for the two companies.

- The taxis need to pay a charge to the taxi companies. Here we assume the charges of the two companies are slightly different to reflect the different payment structures for telephone service. It is assumed that the payment for the telephone service is fixed for Bergen Taxi, which is 270 NOK. In comparison, the payment is divided into two parts for Norgestaxi. One is a monthly fee of NOK 6500 NOK, equals to 217 NOK per day, and the other part

[3] The assumption is based on the data given by Norgestaxi and is tested in the simulation model.

[4] (300,000 NOK-50,000 NOK)/(365*3 years)=228NOK/per day

is 4% of the gross income. According to the simulation result the total payment is about 336 NOK per day[5]. Therefore, the difference of the charges (i.e., 270 NOK versus 336 NOK) is the only cost difference of running a taxicab for the two companies in the model, reflecting economies of scale. And this difference will vary with the relative revenue per taxi in the two companies modeled.

- The other costs, such as administrative cost, gasoline expenses, are not included in the model.

The above-mentioned five basic assumptions apply to most of the simulations. However, they will also be adjusted in specific cases to explore other settings. Any adjustment of the basic assumptions is described in the following case studies.

[5] This amount somewhat overstates the charge paid for the dispatch service in Norgestaxi, but does not influence the simulation model's allocation of customers or trips between the two taxi companies. The only effect is that Norgestaxi's profitability is slightly underestimated.

3. SIMULATION

Model 1: Scale Simulation

In the first model we design three different simulations attempting to address the problem of optimal scale for Norgestaxi. The first one assumes the size of Bergen Taxi is kept constant and analyzes the result of any adjustment in the size of Norgestaxi. The second one keeps the size of Norgestaxi constant and adjusts

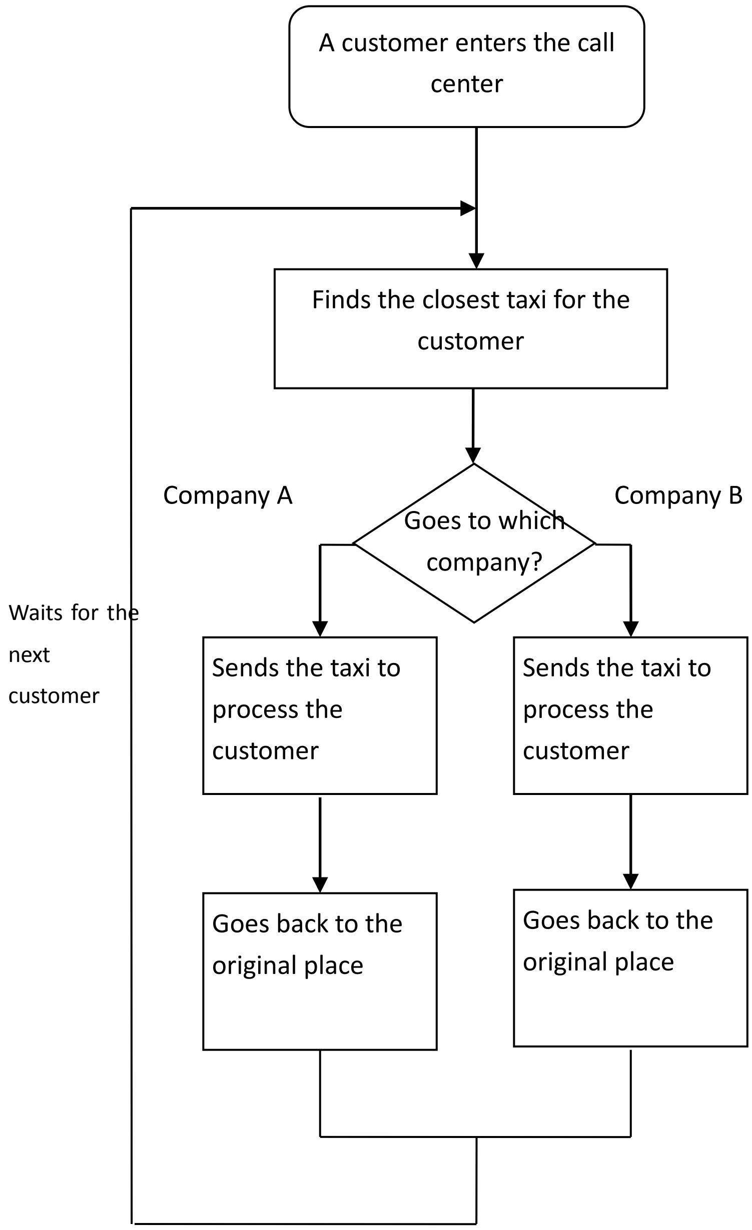

Figure 3: The process of simulation in model 1

the size of Bergen Taxi. The third one assumes that the total market demand will fluctuate with the size of Norgestaxi. In this model, the customers are assumed to have no preference.

- The first simulation attempts to test the optimal number of taxicabs for Norgestaxi in order to obtain the best result in the competition. Norgestaxi is assumed to have 25 taxicabs corresponding to 142 taxis in the Bergen market, and we simulate the different situations when more or fewer taxicabs are owned by Norgestaxi, and get the revenue and the cost for Bergen Taxi and Norgestaxi respectively. We also conduct a sensitivity test to investigate whether in such a situation the "weak preference for the bigger company" assumption will have significant impact on our model.

  An implied assumption in this simulation is that the market size will not change with the number of the taxicabs, as is specified in assumption 2 above. That is to say, no matter how many new taxicabs are introduced, the distribution of the number of customers will be the same.

- The second simulation aims to test how the change of the size of Bergen Taxi will affect the performance of Norgestaxi. The simulation has the same assumptions as those in the first simulation except that the scale of Norgestaxi is kept constant, whereas the number of taxis held by Bergen Taxi is varied.

- The third simulation also has the same assumptions; however, the total market demand is set to fluctuate in proportion to the changes in the number of taxis held by Norgestaxi.

Result

Constant size in Bergen Taxi, varying size in Norgestaxi

Table 2 shows the first simulation result. It is noteworthy that the "profit" in the table refers to the value equal to "revenue" minus "cost" while the "cost" is simply comprised of only three parts, as discussed in assumption 5 (i.e., the depreciation cost, the charge for the call centre and the wage cost.) Hence, the "profit" here is not the true profit, but the result before administrative costs, gasoline expenses and other costs not included in the model. We denote it as "profit" for convenience purpose only. In the current situation, the revenue per day for Norgestaxi is 432,000 NOK[6] while for Bergen Taxi it is 1,436,000 NOK. The cost will make up about 77.1% of the total revenue for Norgestaxi and 74% for Bergen taxi.

Unit: 1000 NOK (per day)

		-20%	-16%	-12%	-8%	-4%	100%	100%	4%	8%	12%	16%	20%
Bergen Taxi	Revenue	1512	1496	1481	1466	1451	1436	1441	1428	1414	1400	1385	1371
	Cost	1108	1099	1090	1081	1072	1063	1066	1058	1050	1042	1034	1025
	Profit	404	398	392	385	379	373	375	369	364	358	352	346
	Gross margin (%)	26.7	26.6	26.4	26.3	26.1	26.0	26.0	25.9	25.7	25.6	25.4	25.2
	Trips per taxi	13.2	13.1	13.0	12.8	12.7	12.6	12.6	12.5	12.4	12.3	12.1	12.0
Norges taxi	Revenue	356	371	386	401	417	432	426	440	454	468	482	496
	Cost	273	285	297	309	321	333	330	341	352	363	375	386
	Profit	83	86	89	92	96	99	97	99	102	105	108	110
	Gross margin (%)	23.3	23.2	23.1	23.0	22.9	22.9	22.7	22.6	22.5	22.4	22.3	22.2
	Trips per taxi	12.3	12.2	12.1	12.1	12.0	11.9	11.8	11.7	11.6	11.5	11.5	11.4

Table 2: Results for both taxi companies of the scale simulation. The scale of Bergen Taxi is kept constant, whereas the number of taxis connected to Norgestaxi increases.

For technical reasons we need to use two ways of allocating the taxicabs in this simulation when we increase the number of taxi cabs, where one is using 5*5 matrix and the other is using 5*6 matrix. Thus, we get two slightly different results of the base case i.e. the 100% scale, as showed in the table 2. That is to say, these differences are caused by the design of the simulation where it is necessary to reassign the position of the taxi cabs.

[6] The revenue per day reflects the number of trips actually performed by Norgestaxi in 2010, 591000 trips or 1619 trips per day on average.

However, since both simulations give quite linear result (R square =0.999) and the result of the 100% scale under the 5*5 matrix are closer to the data offered by Norgestaxi, the result in Table 2 will be adjusted based on the 5*5 matrix. To illustrate, as shown in the Figure 3, the green dash line represents the adjusted result of the capacity utilization of Bergen taxi.

Unit: 1000 NOK (per day)

		-20%	-16%	-12%	-8%	-4%	100%	4%	8%	12%	16%	20%
Bergen Taxi	Revenue	1512	1496	1481	1466	1451	1436	1420	1405	1390	1375	1360
	Cost	1108	1099	1090	1081	1072	1063	1054	1045	1036	1027	1018
	Profit	404	398	392	385	379	373	366	360	354	347	341
	Gross margin %	26.7	26.6	26.4	26.3	26.1	26.0	25.8	25.6	25.4	25.3	25.1
	Trips per taxi	13.2	13.1	13.0	12.8	12.7	12.6	12.4	12.3	12.2	12.0	11.9
Norges taxi	Income	356	371	386	401	417	432	447	462	478	493	508
	Cost	273	285	297	309	321	333	345	357	369	381	393
	Profit	83	86	89	92	96	99	102	105	108	112	115
	Gross margin %	23.3	23.2	23.1	23.0	22.9	22.9	22.8	22.7	22.7	22.6	22.6
	Trips per taxi	12.3	12.2	12.1	12.1	12.0	11.9	11.8	11.8	11.7	11.6	11.6

Table 3: Adjusted results for both taxi companies of the scale simulation.

Table 3 shows the change of revenue, cost and profit per day when the number of taxicabs in Norgestaxi is adjusted from reducing 20% of the total taxicabs to increasing 20% of the total taxicabs. This means that Norgestaxi has between 19% and 27% of the taxis in the Bergen market instead of 23% share as in the base case.

It can be seen that if Norgestaxi reduces the number of taxicabs, the revenue of Norgestaxi will reduce while that of Bergen Taxi will increase. The increased revenue of Bergen Taxi will be larger than the reduced revenue of Norgestaxi. This result illustrates that under the current circumstance, the capacity of the taxi cabs in Bergen is not fully utilized and reducing the number of taxicabs will help to increase the utilization level, i.e., the number of trips per day for taxis in the Bergen market may be increased. Furthermore, the customers originally served by the removed taxicabs are captured by the remaining taxicabs, and

Bergen Taxi captures more. If Norgestaxi increases the number of taxicabs, the revenue of Norgestaxi will increase while the profit of Bergen Taxi will reduce because it suffers the customer loss.

We also notice that the gross margin of both companies is reduced when the number of the taxicabs for Norgestaxi increases. This is caused by the lower utilization of the taxicabs since demand is constant in the model.

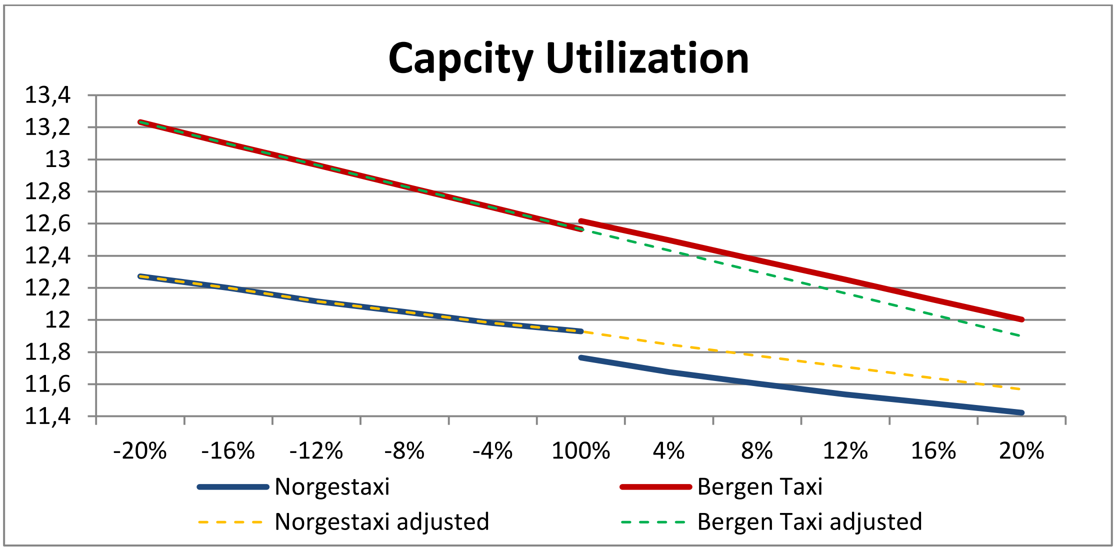

Figure 4: The capacity utilization of both companies

The analysis above can also be proved by the data of the capacity utilization. We simulate the number of trips per taxi per day for both companies as a proxy for the capacity utilization. When Norgestaxi increases its taxicab number, both companies will have lower average number of trips per taxi per day. Bergen Taxi changes more rapidly.

The above result shows that when Norgestaxi has more taxicabs, the "profit" is higher, whereas the gross margin is reduced for both companies. So should Norgestaxi have more taxicabs? Here we need to take into account other costs in addition to the three cost components mentioned in the assumption. The simulation results indicate that if Norgestaxi taxi increase or remove one taxicab; its profit will increase or reduce from 546 NOK to 583 NOK. So theoretically if other variable costs, including gasoline expenses, are less than 546 NOK per taxicab per day, Norgestaxi can consider having more taxicabs. If the other costs are more than 583 NOK per taxicab, Norgestaxi can consider reducing taxicabs. We have also done sensitivity tests for other scale adjustments, such as reducing the taxicab number by 4%, 8%, etc. Since the simulation result is fairly linear, the conclusion is rather similar.

Remaining Costs	**>583NOK**	**>546 NOK while <583 NOK,**	**<546NOK**
Decision	less taxicabs	remain the same	more taxicabs

Table 4: Scale adjustment decision for Norgestaxi

It is important to note that Bergen Taxi may benefit substantially from the downsizing of its competitor and become more dominant. Therefore it is not reasonable for Norgestaxi to cut many taxicabs. It will lead to a great loss of market share and the company will become weaker in the competition.

Finally, we test whether the “weak preference for the bigger company” assumption will have a significant impact on our model in the current situation when Norgestaxi has 142 taxicabs. The t-Test result below shows that assumption does not influence our conclusion. We find that the revenue for Norgestaxi will only increase marginally if the customers do not have any preference over the two companies, and the change is not statistically significant for all the cases we discuss above. There could be due to two reasons why we do not get a big difference. One of the reasons is that in our model, the scale of Bergen Taxi is far larger than that of Norgestaxi even when Norgestaxi has 20% more taxicabs. Hence, there are not so many chances that both companies will have the same closest distances to the target customers. Another reason is that the taxicabs for both taxi companies are evenly distributed in the model and they are assumed not to be in the same position all the time, so both companies will not have much “direct” competition.

Unit: NOK (per day)

	-20%	NO PREFERENCE	-16%	NO PREFERENCE	-12%	NO PREFERENCE
Revenue	355533	355541	371108	371124	386170	386184
T-test		0.0046		0.0089		0.0075
	-8%	**NO PREFERENCE**	**-4%**	**NO PREFERENCE**	**100%**	**NO PREFERENCE**
Revenue	401499	401521	416502	416524	431988	432010
T-test		0.0118		0.0114		0.0112
	4%	**NO PREFERENCE**	**8%**	**NO PREFERENCE**	**12%**	**NO PREFERENCE**
Revenue	439777	439794	453900	453916	467948	467965
T-test		0.0089		0.0088		0.0090
	16%	**NO PREFERENCE**	**20%**	**NO PREFERENCE**		
Revenue	482241	482258	496418	496435		
T-test		0.0088		0.0090		

Table 5: T-test result

Constant size in Norgestaxi, varying size in Bergen Taxi

The table below shows the second simulation result when the number of taxicabs for Bergen Taxi is set to be76%, 81%, 110% and 120% of the current level respectively.

Unit: 1000 NOK (per day)

		76%	81%	100%	110%	120%
Bergen Taxi	**Revenue**	1333	1365	1436	1473	1550
	Cost	949	979	1063	1110	1178
	Profit	384	386	373	363	372
	Gross margin	28.8%	28.3%	26.0%	24.6%	24.0%
	Trips Per Taxi	15.4	15.7	12.6	11.6	11.2
Norgestaxi	**Revenue**	535	503	432	395	318
	Cost	397	377	333	310	262
	Profit	137	125	99	85	56
	Gross margin	25.7%	24.9%	22.9%	21.5%	17.6%
	Trips per taxi	14.8	13.9	11.9	10.9	8.8

Table 6: Results for both taxi companies of the scale simulation. The scale of Norgestaxi is kept constant, whereas the number of taxis connected to Bergen Taxi is varied.

As expected, Norgestaxi will directly benefit if the Bergen Taxi reduces its taxicab number. The revenue for Norgestaxi is increased from 333,000 NOK to 397,000 NOK and its profit goes up by 40%. The utilization of taxicabs is increased from 11.9 trips per taxi per day to 14.8.

However, the magnitude of influence on Bergen Taxi is not as significant as the magnitude of influence of the taxicab number reduction. For instance, when 24% of the taxicabs for Bergen Taxi are cut, the revenue for Bergen Taxi is only reduced by 7.1% and unexpectedly, the profit is increased by about 3%. One of the factors contributing to that is when reducing its taxicabs, the Bergen Taxi still has scale advantage compared to Norgestaxi, and hence it will not lose too many customers to Norgestaxi. Another factor is that reducing taxicabs will help Bergen Taxi to increase the utilization of the taxicab. When 24% of its cabs are cut, the trips per taxi for Bergen Taxi are increased from 12.6 to 15.4. Also, reduction of taxicab will help Bergen Taxi to decrease the costs related to the taxicabs operation, i.e., the salary for taxi drivers and the cost of using taxicabs, as illustrated in the assumption 5 in the chapter 2,. These factors may help Bergen Taxi to increase its profit, as revealed in the simulation result above.

However, when Bergen Taxi tries to increase the taxicabs, results show that Norgestaxi will suffer great lost for that. For example, when Bergen Taxi have 20% more taxicabs, the revenue for Norgestaxi will decrease from 432,000 NOK to 318,000 NOK per day, and the profit will decrease from 99,000 NOK to 56,000 NOK. At the same time, although Bergen Taxi has higher costs, it still keeps its profit. More scale advantage gotten by Bergen Taxi explained the situation.

Market demand varying with the size of Norgestaxi

In the third simulation, further investigation is made when the total demand in the model is adjusted in proportion to changes in the size of Norgestaxi. That is to say it is assumed that Norgestaxi is the marginal supplier who will have to adjust to demand changes.

Unit: 1000 NOK (per day)

		-8%	-4%	100%	4%	8%	12%	16%	20%
Bergen Taxi	Revenue	1353	1395	1436	1479	1518	1555	1593	1629
	Cost	1015	1039	1063	1088	1111	1133	1155	1176
	Profit	339	356	373	391	407	422	438	453
	Gross margin	25.0%	25.5%	26.0%	26.4%	26.8%	27.2%	27.5%	27.8%
	Trips per taxi	11.8	12.2	12.6	12.9	13.3	13.6	13.9	14.3
Norges taxi	Revenue	368	399	432	457	492	527	563	601
	Cost	288	310	333	351	376	400	425	451
	Profit	80	89	99	106	116	127	138	150
	Gross margin	21.7%	22.3%	22.9%	23.1%	23.6%	24.1%	24.5%	24.9%
	Trips per taxi	11.0	11.5	11.9	12.1	12.6	13.0	13.4	13.8

Table 7: Results for both taxi companies of the scale simulation when the total demand is adjusted in proportion to changes in the number of taxis in Norgestaxi

The simulation result above shows the revenue for both companies increases steadily. In addition, we find that about 63.1% of the increased revenue will go to Bergen Taxi while 36.9% will go to Norgestaxi, and these two figures keep stable in all the scenarios we simulate.

Model 2: Promotion Simulation

The second simulation aims at exploring the influence of marketing campaign on the operating and competition of the two companies. In the second model the customers are divided into two groups. The first group gets onto a taxicab in the street and the second group calls the companies to order a taxicab.

For the first group, we hold the same assumption as in the first model that the customers generally do not have preferences. They will get onto the taxicabs which are closest to them, except when there are two taxicabs at the same distance to a customer, he will choose the bigger company, Bergen Taxi.

For the second group, we assume that the customers have preferences when they call to order a taxicab. This can be due to the fact that for the people in Bergen, the brand name of Bergen Taxi is easier to be recalled and found in the search engine. There can be many other subtle behavioral factors which lead to the preferences of the customers.

Norgestaxi estimates that about 60% of the total customers in Bergen will order the service by telephone, and the simulation is based on this proportion. That is to say, in our setting 60% of the customers in the model have specific preferences for one of these two companies and are willing to wait a longer time to get the service.

Besides, we test the model and find that among the customers who order taxicabs by phone, 22.3% will choose Norgestaxi and the rest will choose Bergen Taxi. We therefore use 22.3% as the basis for our test. The objective of the model is to test the influence on the total revenue and profit of two companies when the proportion of customers choosing Norgestaxi is increased. We increase the proportion by 1% every time to explore the income changes.

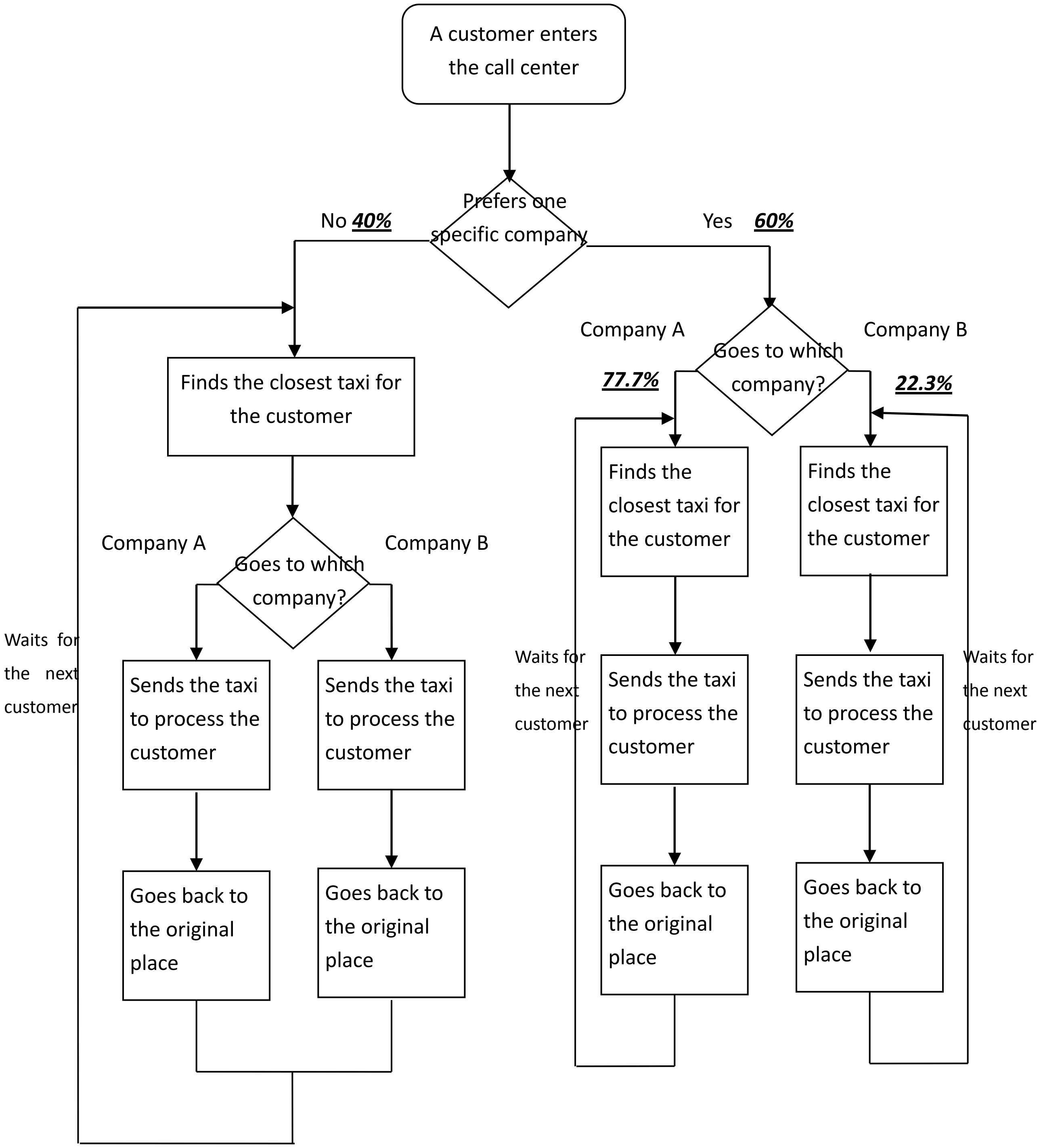

Figure 5: The process of simulation in model 2

Result

The simulation result shows that if the proportion of the customers choosing Norgestaxi by telephone is adjusted, the influences on the revenue and operating income of both companies are large and statistically significant. This is illustrated in the following table. Norgestaxi will benefit significantly from higher customer recognition and Bergen Taxi will suffer the loss of customers.

Unit: 1000 NOK (per day)

	Share of telephone orders to Norgestaxi	22.3	23	24	25	26	27	28
Bergen Taxi	Revenue	1437	1431	1423	1414	1406	1397	1389
	Cost	1064	1060	1055	1050	1045	1040	1036
	Profit	373	371	367	364	360	357	353
	Gross margin	26.0%	25.9%	25.8%	25.7%	25.6%	25.5%	25.4%
	Trips per taxi	12.6	12.5	12.5	12.4	12.3	12.2	12.2
Norges taxi	Revenue	431	436	445	453	462	470	478
	Cost	332	336	341	347	352	357	362
	Profit	98	100	104	107	110	113	116
	Gross margin	22.8%	23.0%	23.3%	23.6%	23.8%	24.1%	24.3%
	Trips per taxi	11.9	12.1	12.3	12.5	12.8	13.0	13.2

Table 8: Results of the promotion simulation when the share of customers calling Norgestaxi increases

If the proportion choosing Norgestaxi is increased, for instance, from 22.3% to 27%, the revenue of Norgestaxi in the model will increase from 431,000 NOK to 470,000 NOK per day and the profit will increase by 15.2%. The change is statistically significant. Capacity utilization analysis exhibits that the average trips operated per taxi per day grows from 11.89 to 12.99. The result shows that an effective marketing campaign has a profound influence on the revenue and profit of the company. Since currently the proportion selecting Norgestaxi is relatively low (22.3%), the company should have very large potentials.

Bergen Taxi suffers directly from the improved recognition of Norgestaxi. When the proportion of Norgestaxi grows to 27%, the daily revenue of Bergen Taxi declines from 1,437,000NOK to 1,397,000 NOK and they will have a profit reduction of 17,000 NOK per day. In the model as there are only two companies, the increased profit of Norgestaxi is directly "stolen" from Bergen Taxi. In reality an effective marketing campaign may also mainly affect the major competitor (i.e., Bergen Taxi) since the other competitors (i.e., Bryggen Taxi and Taxi 1) are small in Bergen.

Unit: 1000 NOK (per day)

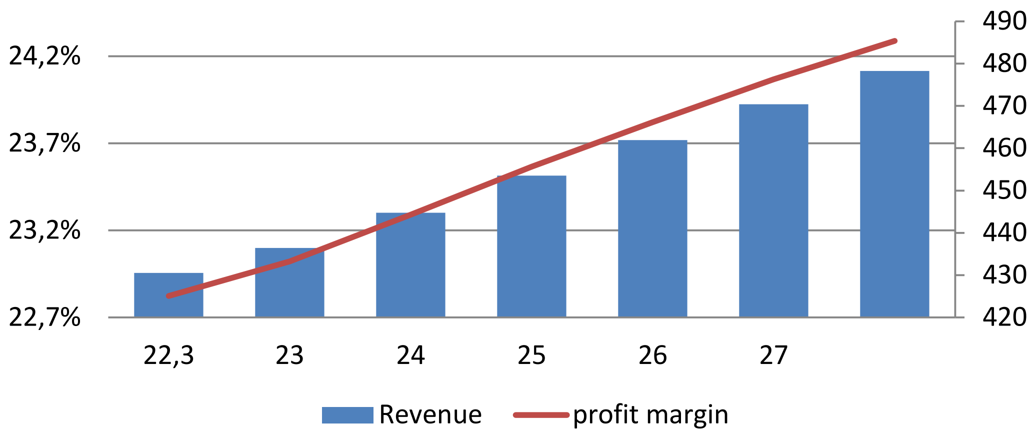

Figure 6: The change of revenue and gross margin for Norgestaxi in the promotion simulation

In reality a marketing campaign may involve high uncertainty. It is difficult to estimate to what extent a marketing campaign can improve the customer recognition from 22.3%. The result of the simulation aims at providing a decision basis for the cost-benefit analysis of the marketing department. The above table shows the revenue, profit and gross margin when the proportion of customers selecting Norgestaxi through telephone ranges from 22.3% to 27%. For example, an increase from 22.3% to 27% brings additional daily revenue of 39,000 NOK which is approximately equal to extra revenue of 14 million NOK (39,000*365) annually, assuming we keep the current level of taxicab number. The same calculation applies to other preference levels. The marketing department can therefore decide the appropriate level of expenses of the marketing campaign based on the different revenue estimates.

We focus primarily on the revenue here because the “profit” we calculated is not the true profit (It does not consider other costs such as gasoline expenses). In addition, as the cost structure in the taxi industry seems to be quite simple and is to a large extent linked to the revenue, it should be straightforward for the company to estimate the profit number based on the revenue result.

Model 3: Airport Group Simulation

The third simulation looks specifically at the customers from the airport. We divide all the customers into two groups: the first group gets onto the taxicab from the city, while the second group is from the airport. The objective is to facilitate the decision-making of whether Norgestaxi should assign some taxicabs specifically for the airport customers and how many taxicabs should be assigned.

Some more assumptions are added in the basic model.

1. The taxi companies divide all the taxicabs into two groups. The first group is only responsible for the customers in the city, and the second group covers only the customers from the airport. Customers in the city are assumed to have no company preference.

2. For the taxicabs assigned in the airport, they operate only from 7 a.m. – 1a.m. the next day because there are no airplanes departing or arriving from 1 a.m. to 6 a.m., and usually the first customer from the airport will arrive after 07 a.m. So during these 6 hours the taxicabs stop running.

3. According to the data given by Norgestaxi, about 19% of the customers are from the airport. Therefore, in our basic model, we assume both company will assign certain taxicabs according to this proportion. In our model, company A assigns 15 taxicabs in the airport and the rest 64 taxicabs in the city. Company B assigns 5 taxicabs in the airport and the rest 20 taxicabs in the city.

4. The trips running from the airport to the city normally cost more money. Therefore we differentiate the average expense for the two groups of customers. We assume that expenses of the customers from the airport follow a normal distribution with the mean equal to 320NOK and the variance equal

to 15. The expenses of the customers from the city follow a normal distribution with the mean 240 NOK and variance equal to 15.

5. The trips from the airport also consume more time. We assume that the time used by the taxicabs starting from the airport in every trip follows a normal distribution with the mean equal to 30 min (one way) and variance equal to 3. The time used by the city taxicabs follows a normal distribution with the mean equal to 20 min (one way) and variance equal to 5.

Result

The simulation result shows that assigning some taxicabs specifically for the airport customers and thereby also operating fewer taxis at night, can significantly improve Norgestaxi's profit. In our basic setting when 20% of the total taxicabs are assigned in the airport, the revenue of Norgestaxi is about 431,000 NOK per day and the capacity utilization is 11.86. This is significantly larger than the revenue when fewer taxicabs are specifically assigned in the airport. The number of trips per cab is slightly lower which is perhaps because now 20% of the cabs operate only 7a.m.-1a.m. the next day. However, this could also be caused by the different design of new model and model 1.

The following graph illustrates the change of the revenue of Norgestaxi when the number of taxicabs assigned in the airport differentiates. The simulation result shows that the revenue is maximized when 24% of the taxicabs are assigned to the airport. We also do t-tests for different cases. The t-tests show that when the proportion of the airport taxicabs is between 20% and 28%, the differences of the revenue are not statistically significant. Therefore, in the model Norgestaxi can either assign 20% to 28% of the taxicabs in the airport and the result is similar. As most of the variable costs (i.e., the gasoline expenses, the labor cost and the telephone charge) are to a large extent related to the revenue, it is very probable that higher revenue implies a higher profit.

When the proportion of the taxi cabs assigned to the airport is smaller than 19%, the revenue of Norgestaxi will drop dramatically. This also implies the importance of the customers from the airport for the taxi business.

Unit: 1000 NOK (per day)

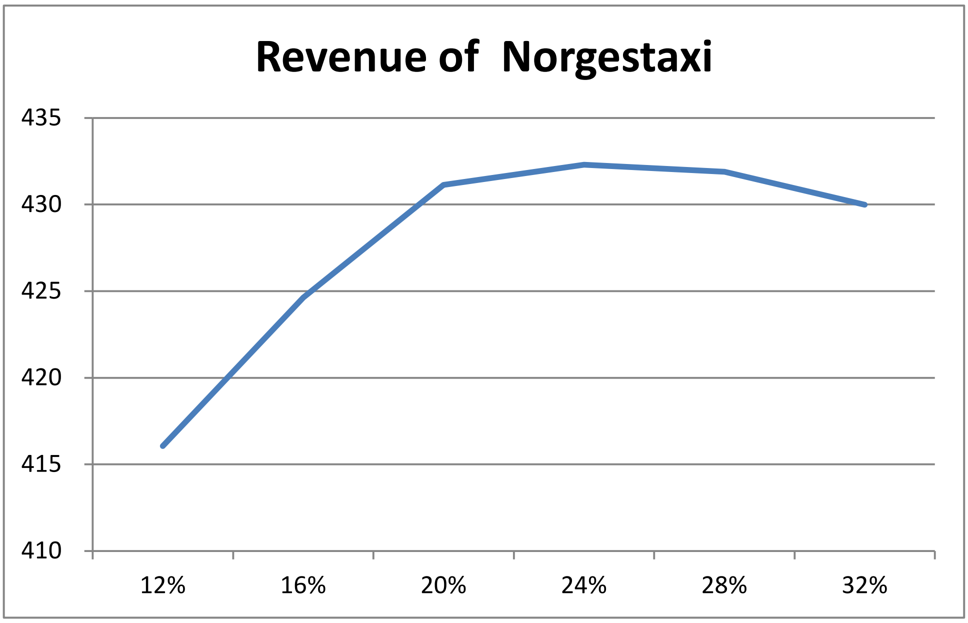

Figure 5: The change of revenue in the airport group simulation

As shown in the following table, when there are 24% of the Norgestaxi cabs assigned in the airport, the revenue is highest at 432,000NOK per day.

Unit: 1000 NOK (per day)

		12%	16%	20%	24%	28%	32%
Bergen Taxi	Income	1459	1451	1445	1443	1444	1446
	Cost	1077	1072	1068	1068	1068	1069
	Profit	382	379	376	376	376	377
	Gross margin	26.2%	26.1%	26.1%	26.0%	26.0%	26.1%
	Trips per taxi	12.7	12.7	12.7	12.7	12.7	12.8
Norgestaxi	Income	416	425	431	432	432	430
	Cost	323	329	333	333	333	332
	Profit	93	96	98	99	99	98
	Gross margin	22.3%	22.6%	22.8%	22.9%	22.9%	22.8%
	Trips per taxi	11.7	11.8	11.9	11.8	11.7	11.5

Table 9: Result of the airport group simulation

The result of the airport group simulation is meaningful in at least two perspectives. First, the airport customers can be more profitable since the average trip is longer and the company may benefit from assigning taxicabs specifically in the airport. More importantly, the result shows that the company may benefit from running fewer taxicabs in the night time when the airport is closed. It is possible that the operating cost saved can cover the potential loss of customers.

Effects of operating fewer taxis in the city market at night

We simulate the capacity utilization when fewer taxicabs are running in the night time. The result further proves the argument. Two situations are simulated and compared. Case A is the same as the basic model (Model 1): all the taxicabs are running 24 hours and all are running in the city. Case B is the basic setting of the airport group model (Model 3), in which the airport taxi group stops operating during 1 a.m. and 7 a.m. The revenue and the average number of trips per taxi for the two cases, i.e., with 100 % or 80% taxis operating in the city, during these 6 hours are calculated respectively.

The fare at night during 10 p.m. to 6 a.m. will be 30% higher. Based our model, we estimate the average fare per trip is about 276 NOK at night（average 369 trips during 1 a.m. to 6 a.m., data given by Norgestaxi）and 213 NOK（average 27 trips during 6 a.m. to 7 a.m., data given by Norgestaxi）in the daytime. Hence we assume the average fare per trip during these 6 hours is 272 NOK[7].

The simulation result is summarized as follows. It compares the cases when 80%

[7] Data given by Norgestaxi show that, the number of trips in the city per day is 753 in the daytime and 563 in the night time; the number of trips during 1 am to 6 am is 369 and that during 6 am to 7 am is 27. As mentioned in the assumption, the average fare in the city for whole day is 240. Assumed that (1) the fare in the daytime in the city is X and that in the night time is 1.3X. 753X+563*1.3X=240(753+563), hence X=276, 1.3X=217.So the average fare during these 6 hours= (276*369+217*27)/(369+27)=272

and 100% of the taxicabs running during the airport closing time. The average number of trips during these six hours at night is 3.36 per taxicab in Case A, and 3.62 in Case B. The t-test shows that the difference of the two numbers is statistically significant. This means that fewer taxicabs running in the night will increase the utilization of the taxicabs for Norgestaxi. Besides, when 20% of the taxicabs stop running during 1 a.m. to 7 a.m., the profit of Norgestaxi during these hours will decrease by only 6,700 NOK per day (from 48,900 NOK to 42,200 NOK). The "profit" here is calculated as revenue minus two variable cost components (i.e., the wages cost ---- 58.5% of the revenue and variable part of the call centre charge ---- 4% of the revenue) without considering the other operating costs. That is to say, if running 20% fewer taxicabs (i.e., about 28 cabs) during the night will help to save the other variable costs by more than 6,700 NOK per day for Norgestaxi, the company should consider to do so. According to our estimate, this should be quite likely.

Unit: 1000 NOK (per day)

Share of taxis operating 24 hours	**80%**	**100%**
Revenue	112.4	130.3
Cost	70.2	81.4
Profit	42.2	48.9
Trips per taxi	3.63	3.36

Table 9: The operation result from 1 a.m. to 7 a.m.

Model 4: Company Size Simulation

The fourth model investigates the cases when both companies have similar sizes. We assume that the scale of the whole taxi business is kept as at the moment. The only change is the number of taxicabs assigned to different dispatching centre, (i.e., Bergen Taxi and Norgestaxi). Hence, we use the same model as model 1 while the only difference to that is the total number of taxis is slightly reduced from 104 to 100. In the first part simulation, Bergen Taxi and Norgestaxi both have 50 taxicabs. In the second one, Bergen Taxi has 60 taxicabs and Norgestaxi has 40 taxicabs. We test different settings to see how the market functions.

Result

In the first part both companies have the same taxicab number. When the customers do not have preferences over companies, the two companies will equally share the market (i.e., each company gets a daily revenue of about 935, 000 NOK). The profit margin of Norgestaxi will be slightly less because of our setting of the telephone charge. The comparison is more interesting when customers' preferences are involved. We maintain the weak preference assumption letting a consumer has a preference for Bergen Taxi only when the two companies have the same chance of getting the customer. We take into account two possible modes regarding the competition between Norgestaxi and Bergen Taxi. We refer to these two modes as:

- The collaboration mode
- The direct competition mode, which is used in the other models

The collaboration mode means the two companies try to identify their own markets, differentiate their services and build their advantages in certain areas.

We simulate this situation by setting the taxicabs of the two companies not overlapped with each other, so the chance of competing for the same customers is lower.

The direction competition mode infers that the two companies focus more on the direct competition between them. They both concentrate on the most profitable areas and try to get as many customers as possible. We simulate this case by setting the taxicabs of Norgestaxi evenly distributed in the city but overlapped with the taxicabs of Bergen Taxi. In this case, the customers' preferences are critical.

The table below shows how the market functions in different cases.

Unit: 1000 NOK (per day)

		Overlapping, without preference	No overlapping, with preference	Overlapping, with preference
Bergen Taxi	Revenue	936	996	1136
	Cost	689	724	806
	Profit	247	272	330
	Gross margin	26.4%	27.3%	29.1%
	Trips per taxi	12.9	13.8	15.7
Norges taxi	Revenue	934	874	734
	Cost	710	673	585
	Profit	224	201	149
	Gross margin	24.0%	23.0%	20.3%
	Trips per taxi	12.9	12.1	10.1

Table 10: The operation result when taxi companies are of similar size i.e., 50:50

The table above shows that if the customers have no specific preferences, the revenue for both companies will be very close regardless of the competition mode. The competition mode matters when the customers have preferences for Bergen Taxi. In the collaboration mode, Norgestaxi's daily revenue is about 874,000 NOK, representing about 47% of the market share. Hence, when the taxi companies identify their own markets customer preferences have limited effect. In the direct competition mode, Norgestaxi loses more customers due to the modeled lower market recognition. The daily revenue is about 734,000, representing only 39% of the market share.

Two straightforward implications can be obtained from the simulation. First, when the two companies have similar size, the market recognition is critical when the companies compete directly in the market. This may be quite challenging for Norgestaxi at the beginning due to the dominant market position Bergen Taxi holds during the past period. Second, if Norgestaxi has lower market recognition, it should try to avoid being involved in direct competition but try to identify its specialized market.

In the second simulation in model 4, Norgestaxi is assumed to have 40 taxicabs and Bergen Taxi has 60. We continue to hold the "weak preference" assumption. The result shows that Norgestaxi's daily revenue is about 741,000 NOK, which is about 39.5% of the market share. This is very similar to its taxicab proportion.

Unit: 1000 NOK (per day)

	NO overlapping, with preferences in both models	**50:50**	**60:40**	**Basic Model (79:25)**
Bergen Taxi	**Revenue**	996	1129	1436
	Cost	724	830	1063
	Profit	272	299	373
	Gross margin	27.3%	26.5%	26.0%
	Trips per taxi	13.8	13.0	12.5
Norgestaxi	**Revenue**	874	741	432
	Cost	673	564	333
	Profit	201	177	99
	Gross margin	23.0%	23.8%	22.9%
	Trips per taxi	12.1	12.8	11.9

Table 11: The operation result when taxi companies are of similar size i.e., 60:40

Bergen Taxi will have about 1129,000 NOK revenue, which is about 1.52 times of the revenue Norgestaxi has, 741,000 NOK. This fits their size ratio (1.5:1.0) quite well. In our first model, Bergen Taxi has 3.15 times as many taxicabs as Norgestaxi does (Bergen Taxi: 79 taxicabs; Norgestaxi: 25 taxicabs), but gets 3.32 times of Norgestaxi's revenue. This shows that if the size difference is larger, the bigger company benefits more from economies of scale, and t-test confirms this inference. When the sizes are closer for both companies, Bergen Taxi will benefit less from economies of scale.

Model 5: Fixed Contract Simulation

The fifth model aims at investigating how the fixed contract affects the revenue and capacity utilization of both companies. At present 1/7 or 14.3 % of the Bergen taxi demand are from long-term fixed contracts and this model takes this into consideration. This implies that the fixed contracts represent 14.3 % of the revenue in the Bergen market in the model. The customers from the fixed contract are considered as a part of those ordinary customers in the simulation model, which means that they have the same pattern as the ordinary customers.

We assume the average time per trip (one way) from the fixed-contract customers follows a normal distribution with mean time equal to 20min, variance 5. The average earning also follows a normal distribution with the average earning of 255 NOK, variance 15. Hence, the fixed-contract trips and the normal trips are similar.

As stated in the assumption of model 2, the telephone-order customers, who account for 60% of the total customers, are assumed to have strong preference for one of the two companies. In the first simulation of model 5, the fixed-contract customers are considered as part of the telephone-order customers.

At present, among all the fixed-contract consumers, 80% will go to Bergen Taxi and 20% will go to Norgestaxi. In the first simulation, we test the variation of operating results when the proportion is changed under the current circumstance. We will test the cases when Norgestaxi gets 20%, 40%, 60% and 80% of the contracted customers respectively.

In the second simulation we have a rough investigation on the impacts of changes in fixed-contract shares when taxi companies are of similar size (i.e., 50:50 and 60:40). However, compared to the first simulation, only fixed-contract customers are considered to have strong preference for one of the two companies, and the rest of the customers are assumed to have no preference.

Result

Fixed-contract simulation when Bergen Taxi has large scale advantage

In the basic model when Norgestaxi has only 20% of the contracts, the daily revenue is about 430,000 NOK. The revenue from the fixed contract sales is 53,000 NOK, which takes up about 12% of the company's revenue.

Unit: 1000 NOK (per day)

		20%	**40%**	**60%**	**80%**
Bergen Taxi	**Revenue**	1437	1397	1359	1318
	Fixed contract revenue	213.4	160.1	106.7	53.3
	Cost	1064	1040	1018	994
	Profit	373	357	341	324
	Gross margin	26.0%	25.5%	25.1%	24.6%
	Trips per Taxi	12.6	12.2	11.9	11.5
Norges taxi	**Revenue**	430	471	508	548
	Fixed contract revenue	53.3	106.7	160.0	213.3
	Cost	332	357	381	406
	Profit	98	113	127	142
	Gross margin	22.8%	24.1%	25.1%	26.0%
	Trips per Taxi	11.9	13.0	14.0	15.1

Table 12: Results of the fixed contract simulation when Norgestaxi's share of fixed contracts varies

The revenue of Norgestaxi increases significantly as the percentage of contacted customers grows. For example, the revenue increases from 430,000 to 471,000 when the percentage increases from 20% to 40%. At the same time, capacity utilization analysis exhibits that the average trips operated per taxi per day grows from 11.88 to 12.99. Recall the marketing campaign simulation in Model 2. An increase of fixed contract proportion from 20% to 40% has approximately the same effect as an increase of the customer preference ratio from 22.3% to 27%

(Model 2). Therefore the revenue growth brought by a higher share of fixed contract is huge. The above table regarding the operation results of different fixed contract proportions can provide information for Norgestaxi to facilitate future fixed-contract bidding efforts.

In our simulation system, when the taxicabs cannot fulfill all the demand from the customers, the system will provide warnings and stop running. This happens when we set Norgestaxi getting 80% of contracted customers. 7 of the 180 runs in the simulation stop running, which shows that Norgestaxi will not be able to handle too many customers and need more taxi. The further test shows that Norgestaxi need to increase its number of cabs more than 20% to avoid stop running in the simulation.

Fixed-contract simulation when Bergen Taxi has less scale advantage

In the second simulation, we further investigate the influence of the fixed contracts when Bergen Taxi has no or less scale advantage. In particular, we want to find out whether Norgestaxi should have more taxicabs to satisfy the increasing demand.

The results are presented in the tables below. The simulation also shows that, when both companies have similar sizes, i.e., 50:50 or 60:40, neither of the companies need to have more taxicabs even if Norgestaxi gets 0 or 100% customers of the fixed contract.

Unit: 1000 NOK (per day)

	Share for Norgestaxi	Original Model	0%	20%	40%	60%	80%	100%
Bergen Taxi	**Revenue**	936	1001	973	947	919	892	865
	Cost	689	727	710	695	679	663	647
	Profit	247	274	263	252	240	229	218
	Gross margin	26.4%	27.4%	27.0%	26.6%	26.1%	25.7%	25.2%
	Trips per taxi	12.9	13.8	13.5	13.1	12.7	12.3	12.0
Norges taxi	**Revenue**	934	866	894	920	948	974	1002
	Cost	710	667	685	701	719	735	752
	Profit	224	198	209	219	229	239	249
	Gross margin	24.0%	22.9%	23.4%	23.8%	24.2%	24.6%	24.9%
	Trips per taxi	12.9	12.0	12.4	12.7	13.1	13.5	13.9

Table 13: The operation result of fixed contract when taxi companies are of similar size i.e., 50:50

Unit: 1000 NOK (per day)

	Share for Norgestaxi	Original Model	0%	20%	40%	60%	80%	100%
Bergen Taxi	Revenue	1129	1180	1152	1126	1097	1070	1043
	Cost	830	860	843	828	811	796	779
	Profit	299	320	309	298	286	275	263
	Gross margin	26.5%	27.2%	26.8%	26.4%	26.1%	25.7%	25.2%
	Trips per taxi	13.0	13.6	13.3	13.0	12.6	12.3	12.0
Norges taxi	Revenue	741	688	716	743	771	798	826
	Cost	564	531	549	565	583	600	617
	Profit	177	157	167	177	188	198	209
	Gross margin	23.8%	688	716	743	771	798	826
	Trips per taxi	12.8	11.9	12.4	12.8	13.3	13.8	14.2

Table 14: The operation result of fixed contract when taxi companies are of similar size i.e., 60:40

Model 6: Market Growth

The sixth simulation is a sensitivity test on whether the taxi market growth will affect the operation of both companies. In this model, we assume two alternative growth rates---- 2% and 5%, and explore whether more taxicabs are needed when market growth is also taken into consideration

Unit: 1000 NOK (per day)

		Original	2%	5%
Bergen Taxi	Revenue	1436	1461	1501
	Cost	1063	1078	1101
	Profit	373	383	400
	Gross margin	26.0%	26.2%	26.6%
	Trips per Taxi	12.6	12.8	13.1
Norgestaxi	Revenue	432	440	454
	Cost	333	338	347
	Profit	99	102	107
	Gross margin	22.9%	23.2%	23.6%
	Trips per Taxi	12.0	12.2	12.5

Table 15: Results of the market growth simulation assuming no change in the number of taxis

As expected, the table above shows that Bergen Taxi will benefit more from the market growth in absolute terms. The increase of revenue per day for Bergen taxi is 25,000 NOK assuming a 2% growth rate and 65,000NOK assuming a 5% growth rate. At the same time, the increases of revenue per day for Norgestaxi are 8,000 NOK and 22,000 NOK respectively. The gross margins changes by 0.6 percentage points for Bergen Taxi and 0.7 percentage points for Norgestaxi, however. More customers will increase Norgestaxi's taxicabs capacity utilization. Capacity utilization analysis exhibits that the average number of trips operated per taxi per day grows from 11.93 to 12.16 and 12.53 respectively.

Test results show that a 5% market growth rate does not affect the size adjustment decision discussed in the first simulation model. That is to say, the conclusion of the first model still holds even when market growth is considered. As showed in the table below, having 4% more taxicabs only slightly increase the profit by 1,000 NOK per day, and the increase is not statistically significant. The "profit" here, as before, does not consider other variable costs including gasoline expenses, so actually the company is losing money when having more taxicabs.

Unit: 1000 NOK (per day)

	5% market growth	5% market growth, 4% cabs more
Revenue	454	464
Cost	347	355
Profit	107	108
Trips per Taxi	12.5	12.3

Table 16: Results of size adjustment by Norgestaxi (including the market growth factor)

4. CONCLUSION

In this section we provide a brief summary on the simulation results.

- In the scale simulation, we provide a cost range for Norgestaxi as a reference. Norgestaxi can estimate its operating costs per taxi per day and decide whether to increase its taxicab number or not. In addition, we find that Norgestaxi will benefit from the size reduction and suffer from the size increase of Bergen Taxi.

- In the scale simulation we also find that even if we assume Norgestaxi is the marginal supplier in the case of increased market demand, most of the new customers still go to Bergen Taxi, while Norgestaxi will get about 37% of the new customers. The result is robust to different scenarios.

- In the promotion simulation, we simulate the additional revenue that Norgestaxi can obtain through a marketing campaign designed to increase its market recognition. Results show that Norgestaxi may benefit greatly through appropriate promotion.

- The airport group simulation shows that Norgestaxi may benefit from assigning a number of taxicabs specifically in the airport and running fewer taxicabs in the night time when the airport is closed. The effect of running fewer taxis at night dominates the effect of higher income per airport trip.

- The company size simulation shows that when both companies have similar scales, market recognition and competition strategy become critical. In addition, the advantages arising from economies of scale become less obvious as should be expected.

- In the fixed-contract simulation, we find that the revenue growth brought by a higher share of fixed contract is huge. We estimate the revenue growth to provide a basis for Norgestaxi's decision-making.

- We simulate two scenarios of market growth, and find that short-term market growth does not affect Norgestaxi's decision-making in its current size.