Decision support model for hub localisation

- A study at a company in the 3PL industry

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With todays' requirement of shorter product life cycles and faster time-to-market, producing companies have an increased demand for faster transports in the supply chain. This puts pressure on freight forwarders to offer their customers a timely and reliable transport service at a reasonable price. Another challenge for the freight forwarders in Sweden is to provide such services in all parts of the country. This pressure is felt by Company X, the Swedish division of one of the largest freight forwarders of road transports in Europe, and they are now facing problems in meeting the scheduled delivery time for deliveries to northern Sweden. A suggested reason for this is the lack of an evidence-based decision-making tool concerning the design of their transportation network. The purpose of this thesis is to develop a decision support model for hub localisation and to perform an analysis of the current hub location by using the model.

New Requirements Put on the Freight Forwarders

The requirements of short delivery times have increased and consumers do not want to wait too long for products to be delivered. Pressure is put on the freight forwarders who need to offer a high quality service to a reasonable price. As road transports is the most flexible transportation mode, it is used for a majority of the transports in Sweden. Moreover, the increase of road transports can be explained by the increased demand of fast and efficient transportation [1]. To accomplish a high quality service, the freight forwarders must offer its customers punctual and short delivery times to all locations in the country. In addition, this service must be provided to the customers on a daily basis. To manage this, the actors in the 3PL industry must identify a suitable design for their transportation network. Furthermore, with the customers' shifting demand patterns together with the typicality of Sweden's geography and demography, it becomes even more difficult to ensure a well-planned network design. This since the distances between sender and receiver can be large, but also since the demand of transportation services vary a lot across Sweden. An important part of the development of the network design is to locate hubs which can support the existing terminals in the network.

Company X's Quality of Service Issue

The issue of offering a high quality service at a reasonable price is also experienced by the focus company of this study, Company X. With the recent change in the site managers' area of responsibility, the company has discovered that many of the deliveries to customers in northern Sweden are not in time. This concern has visualised the fact that the company today lacks an evidence-based decision support regarding the design of the hub network. With the issue of inadequate service quality, the Company doubts the location of the main hub.

The purpose of this study is twofold; first, to develop a decision support model, which should be used to evaluate where to locate a hub, and second, to perform an analysis of the current hub localisation. The model will include the qualitative and quantitative factors that affect the localisation of a hub. These factors will be evaluated in order to find an optimal location for a hub, supporting the transportation flow.

Factors Affecting Hub Localisation

The factors affecting hub localisation at Company X were gathered through a literature review, interviews and a questionnaire. As a result, 16 factors were found. These were identified as either qualifiers, factors that each town must fulfil in order to qualify as an alternative, or parameters, factors which are wishful that the alternatives fulfil. The recognised qualifiers are presented in Table 1.

Table 1: Identified qualifiers

No.	Qualifier
1	Highway access
2	Labour availability
3	Delivery time to customers
4	Driving and rest periods
5	Environmental regulations
6	Construction feasibility

The towns can be evaluated for each qualifier by using a combination of indicators and it can then be concluded if the examined towns fulfil the qualifiers. For example, highway access can be evaluated by looking at the distance from the town to a junction point of two major roads.

The acknowledged parameters are presented in Table 2.

Table 2: Identified parameters

No.	Parameter
A	Railway access
B	Congestion
C	Living costs and family conditions
D	Location costs
E	Wages
F	Weather
G	Closeness to similar companies
H	Cost of return goods flows from northern Sweden
I	Closeness to nearby terminal to support goods handling at hub

The alternatives are, for each parameter, evaluated based on how well they fulfil the parameter compared to the other alternatives. This evaluation can be performed by using a set of indicators for each parameter. For instance, railway access can be assessed based on the closeness to a railway loading zone.

The Decision Support Model

In order to perform the analysis the model needed to be constructed. The model is aimed to be a support for decisions when evaluating where to locate a hub. According to Holme & Solvang (1997) a model needs to include all relevant parameters to be able to represent the problem situation but at the same time be simple and clear to keep the overview [2]. By reviewing the literature and discussing the model with the supervisor at Company X, a model was constructed according to Company X's desires to solve the problem. The model is based on theoretical frameworks regarding facility localisation but is also integrated with opinions from Company X. The output of the model construction phase, in other words the complete decision support model, is presented in Figure 1.

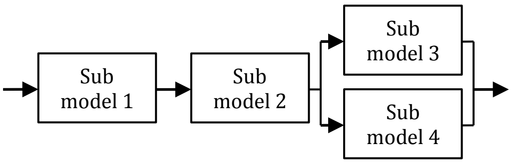

Figure 1: The outline of the decision support model

In creating the spread sheet model a number of sub models were built:

1. Completion of Centre-of-Gravity analysis
2. Identification of towns satisfying the qualifiers
3. Calculation of parameter score
4. Estimation of transportation cost

In the first sub model, a Centre-of-Gravity analysis is completed. The input data to the model are coordinates for current terminals, goods volumes per line, and cost of goods volumes per line. This results in an output, which is the centre of gravity. In the second sub model, towns in the proximity of the centre of gravity can be analysed in an iterative process according to the qualifiers. The iteration is stopped when the user have found the wished number of towns which fulfil the qualifiers. These towns are called alternatives for hub location, short alternatives, and are further evaluated in sub model 3 and 4. In the third sub model, the weight for each parameter first needs to be recognised. This is done by using the Analytical Hierarchy Process (AHP) where the parameters are pairwised compared by managers at Company X to evaluate how important they are to consider when deciding of a hub localisation. The result is presented in Table 3.

Table 3: Recognised parameter weights

No.	Parameter	Weight
A	Railway access	0.05
B	Congestion	0.31
C	Living costs and family conditions	0.21
D	Location costs	0.10
E	Wages	0.05
F	Weather	0.01
G	Closeness to similar companies	0.06
H	Cost of return goods flows from northern Sweden	0.12
I	Closeness to nearby terminal to support goods handling at hub	0.08

It can be concluded that parameter A, congestion, is the most important while parameter F, weather, is the least important for Company X. Next, the parameter score for each alternative can be calculated. The alternatives are compared in the same way with the AHP to evaluate how well they satisfy each parameter. As a result, each alternative will receive a parameter score. Next, the transportation cost for each alternative hub location can be estimated based on the input data to sub model 1. Finally, the user obtains a decision support where he or she can compare the alternatives' parameter score and transportation cost in order to decide where to locate a hub.

Current Hub Location No Longer Optimal

The result of the analysis shows that the current hub at Company X has not the best location but that there are two other alternatives; Uppsala and Gävle, which are equally good. Uppsala has the highest parameter score of 0.37 but is only slightly better than Gävle, which has a score of 0.36. Though, Gävle has the lowest transportation cost, even if it is only 1.3% lower compared to Uppsala.

However, the shortages of the model must be considered when the result is discussed. To investigate how sensitive the model is, a sensitivity analysis has been conducted. It concludes that the Centre-of-Gravity analysis is not very sensitive for changes in input data. On the other hand, the parameters' comparison values are more sensitive since the alternative with highest parameter score changes as the comparison value varies. Therefore, it is difficult to conclude the exact parameter score for the alternatives in the analysis. The transportation cost is not sensitive for changes in input data, however, the variable transportation cost in this estimation is assumed to be the same for all the alternatives. In reality this is not necessarily true, but this assumption was required to be made due to limitations in available data.

Furthermore, the evaluation of the qualifiers and parameters are made in a subjective way as the model is built this way. This is because the user decides how these factors should be evaluated. However, the evaluation performed by the authors is considered trustworthy since objective indicators were used during the analysis. In addition, the result of the evaluation was validated by the supervisor at Company X

With these aspects in mind, the output of the model is considered to be rather reliable. Moreover, since the aim of the model output is to deliver a decision support for hub localisation the parameter score and transportation cost must not be exact. It should rather give an indication to Company X of how well the alternatives suites as hub locations and can be used as a basis for further discussions.

With the resulting model output, the authors cannot make a decision of which location that is the best one. The differences between Uppsala and Gävle are too small to result in an argument for one or the other as the most optimal hub location.

To Sum Up

The developed model can be used as a support for decisions regarding hub localisation. There are a number of factors to consider when locating a hub, which are qualifiers, factors needed to be fulfilled, and parameters, factors wished to be fulfilled. It cannot be distinguished which alternative that is the best hub localisation in the current network. The difference between the alternatives Gävle and Uppsala is marginal. Though, this can be seen as an indication that the location of the current hub should be questioned. However, there are aspects that are not included in the model that need to be investigated before making a decision. It is recommended to implement the model in the organisation but also reflect on the impact of factors that were not considered in the model, due to delimitations.

References

[1] Lumsden K. 2007, *Fundamentals of Logistics*, Chalmers University of Technology, Division of Logistics and Transportation.

[2] Holme I. & Solvang B. 1997, *Forskningsmetodik – Om kvalitativa och kvantitativa metoder*, Second edition, Studentlitteratur, Lund.