

Forecasting software visualizations: An explorative study

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ABSTRACT

A qualitative explorative evaluation considered the effects of six visualization interfaces of sales forecasting systems on 60 university students. The study builds on earlier research from the domain of business forecasting in supply chain industries. The evaluation generates exemplar interfaces derived from the theoretical framework and task analysis of interviews with 20 expert users and designers of forecasting systems. The implications for information visualization and interaction design are discussed.

Categories and Subject Descriptors

H5.2 [Information Interfaces and Presentation]: User Interfaces-*Evaluation/Methodology*; H4.8 [Information Systems Applications]: Types of Systems- *Decision Support*

General Terms

Design, Human Factors, Verification.

Keywords

Knowledge visualization, Visual analytics, Decision making process, Explorative evaluation.

1. INTRODUCTION

This paper investigates the problem of designing effective visualizations for sales forecasting systems. Sales forecasting is clearly an important area for businesses in its own right, but also shares features with other domains, such as the environment or security, where sophisticated statistical and mathematical tools are used as part of a decision support process. Sales forecasting is often seen as a statistical problem; choosing the right algorithm, to give the most 'accurate' results. However, it is also an intrinsically human process involving frequent 'adjustments' to include expert knowledge such as the impact of sales promotions or weather, and it is also embedded in an organizational and political context [17, 19, 10, 23]. As more and more complex interactive computation and visualization is used to support human activity in the field known as visual analytics [27], the evidence we present from the well established

domain of forecasting [20, 29], may offer insights that can help inform broader understanding in this growing area.

2. VISUALIZATIONS OF KNOWLEDGE PROCESS

Information visualization helps to understand data using interactive abstract visual representations [3]. Interactive exploration of the data or knowledge that has been negotiated before becoming available within a system can lead to many discoveries in terms of relations, patterns, outliers and so on. Visual analytics is the science of analytical reasoning facilitated by interactive visual interfaces [26, 27]. The term is relatively new and has arisen from recognition of common issues in areas as diverse as security, business intelligence, and environmental monitoring. In these and other areas interactive visualisation is combined with elements of data processing or machine learning. The domains share a need to allow users to understand and interact with complex underlying data, in order to see structure or make predictions that would be impossible for a human analyst or automated reasoning to do alone. Sales forecasting existed long before the term was coined, but is a well-established example of just such interactions.

The grand challenge in the visual analytics research agenda calls for developing information visualization to perform data analysis as well as structured reasoning. This includes the construction of arguments, convergent-divergent investigation and evaluation of alternative hypotheses. In this way, sense-making is facilitated. [15] compared commercial information visualization systems that revealed which systems were fastest and most accurate for various benchmark tasks. Because the systems differed from each other in many ways, including visual design, interaction style, and available visualization techniques, the author could only guess at the reasons behind performance differences. [28] suggest that if the goal of visualization is for expert users to gain insight into their own data and communicate it to others over an extended time period, and the goal of evaluation is to understand how to best design visualization tools to support these users, then quantitative lab studies fall short. Ideally, we would like to understand which features of a visualization tool make it useful for complex, long-term data analysis by domain experts.

When it comes to decision making and forecasting, it is important to externalize the knowledge process leading to a

sales forecast, a projection that defines and relates the various factors in an understandable way. This study, therefore, builds on a theoretical framework and task analysis of interviews with 20 expert users and designers of forecasting systems. The conceptual analysis highlighted users' difficulties in effective visualizations of forecasting software when attempting major forecasting tasks (e.g. reporting and justifying the final system forecasts, and adjusting those based on market knowledge). Consequently, a qualitative explorative evaluation [5] considered six visualizations of sales forecasting systems. The implications for knowledge visualization and interaction design are discussed.

3. FORECASTING SUPPORT SYSTEMS

Forecasting support systems are ubiquitous in companies operating across the supply chain from raw materials supply to retailing. They are often integral to an ERP system such as SAP, alternatively delivered through a stand-alone package which delivers forecasts into other elements of the planning system. Excel remains apparently the most common software tool for producing forecasts. A current review of such systems is given by [16], whilst [7] have described the common features and their limitations when used in organizational forecasting. Taken from [2, p.8] forecasting support systems (FSS) can be defined as:

'A set of procedures (typically computer based) that supports forecasting. It allows the analyst to easily access, organize and analyze a variety of information. It might also enable the analyst to incorporate judgment and monitor forecast accuracy'.

Sales forecasting systems are used to project future sales demand for each stock-keeping-unit (SKU) on a daily, weekly, or monthly basis. Typically, forecasts at the SKU level must be made for a large number of items, and these items are usually grouped into a product hierarchy. The end-user of the system usually concentrates on forecasting a large number of disaggregated series based on sales figures and provides detailed explanations and reporting. Ideally, the user should also possess adequate statistical knowledge in order to understand time-series and product sales trends, however often supply chain forecasters have only very limited background in even basic statistics. Existing studies in the area of forecasting shed light in the support of user adjustments [7, 8, 23] and the effective use of statistical forecasting methods when forecasting [29].

3.1 Main literature themes

The main scope of sales forecasting systems as used on supply chain industries are to:

1. Estimate sales in order to inform purchases, stocking levels, and budgeting decisions.
2. Generate meaningful report outputs that go to decision makers with less understanding of the underlying statistics and forecasting methods, but more knowledge of the contextual factors that impact on sales.
3. Enable reasoned user adjustments to provide an accurate and acceptable estimation of future sales.

In figure 1 follows a screenshot of a typical forecasting system and a graphically-generated forecast for a beer product:

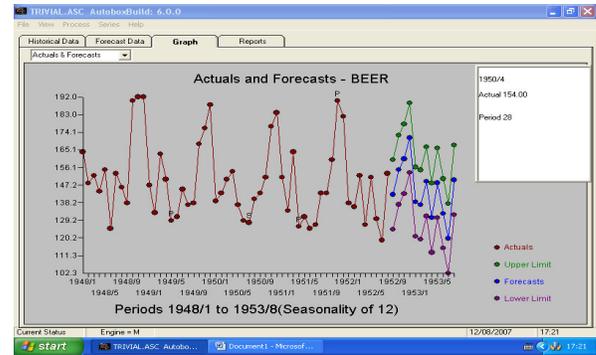


Figure 1: Beer product forecast generated from www.autobox.com

Specifically, the software includes algorithms for time-series analysis including seasonal factors, trends, autocorrelation analysis, descriptive and explanatory analysis as well as basic visualization (time-series graphs). The basis statistical model generated from the system is typically used to make human adjustments [7, 9, 13]. For many of the products the forecasting is straightforward, and professional forecasters tend to focus their attention on a small number of products that are in some way exceptional and are organizationally important (e.g. the most profitable). This may be because of external conditions (e.g. sunny weather affects ice cream sales), or because they are important for the organization (e.g. the subject of a special sales campaign).

3.2 A grounded FSS design framework

Initially, our study was based on a total of 20 substantive semi-structured interviews (10 forecasters and 10 systems designers) with different roles and years of experience in FSS. The aim of these interviews and observations was to reflect on how systems are actually used and obtain context-specific information about FSSs design. Their average experience in supply chain forecasting was 13.3 for users and 20.1 years for designers, respectively. Data were also analyzed from the organizations visited such as forecasting reports, forecasting process diagrams, forecasting systems screenshots and user training documents.

The interview guide was partially adapted from [21] to address issues of organizational forecasting but this was further enriched with questions specifically applying to designers and system users. The interviews lasted between 1 and 1.5 hours and focused on three key areas. Specifically, the interviews addressed the *process of developing forecasts*. Initially, the questions were about interviewees' experiences of using their FSS, the stages of the forecasting process, user motivations and their systems' role during forecasting. *Organizational aspects of systems use* were also considered as a focus of the interviews with emphasis on the different people involved in the forecasting process forecast accuracy considerations, and socio-organizational factors that may influence forecasts. Lastly, *system functionality and design* generated a set of activities that people engage in when producing product forecasts. The interview protocols for designers and users differed in reflecting their differing roles, but were otherwise designed as similarly as possible in order to be able to make effective comparisons that characterise their viewpoints on similar topics.

Designers and users were encouraged to discuss wider aspects of system interface design and forecasting practices as they felt appropriate. The analysis of organizational documents was used as complementary data. These data were compared and analyzed in conjunction with interviews and observations.

Grounded theory [11, 25] was used to analyze the interviews of designers and forecasters. This type of approach was thought to be particularly useful due to the exploratory nature of this study as well as ensuring that data collection/analysis and emerging issues are closely related to each other. Grounded theory is also a 'theory discovery methodology' and therefore it can lead to a sound theoretical framework for the design of FSS. In the current study, we mainly confined ourselves to the 'Smorgasbord' principle [24, p.8]. That is to say, analytical procedures, from the Straussian version of grounded theory that best suited the purposes of the current research, were used. [12] claims that the Straussian approach is closer to 'full conceptual description'. The theoretical framework was derived from the interview and observational data using a constant comparative method of analysis with four stages: generating initial concepts and their properties (open coding); integrating concepts and their properties (axial coding); delimiting the theoretical (selective coding) framework; and writing the theoretical framework. The core concepts of the resulting theoretical framework are the following:

1. Interacting with products and their behavioural essentials
2. Producing reasonable and actionable forecasts
3. Negotiating products' forecasts: The role of forecast reports and review meetings
4. Informal communication as generator of product knowledge
5. The forms and influence of politics in forecasting.

The theoretical framework of professional forecasters and designers of FSS provided a comprehensive answer to the research question: What are the socio-contextual processes that should be considered when designing forecasting systems for supply chain organizations? Many of the concepts and relationships emerged from the data are generically described: a balance between interface visualization of historical sales data and product knowledge (e.g. price changes), a focused attention on products and their importance, and aspects of negotiations that are generated through forecast reports and forecasting review meetings. The framework also highlighted informal communications during the forecasting process, a merging of reasonable forecasts and actions, and the political underpinnings of organizational forecasting [10].

As a result of the designers and users' insights on FSS socio-contextual processes of FSS in supply chain, we have been able to generate a set of implementable design issues:

1. Highlighting the features (e.g. growth, sales trend) of a product or a group of products
2. Addressing the knowledge generated from informal communications during the forecasting process
3. The dynamic interchange of historical sales data and product knowledge
4. Providing users with the ability to annotate and negotiate elements of forecasting

5. Enhancing user awareness of organizational knowledge by providing appropriate interface navigational cues.

There are potential design implications from all the above issues, but in this paper we focus on note-taking, which impacts the first four of these design issues. It has the additional advantages of being easy to implement and test in a quasi-experimental setting. This feature is also symbolic of the need to take into account the observation that interaction with FSS is not just a closed 'event' for the user, but is historically linked to previous use of the system and organizationally dependent on the wider business context. Combining the knowledge evident in the forecasting process with reflective functionality in the FSS, such as a note-taking area, may enable an enhanced user experience and increased organizational value. Note-taking can be used at different stages of product forecasting and for different purposes. From this point of view, the note-taking facility contains a compilation of collaboration, process related, and self-reflective functionality that can incorporate intended meaning in this context. At the same time, it may provide users with the opportunity to externalize and publish their views on important organizational issues and make explicit product-specific knowledge that comes from different sources.

3.3 Explorative visualizations in FSSs

Six sales forecasting system functional prototypes were designed in order to examine the usefulness of (a) relevant activities/product knowledge for supply chain forecasting and (b) the insights from user annotations when forecasting using various system interfaces. The six prototypes manipulate these aspects in different ways: whether or not note taking is allowed, whether or not it is in the context of other information, and whether the notes and information are structured. They are described in more detail in section 5. Although the prototypes were implemented from scratch, ForecastPro (www.forecastpro.com) was used as the basis of normative FSS design (due to its interface usability and overall layout) and progressively added features that reflected different layouts and structures in a forecasting process. ForecastPro is commercial forecasting software which is also used for academic purposes. Moreover, we explored whether particular interfaces improve the users' focus on product knowledge as well as whether they encourage recommendation of specific actions based on the forecasts.

3.4 Pilot phase

The six user interfaces evaluated in a pilot phase with 7 postgraduate students knowledgeable about forecasting studying at Lancaster University Management School. As a result of the user feedback and comments received from the pilot study, a second design specification for the forecasting interfaces was drawn up. Unlike the preliminary specification, the pilot study was concerned with the 'look' and 'feel' and 'overall functionality' of the interfaces. The main design recommendations derived from pilot users were to as follows:

- a) Provide monthly sales history and forecasts data points in graph
- b) Provide a drop down menu rather than a static box for specified forecast horizons at 1, 3, 6, and 12 months
- c) Provide more comprehensive description of product-specific knowledge, and
- d) Redesign the user annotations functionality layout.

After these modifications, the forecasting interfaces were in their final form for the main explorative evaluation.

4. THE TASK AND STUDY PROCESS

The forecasting task was to develop sales demand forecasts for one year ahead so as to simulate the supply chain context requirements. There were 4 artificially generated time series of the previous monthly individual product sales from January 2000 until February 2003 (39 data points per series). Users were told that the forecasts were indeed considered important for planning future demand for the given products. Lastly, users were required to save all information and the forecasts obtained for each of the products to the database.

The interfaces were implemented through Borland Delphi Development System. All interfaces contained the same product sales data, database, and overall layout. The interface designs described were kept to a 'minimal' set of functionality (see figure 2).

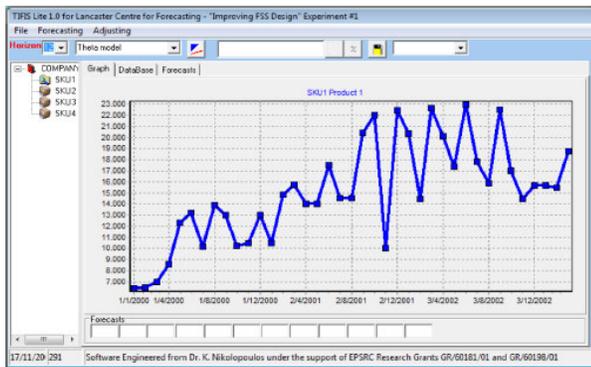


Figure 2: Prototype forecasting interface for SKU1

The prototype forecasting interface for the study task was given to 10 users without any additional product-related knowledge. The same prototype interface supplemented by a product-knowledge information (e.g. the product is in its growth phase, we are enjoying an overall 80% share on this product) was given to a different set of 10 users. The following section provides a description of the explorative evaluation process followed.

4.1 User characteristics

The main study was conducted with a total of 60 students (31 women and 29 men), consisting of 12 postgraduates and 48 undergraduate studying at Lancaster University Management School. Their age ranged between 20 and 29 years old. All users had relevant knowledge of sales forecasting, and the potential to use forecasting systems in their professional career. Each user received £5 for their participation to the study. Keystroke data, including users' entries made on available user annotations designs were collected as part of the evaluation process.

4.2 The explorative evaluation process

Users were given a few minutes to read the study purposes and general description of the organizational forecasting process. Each user was exposed to a single interface to evaluate. In addition, we verbally presented an overview of the study, while demonstrating the process of interacting with the system to develop a product forecast. Users were required to produce sales forecasts for each of the 4 products individually and in any order

they wished. When undertaking the evaluation, users did not have to follow any particular process of producing the forecasts but could exit the study only upon completion of all forecasts or when indicated (e.g. when they have actually gone through the process of interaction and for some reason had not produced forecasts). Moreover, there was no time limitation to complete the study.

4.3 Quantitative results

The descriptive results for the overall forecasting task are presented in table 1. No significant differences between the different interfaces with regard to the overall time to complete the task were found. Thus, user groups spent on average between 12.4 and 18.6 minutes to complete the forecasting task independent of the type of interface they used.

Table 1: Total time to complete the forecasting task

Type of interface	N	Mean	Std. deviation
Experimental	10	15.45	6.87
Experimental+paper	10	17.17	7.73
Freeform	10	18.60	7.10
Freeinfo	10	17.60	5.12
Activnote	10	12.48	5.72
Activeplus	10	16.34	9.72
Number of users	60		

In the following section, we reflect on the design concepts that have arisen as a result of this explorative evaluation study.

5. INSIGHTS ON VISUALIZATION

Overall, all users found the prototypes useful and effective in retrieving the required product, forecast data, and forecasting methods. Moreover, they found the information to be clearly presented, understandable and consistent. Our focus of reflection is on the ways the designed FSS interfaces affected the style of use and annotations.

5.1 The prototype experimental interface

The experimental interface was designed so as to provide the first group of 10 users with the ability to produce forecasts emphasising the statistical forecasting methods and the historical data on each product. The main observations derived from the explorative evaluation with the experimental FSS interface were as follows:

- Users relied heavily on their judgements to develop all four product forecasts
- Most users indicated the need to retain a record of the forecasting process
- One of the users placed handwritten notes on the paper given in order to highlight his suggestions with regard to the products.

Overall, the experimental interface did not appear to fulfil the product-specific interaction challenges of users. Users sought ways of justifying their judgements and recording their forecasting process and expectations when examining the sales trends.

5.2 Experimental interface with paper information evaluation

In addition, the same system interface with the addition of printed product knowledge (e.g. selling price is currently 10.02 and is expected to rise by 10% from March 2003) was given to the second group of 10 users participating in the evaluation. All users considered the paper-based information available for each product to the experimental forecasting prototype. However, it was not clear which parts of this knowledge they included in their forecasts, nor did they express their view directly on the aspects which had proved useful for the specific product forecasts. The printed information did not encourage users to recommend specific actions based on the produced forecasts.

5.3 Freeform interface evaluation

In the ‘freeform’ forecasting interface, users were provided with space called a notepad, literally a box in which users could type anything they wanted. The notepad did not guide the participants in any specific way of using it. This feature provided users with the opportunity to comment on issues that they found relevant to the specific product forecasts. We hypothesized that such a feature would encourage users to reflect on the forecasting process and highlight issues of users’ interest for specific products. Figure 3 shows a typical screen of this interface version.

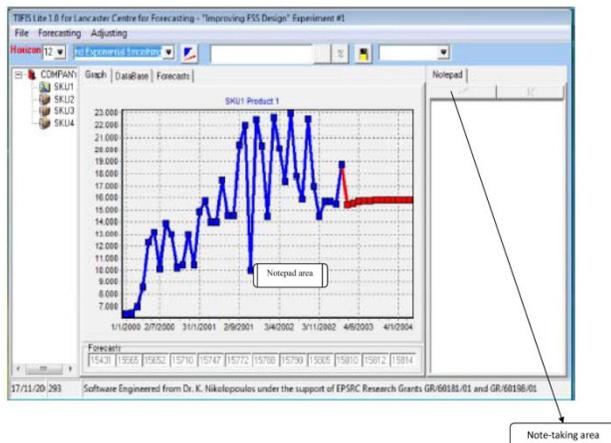


Figure 3: Freeform forecasting prototype for SKU1

For SKU1 user annotations were focused on comments about the effective utility and quality of forecasting methods available to the system. There was also clear evidence that users focused on previous sales trend in order to choose the most suitable forecasting method. The following extract from user 2 evaluation of the freeform interface indicated users’ tendency to choose a ‘reasonable’ forecasting method in order to produce product forecast:

“I don’t really think that any of the provided methods gives a good forecast, however I think this (the chosen method) would be the most reasonable option as there seems to be an increase in sales if you look at the overall pattern”

Users were also inclined to compare forecast performance and quality for each forecasting method in order to determine the best option. Users also suggested possible actions based on the forecast. For SKU3 the actions mainly took the form of suggested price changes (note made by user 7):

“This model seems to be very correct. And as a project manager, I would suggest lowering the price in the winter time in order to boost sales as the product historically seems to slump around this period, and is predicted to in the future”

The ‘freeform’ interface as designed for this study also led users to compare forecasting methods quality with emphasis on the following issues: method selection, adjusting the forecasts and reflecting their views for these adjustments as user 4 notes on SKU4 forecast in the following extracts:

“I have used the Dampen trend Exponential model because it best fits the previous trend, with one adaptation for it to reflect the tendency for the periodic peaks”

“The theta model was the best used as the forecast given was the closest to the model, which is where the forecast points could be done more accurately if details were known”

In essence, users in the ‘freeform’ interface have (a) focused on statistical method selection and comparison (b) been concerned about the lack of additional contextual information (e.g. events) that would enable possible changes in forecasts (c) made limited use of the notepad section and (d) made specific-although quite limited in quantity-actionable comments (e.g. lowering the product price) based on the developed forecasts.

In summary, the ‘freeform’ interface enabled users to focus on product trends and fluctuations observed at the data, and to elaborate the process of statistical method selection. In addition, the ‘freeform’ interface design highlighted very limited opportunities for user reflection and particular suggestions for actions based on the forecasts. The following sections further evaluate the ‘freeinfo’ interface that provided users with specific online knowledge applied to each product.

5.4 Freeinfo interface evaluation

In the ‘freeinfo’ interface, users were provided with the annotation feature (identical to the ‘freeform’ interface) together with unclassified knowledge related to each of the products. Again, users could type anything they wanted using the available freeform notepad. We hypothesized that this type of interface would encourage users to reflect on their views with regard to specific product forecasting issues. In addition, the relevant product knowledge may lead users to provide focused annotations that point to organizational actions. Figure 4 provides the particular interface design with an example of graph forecast for SKU2.

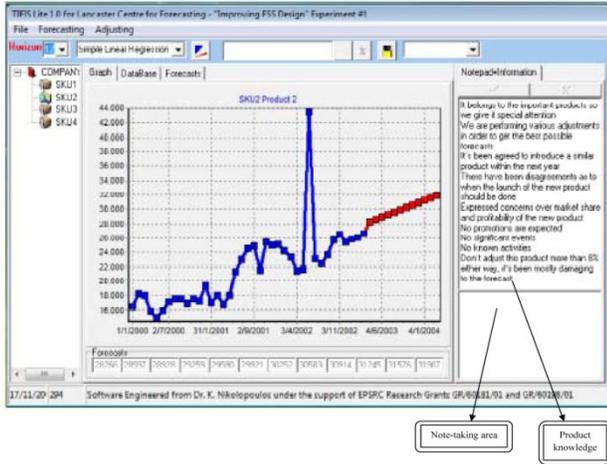


Figure 4: Freeinfo forecasting prototype for SKU2

The user evaluation revealed that for all 4 products, users did not provide a great number of annotations (2 for SKU1, 1 for SKU2, 3 for SKU3, and 1 for SKU4, respectively) despite the availability of the notepad feature. The comments, however, were focused on suggested actions of each of the products with clear consideration of the provided product-specific knowledge. For example, consider the following comment made by users 4 and 6 referring to SKU1 and SKU2 forecasts, respectively:

“It is not necessary that we employ another 2 sales people, but promotions would be an incentive for the already existing ones”

“I don’t think the product should have a significant change over the new since they are similar and it wouldn’t offer more profitability”

It thus appeared that the ‘freeinfo’ interface encouraged users to consider the value of information provided and lead them to make very focused and directed comments. However, despite the quantity of information provided only 7 total annotations made. In addition, it looked as if users were confused and were not able to relate the organizational knowledge with product forecasts.

Overall, it could be argued that this type of interface design did not help users to focus their attention on the specific product knowledge. However, the quantity of comments made suggest that users were primarily focused on the graphical forecast. The following prototype was designed so as to provide users with the ability to annotate under various predefined relevant categories (e.g. promotions, colleagues advice) without them having additional product knowledge available.

5.5 Activnote interface evaluation

The ‘activnote’ interface design consisted of a listing of each category of product knowledge where users could add or exclude notes. Adjacent to each variable was a blank text box into which participants could enter their notes with regard to the relevant forecasting activity. However, no information with regard to specific products was described. Hence, users could only see the category of the relevant activities and subsequently annotate with reference to specific products. We hypothesized that such a combination of structured annotations based on categories (without the additional information) of relevant product knowledge would encourage users to suggest specific and directed actionable points for specific products. Rather than providing users with a general note-taking facility, it was

hypothesized that providing a way of categorizing the notes would encourage users to reflect on product forecasting. Figure 5 shows a screen snapshot of this version of the interface with an example of graph forecast for SKU3.

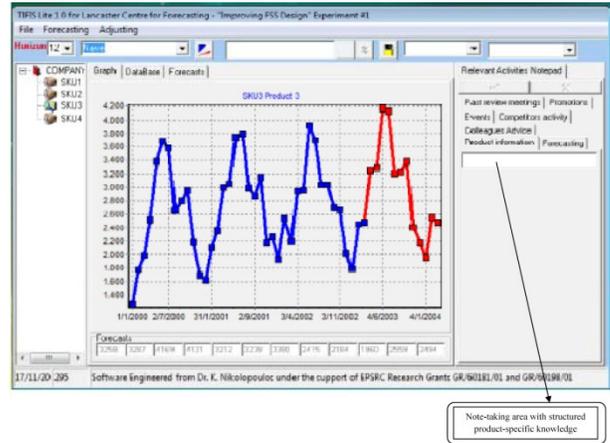


Figure 5: Activnote forecasting interface for SKU3

The functional prototype which enabled users to annotate based on specific categories revealed a set of product-specific issues.

Specifically, users for SKU1 mainly questioned the forecasts produced and highlighted the need to explore the reasons for this and required price information for each forecast period. Consider the following examples taken from user 7 and user 1, respectively:

“Research reasons for why the demand is not smoother”

“It would be good to know the respective prices for each period”

Similar concerns for price changes were expressed for SKU2. In addition, users have suggested discussing the possible influences of specific monthly forecasts to the overall demand trend. This was particularly commented by user 7:

“Point 30/06/2002 may well influence forecasting, it seems quite random, may be look in to this huge fluctuation? Was there a reason for it and can this mistake happen again”

Users have also suggested specific actions which were related to statistical forecasting (e.g. maintain the trend of multiplicative seasonality) issues, and forecast quality. The need for communication proved also to be relevant user annotations. The following extract taken from user 7 when forecasting SKU4 highlights this tension:

“There are some very big swings, forecast seems irrelevant, we should be looking to why and forecast better”

Quite clearly also, user 1 comments’ indicated specific actions based on the forecast:

“It is a consideration that this product should possibly be discontinued within next year as the forecast shows a low level of sales which are also gradually declining”

In summary, users through the extensive use of ‘activnote’ FSS were stimulated to provide and suggest specific actions and actively looked to structure this annotation in the most relevant category. The current interface annotations described user queries and concerns. Most importantly, users have provided comments that directly prompted for (a) action with regard to the forecasts (b) organizational communication and discussion

based on forecasts and (c) better product forecasting management. The following prototype embeds the design features described in the ‘activnote’ interface and discuss the issues arisen.

5.6 Activplus interface evaluation

The ‘activeplus’ interface design provided users’ with structured product knowledge and the opportunity to annotate under the most relevant category. The product-specific information was under the relevant tab and users could annotate under the specific tab. In addition, users could reflect their views in the note-taking area provided at the right of the screen. The main difference with the previously described prototype design was that users could add commentary having the knowledge visible under the relevant category, whereas previously they could only see the category of annotation without being able to supply additional information. Figure 6 shows a screenshot of this type of interface.

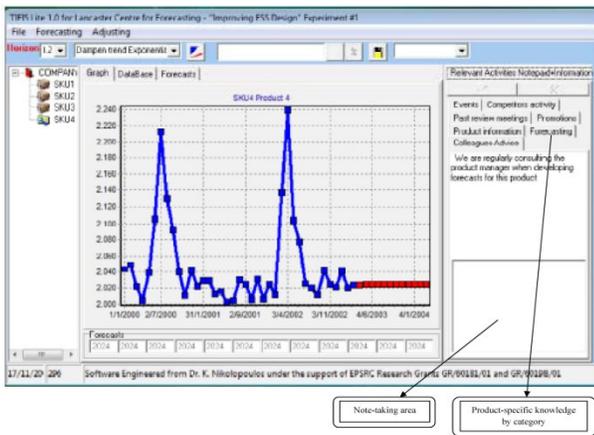


Figure 6: Activeplus forecasting interface for SKU4

It was hypothesized that this type of interface would encourage users to potentially add information considering the context and the richness of product knowledge available within the FSS system.

Specifically, users’ annotations were focused on issues related to: forecast trend, product management and behavioural essentials (e.g. the product is relatively inelastic). User 1, for example, provided the following comment with regard to SKU1 forecast:

“As the product is in its growth stage, it will be hard to forecast the exact sales figures. However, the trend seems to suggest that sales are increasing while the rate at which the sales increase is slowing down”

With consistent emphasis on forecast trend, users’ annotations were focused on the impact of forecast methods (e.g. by comparing their performance) and statistical issues given the provided information. The action users suggested took the form of organizational strategies (e.g. marketing and promotional activities). User 7 suggests when exploring SKU3 sales trend:

“The highest sales for this product are expected to be in summer period. So the manager has to take further actions”

The user annotations on the ‘activeplus’ interface confirmed the emphasis on statistical issues’ advice on forecasts. Furthermore, user annotations suggested that users highly appreciated the supporting nature of product-specific knowledge. Users were

able to provide specific actions that are directed towards specific products. The “need for communication” was indicated by the following comment made by user 1:

“We should discuss how stock is related to the high sales period in July every year, and how this can be monitored”

The ‘active plus’ prototype stimulated in total 50 annotations made by users categorized to the following categories (see table 2).

Table 2: User annotations by respective categories

Category	User annotations
Product information	21
Forecasting	5
Past review meetings	10
Promotions	1
Events	3
Competitor’s activity	5
Colleagues’ advice	5

When using the ‘activplus’ FSS interface users constantly provided a great amount of annotations in comparison with the other FSS designs. This way, users not only externalized but also specified the relationships between SKU forecasts and structured annotations.

Benefits of this type of interface have observed to be:

- Visualization of product-specific knowledge in conjunction with annotation space communicated better the relationship between forecasting and organizational knowledge
- Structured product activities emphasized consistency of the relevant information for each product
- Visualization of information and annotations seemed to improve user focus, and to stimulate user queries for further product knowledge
- The relationship between forecast, sales trend and information became more explicit and lead to many more direct, actionable user recommendations.

In summary, the users have focused on product information and signified past review meetings as important when forecasting. Furthermore, forecasting issues were also important in that the interface clarified statistical aspects where users would like further insights. Competitor’s activity and colleagues’ advice were equally appreciated. The whole analysis had the potential to become part of a forecasting report that could be presented to others along with the forecasts themselves.

6. DISCUSSION AND IMPLICATIONS

The explorative evaluation conducted was shaped by ideas described by [5] with regard to user evaluation studies for information visualization. The most important concepts users addressed which apply to the domain of forecasting systems are:

1. The importance of the product’s stage in its life-cycle
2. Statistical forecasting issues
3. The knowledge generated in past forecasting meetings
4. Colleagues’ advice on specific product forecasting, and
5. Focused action based on the produced forecasts.

Moreover, the product-specific knowledge appeared to provide a point of reference and supporting mechanism when users developed their sales forecasts. Specifically, this visualization support in the ‘activnote’ (section 5.5) and ‘activplus’ (section 5.6) interfaces helped users to externalize their mental models about forecasting analysis and link the artifacts to the visualizations. Finally, the most relevant product knowledge enabled the user/forecaster to validate their forecasts, and reuse this knowledge when looking for alternate forecasts.

6.1 Forecasting software designs

From a design point of view, it can be suggested that FSS should embed relevant knowledge modifiable by users during interaction. For example, demand forecasting interfaces may supply users with a pop-up window that highlight possible price changes or colleagues’ temporal advice relevant to the sales forecasts. Also there is a need to summarize past information on events effectively as [18] showed. Furthermore, FSS interfaces may benefit from providing an easy way to navigate between the different forecasting tasks and product knowledge by integrating next/previous buttons and/or sidebars with task previews and short descriptions of the requirements of each task. Simple design features, such as the notepad enabled users to understand, compare, and communicate relationships between activities and products. However, such design enhancements, need to augment the existing structure and interface layouts of FSSs [16].

6.2 Limitations

We have evaluated the designed interfaces with university students due to the difficulty of gaining feedback from industry users. It should be acknowledged that this is a limitation as students did not have much experience of using forecasting systems. On the other hand, this explorative evaluation was probably more inclusive of the notion of ‘users’ as management school students were quite likely to qualify as forecasting analysts. As [4] suggest:

‘Because our current students are future practitioners, research that meets their needs will eventually build our influence in the practitioner community’.

Our study was based on the responses of management school students but we aim to involve real users and test more complete interfaces in our next study. However, we have tried to overcome the issue of users being unfamiliar with commercial forecasting systems by designing prototypes based on a commercially available forecasting system. The study sample size was also relatively small, but this probably more affected the quantitative rather than the qualitative insights of the designed interfaces. We still have more design insights to gain from considering further exploratory forecasting tasks (extending the one used in our study).

6.3 Further research

This user evaluation study stimulates a number of questions calling for further investigation: How product-specific knowledge affect the users’ forecasting process and interaction with the FSS? What is the impact of the quality of product market knowledge on forecasting a given product? Do these propositions for single-user interaction with FSS hold in a group

forecasting process? Would different visualizations of product-specific knowledge in the designed interfaces impact on user’s forecasting strategies? Overall, this study represents a first attempt to test the effectiveness of different forecasting system interface designs through a user orientated perspective. Other important areas for FSS are how to design visualizations that allow:

1. Structured product management in order to represent their behaviour at meaningful -for the organization- levels of aggregation.
2. Users to recommend specific actionable points based on forecasting cycles.

Further research will examine different navigational aids to give the user, difficult to achieve otherwise, the distribution and sources of knowledge, as presented by the sales data set and past forecasts. This is a new approach to modelling in the forecasting industry, which is usually based on a singular emphasis on achieving ‘accurate’ forecasts. Further research with some real life users from the supply chain industry would distinguish the appropriateness of the new design features for forecasting. Certainly, difficulties in implementation and testing in real life forecasting also suggests the need to design interfaces with a mix of notes and product knowledge.

7. CONCLUSION

In summary, this paper offers insights into different visualizations of sales forecasting systems aimed to support the task of producing forecasts. We explored different visualizations in the domain of forecasting systems that not only support the *cognitive* analytical reasoning process but also the *motivational* aspects of these interactions. We derived requirements for these motivational aspects from a grounded theoretical framework and a detailed task analysis of sales forecasts in supply chain industries. Our qualitative analysis of this data is useful for studying complex, open-ended tasks where performance cannot be easily quantitatively assessed. Our study is in line with [6, 14] that call for grounded and qualitative approaches in information visualization situated within the context of use. Moreover, [6, 14] stress the need to gain insights about data and knowledge as one of the main purposes of information visualization [3, 26]. Their arguments call for assisting humans in representing information and visualizations not only for cognitive support, but also for motivational support of their interactions with a system. Being aware that the goal of sales forecasting is to provide an ‘accurate’ estimation and particular actions that fulfill organizational goals, effective visualizations is a central challenge for forecasting systems designers and users.

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