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Business Intelligence and Strategic Decision Simulation

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***Abstract*—**The purpose of this study is two-fold. First, it attempts to explore potential opportunities for utilizing visual interactive simulations along with Business Intelligence (BI) as a decision support tool for strategic decision making. Second, it tries to figure out the essential top-level managerial requirements that would transform strategic decision simulation into an integral component of BI systems. The domain of particular interest was the application of visual interactive simulation capabilities in the field of supply chains.

A qualitative exploratory method was applied, through the use of interviews with two leading companies. The collected data was then analysed to demonstrate the difference between the literature perspective and the practical managerial perspective on the issue. The results of the study suggest that although the use of simulation particularly in managing supply chains is very evident in literature, yet, in practice such utilization is still in its infancy, particularly regarding strategic decisions. Based on the insights a prototype of a simulation based BI-solution-extension was developed and evaluated.

***Keywords*—**Business Intelligence; decision support; strategic decisions; simulation; SCM

I. Introduction

MANAGERS are constantly pressured to make economic decisions in an efficient and effective way. Such decisions vary in their degree of importance and complexity. The more complex the problems become, the larger the number of the variables taken into consideration, and the higher the need to rely not only on intuition and experience but also on more quantitative methods and decision support tools. The field of decision support has been continuously evolving since the 1960's. Advancements have been regularly taking place since the origin of Operations Research (OR) till the development of BI. And since decision support is a highly demanding field, more advancements are expected to come.

Reviewing literature has shown that there are very limited attempts to make use of BI capabilities of historical data analysis along with the capabilities of utilizing OR technologies such as simulations. Mainly three papers were found discussing the integration between BI and simulation, yet the suggested integration purpose was relatively different from the intended purpose of this study.

The first paper by Fazlollalhi and Vahidov, discussed the usage of Genetic Algorithms from the data mining field with Monte Carlo probabilistic simulations to improve the process of searching for and evaluating various what-if scenarios [7]. The second paper by Li et al. discussed the use of BI as a knowledge engine to drive the simulation and optimization engine used for scheduling purposes [13]. Finally, Zhang et al., described a possible synergy that can be achieved between knowledge management systems and simulation. They explained this by saying that the process of building simulation models generates organizational knowledge, which can benefit from knowledge management systems. They added that when simulations are run, valuable information is generated, which could be fed into BI systems [24]. Yet, no explicit reference was made in literature to how visual interactive simulations in particular can be used along with BI to support strategic decisions.

With the research gap recognized, the purpose of this study is to dig into the opportunities of using visual interactive simulations as a decision support tool in coordination with BI to support decisions at the strategic level. Furthermore, the study attempts to discover the managerial requirements that would bring about a successful integration of BI and visual interactive simulation. The domain of particular interest was SCM. The research questions addressed by this study are:

1) How can the use of visual interactive simulation along with BI support strategic decision making?

2) What are the requirements needed to transform strategic decision simulation into an integral component of BI systems?

This paper is organized into four main parts. First, a theoretical background covering decision making, decision support and simulation will be briefly presented. Then, the empirical research done to arrive at the purpose of this study will be outlined with focus on the research design, the data collection methods and the selection of study subjects. Afterwards, the results of the empirical research will be presented. The third part of this paper will present the developed prototypical implementation of a simulation based BI extension. Finally, some concluding remarks about the entire study will be given.

II. Theoretical Background

A. Decision Making and Decision Support

Decision making is often viewed as what managers do, as it is one of the main managerial functions described by Henry Mintzberg. Typically, the decision making process passes through three stages which are not necessarily sequential. These stages are intelligence, design and choice. Intelligence is the information gathering stage where a problem/opportunity is identified. Design is when a set of possible solutions are outlined to address the identified problem or utilize a possible opportunity. Finally, choice is when one of the designed

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solutions is selected for implementation [6]. In today's businesses, decisions are being made continuously by people at different levels in the organizational hierarchy and with different degrees of importance and criticality. This implies that decisions can be classified in terms of two dimensions, namely, scope and nature. In terms of scope, decisions are either: strategic, tactical or operational, while in terms of nature, decisions can be classified into structured, semi structured or unstructured decisions [21][14]. Regardless of which type of decision classification is used, it has been common to view the decision making style as either (being) rational or intuitive. With lots of controversies regarding the usefulness and relevance of each approach, it is believed that a mixture of both techniques with additional technological support for decision making would be most useful. Bonabeau explains that rational decisions can be made in reasonable amount of time with a combination of experience, analytical skills and supporting technological decision support tools [4].

Moving on to decision support, it is important to mention that although the meaning of decision support is simple and might seem intuitive, yet, the term usually refers to different things depending on context and time. These days, the term is usually mentioned in the context of data warehouses and Online Analytical Processing (OLAP) [10]. Ten years earlier, decision support was coined with Decision Support System (DSS). Even earlier decision support was used to refer to OR [3]. With DSS as a starting point, Power's categorizing framework will be shortly presented. This framework includes a categorization, which separates between DSSs based on the technology component that drives the decision support functionality. It classifies DSSs into five categories which are: data-driven, document-driven, model-driven, communication-driven, and knowledge-driven DSSs [16][17].

Data-driven DSSs provide their functionality through the manipulation of huge amounts of data [22]. Typical examples of data-driven DSS include: BI and OLAP [17]. On the other hand, Kopackova and Skrobaekova view BI as an umbrella term that includes not only data-driven DSS but also model-driven, knowledge-driven as well as document-driven DSS; thus excluding only communication-driven DSS from the umbrella of BI [11]. Figure 1 elaborates on this matter.

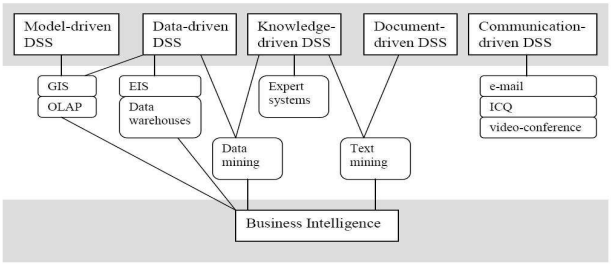

Fig. 1 Components of BI and DSS (adopted from [11])

Document-driven DSSs as opposed to data-driven DSSs utilizes unstructured documents and web pages which may entail hypertext documents, images, sound, and video. It is capable of complex retrieval and analysis of such unstructured data sources with the use of processing and storage technologies [16][17]. Moving forward, model-driven DSSs are highly dependent on complex algorithms that form the model component of the DSS [22]. Models used in model-driven DSS include: algebraic, decision analytic, financial, simulation and optimization models. These models give the decision maker the opportunity to manipulate the different parameters, which could be useful for conducting what-if analysis [17].

Knowledge-driven DSSs can also be referred to as suggestion DSS or management expert system, as they provide recommendations based on a computerized problem-solving expertise in a specific domain [16][17], with the use of artificial intelligence or statistical tools [17]. Finally, communication-driven DSS represents a category of DSS that depends on advancements in communication and information technology for supporting shared decision making [17]. Examples of communication-based DSSs include: electronic white boards, computer-based bulletin boards, chat tools, and email [16].

B. Simulation within SCM

Simulation can be defined as the process of designing models that represent a real system and then consequently using these models to conduct experiments to gain a better understanding of the modelled situation or for evaluating various courses of action [8].

There are various reasons for using simulation. Simulations can help in decisions making on strategic, tactical as well as operational levels. Some of the application areas of simulation that were found in literature include the following five categories. First, optimization, where there is an attempt to figure out the situation that yields the minimum or maximum value of a certain variable. Second, decision analysis, where two or more courses of action are compared quantitatively to determine which (if any) is most suitable; to formulate a go/no-go decision. Third, diagnostic evaluation, where there is an attempt to figure out the causes for certain recurring problems. Fourth, risk management, where the use of simulation may help in designing risk mitigation plans [9]. Finally, project planning, through searching for the best manner to implement a project in a way that minimizes costs and risks and adheres to time schedules [12]. Furthermore, Kellner et al. listed another six application areas of simulation which are: Strategic management, Planning, Process improvement and technology adoption, control and operational management, understanding and training and learning [9]. Having presented some generic application areas for simulation, it is essential to demonstrate the strong link between simulation and SCM that was found in literature. It has been stated that "simulation is often regarded as the proper means for supporting decision making on supply chain design" [23].

There are some typical supply-chain related questions that can be answered using simulation, i.e. [5]:

- Which supplier policy is achieving best delivery performance under a given demand pattern?
- Which supplier policy is most robust under demand fluctuation?
- Which is the most cost saving inventory policy under a given demand pattern?
- How would profit be impacted by adding xx percentage more capacity?
- What is the trade-off between delivery performance and inventory cost when building more inventories?
- What is the impact of information accuracy on the manufacturing performance? (e.g. cycle time, order fill rate)

As a matter of fact, the combination of strategic decision support and simulation is not sufficient addressed right now. As the empirical study will show, strategic decisions like the selection of logistic service providers or the choice of hiring warehouses (locations and amount) which regards to historical data like orders and customer locations and nonmonetary weak factors like strategic alignments, could be better supported with the aid of simulation based BI tools.Yet, in order to be able to provide answers to the above mentioned questions, there is a set of requirements and features that should be made available. Most important are the ones related to the user interface. It has been stated that the user interface of the simulation tool should allow for the active and joint participation of the parties involved in the decisions making. Furthermore, this interface should be simple where the decision variables are represented in a way that appeals to the imagination of the decisions makers which are in the cases considered primarily managers. In other words, all elements of the models should be visible, clear and understandable to the end users [23].

III. Research Design

To answer the research questions previously mentioned, it was essential to establish an empirical framework that guides the research process and sets focus on the aspects that need to be investigated. Figure 2 outlines the research framework in use. The figure reflects the key areas that the study intended to examine to arrive at answers to the research questions. This includes critical understanding of the current methods in use (represented by the "as-is" bubble in the figure), then eventually understanding the possible opportunities that may arise from using simulations for strategic decision support (represented in the to-be bubble in the figure) and finally investigating the transitional path of moving from the current as-is situation to the to-be situation with focus on essential requirements as well as possible barriers. Furthermore, the framework sets a scope restricting the types of companies that will be addressed by this study to those large companies with dispersed locations, that are highly dependent on logistics which has been identified as a typical application area of simulation.

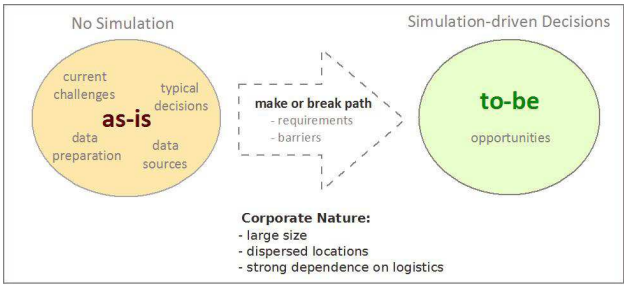

Fig. 2 Research Framework

In light of the presented framework, it was determined that this study should be dependent on action design research [19]. Therefore in a first step a requirements analysis based on qualitative methods was carried out. The dependence on qualitative methods was driven by the nature of the problem at hand, which requires exploring aspects such as opportunities and requirements which are more suitably gathered qualitatively with focus on analysing words, concepts, and ideas rather than numbers. In a second step the findings are transformed into a prototypically implementation of a simulation based BI extension. The third step of the so called design oriented research is the evaluation, which is conducted with presentations and discussions of the prototype as well as with peer reviewed publications [2].

The research design used in the empirical study was a survey with multiple semi-structured, face-to-face interviews. Since the study does not attempt to provide an extensive analysis of a unique case in particular, it has been decided to depend on surveys rather than case studies. The reliance on interviews rather than questionnaires is justifiable because although interviews tend to be more time consuming, yet the two-way interaction enabled by the nature of interviews was needed to acquire in-depth knowledge about the subject area. This need was driven by the exploratory nature of the study.

Furthermore, the choice of face-to-face rather than phone interviews was based on the fact that usually face-to-face interviews tend to have higher response rates than phone interviews [15]. The interviews were semi-structured with a set of prepared open-ended questions that gave direction to the interview without restricting the smooth flow of conversation, where interviewees were given the chance to elaborate more and reflect on their own experiences. The questions were in line with the framework presented above.

A. Selection of Study Subjects

This section presents the rationale behind the selection of the study subjects, by listing the criteria for such selection. Then, it presents some background information about the selected companies as well as the interviewees with which the interviews were conducted, while keeping the identities of those companies and individuals anonymous for confidentiality reasons.

The choice of study subjects was mainly driven by two factors, namely relevance and accessibility. Relevance implies a fit to the research questions as well as the application field

which is supply chains / management. Candidate companies who were considered relevant were required to have a strong reliance on logistics in their business, thus the logistics function should be either their core line of business or a major department that is a major contributor to the success of the company. Furthermore, it was required that candidate companies would be large companies with dispersed locations; a characteristic that would make their decision making process -as regards to logistics in particular- much more complex and thus increasing the possibility of their need for simulation capabilities. As for the factor of accessibility, this means that the researcher would be granted access to enter the company and personally meet a high-position representative from the logistics function to conduct a face-to-face one hour interview. Furthermore, due to limitation in time and resources, accessibility also imposed the need that the candidate companies would have locations inside Germany.

After considering factors of relevance and accessibility, two companies were selected for conducting the semi-structured interviews. Given that this study does not (by any means) attempt to generalize the results and that the results are subject to future verification/falsification by future research, the use of two companies was sufficient for the purpose and feasible within the resources available for the researcher.

The first company is an international company head quartered in Germany. It is considered a market leader in the field of banknotes (as a supplier of paper as well as printing services). The complexity of the company's operations is not only due to its diverse activities but also due to its global orientation as it has subsidiaries and joint ventures across thirty countries all over the globe. The interviewee from the first company was the senior logistics manager in charge of the global logistics of banknote processing at the company. He was positioned at the third level from the top of the organizational hierarchy thus his position reflected his major concern with strategic decisions as regards to the supply chain. His current department highly appreciates the strategic value that the logistics function can bring to their company, yet according to the interviewee, this paradigm of thought has only been there for almost a year, when a new unit under the name of "Strategic Supply Chain Unit" has been established.

The second company that was selected to be interviewed is also head quartered in a German city, which satisfies the accessibility criterion. It is considered a logistics service provider that helps other companies managing their supply chain(s), allowing those companies to focus on their core business. In addition to its great relevance to the supply chain and logistics industry, the company satisfied the second relevance criterion by having thirty four locations throughout Europe with nearly two thousand employees. The interviewee from the second company was the manager of the electronics business unit. He has a good mix of Information Technology (IT) and business knowledge. This is due to the fact that he has a strong background in computer science and at the same time has been working in various positions that supported the enhancement of his managerial skills including his work as project lead and worldwide consultant prior to working as the manager of the electronics business unit at his current company. His IT background was reflected in his interest in introducing innovative solutions into his department that may facilitate its work as well as increase its efficiency and effectiveness.

B. Data Collection Procedures

The interviews were audio recorded with the permission of the interviewees to increase the reliability of the collected data and reduce the dependence on the need to recall the interview's data. Yet, notes were also taken to pinpoint important aspects during the interview as well as to reduce the risk of the sole dependence on the recordings. The interview started by briefly introducing the topic of the study and then clearly stating the intended purpose of the interview. The interview consisted of five main questions that were in line with the research questions.

First, the interviewees were asked about the typical strategic decisions that they take as a part of their job responsibility. This question was intended to reflect their information needs, the nature of the decisions taken and the degree of complexity involved in the addressed tasks. The second question focused on their current methods of arriving at those decisions, focusing on participants in the decision making process as well as on the data that they are working with. The third question was aimed at finding out the problems with the current methods in use, with the purpose of checking whether there is a match between their current problems and the benefits offered by the use of simulation. The fourth question introduced the concept of interactive simulation for strategic decision support and subsequently focused on finding out specific decisions that the interviewees believe might make use of this technology as well as possible barriers for the emergence of such technology. The fifth question was a closing question to check the willingness of the interviewees to offer us future support by testing the later on developed prototype that allows simulation-based strategic decision support for supply chains.

IV. Results

This section will present the results of the two interviews, one at a time by documenting the answers of the interviewees to the main interview questions. It is important to note that the sequence of conversation has been slightly adapted to fit the logical sequence of documenting the answers. This was particularly needed because the interview was semi-structured and gave the interviewees the total freedom to elaborate; which frequently led them to discussing topics that were found more relevant in covering other questions. To ensure consistency, the same set of questions was used in both interviews.

A. First Interview

When asked about the typical decisions that he takes, the interviewee's answers reflected his major concern with performance monitoring, represented in their ability to have the right inventory at the right place and time with minimum loss and damage. This is particularly enabled through monitoring the service levels of the logistics service providers by ensuring that they are serving them within the accepted levels of performance. In addition to performance monitoring, the interviewee mentioned location decisions of their different warehouses as another concern; especially that they have four different types of storage locations differing in size and targeted service area.

The second question was then concerned with discovering their current methods of addressing the above mentioned issues. When asked, the interviewee replied that they are depending on their own Enterprise Resource Planning (ERP) system to acquire data that is combined with data provided by their logistics service providers into a data warehouse which is considered the basis for their reporting system. It is worth mentioning that the data sources used by the company are their own ERP systems, their logistics service providers' systems, their suppliers' inventory systems as well as some internal transactional inventory system. With these data sources, they are still having problems with getting all the shipment data into their own data warehouses.

After spending the first two questions for understanding the interviewee's major decisions areas, their decision support methods, and the problems that his department faces, the concept of visual interactive simulation was briefly introduced. The interviewee's response reflected his awareness of the existence of many simulation tools in the market, yet, he responded by stating that his company is currently not depending on any visual simulations, particularly in the logistics function. He added by explaining that decisions requiring simulations are very infrequent in their department. In such cases, they choose either to depend on students with strong IT background to perform different spreadsheet-based simulations or in some cases, they seek the assistance of consultancies.

The interviewee first did not see the value nor the need to invest in a simulation tool. Yet, later on in the interview he mentioned that there may be cases where simulation tools could be useful, yet costs as well as the complexity of the simulation tools act as inhibiting factors. Finally, as a closing question, the interviewee was asked about his future interest in testing a prototype that may illustrate more the usefulness of using visual interactive simulations for supporting supply chain-related decisions and he responded positively with his interest to try it and provide feed-back.

B. Second Interview

In the second interview with the electronics business unit manager of a logistics service provider, the following were the interviewee's answers. When asked about the strategic decisions that he encounters, he stated that sometimes there is a need to address issues such as whether their current capacity and work flow structure is capable of handling future demands or not. For the interviewer, these are critical and challenging questions. In spite of the fact that these questions are not necessary typically strategic, yet it can be argued that capacity planning is a tactical decision with a strategic impact. In elaboration to that point of view, the interviewee stated that the work environment is very dynamic with continuous changes and very demanding customers. Those customers, who are continuously in search for optimizing their supply chains.

In answer to the second question that was inquiring about their current methods of addressing the above mentioned issues, he stated that they are using a separate logistics data warehouse (or a data mart) in which they store historical data. Then, using spreadsheets, they try to forecast and calculate some values that may help them in planning. So, their main dependence is on reports and spreadsheet calculations. Yet the interviewee stated that he is not satisfied with the current methods as they are only dependant on basic calculations. Furthermore, another negative aspect is that their logistics data warehouse is not integrated with the financial data warehouse that is in use.

As for the data preparation, the interviewee stated that the IT department is the main entity responsible for this task. This is because there is no easy way to extract data for top managers themselves, thus there is a need to depend on more technical-oriented people to do that task. The interviewee pointed out that he considers this one of the weak points of their current methods, because despite the fact that the IT people are doing a great job, yet, it still consumes valuable decision making time which could have been saved if there was an easy one-click, drag and drop way for manager to do the job by themselves.

Throughout the interview, the interview has been pointing out possible opportunities for applying simulation at his department. These opportunities mainly fall under decision support in operations, but also some strategic decisions were mentioned. In reference to the question of what would make or break such a simulation tool, the interviewee stated that a barrier for adopting simulation at his department is to convince a warehouse manager who has spent twenty years in his job that there is a better way of doing it. In order to do so, there should be a clear added-value from using simulation that justifies to such managers the need for change. In continuation to what could make-or break a simulation tool, the interviewee stated that the number one requirement for the success of a simulation tool at his company is the ease of use. He explained that the ease of use is not only restricted to the tool, but also to the metadata that would describe what is really needed to make decisions and which kind of information a manager needs to make a decision. He went on by saying that although there is a common assumption that the general managers do not like to use tools to get the results and information on their own, it is important to point out that if the manager was shown that he can drill down to the results he needs within seconds, then he

would be willing to use such a tool. What the general managers really would like is to do the simulations on their own and not to ask the financial manager to do it for them and get the results one day later, when it will not be useful to them anymore. But, he added that if there is a need to go for a lesson to learn how the tool works, then it will not be used. Finally, when closing the interview, the interviewee was asked about his willingness to test and give feedback on a prototype that attempts to utilize visual interactive simulations for supporting supply chain- related decisions, he responded with a yes.

V. Findings and limitations

The findings of the study suggest that the use of simulation for supporting supply chain related strategic decisions is still in its infancy. In spite of the fact that in literature, it has been explicitly stated that "simulation is often regarded as the proper means for supporting decision making on supply chain design" [23], yet in practice, the use of simulation, particularly visual interactive simulation is still not common – either for operational nor for strategic tasks. Nevertheless, there are a lot of foreseen opportunities for successful utilization of simulation in the field of SCM, as well as some requirements that managers believe are essential for the success of using simulation as a decision support tool. During the two conducted interviews, one strategic scenario was identified as possible opportunity for the use of simulation, which is the SCM configuration planning.

There was a match between the study findings and previous findings as regards to possible application areas of simulation for decision support. Broadly speaking, in all scenarios, advanced planning was a common objective. Thus according to Chang and Makatsoris, using simulations could be found useful as there is a possibility to test and evaluate the performance of different plans prior to their actual execution [5]. In addition to the relevance of the mentioned scenarios to planning as a broad umbrella term, when comparing the interview results with the reviewed literature, the opportunities described in both interviews greatly match some of the opportunities explicitly mentioned in literature. Specifically, there was a reference in literature to optimization as a possible use of simulation, where there is an attempt to figure out the environment configuration that yields a minimum or maximum value for a certain variable [12].

Moving on to analysing the requirements gathered for ensuring successful use of visual interactive simulations with BI for decision support, there were mainly two critical requirements referred to in the second interview. These requirements are namely, ease of use as well as high speed of performance. The ease of use requirement matches findings in literature where there was a focus on interface simplicity as a focal feature in judging simulation tools [20].

It is is important to note that compared to some of the requirements and feature lists found in literature, the results were very broad, looking at technology as a black box without going into technical details. This was particularly due to the managerial nature of the respondents being interviewed. Moving on to the combined utilization of BI capabilities along with simulation capabilities, it is worth mentioning that throughout the interviews, no explicit reference to the term BI was made. This was intended so as to avoid the use of buzzwords that could be interpreted differently in different contexts and by different people. Thus it was left to the researcher to carefully interpret the interviews' transcripts to find out whether the use BI was possible in coordination with simulation. This was noted in the second interview when the interviewee referred to the use of historical data particularly from their data warehouses to support long term simulations. Reference to the data warehouse and historical data was considered an implicit reference to BI since according to Balaceanu, the data warehouse is the core of the BI environment [1].

The major limitation of this study is the inability to generalize the findings to a broader population. This limitation is caused by many reasons inherited in the research methodology. First, the number of interviewed managers was limited only to two due to restrictions on the accessibility to information as well as limited time span. A second reason for the limits on generalizability of this study is the fact that the study was qualitative, thus, it cannot be extended to larger populations with a high degree of certainty as it was not tested statistically to prove its significance. Furthermore, as regards to the collected data, there were some limitations that restricted the ability to draw more detail-rich conclusions. First of which was that in spite of the fact that both of the interviewed managers had some foundational technical background, with the second one more oriented towards computer science, the ability to collect technical requirements was not possible, that is why the study focused on top level, abstract, managerial requirements.

VI. Prototypical Implementation

This section presents the development of a simulation-based BI-extension as the second step of this research, where the findings from the literature review as well as from the empirical study are used to design a prototypical implementation. The goal of the prototype is to demonstrate the feasibility of such an approach as well as to evaluate further research areas in this area.

As shown above, there is a need for strategic decision support in supply chain configuration with the aid of simulation. The prototype is built to demonstrate the feasibility of supporting the decision making process of supply chain managers, concentrating on the following two questions:

- number of warehouses from cost and strategic perspective
- location of warehouses from cost and strategic perspective

Therefore the following scenario is assumed: the supply chain manager works at a manufacturing company, which produces goods at only one location. All goods are then delivered to customers by third party service providers.

Therefore yearly contracts are negotiated on the base of a weight – distance matrix. This means that service providers offer shipments calculated by weight and distance. In addition, the company has service level agreements with its customers which guarantee a 24 hour shipment. The company also has the possibility to rent warehouses for yearly rates (plus initial costs) at different locations. With these warehouses, the company could possibly save money by sending one combined shipment to the warehouse and distribute this into a number of smaller shipments to nearby customers. The optimum cost of such a supply chain configuration would have to be determined by trying out various possible setups, taking into account the number of warehouses, the short distance delivery costs, the long distance warehouse supply costs as well as the warehouse rental costs. Therefore the input data for the prototype are customer locations, the orders, weight-distance-cost tables from the service provider as well as warehouse costs (rent and initial costs). The historical order data is provided by the business intelligence environment. Figure 3 (top) shows the prototypical implementation of this data. Part of this screen also shows the chosen number of warehouses as well as the calculated costs (total/year). It has to be mentioned that the prototype calculates the locations of the warehouse by a K-Means Clustering Algorithm. The location of the customers and the optimal locations of the warehouses are also displayed on a map (cf. Figure 3 bottom).

The next version of the prototype will contain an interactive surface which allows the manager to drag and drop warehouses at particular locations, given strategic considerations. Also the manager would have the opportunity to simulate scenarios, like increasing the importance of certain regions or strategic motivated locations for warehouses. The major benefit of such an interactive simulation environment is that the opportunity costs can always be compared to the optimal costs.

First reactions to the current prototype show that this kind of decision support seems to be very welcomed by managers. The next step is an evaluation including a larger number of companies. Thereby the generalizability of the acquired results, with a particular focus on logistic service providers, should be improved. Furthermore, a more diverse sample should be included in testing this future prototype with a combination of representatives from IT departments as well as management.

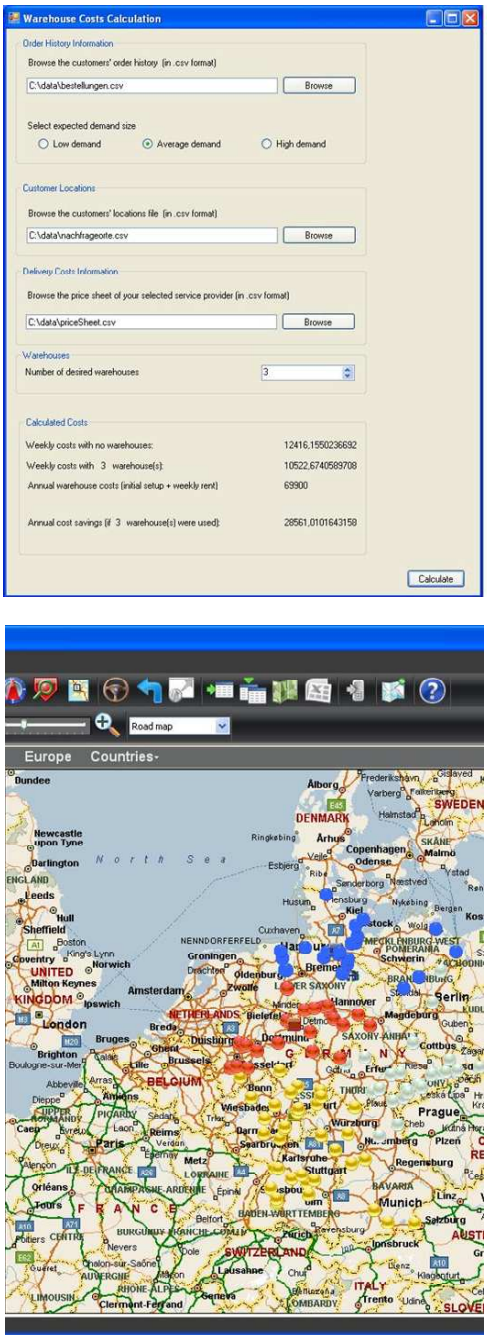

Fig. 3 Prototypical implementation

VII. Conclusion

The complexity and dynamism in today's business environment is continuously increasing at a very fast pace, that is driven by the increasingly fierce competition in the global world. This demanding environment has created a need for innovative solutions that would support decision makers in their increasingly challenging tasks. Using visual interactive decision simulation as a decision support tool with the utilization of historical data analysis from BI was seen as an attractive solution that can present valuable opportunities to

decisions makers. Thus, the purpose of this study was to dig into these possible opportunities and eventually search for the essential features that would ensure the success of this attempt. However, the results of this study have revealed that using visual interactive simulations is still under-developed and requires efforts from both the IT and management in order to allow for successful utilization. Thus, regardless of the fact that literature is rich in examples of possible opportunities of using simulations for supporting decision making by managers, more practical demonstrations should be provided to managers so that they can visualize and experience the benefits that simulations can bring about, where constructive feedback could be collected from both management and technical representatives that would eventually enable successful introduction of simulations as an integral part of BI applications in the market.

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