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Competition in the Bergen Taxi Market

A Simulation Analysis

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Abstract

By building up simulation models using WEBGPSS language, this thesis 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.

Acknowledgement

I would like to express my deepest thanks to my main thesis supervisor, Professor Kurt Jörnsten, and two other supervisors Professor Siri Pettersen Strandenes and Professor Rolf Jens Brunstad. The thesis is related to a SNF research project with Norgestaxi, and all the three professors supervised my work. They provided me with very valuable help and suggestions during the whole thesis writing process. I really appreciate their attitudes of being extremely detail-oriented and responsible. Writing the thesis with them is a great learning experience for me.

I also want to thank Professor Ingolf Ståhl, the developer of WEBGPSS. He gave me great help in his simulation class, and stimulated my interest in related research topics. He also introduced me to work with this project. Whenever I encountered a problem, he always discussed with me possible solutions through emails. I really appreciate his kindness.

Moreover, I would like to thank Norgestaxi, which financed the SNF project and provided me with the data used in the thesis. They also gave great comments and suggestions when the report was presented to them.

I would like to give this thesis to my baby girl, born on 10th November 2011, and wish her a happy life. Moreover, the work would not have been completed without the support from my husband and I feel very grateful for that.

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1. Background

This report is part of the SNF Project No.7886 "competition in the taxi industry," a consulting project financed by Norgestaxi. The paper serves as a consulting report for Norgestaxi with an objective of improving its operation performances in the Bergen area. In this report six simulation models are designed to explore the taxi market in Bergen. The simulation language is WEBGPSS[1], which is one of the most updated versions of GPSS (the General Purpose Simulation System), a discrete time simulation language. In the first section, a general situation of the Bergen taxi industry is provided.

1.1 The General Information of the Taxi Business in Bergen

By the end of 2010, a total of 2.7 million cars have been registered in Norway, 2.3 of which are private cars. That is to say, on average two Norwegians own a car. In order to guarantee the revenue of the taxicab-owners, Norway has a licensing scheme to control the number of taxicabs in the market. In the following table, the figures show that the number of taxicabs has only slightly increased during the past 3 years in the Hordaland region.

	2008	2009	2010
Inhabitants(1000)	469.7	477.2	484.2
Number of taxi licenses / taxicabs	888	915	919
Inhabitants per taxicab	529	522	527

Table 1: Taxis Situation in Hordaland Region

In Norway usually every operator is only allowed to own one license, which is personal and required to be affiliated to a specific dispatching center. Every year only a limited number of licenses are allowed to switch to other dispatching

[1] http://webgpss.com/

centers. In the Bergen area, there are only several dispatching centers. They are respectively Bergen Taxi, NorgestaxiAS, Taxi 1, Bryggen Taxi SA, and so on, in which Bergen Taxi and Norgestaxi AS are by far the two biggest. In 2010, there are in total 694 taxicabs in Bergen ，of which Bergen Taxi has 448 and Norgestaxi has 142.

In this report, in consistence with the request of Norgestaxi I consider the taxicabs as being belong to the dispatching center. Each dispatching center, such as Norgestaxi, is assumed to be an entity owning the taxicabs, although in fact they are owned by the owners. This setting facilitates Norgestaxi's decision-making, and also makes the report more straightforward.

Because of the restriction of the licenses, most of the taxicabs are required to run 24 hours per day. The salary for the taxi drivers takes up a large part of the revenue. For example, the taxi owners affiliated to Norgestaxi need to pay 45% of gross income as salary to the taxi drivers and 30% of these 45% as social costs, so in total 58.5% (45%+0.3*45%) of the gross income is allocated to the taxi drivers.

Taxi serves as a complement to the public transports, especially when the buses and metro are rare in the late night time. In Norway, public transportations are usually quite mature in big cities, such as Bergen. Hence, a great part of demand for the taxi service comes in the late night. As shown in Figure 1, the peak hours of taxi service demand for Norgestaxi are during 0 a.m. to 3 a.m., when most of the buses stop operating in Bergen. In our discussion, it is assumed that this trend could represent the situation of the whole taxi business in Bergen. Data given by Norgestaxi also shows that the number of trips during 0 a.m. to 4 a.m. accounts for about 24% of the total trips in Bergen in 2010.

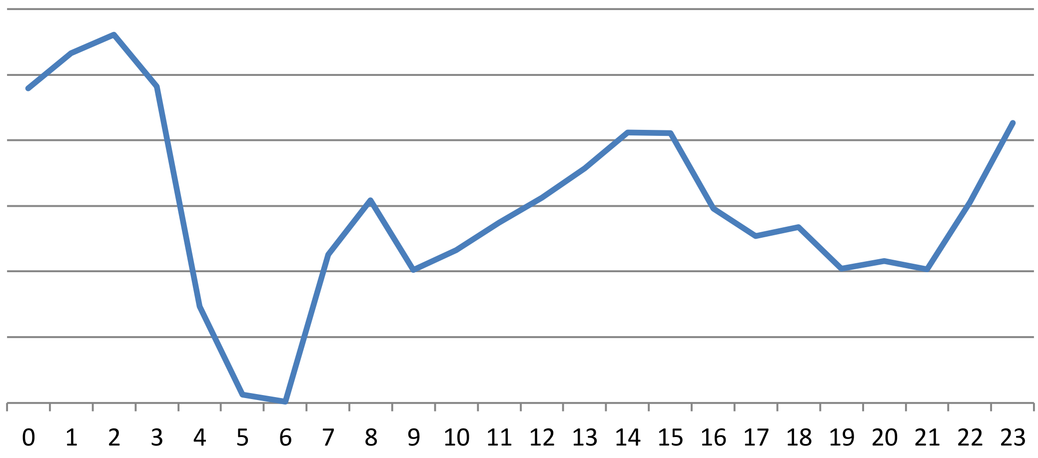


Figure 1: Demand for Norgestaxi 2010

The Norwegian taxi industry can be divided into three major market segments (Bekken and Longva, 2003). They are respectively the taxi rank segment, the hailing segment and the telephone-booking segment. The taxi rank segment refers to customers getting service at a place where taxis park while waiting for the customers. The hailing segment refers to customers hailing a taxi from the street. These first two segments can be viewed as the street work segments. The common characteristics of these two segments are that customers have little preferences over taxicabs from different companies. In most cases the taxicab that comes first wins the customer. In the following discussion, these two segments are not distinguished from each other and treated as one segment. The telephone-booking segment, in which customers get service by booking a taxi via telephone, is significantly different in this aspect. When the customers try to get the taxi service over telephone, usually they have a preference over one specific company. They will choose a company before they call. This gives an important implication in my model building. In some models I assume customers have no preference, while I also investigate the cases when they do have preferences, which is illustrated in detail in the models.

1.2 Objectives

In this part, six main objectives for this report are presented.

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

  Due to the high cost of running a taxicab and the industry's fluctuating demand pattern, it is important for a dispatching center to optimize the number of taxicab it owns in order to maximize the profit. This is also the primary objective that this report would like to achieve.

- ***Objective 2:*** to investigate how an improved market recognition would affect the operation results and the competition in the industry.

  This simulation model focuses on how the customers' preference affects the taxi business. It distinguishes the two segments, the street work segment and the telephone-booking segment. I specifically look at the influence of an increased recognition and market share on the operation results of the companies. This improved market share can be achieved through a potential marketing campaign, or efforts in improving the services and customer experiences.

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

  Revenue from the trips in the airport is also very important for the taxi companies, which takes up about 19% of the total trips for Norgestaxi in Bergen in 2010. Those customers who go to the airport belong largely to the telephone-booking segment while those who start travelling from the airport belong to the taxi rank segment. In our third simulation I discuss whether

Norgestaxi should assign a number of taxicabs for the latter group (i.e., from airport to the city), in which customers usually have no preference and follow a “first-in, first-out” rule. For this group of customers it is crucial for the taxi dispatching center to arrange the taxicab fleet in an efficient way.

- ***Objective 4:*** to investigate the hypothetical cases when Norgestaxi and its largest competitor, Bergen Taxi have closer scales.

  At the moment Bergen Taxi has 448 taxicabs and Norgestaxi has 142. Bergen Taxi is obviously in a more dominant market position, which has a significant influence on the two companies’ competition strategy. With the request of Norgestaxi, I also simulate the different cases when the two companies have closer scale ratio, for instance 50:50 or 60:40, which gives us further insight on the potential change of competition situation.

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

  Public contract also constitutes a large proportion of the taxi companies’ revenue. In Bergen, about 1/7 of the taxi services come from the public contract. Companies who win the competitive bidding get a large share of the contract and the share could be changed every few years. These contracted trips are mainly hospital and school transportations. Currently Bergen Taxi has 80% of the total contracted trips in Bergen and Norgestaxi gets the rest 20%. I test in the simulation model to see how different shares of fixed contracts among these two firms affect their business when both companies maintain the current scale and have closer scale ratio, i.e., 50:50 and 60:40.

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

  With regard to the final request from Norgestaxi I also develop a model introducing an expected growth rate of the market, and explore whether market growth brings more demand for new taxicabs.

1.3 Thesis Organization

The thesis is organized as follows. The next chapter introduces the assumptions for the investigation and the simulation models. The third chapter briefly introduces the simulation language WEBGPSS and develops the simulation models based on our assumptions and the objectives. The fourth chapter provides the analysis and the results of the simulation models. A summary and a discussion on limitations and topics for future research are covered in the last chapter.

2. The Model Statement and Assumptions

This chapter discusses the general model statement and the basic assumptions. In total six simulation models are developed for different objectives. These models are mostly based from a set of basic assumptions. The assumptions are also adjusted in specific cases, and any adjustments from the basic assumptions are provided in the fourth chapter in the discussions of the specific cases.

2.1 Framework of the Simulation Model

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 2.

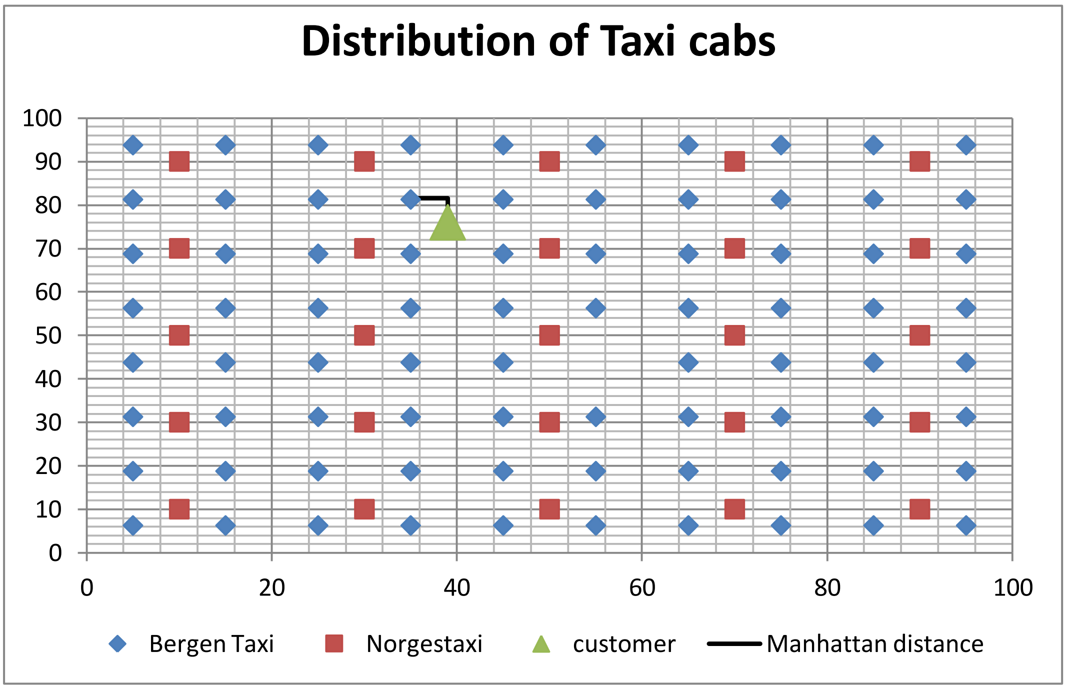


Figure 2: The allocation of taxi cabs in the basic case and an example of the Manhattan distance

The customers arrive in the system according to a certain pattern further 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 to pick up the customer, among the taxis of the designated companies. Otherwise, the system calculates the distance between the customer and the taxicabs for both companies and the taxi which is closest to the customer picks up the customer. After serving the customer, the taxi goes back to its original place.

2.2 Assumptions of the Models

Here some important assumptions are introduced to the basic model.

- ***Assumption 1: Two Companies in the Market***

  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.

- ***Assumption 2: 24 Hours Running***

  All the taxicabs in the system are running 24 hours a day.

- ***Assumption 3: Arrival Pattern***

  The total number of customers is exogenously given. The customers 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 I 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 2: The Interval of the Customers' Arrival

- ***Assumption 4: Perfect Information for Taxi Companies***

In models where customers do not have a preference over the taxi companies, the taxi companies are assumed to have perfect information when and where the customer arrives in the system. Hence, the taxi companies are able to know exactly the distance to the target customer. Generally speaking, customers who do not have a preference for one of the taxi companies get into the first taxi that comes to them. (The distance between the taxi and the customer is calculated based on "the Manhattan distance[2]) 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 company, Bergen Taxi. I refer to this as "weak preference for the bigger company", which is set up for convenience of model design. In my study I also do sensitivity test when this weak preference assumption is removed and see if it will affect the result.

- ***Assumption 5 ：Travel Time and Earning Per Trip***

[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.

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

The above assumptions apply to the taxicabs in both companies.

➢ ***Assumption 6 : Cost of Running a Taxicab***

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.

i. 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.

ii. 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 different simulations.

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

iii. The taxis need to pay a charge to the taxi companies. Here I 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

[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

part is 4% of the gross income. According to the simulation result the total payment is about 336 NOK per day. 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. This difference varies 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 models.

The above-mentioned five basic assumptions apply to most of the simulations.

2.3 Report Content Generated in the Simulation

The simulation models generate reports based on the assumptions I set. Each report provides us with a group of data, which mainly includes:

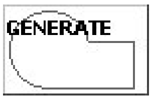
- the total revenue of Company A per day
- the total cost of Company A per day
- the total revenue of Company B per day
- the total cost of Company B per day
- the charge that the taxi owners of company B pay to call center per day
- the number of trips per day for each taxi

I investigate the models based on these figures.

3. Introduction of the WEBGPSS Language

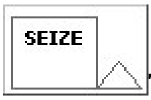
The simulation model designed in this research is based on the WEBGPSS software. WEBGPSS is a stream-lined version of GPSS, the General Purpose Simulation System, which is a discrete time simulation language. In WEBGPSS, there are 16 different blocks available for the users, some basic blocks of the WEBGPSS and the simulation models applied in this thesis are introduced.

3.1 The Introduction of the Blocks in WEBGPSS



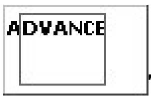
The GENERATE block is to start the transactions. In our model, it is used to define the arrival pattern of the customers, the total operation time and so on.

The TERMINATE block terminates transactions.

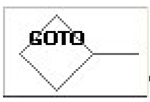


The SEIZE block is used to seize a facility (serving one transaction at a time; is connected with RELEASE).In our model it used to catch the customers.

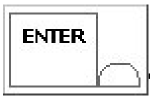
The RELEASE block releases a facility (is connected with SEIZE).



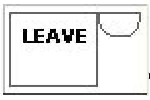
The ADVANCE block causes a planned time delay. In our model, it is used to define the transaction to handle a customer.



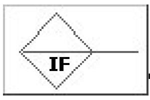
The GOTO block makes a transaction jump (to a different block), either unconditionally or with a certain probability.



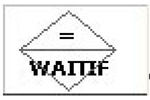
The ENTER block utilizes a part of a storage, i.e. a station that can serve several transactions at the same time (is connected with LEAVE).



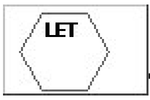
The LEAVE block frees part of a storage (is connected with ENTER).



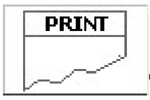
The IF block gets a transaction to jump in the program if a certain condition is fulfilled.



The WAITIF block keeps a transaction waiting in front of a block if, and as long as, a certain condition holds.



The LET block assigns and changes the value of a X$-value. It is used to do all the calculating work in the model.



The PRINT block produces a user defined output in the simulation results.

3.2 Explanations to the Simulation Codes

In the following part, I will give some explanations about the modes in the WEBGPSS language by using model 1 as an example. Firstly, the flowchart bellow illustrates how the system processes customers when they enter system in model 1. Secondly, I will illustrate the design of the simulation in WEBGPSS codes and give some notes to explain the codes.

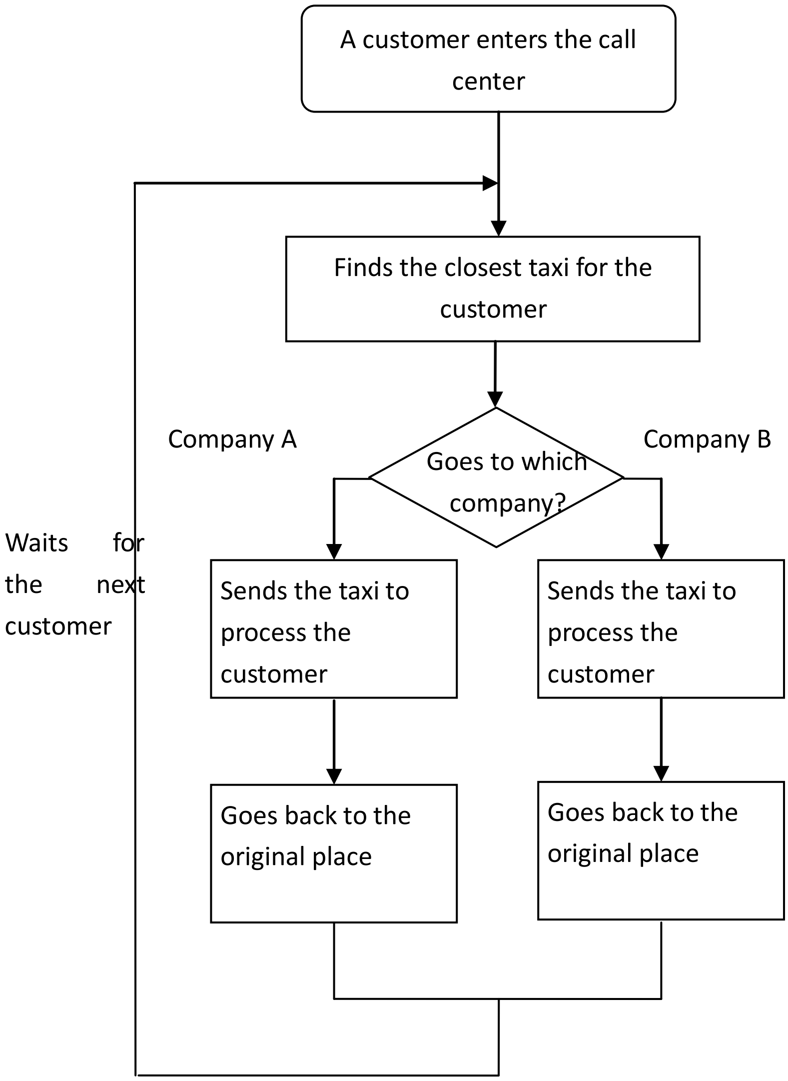
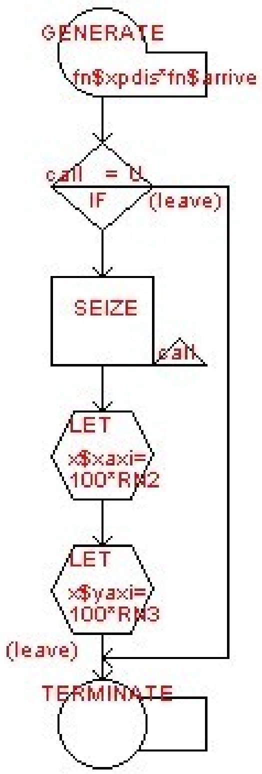


Figure 3: The process of simulation in model 1

In the simulation model in WEBGPSS different segments are used to represent different functions. I have some explanations to our simulation model using

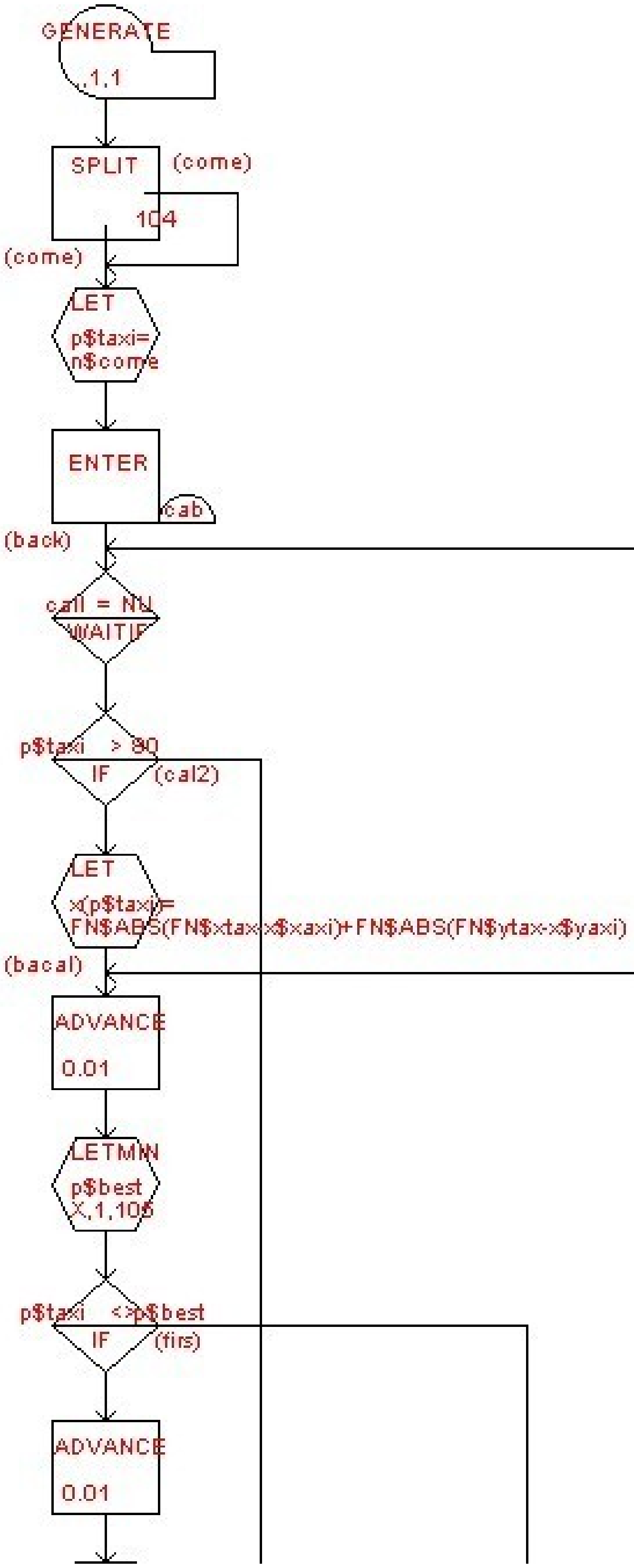
WEBGPSS language in the following part. (Explanations are given after some of the command codes, spaced by symbol "!") Only the codes of the model 1 are discussed here, where I assume all the customers have no specific preference over any of the two companies by default.

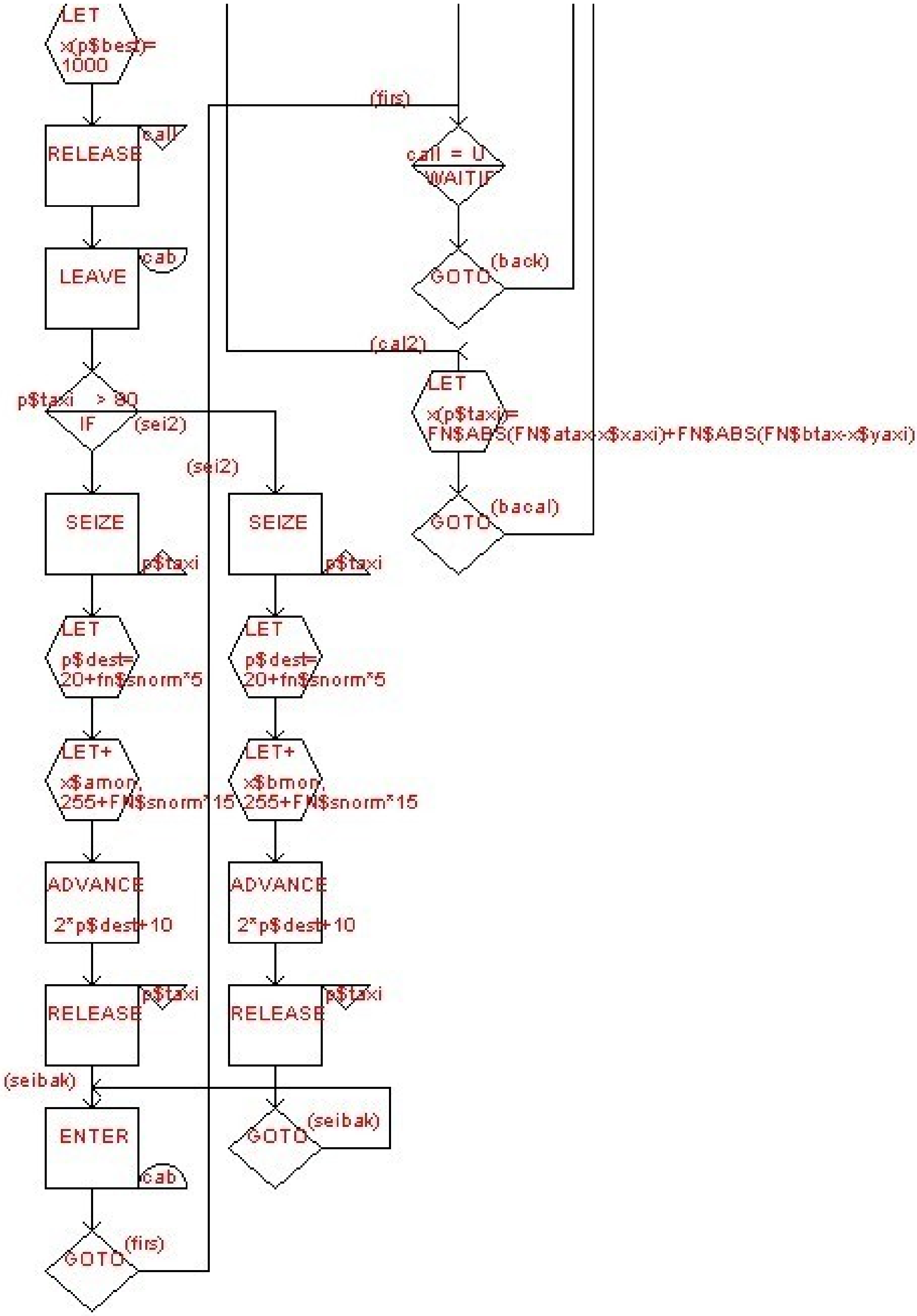
- The first segment is designed to describe the arrival pattern of the customers. The codes are below:




```
          GENERATE fn$xpdis*fn$arrive      ! The arrival pattern of the customers
           IF call=U,leave
           SEIZE call ! The customer is seized by the call center
           LET x$xaxi=100*RN2 !The position of the customers (X-axis)
           LET x$yaxi=100*RN3 ! The position of the customers (Y-axis)
leave     TERMINATE
```

- The second segment is designed to find out the closest taxicab for the customer and send the taxicab to process the customer. The codes are below:


GENERATE
,1,1
SPLIT
104
(come)
(come)
LET
p$taxi=
n$come
ENTER
cab
(back)
call = NU
WAITIF
p$taxi > 80
IF
(cal2)
LET
x(p$taxi)=
FN$ABS(FN$xtax-x$xaxi)+FN$ABS(FN$ytax-x$yaxi)
(bacal)
ADVANCE
0.01
LETMIN
p$best
X,1,105
p$taxi <>p$best
IF
(firs)
ADVANCE
0.01



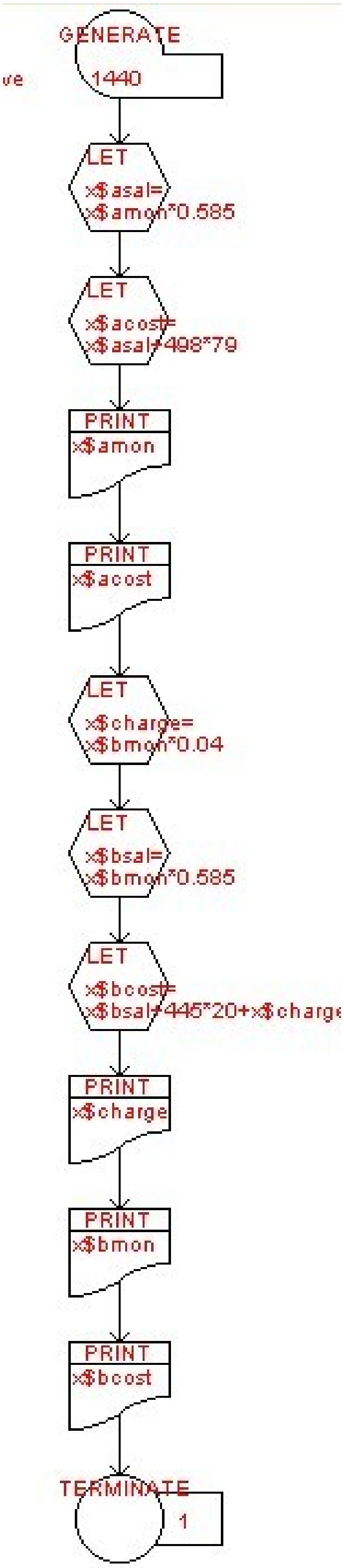

```
        GENERATE ,,1,1
        SPLIT 104,come ! In total 105 taxicabs are in the system.
come    LET p$taxi=n$come ! Assign a number to every taxicab.
        ENTER cab
```

```
back     WAITIF call=NU ! The taxicab waits if there is no customer in the system.
         IF p$taxi>80,cal2
         LET    x(p$taxi)=FN$ABS(FN$xtax-x$xaxi)+FN$ABS(FN$ytax-x$yaxi)    !
         Calculate the distance between the customer and the taxi.
bacal    ADVANCE 0.01
         LET p$best=MIN,X,1,105 ! Find out the closest taxicab.
         IF p$taxi<>p$best,firs
         ADVANCE 0.01
         LET x(p$best)=1000
         RELEASE call
         LEAVE cab
         IF p$taxi>80,sei2
         SEIZE p$taxi ! Set the closest taxicab occupied.
         LET p$dest=20+fn$snorm*5 ! The time of a trip.
         LET+ x$amon,255+FN$snorm*15 ! The income of a trip.
         ADVANCE 2*p$dest+10
         RELEASE p$taxi !The taxicab finishes serving the customers.
seibak   ENTER cab
         GOTO firs
firs      WAITIF call=U  ! (Loc: -9,+2)
         GOTO back ! The taxicab goes back to the original point and waits for the
next customer.
cal2         LET x(p$taxi)=FN$ABS(FN$atax-x$xaxi)+FN$ABS(FN$btax-x$yaxi)
         GOTO bacal
sei2      SEIZE p$taxi     ! (Loc: +0,-1)
         LET p$dest=20+fn$snorm*5
         LET+ x$bmon,255+FN$snorm*15
         ADVANCE 2*p$dest+10
         RELEASE p$taxi
         GOTO seibak
```

- The third segment is designed to generate a report at the end of a day. The codes are below:

```
GENERATE 1440 ! At the end of each day.
LET x$asal=x$amon*0.585 ! Calculate the salary of Company A.
LET x$acost=x$asal+498*79 ! Calculate the total cost of Company A.
PRINT x$amon ! Print the total revenue of Company A.
PRINT x$acost ! Print the total cost of Company A.
LET x$charge=x$bmon*0.04 ! Calculate the 4% charge on Company B.
LET x$bsal=x$bmon*0.585 ! Calculate the salary of Company B.
LET x$bcost=x$bsal+445*20+x$charge ! Calculate the total cost of Company
B.
```

PRINT x$charge !Print the 4% charge on Company B.
PRINT x$bmon ! Print the total revenue of Company B.
PRINT x$bcost ! Print the total cost of Company B.
TERMINATE 1 ! Finish one simulation run.



The three above-mentioned segments are also applied as the basic parts in most of the simulation models in this thesis. More codes about the other simulation models can be found in the appendix.

4. Simulation

4.1 Model 1: Scale Simulation

In the first model I 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 the size of Bergen Taxi. The third one assumes that the total market demand fluctuates 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 I 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. I also conduct a sensitivity test to investigate whether in such a situation the "weak preference for the bigger company" assumption has a significant impact on our model.

  An implied assumption in this simulation is that the market size does 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 is the same.

- The second simulation aims to test how the change of the size of Bergen Taxi affects 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 3 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 comprised of only three parts, as discussed in assumption 5 (i.e., the depreciation cost, the charge for the call center and the wage cost.) Hence, the "profit" here is not the true profit, but the result before administrative cost, gasoline expenses and other costs not included in the model. I denote it as "profit" for convenience purpose only. In the current situation, the revenue per day for Norgestaxi is 432,000 NOK[5] while for Bergen Taxi it is 1,436,000 NOK. The cost makes 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 3: 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.

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

For technical reasons I need to use two ways of allocating the taxicabs in this simulation when I increase the number of taxi cabs, where one is using 5*5 matrix and the other is using 5*6 matrix. Thus, I get two slightly different results of the 100% scale, as shown in the table 3. That is to say, the differences are caused by the design of the simulation where it is necessary to reassign the position of the taxi cabs.

However, since both simulations give a 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 3 is 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 4: Adjusted results for both taxi companies of the scale simulation.

Table 4 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 reduces while that of Bergen Taxi increases. The increased revenue of Bergen Taxi is 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 helps 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 increases while the profit of Bergen Taxi reduces because it suffers the customer loss.

I 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.

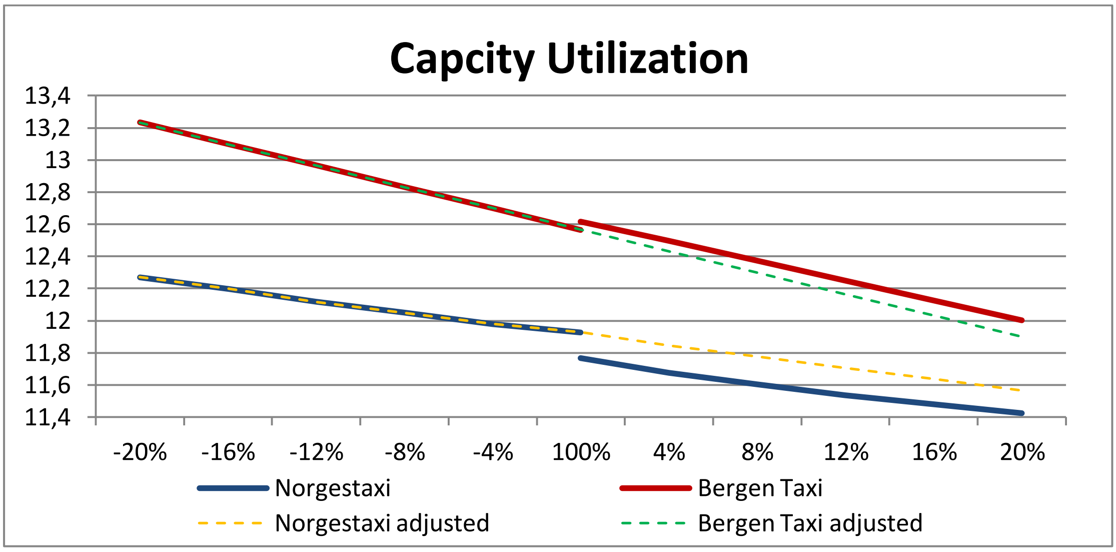


Figure 4: The capacity utilization of both companies

The analysis above can also be proved by the data of the capacity utilization. I 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 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 I 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. I 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 5: 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 leads to a great loss of market share and the company becomes weaker in the competition.

Finally, I test whether the “weak preference for the bigger company” assumption has 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. I find that the revenue for Norgestaxi only increases marginally if the customers do not have any preference for the two companies, and the change is not statistically significant for all the cases I discuss above. There could be due to two reasons why I 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 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 do 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 6: T-test result

Constant size in Norgestaxi, varying size in Bergen Taxi

The table in Table 7 shows the second simulation result when the number of taxicabs for Bergen Taxi is set to be 76%, 81%, 110% and 120% of the current level respectively.

As expected, Norgestaxi 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 does not lose too many customers to Norgestaxi. Another factor is that reducing taxicabs helps 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 helps 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 6 in the chapter 2. These factors may help Bergen Taxi to increase its profit, as revealed in the simulation result below.

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 7: 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.

However, when Bergen Taxi tries to increase the taxicabs, results show that Norgestaxi suffers great lost for that. For example, when Bergen Taxi have 20% more taxicabs, the revenue for Norgestaxi decreases from 432,000 NOK to 318,000 NOK per day, and the profit decreases 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 Noregestaxi

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 has 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 8: 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, I find that about 63.1% of the increased revenue goes to Bergen Taxi while 36.9% goes to Norgestaxi, and these two figures keep stable in all the scenarios I simulate.

4.2 Model 2: Improved Market Share Simulation

The second simulation aims at exploring the influence of an improved customer recognition and market share on the operation 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, I hold the same assumption as in the first model that the customers generally do not have preferences. They get onto the taxicabs which are closest to them, except when there are two taxicabs at the same distance to a customer, the customer will choose the bigger company, Bergen Taxi.

For the second group, I assume that the customers have preferences when they call to order a taxicab. This can be due to many aspects. Customers may have different perceptions of the service quality of the two companies (e.g., shorter waiting time). It may be due to customer recognition. For instance, 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 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, I test the model and find that among the customers who order taxicabs by phone, 22.3% choose Norgestaxi and the rest choose Bergen Taxi. I, therefore, use 22.3% as the basis for our test. I increase the proportion by 1% every time to explore the income changes.

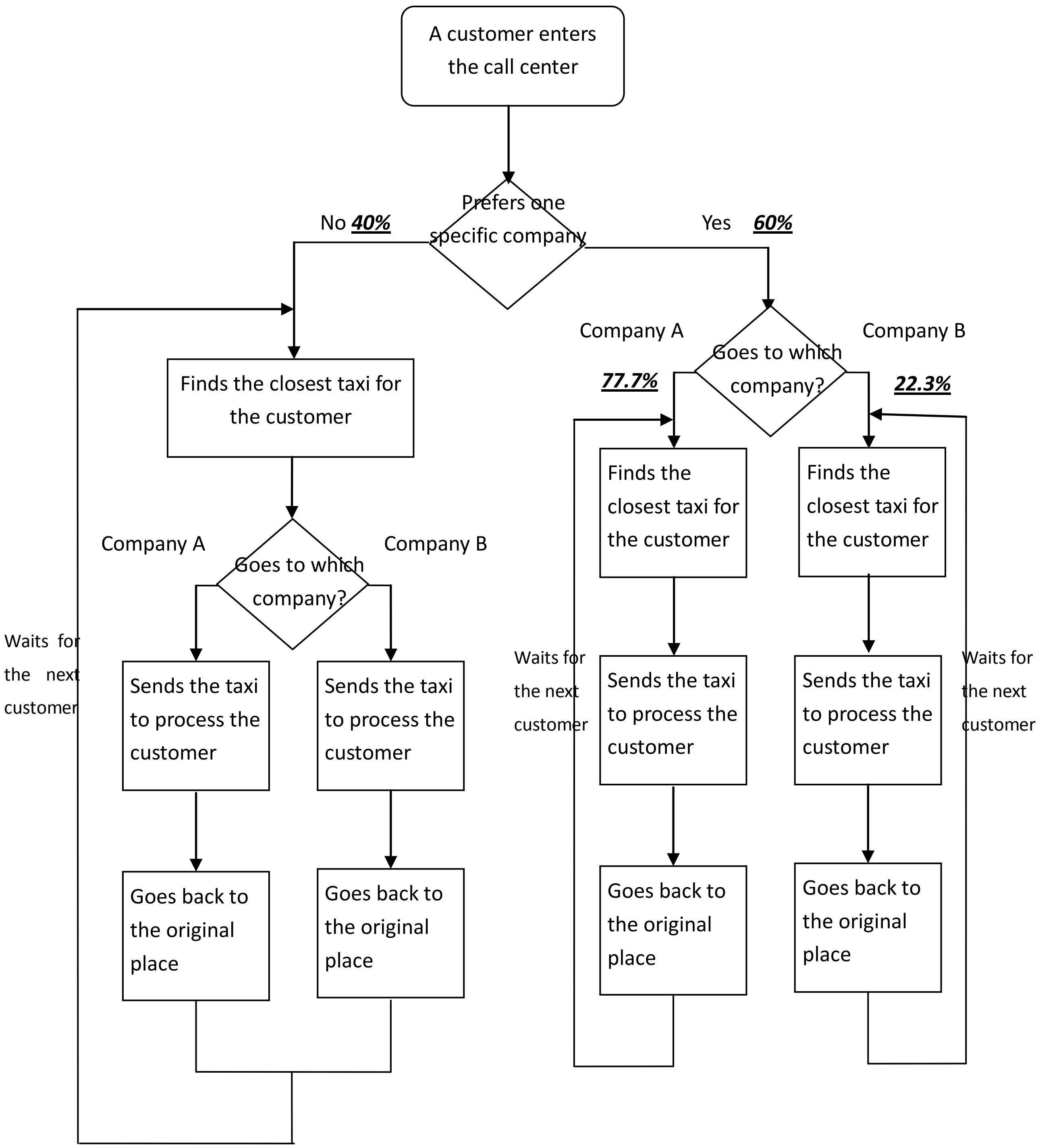


Figure 5: The process of simulation in model 2

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. I assume that this increase can be induced by a marketing campaign. It can be achieved through other ways, for instance, improving service quality and reducing waiting time. I use marketing campaign as an example and the same results can be interpreted in the same way if we assume it is a service improvement that induces the higher customer recognition.

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 benefits significantly from higher customer recognition and Bergen Taxi suffers 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 9: 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 increases from 431,000 NOK to 470,000 NOK per day and the profit increases 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 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)

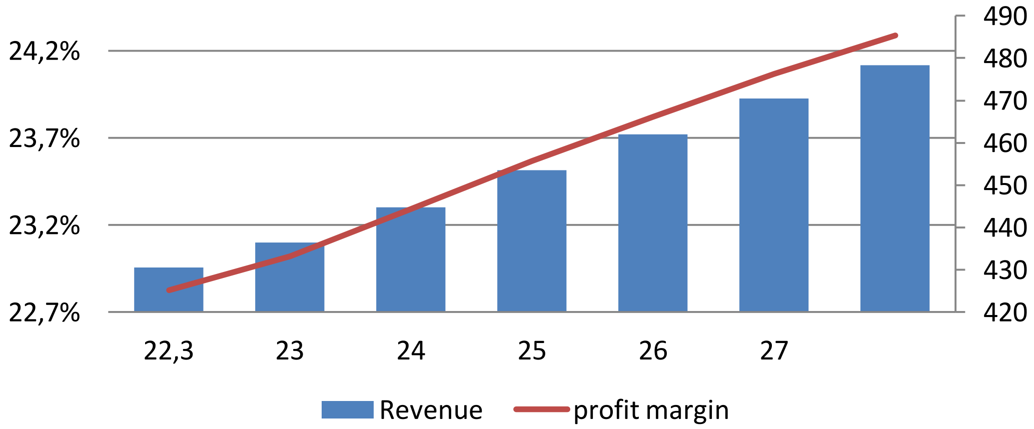


Figure 6: The change of revenue and gross margin for Norgestaxi in the promotion simulation

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 I 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.

The same intuition applies if we assume that the improved telephone-ordering market share is achieved in other ways, such as an effort to improve service and reduce waiting time. Then the simulation results can be interpreted as a basis for the cost-benefit analysis for such an effort. If a service-improving effort is estimated to be able to increase the market share by a certain amount, and the increased revenue (estimated through simulation) is able to cover its cost, such an effort should be implemented.

I focus primarily on the revenue here because the "profit" I 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.

4.3 Model 3: Airport Group Simulation

The third simulation looks specifically at the customers from the airport. I 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 arrives after 7 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, I assume both company 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 I differentiate the average expense for the two groups of customers. I assume that expenses of the customers from the airport follow a normal distribution with the mean equal to 320NOK and the standard deviation

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

5. The trips from the airport also consume more time. I 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 standard deviation equal to 3. The time used by the city taxicabs follows a normal distribution with the mean equal to 20 min (one way) and standard deviation 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. I 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 drops dramatically. This also implies the importance of the customers from the airport for the taxi business.

Unit: 1000 NOK (per day)

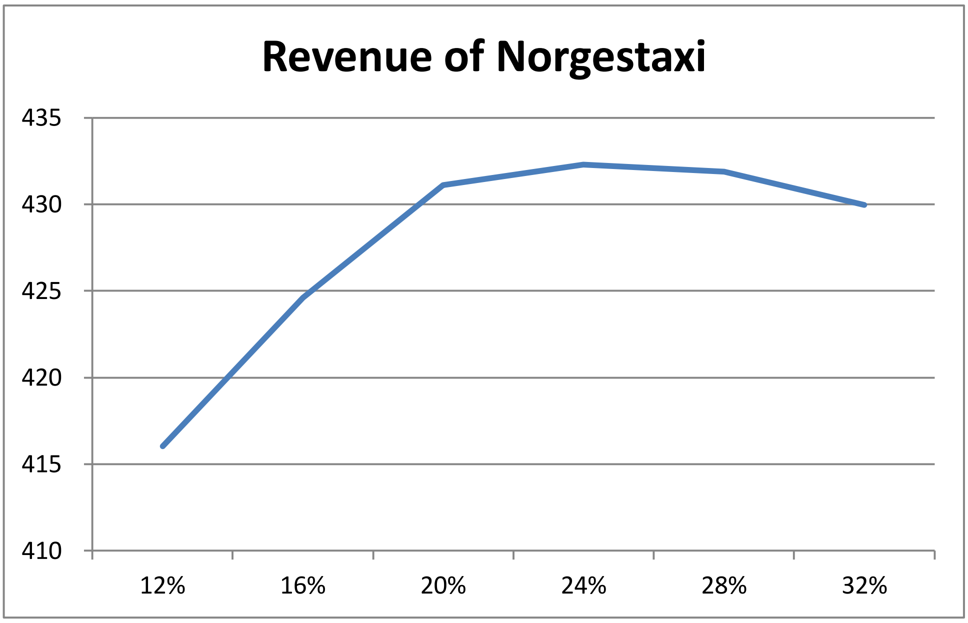


Figure 7: The change of revenue in the airport group simulation

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 10: 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

I 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 is 30% higher. Based our model, I 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 I assume the average fare per trip during these 6 hours is 272 NOK[6].

[6] 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

The simulation result is summarized as follows. It compares the cases when 80% 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 increases 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 decreases 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 center 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 helps 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 11: The operation result from 1 a.m. to 7 a.m.

4.4 Model 4: Company Size Simulation

The fourth model investigates the cases when both companies have similar sizes. I 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 center, (i.e., Bergen Taxi and Norgestaxi). Hence, I use the same model as model 1 while the only difference 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. I 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 equally share the market (i.e., each company gets a daily revenue of about 935, 000 NOK). The profit margin of Norgestaxi is slightly less because of our setting of the telephone charge. The comparison is more interesting when customers' preferences are involved. I 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. I take into account two possible modes regarding the competition between Norgestaxi and Bergen Taxi. I 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. I 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. I 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)

		No 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 12: 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 is 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 NOK, 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. I 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 13: The operation result when taxi companies are of similar size i.e., 60:40

Bergen Taxi has 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 benefits less from economies of scale.

4.5 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.

I assume the average time per trip (one way) from the fixed-contract customers follows a normal distribution with mean time equal to 20min, standard deviation 5. The average earning also follows a normal distribution with the average earning of 255 NOK, standard deviation 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% go to Bergen Taxi and 20% go to Norgestaxi. In the first simulation, I test the variation of operating results when the proportion is changed under the current circumstance. I test the cases when Norgestaxi gets 20%, 40%, 60% and 80% of the contracted customers respectively.

In the second simulation I investigate 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 14: 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 I set Norgestaxi getting 80% of contracted customers. 7 of the 180 runs in the simulation stop running, which shows that Norgestaxi is not 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 this overloading problem.

Fixed-contract simulation when Bergen Taxi has less scale advantage

In the second simulation, I further investigate the influence of the fixed contracts when Bergen Taxi has no or less scale advantage. In particular, I 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 15: 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 16: The operation result of fixed contract when taxi companies are of similar size i.e., 60:40

4.6 Model 6: Market Growth

The sixth simulation is a sensitivity test on whether the taxi market growth affects the operation of both companies. In this model, I 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 17: Results of the market growth simulation assuming no change in the number of taxis

As expected, the table above shows that Bergen Taxi benefits 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, having more customers increases 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 18: Results of size adjustment by Norgestaxi (including the market growth factor)

5. Conclusion

5.1 Summary

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

- In the scale simulation (Model 1), I provide a cost range for Norgestaxi as a reference for the optimal scale decision. Norgestaxi can estimate its operating costs per taxi per day and decide whether to increase its taxicab number or not. In addition, I find that Norgestaxi benefits from the size reduction of Bergen Taxi, and suffers from its competitor's size increase.

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

- In the improved market recognition simulation (Model 2), I simulate the additional revenue that Norgestaxi can obtain through a potential marketing campaign designed to increase its market recognition. Results show that Norgestaxi may benefit greatly through appropriate promotion, if it succeeds in improving customer recognition.

- The impact of the market campaign can also be analogous to any efforts that can induce an increase in brand recognition and telephone-ordering market share, such as an effort to reduce customer waiting and improve service quality. The simulation results show the benefits of such efforts and can be used in cost-benefit analysis.

- 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 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, I find that the revenue growth brought by a higher share of fixed contract is huge. However, the capacity of Norgestaxi limits its ability to compete for such contracts. I estimate the revenue growth to provide a basis for Norgestaxi's decision-making.

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

5.2 Limitation and Future Work

The models applied in this study investigate the taxi business in Bergen from the perspective of Norgestaxi. The data for these models are mainly given by Norgestaxi. Hence, it is possible that the data I use might not well reflect the real situation of the taxi business in Bergen.

There are also some limitations existing in the process of model design. Some of the assumptions I make might be less realistic.

- First, the taxicabs from each company are assumed to be distributed evenly in the whole city. However, in reality a large part of the taxicabs are concentrated in some areas, for example, the city center, where there are more customers.

- Second, it is also assumed that the customers arrive in the system at any point with equal chance. In reality, customer demand is concentrated in some areas.

- Third, the taxicabs in the system are set to go back to its original point after serving the customers, which to some extent is realistic in the Bergen taxi business. However, some taxi drivers actually might choose some other points where they expect more customers. This assumption also excludes the possibility that the taxi driver might have a chance to get a new customer right after one service.

  The simplification may lead to a problem, which is illustrated as follows. The only criterion for the customers to choose taxicabs in some models is the "distance". A customer chooses a taxicab when it is closest to him/her. Since the larger company always has more taxicabs, the distribution of its taxicabs is more intensive. Hence, the taxicabs from the bigger company have a higher chance to get the customers. The simulation results also prove this. The number of trips per taxicab for company A is always larger than that for company B. So does the gross margin. This might reflect the fact that the bigger company has scale advantage. However, it also excludes the possibility that the smaller company might achieve higher taxicabs utilization through a better arrangement of its taxi fleet. Since I only get the data from Norgestaxi, it is difficult to prove this point.

- Fourth, even though the dynamic demand for the taxi service is taken into account in this simulation, more work could be done. Because of the limitation of the simulation language, the model simply divides the demand into three situations, which causes the demand curve in the simulation to be much flatter than the actual demand curve. In my simulation, the results show that the taxicabs for both companies are able to handle the customer at any time of the day. However, it is entirely possible that the demand for the taxi service is larger than the supply in some rush hours and there can be more detailed modeling on that.

5.3 Future Work

This study models the taxi business in Bergen and gives advices for Norgestaxi based on the simulation results. However, the model is only a simplification of the real taxi business. It leaves room for future work in order to get a more realistic simulation of the taxi business.

First, more detailed data could be collected, such as the distribution of the taxi fleet and the customers in the city. Second, other costs of the taxi operation, such as gasoline expenses, could be taken into account to get a better analysis. Since I do not have access to such data, I cannot make a more accurate estimate. Third, more exploration on the taxi-drivers' behavior could be done. It is possible that the taxi-drivers may become more aware of the arrival pattern through learning and know how to choose better positions for themselves to pick up more customers. This requires more investigation of the drivers' behavior and modeling of their learning ability.

6. Appendixes

6.1 Codes to Allocate the Taxicabs for Both Companies

```
xtax FUNCTION p$taxi,C

1 5

2 15

3 25

4 35

5 45

6 55

7 65

8 75

9 85

10 95

11 5

12 15

13 25

14 35

15 45

16 55

17 65

18 75
```

19 85

20 95

21 5

22 15

23 25

24 35

25 45

26 55

27 65

28 75

29 85

30 95

31 5

32 15

33 25

34 35

35 45

36 55

37 65

38 75

39 85

40 95

41 5

42 15

43 25

44 35

45 45

46 55

47 65

48 75

49 85

50 95

51 5

52 15

53 25

54 35

55 45

56 55

57 65

58 75

59 85

60 95

61 5

62 15

63 25

64 35

65 45

66 55

67 65

68 75

69 85

70 95

71 5

72 15

73 25

74 35

75 45

76 55

77 65

78 75

79 85

80 95

ytax FUNCTION p$taxi,C

1 6.25

2 6.25

3 6.25

4 6.25

5 6.25

6 6.25

7 6.25

8 6.25

9 6.25

10 6.25

11 18.75

12 18.75

13 18.75

14 18.75

15 18.75

16 18.75

17 18.75

18 18.75

19 18.75

20 18.75

21 31.25

22 31.25

23 31.25

24 31.25

25 31.25

26 31.25

27 31.25

28 31.25

29 31.25

30 31.25

31 43.75

32 43.75

33 43.75

34 43.75

35 43.75

36 1000

37 43.75

38 43.75

39 43.75

40 43.75

41 56.25

42 56.25

43 56.25

44 56.25

45 56.25

46 56.25

47 56.25

48 56.25

49 56.25

50 56.25

51 68.75

52 68.75

53 68.75

54 68.75

55 68.75

56 68.75

57 68.75

58 68.75

59 68.75

60 68.75

61 81.25

62 81.25

63 81.25

64 81.25

65 81.25

66 81.25

67 81.25

68 81.25

69 81.25

70 81.25

71 93.75

72 93.75

73 93.75

74 93.75

75 93.75

76 93.75

77 93.75

78 93.75

79 93.75

80 93.75

atax FUNCTION p$taxi,C

81 10

82 30

83 50

84 70

85 90

86 10

87 30

88 50

89 70

90 90

91 10

92 30

93 50

94 70

95 90

96 10

97 30

98 50

99 70

100 90

101 10

102 30

103 50

104 70

105 90

btax FUNCTION p$taxi,C

81 10

82 10

83 10

84 10

85 10

86 30

87 30

88 30

89 30

90 30

91 50

92 50

93 50

94 50

95 50

96 70

97 70

98 70

99 70

100 70

101 90

102 90

103 90

104 90

105 90

6.2 Codes for Model 2

arrive FUNCTION cl,D

```
360 1.12

900 1.05

1440 1.13

whtogo FUNCTION x$choice,C

1 stree

2 bercom

3 norcom

choice FUNCTION RN3,R

1 40

2 46.62

3 13.38

cab CAPACITY 105

cab2 CAPACITY 12

        GENERATE ,,1,1  ! (Loc: -9,+0)

        SPLIT 104,come

come    LET p$taxi=n$come

        ENTER cab

back    WAITIF call=NU

        IF p$taxi>80,cal2

        LET x(p$taxi)=FN$ABS(FN$xtax-x$xaxi)+FN$ABS(FN$ytax-x$yaxi)

bacal   ADVANCE 0.01

        GOTO fn$whtogo
```

```
bercom   LET p$best=MIN,X,1,80
         GOTO huiju
norcom   LET p$best=MIN,X,81,105
         GOTO huiju
stree    LET p$best=MIN,X,1,105
huiju    IF p$taxi<>p$best,firs
         ADVANCE 0.01
         LET x(p$best)=1000
         RELEASE call
         LEAVE cab
         IF p$taxi>80,sei2
         SEIZE p$taxi ! (Loc: +5,+2)
         LET p$dest=20+fn$snorm*5
         LET+ x$amon,255+FN$snorm*15
         ADVANCE 2*p$dest+10
         RELEASE p$taxi
seibak   ENTER cab
         GOTO firs
firs  WAITIF call=U      ! (Loc: -9,+2)
         GOTO back
cal2 LET x(p$taxi)=FN$ABS(FN$atax-x$xaxi)+FN$ABS(FN$btax-x$yaxi)
         GOTO bacal
```

```
sei2 SEIZE p$taxi ! (Loc: +0,-6)
        LET p$dest=20+fn$snorm*5
        LET+ x$bmon,255+FN$snorm*15
        ADVANCE 2*p$dest+10
        RELEASE p$taxi
        GOTO seibak


        GENERATE fn$xpdis*fn$arrive   ! (Loc: +1,-8)
        IF call=U,leave
        SEIZE call
        LET x$choice=fn$choice
        LET x$xaxi=100*RN2
        LET x$yaxi=100*RN3
leave   TERMINATE


        GENERATE 1440
        LET x$asal=x$amon*0.585
        LET x$acost=x$asal+498*79
        PRINT x$amon
        PRINT x$acost
        LET x$charge=x$bmon*0.04
        LET x$bsal=x$bmon*0.585
```

```
    LET x$bcost=x$bsal+445*25+x$charge
    PRINT x$charge
    PRINT x$bmon
    PRINT x$bcost
    TERMINATE 1

START 1
END
```

6.3 Codes for Model 3

```
arrive FUNCTION cl,D
360 1.12
900 1.37
1440 1.53
airp FUNCTION cl,D
900 4.55
1440 4.3
cab CAPACITY 84
cab2 CAPACITY 20
btaxi CAPACITY 5
    GENERATE ,,1,1  ! (Loc: -9,+0)
    SPLIT 83,come
```

```
come      LET p$taxi=n$come
          ENTER cab
back      WAITIF call=NU
          IF p$taxi>64,cal2
          LET x(p$taxi)=FN$ABS(FN$xtax-x$xaxi)+FN$ABS(FN$ytax-x$yaxi)
bacal     ADVANCE 0.01
          LET p$best=MIN,X,1,84
          IF p$taxi<>p$best,firs
          ADVANCE 0.01
          LET x(p$best)=1000
          RELEASE call
          LEAVE cab
          IF p$taxi>64,sei2
          SEIZE p$taxi
          LET+ x$amon,240+FN$snorm*15
          LET p$dest=20+fn$snorm*5
          ADVANCE 2*p$dest+10
          RELEASE p$taxi
seibak    ENTER cab
          GOTO firs
firs  WAITIF call=U       ! (Loc: -9,+2)
          GOTO back
```

```
cal2 LET x(p$taxi)=FN$ABS(FN$atax-x$xaxi)+FN$ABS(FN$btax-x$yaxi)

     GOTO bacal

sei2 SEIZE p$taxi ! (Loc: +0,-1)

     LET+ x$bmon,240+FN$snorm*15

     LET p$dest=20+fn$snorm*5

     ADVANCE 2*p$dest+10

     RELEASE p$taxi

     GOTO seibak



     GENERATE fn$xpdis*fn$airp,,361

     SEIZE queue

     TERMINATE



     GENERATE 0.01,,,20

inn  LET p$taxi=n$inn+84

     ADVANCE 0.1

     ENTER cab2

airp WAITIF queue=NU

     LEAVE cab2

     RELEASE queue

     IF p$taxi>99,line2

     SEIZE p$taxi
```

```
        LET p$dest=30+fn$snorm*3
        LET+ x$aair,320+FN$snorm*15
        ADVANCE 2*p$dest
        RELEASE p$taxi
bline   ENTER cab2
        GOTO airp
line2   SEIZE p$taxi  ! (Loc: -5,+2)
        ENTER btaxi
        LET p$dest=30+fn$snorm*3
        LET+ x$bair,320+FN$snorm*15
        ADVANCE 2*p$dest
        LEAVE btaxi
        RELEASE p$taxi
        GOTO bline


        GENERATE fn$xpdis*fn$arrive   ! (Loc: +1,-8)
        IF call=U,leave
        SEIZE call
        LET x$xaxi=100*RN2
        LET x$yaxi=100*RN3
leave   TERMINATE
```

```
    GENERATE 1440
    LET x$asal=(x$amon+x$aair)*0.585
    LET x$acost=x$asal+498*79
    PRINT 'amon',x$amon+x$aair
    PRINT x$acost
    LET x$charge=(x$bmon+x$bair)*0.04
    LET x$bsal=(x$bmon+x$bair)*0.585
    LET x$bcost=x$bsal+445*25+x$charge
    PRINT x$charge
    PRINT 'bmon',x$bmon+x$bair
    PRINT x$bcost
    TERMINATE 1

START 1
END
```

6.4 Codes for Model 4

6.4.1 Scale Size, i.e., 50:50

```
arrive FUNCTION cl,D
360 1.12
900 1.05
1440 1.13
```

```
cab CAPACITY 100

cab2 CAPACITY 12

      GENERATE ,,1,1  ! (Loc: -9,+0)

      SPLIT 99,come

come      LET p$taxi=n$come

      ENTER cab

back      WAITIF call=NU

      IF p$taxi>50,cal2

      LET x(p$taxi)=FN$ABS(FN$xtax-x$xaxi)+FN$ABS(FN$ytax-x$yaxi)

bacal      ADVANCE 0.01

      LET p$best=MIN,X,1,100

      IF p$taxi<>p$best,firs

      ADVANCE 0.01

      LET x(p$best)=1000

      RELEASE call

      LEAVE cab

      IF p$taxi>50,sei2

      SEIZE p$taxi

      LET p$dest=20+fn$snorm*5

      LET+ x$amon,255+FN$snorm*15

      ADVANCE 2*p$dest+10

      RELEASE p$taxi
```

```
seibak    ENTER cab
          GOTO firs
firs  WAITIF call=U      ! (Loc: -9,+2)
          GOTO back
cal2 LET x(p$taxi)=FN$ABS(FN$atax-x$xaxi)+FN$ABS(FN$btax-x$yaxi)
          GOTO bacal
sei2 SEIZE p$taxi ! (Loc: +0,-1)
          LET p$dest=20+fn$snorm*5
          LET+ x$bmon,255+FN$snorm*15
          ADVANCE 2*p$dest+10
          RELEASE p$taxi
          GOTO seibak

          GENERATE fn$xpdis*fn$arrive   ! (Loc: +1,-8)
          IF call=U,leave
          SEIZE call
          LET x$xaxi=100*RN2
          LET x$yaxi=100*RN3
leave     TERMINATE

          GENERATE 1440
          LET x$asal=x$amon*0.585
```

```
    LET x$acost=x$asal+498*50

    PRINT x$amon

    PRINT x$acost

    LET x$charge=x$bmon*0.04

    LET x$bsal=x$bmon*0.585

    LET x$bcost=x$bsal+445*50+x$charge

    PRINT x$charge

    PRINT x$bmon

    PRINT x$bcost

    TERMINATE 1


START 1

END
```

6.4.2 Scale Size, i.e., 60:40

```
arrive FUNCTION cl,D

360 1.12

900 1.05

1440 1.13

cab CAPACITY 100

cab2 CAPACITY 12

    GENERATE ,,1,1  ! (Loc: -9,+0)
```

```
        SPLIT 99,come
come    LET p$taxi=n$come
        ENTER cab
back    WAITIF call=NU
        IF p$taxi>60,cal2
        LET x(p$taxi)=FN$ABS(FN$xtax-x$xaxi)+FN$ABS(FN$ytax-x$yaxi)
bacal   ADVANCE 0.01
        LET p$best=MIN,X,1,100
        IF p$taxi<>p$best,firs
        ADVANCE 0.01
        LET x(p$best)=1000
        RELEASE call
        LEAVE cab
        IF p$taxi>60,sei2
        SEIZE p$taxi
        LET p$dest=20+fn$snorm*5
        LET+ x$amon,255+FN$snorm*15
        ADVANCE 2*p$dest+10
        RELEASE p$taxi
seibak  ENTER cab
        GOTO firs
firs    WAITIF call=U       ! (Loc: -9,+2)
```

```
      GOTO back
cal2 LET x(p$taxi)=FN$ABS(FN$atax-x$xaxi)+FN$ABS(FN$btax-x$yaxi)
      GOTO bacal
sei2 SEIZE p$taxi ! (Loc: +0,-1)
      LET p$dest=20+fn$snorm*5
      LET+ x$bmon,255+FN$snorm*15
      ADVANCE 2*p$dest+10
      RELEASE p$taxi
      GOTO seibak

      GENERATE fn$xpdis*fn$arrive   ! (Loc: +1,-8)
      IF call=U,leave
      SEIZE call
      LET x$xaxi=100*RN2
      LET x$yaxi=100*RN3
leave     TERMINATE

      GENERATE 1440
      LET x$asal=x$amon*0.585
      LET x$acost=x$asal+498*60
      PRINT x$amon
      PRINT x$acost
```

```
    LET x$charge=x$bmon*0.04

    LET x$bsal=x$bmon*0.585

    LET x$bcost=x$bsal+445*40+x$charge

    PRINT x$charge

    PRINT x$bmon

    PRINT x$bcost

    TERMINATE 1


START 1

END
```

6.5 Codes for Model 5

```
arrive FUNCTION cl,D

360 1.12

900 1.05

1440 1.13

whtogo FUNCTION x$choice,C

1 stree

2 bercom

3 norcom

choice FUNCTION RN3,R

1 40
```

```
2 43.76

3 16.24

cab CAPACITY 105

cab2 CAPACITY 12

        GENERATE ,,1,1  ! (Loc: -9,+0)

        SPLIT 104,come

come    LET p$taxi=n$come

        ENTER cab

back    WAITIF call=NU

        IF p$taxi>80,cal2

        LET x(p$taxi)=FN$ABS(FN$xtax-x$xaxi)+FN$ABS(FN$ytax-x$yaxi)

bacal   ADVANCE 0.01

        GOTO fn$whtogo

bercom  LET p$best=MIN,X,1,80

        GOTO huiju

norcom  LET p$best=MIN,X,81,105

        GOTO huiju

stree   LET p$best=MIN,X,1,105

huiju   IF p$taxi<>p$best,firs

        ADVANCE 0.01

        LET x(p$best)=1000

        RELEASE call
```

```
      LEAVE cab
      IF p$taxi>80,sei2
      SEIZE p$taxi ! (Loc: +5,+2)
      LET p$dest=20+fn$snorm*5
      LET+ x$amon,255+FN$snorm*15
      ADVANCE 2*p$dest+10
      RELEASE p$taxi
seibak    ENTER cab
      GOTO firs
firs  WAITIF call=U      ! (Loc: -9,+2)
      GOTO back
cal2 LET x(p$taxi)=FN$ABS(FN$atax-x$xaxi)+FN$ABS(FN$btax-x$yaxi)
      GOTO bacal
sei2 SEIZE p$taxi ! (Loc: +0,-6)
      LET p$dest=20+fn$snorm*5
      LET+ x$bmon,255+FN$snorm*15
      ADVANCE 2*p$dest+10
      RELEASE p$taxi
      GOTO seibak


      GENERATE fn$xpdis*fn$arrive   ! (Loc: +1,-8)
      IF call=U,leave
```

```
        SEIZE call
        LET x$choice=fn$choice
        LET x$xaxi=100*RN2
        LET x$yaxi=100*RN3
leave   TERMINATE

        GENERATE 1440
        LET x$asal=x$amon*0.585
        LET x$acost=x$asal+498*79
        PRINT x$amon
        PRINT x$acost
        LET x$charge=x$bmon*0.04
        LET x$bsal=x$bmon*0.585
        LET x$bcost=x$bsal+445*25+x$charge
        PRINT x$charge
        PRINT x$bmon
        PRINT x$bcost
        TERMINATE 1

START 1
END
```

6.6 Codes for Model 6

```
arrive FUNCTION cl,D

360 1.1

900 1.03

1440 1.11

cab CAPACITY 105

cab2 CAPACITY 12

        GENERATE ,,1,1  ! (Loc: -9,+0)

        SPLIT 104,come

come    LET p$taxi=n$come

        ENTER cab

back    WAITIF call=NU

        IF p$taxi>80,cal2

        LET x(p$taxi)=FN$ABS(FN$xtax-x$xaxi)+FN$ABS(FN$ytax-x$yaxi)

bacal   ADVANCE 0.01

        LET p$best=MIN,X,1,105

        IF p$taxi<>p$best,firs

        ADVANCE 0.01

        LET x(p$best)=1000

        RELEASE call

        LEAVE cab

        IF p$taxi>80,sei2
```

```
        SEIZE p$taxi
        LET p$dest=20+fn$snorm*5
        LET+ x$amon,255+FN$snorm*15
        ADVANCE 2*p$dest+10
        RELEASE p$taxi
seibak  ENTER cab
        GOTO firs
firs    WAITIF call=U       ! (Loc: -9,+2)
        GOTO back
cal2 LET x(p$taxi)=FN$ABS(FN$atax-x$xaxi)+FN$ABS(FN$btax-x$yaxi)
        GOTO bacal
sei2 SEIZE p$taxi  ! (Loc: +0,-1)
        LET p$dest=20+fn$snorm*5
        LET+ x$bmon,255+FN$snorm*15
        ADVANCE 2*p$dest+10
        RELEASE p$taxi
        GOTO seibak


        GENERATE fn$xpdis*fn$arrive   ! (Loc: +1,-8)
        IF call=U,leave
        SEIZE call
        LET x$xaxi=100*RN2
```

```
        LET x$yaxi=100*RN3
leave   TERMINATE


        GENERATE 1440
        LET x$asal=x$amon*0.585
        LET x$acost=x$asal+498*79
        PRINT x$amon
        PRINT x$acost
        LET x$charge=x$bmon*0.04
        LET x$bsal=x$bmon*0.585
        LET x$bcost=x$bsal+445*25+x$charge
        PRINT x$charge
        PRINT x$bmon
        PRINT x$bcost
        TERMINATE 1


START 1
END
```

7. Reference

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