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Understanding the use of forecasting software: an interpretive study in a supply-chain company

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Abstract

A study of short-term forecasting in UK supply chain companies has revealed that some companies make limited use of the facilities that are available in the statistical forecasting software that they have purchased. Despite their costs, the software packages are often used for little more than data display. Management judgment is the predominant, or even exclusive, element in the derivation of the forecasts. An in-depth interpretive study was conducted in one company to investigate the reasons for this. The interpretive approach focuses on the way people make sense of the world, both individually and through social interaction. Observations were made of the company's forecasting process and semi-structured interviews were conducted with participants. An analysis of the information gathered, using actor-network theory, indicated that the purchase, and subsequent under use of the software resulted from the alignment of the perceived interests of the software vendors, senior and middle management and other participants in the forecasting process. The software's primary role was to act as a focus for discussion with its statistical aspects subservient**.** The case demonstrates how stable but dysfunctional patterns of software usage can persist due to the resilience of an Actor-Network.

Key Words

Actor-Network Theory; Forecasting; Decision Support Systems; Expert Judgment; Interpretive study; Software usage; User acceptance

Introduction

Consider the following situation. Several years ago a cost-conscious supply-chain based company in the UK, which prides itself on its application of modern management methods, paid out around £30,000 for forecasting software (the latest version of the software cost over £100K in 2005). The software consists of a data base and query language, various statistical forecasting algorithms, graphical facilities and an interactive component which permits the user to adjust the statistical forecast that the software has initially generated. .Software packages like this are promoted by vendors largely on the basis of the accuracy of their in-built *statistical* methods. Yet, when the software is actually used by the managers in the company, they may override the statistical forecasts it produces to obtain forecasts that 'look right'. They then often go on to further adjust this 'statistical' forecast for 'market intelligence'. This leads to a 'final forecast' that is then used elsewhere in the supply chain operation. In essence, the statistical power of the package is hardly used and the resulting final forecasts are based almost entirely on management judgment. Effectively, the expensive software is employed as a second rate data display device to show recent past demand history -second rate, because the length of history that can be displayed is severely restricted and the flexibility, and clarity of the graphical representations of data is less than that of standard spreadsheet packages. Despite this, the managers perceive that they are making extensive use of the package.

The decision of the managers to purchase and then use the software in this way appears to be questionable and it is in conflict with recommended best practice summarized, for example, in Sanders and Ritzman (2001). Yet it is probably reasonable to assume that, individually, the managers are behaving rationally according to their own perspectives, beliefs and motives (Kanter, 1977). Uncovering these is unlikely to be achieved through a 'traditional' survey device like a postal questionnaire, though to date this approach has been the predominant method for investigating forecasting practices in companies (e.g. Dalrymple, 1987; Klassen and Flores, 2001; Mady, 2000; Sanders and Manrodt, 1994). The questions posed in these questionnaires have been based on the researchers' own assumptions about the world, uninformed by internal experience of the companies responding and the perceptions of their staff. Moreover, the use of postal questionnaires did not permit the researchers to observe the environment within which the software was used or to probe beyond the initial responses to the questions.

To try to explain the situation we need a research methodology that reveals a deep understanding of reasons for the managers' behavior and of the social and organizational context in which they operate. This suggests an interpretive approach (Walsham, 1995, Nandhakumar and Jones, 1997; Easterby-Smith et al, 2002). Interpretive research methods focus on the way that people make sense of the world, individually and through social interaction. Reality is viewed as something determined by people, not as an external objective phenomenon. The aim of interpretive research is therefore to understand the different constructions and meanings which people attach to their experiences -in this case their experiences of using a forecasting system.

One interpretive approach that has achieved some prominence in information systems research is based on actor-network theory (ANT) (Latour, 1987; Callon, 1991; Akrich, 1992; Vidgen and McMaster, 1996; Walsham and Sahay, 1999). In this paper we use the perspective afforded by ANT to identify the interactions between the key actors in the forecasting process and to show how this process is aligned with the interests of these actors. The insights revealed through ANT enabled us to develop an extensive explanation for the persistence of a process that most forecasting researchers would regard as being far from optimal. This explanation may have important implications for those seeking to influence forecasting practise in commercial organisations.

Although we have observed similar behaviour to that described at the start of this paper in several companies, in common with many other interpretive studies we decided to focus on one company - a leading UK pharmaceutical company. There are a number of advantages to this approach (Walsham, 1995). It allows a situation to be studied in depth and, as Alexander (2004) argues, the social unit can be studied as a whole. Further, unlike quantitative research, which depends on large samples and statistical inference, explanations of phenomena are supported by logical inference, and they are validated through theoretical and practical dialogue.

The research involved visits to the company's headquarters by two or three researchers. The initial visit included a presentation by the company's managers, followed by a general question and answer session. The researchers also observed two meetings where the forecasts were finalised and conducted semi-structured interviews with the main participants in the forecasting process: two Logistics Managers, a Product Manager, a Marketing Manager, a Finance Manager, the placement student who was acting as a Commercial Manager and a[stock] Replenishment Planner. Independent sets of notes were taken by each of the researchers at all meetings and interviews, which were also tape recorded. The research team sent a summary of their understanding of the organisation and its forecasting process to the company for validation and any necessary corrections. In addition, members of the team attended two user conferences run by the company which produced the forecasting software and also interviewed two of their software developers. . Note that, while our approach is predominantly interpretive, we have also had access to statistical evidence and have used this to triangulate and strengthen our findings (Nardulli, 1978). This consisted of a sample of 3264 forecasts that were supplied by the company and for which the actual outcomes were known.

The rest of the paper is organised as follows. We first indicate why we chose actor-network theory to try to gain insights into the reasons underlying the origins and continued existence of the company's forecasting process The next section describes the company, its decision to purchase the forecasting software and the way in which the software is currently being used. Statistical evidence is used to present an additional perspective of the efficacy of aspects of the company's forecasting process. Finally, we present our conclusions, and reflect on the strengths and limitations of our approach together with the business and organisational implications.

Methodological Aspects

Our beliefs and preconceptions as researchers

Before describing the company's forecasting process it is important to declare our own beliefs and inevitable preconceptions as researchers Such a declaration is accepted as being good practice in interpretive research, particularly given our direct interaction with the forecasters (Klein and Myers, 1999).

Our belief, based on extensive research, is that, in general, the optimum approach to forecasting is to allow *appropriate* statistical forecasting methods to identify regular patterns in data (assuming that sufficient data is available for this purpose) (Goodwin, 2002). Failure to do this can lead to forecasters reading false patterns into the noise that appears in time series (O'Connor et al, 1993). Judgmental adjustments should only be applied to statistical forecasts when the forecaster has important information about forthcoming events that is not available to the statistical method. (Sanders and Ritzman, 2001; Fildes et al. *forthcoming*). Further, the size of these adjustments should be accounted for and their rationale recorded (Goodwin, 2002) and they should, in general, be true adjustments to statistical forecasts –accounting only for the extra information- rather than replacements of these forecasts (Goodwin and Fildes, 1999). Finally, any choice of method, or any decision on what length of series history to employ should be informed, as far as possible, by empirical evidence.

As we will show, the forecasting process employed by this company deviated significantly from this 'normative' approach; the core question we address is why this was this was the case and whether their adopted practices incurred unnecessary costs in conflict with their expressed objectives. Our preconception at the start of the study was that situations like this, where the organisational process differed substantially from the normative, could partially be remedied through software design and appropriate training of company staff. Such software would meet the requirements of the company by containing appropriate statistical methods, together with support mechanisms to aid judgmental interventions such as extensive on-line guidance. Furthermore, these facilities would be provided in such a way that they would be accepted by users because of their ease of use, demonstrable effectiveness (results demonstrability) and other attributes, as suggested by Venkatesh and Davis's (2000) technology acceptance model (TAM2).

Our observations at the pharmaceutical company caused us to question our preconceptions and to search for a rich explanation of how its forecasting process had arisen and endured. Actor–network theory helped to provide this explanation.

A theoretical framework

A number of researchers have proposed models that attempt to explain the use of technology in organisations. (see Orlikowski,1992, for a critical review of some of these models). The models vary in the relative importance that they place on the role of humans and technology in influencing each other and in shaping working practices. For example, at one extreme, the technological imperative model (e.g., Siegel et al, 1986) implies that technology is an exogenous influence on human behaviour and organisational attributes. This view discounts the actions of humans in developing, appropriating and changing technology and assumes that people operate and behave like machines. Under this assumption, ‘people compliantly carry out the orders and commands they receive, making efficient and effective use of all information and all technologies available to them’ (Davis et al, 1992). This can be contrasted with models which adopt a ‘strategic choice’ perspective and presume that technology is not an exogenous force but instead is itself shaped by humans operating within the organisations where it is deployed (e.g. Davis and Taylor, 1986. , Zuboff, 1988).

Actor-network theory (ANT) (Latour, 1987, Callon, 1991, Akrich, 1992,) avoids the dichotomy between human and non-human entities by using the concept of an actor (or actant). An actor is any element which has the power to initiate action and can be either a human, a collection of humans or an item such as a heavy hotel key (which causes a guest to return it to reception) or a computer program. Actors all have interests and they try to enrol other actors in order to create an alignment of the other actors' interests with their own. The result of successful enrolment is an actor network. This network relates, not to the static relationships between the actors, but to the processes in which they are involved (Zackariasson and Wilson, 2004).

Three key concepts associated with ANT are inscription, translation and irreversibility. When a technical artefact is created by an actor certain functions are inscribed into it which are designed to protect the actor’s interests. This process of inscribing involves the designer anticipating how future actors might use the artefact. In this process, designers define actors with ‘specific tastes, competencies, motives, aspirations, political prejudices and the rest..' (Akrich, 1992). Translation refers to the process of 're-interpreting, re-presenting or appropriating other actors' interests to one's own' (Callon, 1991).

The inscription of an artefact is an embodiment of the translation. However, users will also translate the system in relation to the tasks they are performing and the context within which they are operating (Hanseth, 2000). Once inscribed the technology itself becomes an actor by influencing its users to follow its program of action. There is, however, no guarantee that users will follow the prescribed pattern of use and the technology may be deployed in ways not anticipated by the designer. The likelihood of deviation from these anticipated patterns depends upon the strength of the inscription. For example an inscription for a software package may take the form of a training course, but if this proved to be too weak, stronger forms could be employed such as manuals or restrictiveness within the program itself (Hanseth, 2000). The strength of inscriptions is a related to the irreversibility of the actor-network. Irreversibility is the degree to which it is subsequently impossible to return to a point where alternative possibilities exist (Walsham, 1997). Actor-networks with high irreversibility have accumulated a resistance to change so it is very difficult, if not impossible, for alternative translations to be made.

ANT has been applied in a number of information systems research projects. For example, Vidgen and McMaster (1996) used it to examine an automated car parking system, Zackariasson and Wilson (2004) used it understand the role of IT in an after-sales organisation while Hanseth and Braa (2000) looked at the role of SAP in influencing change in a company. However, ANT's symmetrical treatment of humans and non-humans is not without its critics. While Hanseth and Braa described the technology they studied as 'a powerful actor.. and an ally' others argue that distinctions between humans and non-humans are necessary. For example, Jones and Rose (2005) argue that 'humans and machines can both be understood to demonstrate agency, in the sense of performing actions that have consequences, but the character of that agency should not be understood to be equivalent. Human agents have purposes and forms of awareness that machines do not'.

Despite these criticisms, ANT would appear to have a number of features that have the potential to illuminate the forecasting process at the pharmaceutical company. Its symmetry means that it will not downplay the role of technologies such as the forecasting package in the formation and continued existence of the process. Moreover, because it focuses on specific actors, it arguably allows a more fine grained assessment than approaches such as Orlikowski's (1992) structurational model which specifies three 'general' components: humans, institutional properties and technology. It also considers the mutual interaction of all of these actors, while for example Orlikowski's model only specifies four interactions. Finally, it guides one towards an assessment of the interests of the actors involved, and how these might be aligned and also helps to explain how these alliances allow processes to endure.

The company and its forecasting process

Background

The organization[1] we studied is a pharmaceutical sales and marketing company. supplying products for treating both animals and humans. Within the company there are three logistics managers who produce the initial forecasts for around 350 stock keep units (SKUs) and manage the inventory. The forecasting process also involves fifteen product managers, who look after the sales of groups of products, and financial and marketing managers. At the time of the study a placement student had also been recruited and he was spending a year using the package to produce forecasts for products with 'well behaved' demand patterns.

Three years before our study, the company had adopted the Six Sigma approach to managing[2]. Two logistics managers had achieved 'green belt' status, while another manager was in the process of becoming a 'black belt'. This indicates that they had achieved a proficiency in the application of statistical tools to management problems, although they had no training in statistical forecasting methods and minimal training

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[1] Aspects of this organisation have been disguised for reasons of confidentiality, both organisational and personal.

[2] Six Sigma is a data driven method for eliminating defects in any process – including those used in manufacturing and service industries

in the use of the package (the manual had been lost a long time ago). One of the Six Sigma projects that coincided with our study concerned the company's forecasting process.

Forecasting had been selected for the Six Sigma treatment (using the DMAIC approach (Brue, 2002)) because, i) in the words of one manager: "it took an enormous amount of time, effort and resources and pain to produce the various forecasts" and ii) there were concerns about forecast accuracy. Accurate forecasts were regarded as desirable by the logistics managers because they reduced the supply chain costs arising from obsolescent products, inefficient use of warehouse space and high inventory levels. In addition, sales targets were closely associated with the forecasts and thus affected the bonuses that had to be paid to sales representatives. Because of this the forecasting improvement project was regarded as "a big strategic project".

The actors and their interests

In seeking to identify the actor network which has created the forecasting process we chose to distinguish between stakeholders (those who have an interest in the process) and actors. Actors not only have an interest in the process, they also have to have the ability to influence the process ("to bend space around themselves" (Sidorova and Sarka, 2002). Table 1 lists the actors we identified.

** Please insert Table 1 about here**

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We then set about classifying the interests of the actors that had become apparent during our field work, using a method suggested by Vidgen and McMaster (1996). This method is based on Mitroff and Linstone's (1993) multiple perspectives approach and considers interests from three perspectives: rational, organisational and personal. The rational perspective is concerned with a scientific world view and considers actors' interests from a viewpoint which is objective, logical and rational. The organisational perspective considers interests from the perspective of 'social entities, politics and the establishment of shared understandings.' Finally, the personal perspective focuses on individual factors 'such as power, influence, prestige, learning, values and experience'. Vidgen and McMaster argue that no single perspective will, by itself, be sufficient to gain insights into complex situations . Table 2 shows our interpretation of the actors' interests using this structure.

The decision to purchase the forecasting software

This forecasting software had been in use for seven years at the time of the study. It was bought 'off-the-shelf' (as opposed to being an in-house development), with some 'personalised' settings tailored to the company by the supplier based on an analysis of the company's sales data. At the time of the purchase it was thought that a forecasting system was needed "to do the job properly" as one logistics manager explained. Before this, individuals had made their own forecasts, often using a ruler to fit a line to paper copies of sales graphs. The package was chosen by a group of middle managers over two alternatives (including an Enterprise Resource Planning (ERP) package) with a 9 to 1 vote in its favour. The choice was primarily driven by the perceived 'user-friendliness' of the package and the marketing and sales people commented that they particularly liked the ease with which the forecasts could be changed to reflect managerial judgment. Interestingly, the marketing and sales staff took a keen interest in the forecasts for their products, which contrasted with the attitude of staff in some other companies visited by the research team. In these other companies sales personnel apparently saw their objectives as maintaining customer relationships and making deals and, in consequence, had little interest in numbers, forecasts and computer packages.

The package was now perceived as being "fairly extensively used" [in the words of one logistics manager], in producing forecasts. Its use was regarded as a big improvement on the previous approach and managers felt that forecasting accuracy had improved –though no empirical data existed to support this. The package was regarded as "the best available" [this quote is from the same logistics manager] and, while some users had complaints about particular facilities, most were generally satisfied with it. Its perceived central role in the forecasting process was never questioned and no one, in the meetings we observed with participants, suggested switching to an alternative package or making other fundamental changes to the existing process.

Insert figure 1 about here

How the package was used

Figure 1 gives an overview of the company's forecasting process. Forecasts of demand were needed looking forward two months, reflecting the production planning requirements of the company's manufacturers. In theory, the derivation of the forecasts involved two main stages. First the forecasters (recall that these were the three logistics managers) cleaned the sales history to remove the effects of stockouts (these are known from data on orders) so that the series represented the level of demand. They then used the package to produce the 'base-line' forecasts (forecasts which took no account of market intelligence (MI)). Secondly, these forecasts were presented at a forecast review meeting where they were adjusted for MI to produce the final forecast.

As we will show below, the actual practice of producing the forecasts involved some blurring of these stages; recent past patterns in the demand were sometimes used as a reason for adjustment at review meetings rather than MI (as should have been the case if the agreed procedures were being followed)

A particular difficulty in producing accurate forecasts arose because of the effects of cross border trade (CBT) where customers buy the company's products from overseas subsidiaries, usually at a lower price. This resulted in many unforeseen fluctuations in the demand data that were used when producing the forecasts. The degree to which CBT had impacted on the most recent observations was also difficult to ascertain as it took time to obtain information on the level of this activity. Apart from CBT, there were many other uncertainties in the market, such as the outcomes of tenders, competitors' actions and consumers' behaviour. For example, with animal medicines, farmers may switch brands when the drug ceases to be effective because bacteria have become resistant to its effects.

Stage 1 Obtaining the baseline forecasts

The patterns of the demand history varied according to the product types. While seasonality may have been observed in some animal product series, it was rarely found in human product series. More fundamentally, the forecasters explained that most products had a life cycle which caused their underlying trend to have a non-linear shape (see fig 2). In the early years of a product's life it took time for demand to build up as doctors needed to be persuaded to prescribe the drug. Following this, the product experienced a mature phase of demand, before finally losing its patent protection. This caused sales to decline as generic products were marketed at a lower price.

Insert figure 2 about here

Despite the existence of the product life cycle, the statistical methods embedded in the software were designed to extrapolate linear trends. To try to adapt these extrapolations, so that they matched the perceived life-cycle pattern, the forecasters proceeded as follows**.**

a) They selected an 'appropriate' length of demand history, for a given product so that the package generated a trend line that gave the best fit to the selected data, using the least squares criterion. Usually two year's of past data were used, but it could be much less (e.g. six months). The forecasters said that they could not obtain a graphical depiction of more than three-year's demand history, even if they wished to, because of a restriction in the software. However, the use of the full two years in developing the statistical forecast sometimes delivered forecasts that were deemed implausible. By manipulating the length of the demand history, more acceptable forecasts could be obtained. The two-month ahead forecasts were then calculated from an extrapolation of the trend line.

b) To further improve the apparent fit of the trend line to the past data and also to obtain forecasts that "looked right", the forecasters often used their judgment to override the forecasts obtained in (a). This could be simply achieved by using a mouse to reposition the position of the trend line on the graph. Thus the forecasters were ostensibly trying to model the non-linear trends resulting from the perceived product life-cycle by fitting and adjusting linear trends to relatively short sequences of past data.

Note that senior management had determined that adjustments of forecasts for MI market intelligence (see below) had to be reported to them with a documentation of their rationale. However, adjustments to the package's forecasts like those that we have just described did not require documentation and reporting. There was some evidence that at least one product manager was exploiting this loophole. It was in his interests for the sales of his product to exceed their forecasts and he therefore tried to arrange for his forecasts to be adjusted downwards at the 'fitting stage' (his forecaster was the placement student) and he subsequently aimed to made few adjustments for MI.

Stage 2 Incorporating the effects of market intelligence (MI)

The package's displays of the forecasts resulting from Stage 1 were presented on a large screen at one of 17 monthly product group review meetings. As mentioned above, the main purpose of these meetings was officially to allow the forecast to take into account market intelligence (MI) The attendees at the forecast review meetings were the relevant product manager, whose role was to adjust the forecast for MI, the relevant forecaster, who might challenge these adjustments, and representatives of the market research, finance and commercial functions. One of the logistics managers said "years ago we owned the [forecasting] process; they [Marketing] owned the forecasts". Since then, senior management had insisted that all parties at the review meetings had to jointly own and agree the forecasts.

The review meetings that were observed differed in character. For example, the first meeting concerned forecasts for animal products. Here, the forecasts that were agreed were based almost exclusively on the product manager's intimate knowledge of his market. These were never challenged. For example, the manager knew that two large customers were 'repopulating' and that this would boost the demand for a particular drug in two month's time.

A meeting to forecast the demand for a human medicine had a number of contrasting characteristics as shown below.

- The meeting was cordial, but there was much debate and participants were prepared to challenge each other's views. Most of the discussion involved the Product Manager and the Logistics Manager. The representatives of the other functions had relatively little to say.
- There was great emphasis on very recent demand history. As stated earlier, the forecast initially presented usually were based on, at most, two year's past data because "further back the trends tend to be different". The appropriateness of this forecast was then assessed by a forensic discussion of very recent demand patterns, with particular emphasis on the last three months. An explanation was sought for every movement in the graph over these months, though reasons for these movements were usually unknown or highly speculative (e.g. "Why was October low and November high?" Answer: "I don't know about October. November is normally part of the wholesaler's build …. We always do better in November. Having said that we didn't last year, did we?") [Quotes are taken directly from tape recordings of the meeting]
- The baseline forecasts were *replaced* by new judgmental forecasts, rather than being adjusted. (Adjustment would have involved assessing the extent to which the baseline forecast need to be changed to reflect MI, rather than the estimation of a completely new 'holistic' forecast.)
- In making the forecasts, the relative demerits of forecasting too low (with the risk of stock-out) and forecasting too high (I would have "egg on my face" [quote from Product Manager]) were weighed against one another with the stock-out risk being considered the most serious, given the nature of the products

The actual forecasting process can thus be summarised as:

Automatic statistical baseline forecast → Replacement with judgmentally derived 'statistical' baseline forecast → Further judgmental adjustment at Review Meeting to obtain final forecast.

The accuracy of the judgemental adjustments: a contrasting perspective

The organisational process we have described was always justified by the organisational actors as an attempt to improve the accuracy of the forecasting support system. If such adjustments have proved consistently helpful, then the conflict between the normatively-derived model and the process merely underlines the limitations of the normative model. We can explore aspects of this issue because, unlike most decision support systems, the forecasting system described here can be unequivocally evaluated as to its effectiveness in delivering accurate forecasts, the overt objective of the forecasting process. The three stages in the procedure: automatic statistical forecast, 'judgemental statistical' forecast, and final market adjusted forecast, can each be compared to the sales outcomes. Such a comparison gives an alternative perspective on the actors expressed rationale for the various interventions they make.

To investigate the extent and effect of judgmental interventions at this stage in the process we carried out an analysis of the accuracy of the sample of 3264 forecasts that were supplied by the company. Because the company had no record of the original forecasts that would have been generated automatically by their forecasting software and because we had restricted access to this software we simulated these forecasts by applying the *Forecast Pro* forecasting system (Stellwagen and Goodrich, 1994), in automatic mode to 24 consecutive months of past demand data. Of course, there may be some discrepancies between our simulated forecasts and those generated by the company's software. However, we are confident that our simulated forecasts provided accurate estimates of the baseline forecasts that the company would have obtained had they applied statistical forecasting techniques, without intervention, to their data as they are based on a similar algorithm.

The effect of the judgmental adjustment to the automatic forecast can be estimated by the difference between the automatic forecasts and the company forecasts. The median absolute percentage difference between the automatic (simulated) forecasts and the baseline judgemental forecasts used by the company was 10.5% (first quartile:

4.6%, third quartile 21.2%). However, the effort that went into making these judgmental interventions in an attempt to improve the baseline forecasts appears to have had no effect on the quality of the final forecasts (i.e. the forecasts produced after subsequent adjustments for MI). Adjusting a baseline forecast so that it was closer to the actual demand was not associated with more accurate final forecasts. For example, the bi-serial correlation between the absolute percentage error (APE) of the final forecast and whether or not the stage 1 adjustment led to a baseline forecast closer to the actual demand was only -0.006 (it was -0.054 when outliers with absolute percentage errors of over 500% were removed). Similarly, the correlation between the size of the adjustment to the automatic forecast (measured as an absolute percentage) and the APE of the final forecast was only 0.009 (when outliers were excluded).

62.3% of the sampled ‘statistical’ baseline forecasts were judgmentally adjusted, ostensibly for MI . Did *these* adjustments lead to improved accuracy? Analysis of the sample indicated that moderate improvements were sometimes achieved: the median absolute percentage error of the baseline forecasts was 17.3%, while that of the adjusted forecasts was 14.3%. However, only 51.3% of forecasts were improved through MI adjustment and the most successful adjustments tended to be larger. Table 1 shows, for the forecasts that were adjusted, the size of the intervention and whether it improved accuracy. Less than 45% of the smallest adjustments (below the first quartile) improved accuracy while over 58% of the largest adjustments (above the third quartile) resulted in improvements. This suggests that the smaller adjustments (and many of the larger ones) involved further tinkering with the baseline forecasts, possibly because the forecasters perceived patterns in recent noise. It seems unlikely that such adjustments would be made because the members of the review meeting were in possession of important MI which was likely to have a major effect on demand.

*Please insert Table 1 about here**

Summary: The Organisation's Forecasting Process

The organisation's forecasters devoted much judgmental effort to establishing the baseline forecasts. As the statistical analysis shows, automatic forecasts from the software would apparently have served them just as well. These refitted baseline forecasts were then often changed again at the meetings, leading to only moderate gains in accuracy in some cases, but reductions in accuracy on nearly half of occasions. 'Optimised' statistical forecasts, based on long demand histories thus had virtually no role at all. How did managers perceive the quality of their forecasting process? The perception of one of the logistics managers was that they were "good on reporting error levels, but not good on using the data that they have to improve forecast accuracy" (e.g. stock level data that were available for some customers were not used.). In particular, this manager thought that there was potential for improving their ability to learn from past forecast errors. However, managers saw little need for fundamental changes in their process or the statistical package that they had purchased.

Formation of the actor-network

The forecasting process we have observed is viewed as satisfactory despite pressures for improvement, through for example, the six sigma initiative. For the purpose of understanding the networked forces that create stability, it is useful to start with the perspective of a single actor who has an interest in changing the status quo. This actor will be referred to as the 'focal actor' and we will aim to show how other actors' alignment with the focal actor's interests leads to the formation of the network (Sidorova and Sarka, 2002) through a process of enrolment. In our case, we will designate the software vendor as the focal actor, though we could have taken the perspective of another actor as our starting point and we would still have derived the same rationale for the formation of the network.

The vendor is interested in obtaining sales of the package. This interest is served by advertising the accuracy and sophistication of the package's inbuilt statistical methods and its facilities for judgmental intervention, together with the package's ease of use (evidence for the highlighting of these attributes can be found on the software company's web site). The vendor will also want to maximise the profit on the sale. This will be achieved by selling a package containing a *standard* (rather than a customised) set of statistical forecasting methods in order to spread the package's development costs . In the words of one software developer: "We live in a commercial reality, you see, and the customer will come along and say I would like something [a new facility] and you say I can't do this unless you co-fund the development" [this quote has been slightly re-worded to improve clarity]. Inscription of the software with easy-to-use facilities for judgmental intervention will thus serve the vendor's interests in a second way because it will effectively place the costs of any local adaptation (or customisation) of the *forecasts* upon the user. This will also reduce the chances of the software being blamed for forecast errors, so ensuring continued use. Continued use is in the vendor's interests because users will pay for the maintenance of the package and will attend user conferences and purchase upgrades. Also, the existence of an active body of existing users is likely to attract new customers.

However, the provision of an easy-to-use facility for judgmental intervention is also in the interests of the company's middle managers. They can be seen to be using an advanced package containing reportedly sophisticated and accurate statistical methods, while at the same time being able easily to control the forecasts. The existence of these facilities for intervention has been particularly useful in the enrolment of the product managers whose participation in forecasting is seen as crucial because of their market intelligence. It allows them to derive prestige by demonstrating their expertise on their markets at forecast review meetings and gives them the opportunity of attempting to push the forecasts in directions that suit the balance of their interests. For example one product manager, commenting on the software, said: "It's there, it's useful, but it needs to be managed since no way can it have the market intelligence".

Despite their limitations from a statistical point of view, the linearity of the package's extrapolations is actually an asset in securing its acceptance. It provides a pretext for interventions, allowing users to make adjustments for other reasons. To maintain their own standing, the logistics managers need to produce baseline forecasts which look credible at review meetings where colleagues have an intolerance of noise in the time series. To achieve this they can use the intervention facilities to fit and refit past trends to different lengths of past history until a close fitting trend is achieved. One logistics manager described the package as being “quite good” because it allowed the graphical fit of the trend line to be easily assessed as judgmental changes were made to it and the length of the demand history.

It is in senior managers’ interests to receive timely forecasts that they perceive to be from an advanced, modern forecasting process yielding baseline forecasts that are as accurate as possible, given current technology. It is also in their interests to ensure the inclusion of all relevant middle managers in the process. The package serves these interests because, when coupled with a projector, it produces graphical and tabular displays that can be used in review meetings involving groups of managers and allows forecasts to be easily and publicly changed during these meetings. The old ‘ruler and paper’ system would not be compatible with such meetings. Senior Managers also want to be able to exercise some control and monitoring of this process. From their perspective the package also has a facility which allows for adjustment for market intelligence (in computing terms this is actually no different from the baseline adjustment) and, by requiring documentation of these adjustments, they perceive that control over the process can be exercised. Also, in relation to total turnover, the cost of the package was small (though it was large enough to be regarded as a serious tool).

How stable is the actor-network? Any proposal to replace the existing package with an alternative would probably be resisted by all of the actors. To the middle managers it would involve the risk of losing the benefits of control over the forecasts, disruption and (in the case of the logistics managers) the need to learn a new package. For the senior managers changing to another package would involve purchasing and other costs, disruption and probably resistance from middle managers. All of this has served to consolidate the alignment of interests of the vendor and middle and senior managers and helped to ensure the irreversibility of the network. Although managers indicated that they felt their forecast’s accuracy could be improved (this was part of their main motive for inviting us into the company) they evidently wished to make these improvements within the existing structure. A suggestion by one the researchers at the end of the interviews that the company might be using inappropriate software, and that what was needed was a model that supported extrapolations based on product life cycles, was received sceptically. It was apparent that the company would like to find ways of making better use of available information in order to improve the quality of their judgmental interventions –the role of the forecasting package would remain unchanged.

Discussion and Conclusions

In this case study we observed a company whose managers perceived that they were making extensive use of an advanced statistical forecasting package and who were generally satisfied with the package. Yet the essential features of the package -its statistical methods which produced linear extrapolations -were not congruent with the company's perceived forecasting task and they were, in reality, not employed at all. Moreover, the main facility that was used, its graphical data display, was limited both in the clarity of its presentation and in the length of history it could handle. From the technological imperative perspective, where people make rational economic decisions and make optimal use of appropriate technology, this situation is inexplicable. However, from the perspective of actor-network theory, where actors form alliances of interests, the decision to purchase and continue to use the package becomes understandable.

The perception that the package was extensively used was a socially constructed reality. Repeated patterns of use over seven years had become institutionalised and reified (Orlikowski, 1992) so that nobody now questioned the role of the package. Actors perceptions of their interests will have been shaped by this socially constructed reality. For example, the belief that the package 'was the best available' will have precluded senior management and other actors from evaluating alternatives.

Our understanding, as researchers, of the role of forecasting packages in supply chain companies has been enhanced as a result of this study. This enhancement has progressed though a series of iterations known as the hermeneutical circle (Klein and

Myers, 1999) which has involved explaining apparently anomalous situations by cross-referencing them to situations that did ‘make sense’ in a manner analogous to the interpretation of an ancient text. As stated earlier, our belief at the outset was that forecasting accuracy in companies like this could be improved though the provision of well designed software that contained appropriate statistical methods and features to support the effective use of management judgment. We still adhere to the core of this belief, but now recognise that, on its own, it is too narrow a view and that the design of software needs to take account of the network of interests of actors associated with it. Well designed software will not be written and used unless it serves the aligned interests of vendors, users, senior managers and others to form new and irreversible actor-networks. Yet poorly, or inappropriately, designed software will ‘succeed’ if it does serve these interests.

Adopting for the moment the normative perspective with which we started, it is tempting to suggest that the pharmaceutical company’s forecasting process could be reconfigured to the benefit of the company, if the actors’ interests could be re-aligned. Such changes might result if external threats or opportunities present themselves, such as the arrival of new personnel who promote the adoption of new ERP software or an influential six sigma campaign (Fildes and Hastings, 1995). However, we recognise that this itself might be a simplification and an intrusion of a technological imperative view into our thinking.

Of course, as a result of such patterns in our thinking, and our position as outsiders, we may never be able to gain a complete understanding of an organization like this and the behaviour of its members. For example, we cannot be sure that the tone and orientation of the semi-structured interviews that we conducted was not, at least unconsciously influenced by our preconceptions and beliefs . Similarly, our presence at review meetings, where we may have been regarded as forecasting experts, may have influenced the processes that took place, despite our attempts to act only as silent, non-judgmental observers. As far as possible, we tried to implement the ‘principle of suspicion’ in case people were simply presenting an ‘official company view’ or a view that was designed to impress us. (Klein and Myers, 1999). We were helped in this by the presence of the placement student. As a ‘relative outsider’, who had nevertheless already worked in the company for nine months, he was able to provide an alternative perspective during his interview. Nevertheless, Myers (1997) has argued that no final interpretation is ever achieved, since each interpretation may itself be subject to critical reflection. Our objective was to achieve at least an improved understanding of the use of forecasting software, explaining through case analysis, what has often proved a conundrum to forecasting researchers with a primarily statistical orientation: why what is normatively viewed as 'best practice' fails to be adopted in organisations that express a commitment to improved accuracy.

This research poses a stark question to software designers and academic forecasters; how the organisational and personal barriers embodied in the actor-network can be overcome to achieve more cost-effective forecasts and useful software. The heavy reliance in organisations like this on actors' interventions makes such an outcome hard to achieve.

References

AKRICH, M. (1992) The description of technical objects. In *Shaping Technology/Building Society* (BIJKER WE and LAW J, Eds), pp205-234, MIT Press, Boston.

ALEXANDER PM (2004) Towards reconstructing meaning when text is communicated electronically, Chapter 2, PhD Thesis, Faculty of Engineering, Built Environment and Information Technology, University of Pretoria.

BARLEY S (1986). Technology as an occasion for structuring: Evidence from observation of CT scanners and the social order of radiology departments. *Administrative Science Quarterly* 31, 78-108.

BERG M (1998) The politics of technology: On bringing social theory into technological design. *Science, Technology and Human Values* 23, 456-490.

BRUE G. (2002) *Six Sigma for Managers* McGraw Hill, New York.

CALLON M (1991) Techno-economic networks and irreversibility. In: *A Sociology of Monsters: Essays on Power, Technology and Domination* (Law J, Ed), pp132-161, Routledge, London.

DALRYMPLE DJ. (1987) Sales forecasting practices, results from a United States survey. *International Journal of Forecasting* 3, 379-391.

DAVIS GB, LEE AS., NICKLES. KR, CHATTERJEE S, HARTHUNG R and WU Y (1992) Diagnosis of an information systems failure. A framework and interpretive process. *Information and Management* 23, 293-318.

DAVIS LE and TAYLOR JC (1986) Technology, organization and job structure. In) *Handbook of Work, Organization, and Society* (DUBLIN R, Ed.) pp379-419. Rand McNally, Chicago.

EASTERBY-SMITH M, THORPE R and LOWE A (2002) *Management Research* Sage Publications. London.

FILDES R, GOODWIN P and LAWRENCE M (*forthcoming)* The design of forecasting support systems and their effectiveness. *Decision Support Systems.*

FILDES R and HASTINGS R (1994) The organization and improvement of market forecasting. *Journal of the Operational Research Society* 45, 1-16.

GOODWIN P (2002) Integrating management judgment with statistical methods to improve short-term forecasts. *Omega, International Journal of Management Science* 30, 127-135.

GOODWIN P and FILDES R (1999). Judgmental forecasts of time series affected by special events: Does providing a statistical forecast improve accuracy? *Journal of Behavioral Decision Making* 12, 37-53.

HANSETH O (2000). Actor-network theory and information infrastructures. In *From Control to Drift* (CIBORRA C, Ed) Oxford University Press, Oxford.

HANSETH O and BRAA K (2000) Who's in control: Designers, managers or technology? In *From Control to Drift* (CIBORRA C, Ed) Oxford University Press, Oxford.

KANTER RM (1977), *Men and Women of the Corporation* Basic Books, New York.

KLASSEN RD and FLORES BE (2001) Forecasting practices of Canadian firms: survey results and comparisons. *International Journal of Production Economics* 70, 163-174.

LATOUR B (1987) *Science in Action* Harvard University Press, Cambridge, MA.

KLEIN HK and MYERS MD (1999). A set of principles for conducting an evaluating interpretive field studies in information systems. *MIS Quarterly* 23, 67-94.

MADY MT (2000) Sales forecasting practices of Egyptian public enterprises: survey evidence. *International Journal of Forecasting* 6, 359-368.

MAKRIDAKIS S, WHEELWRIGHT SC. and HYNDMAN, R.J.(1998) *Forecasting. Methods and Applications* 3rd edition Wiley, Chichester.

MITROFF I.and LINSTONE H (1993) . *The Unbounded Mind. Breaking the Chains of Traditional Business thinking* Oxford University Press., New York.

MYERS MD (1997). Critical ethnography in information systems. In *I.S. and Qualitative Research* (LEE AS, LIEBENAU J. and DEGROSS JI, Eds.), pp. 277-300,. Chapman & Hall, London.

NANDHAKUMAR J and JONES M (1997) Too close for comfort? Distance and engagement in interpretive information systems research. *Information Systems Journal* 7, 109-131.

NARDULLI PF (1978) *The Courtroom Elite: An Organizational Perspective on Criminal Justice* Ballinger Press, Cambridge, MA, ORLIKOWSI WJ (1992) The duality of technology: Rethinking the concept of technology in organizations. *Organizational Science* 11, 404-428.

ORLIKOWSI WJ (2000). Using technology and constituting structures: A practice lens for studying technology in organizations. *Organization Science* 11, 404-428.

O'CONNOR M, REMUS W and GRIGGS K (1993). Judgemental forecasting in times of chang. *International Journal of Forecasting* 9, 163-172.

ROSE J qnd JONES M (2005). The double dance of agency: A socio-theoretic account of how machines and humans interact. *Systems, Signs and Actions* 1, 19-37.

SANDERS NR and RITZMAN LP (2001). Judgmental adjustment of statistical forecasts. In. *Principles of Forecasting* (ARMSTRONG JS, Ed), pp 405-416, Kluwer Academic Publishers, Norwell:MA.

SANDERS NR and MANRODT K B (1994) Forecasting practices in US Corporations: Survey results. *Interfaces* 24, 92-100.

STELLWAGEN EA and GOODRICH RL, (1994), *Forecast Pro for Windows*, Business Forecast Systems Inc., Belmont, MA..

SIDOROVA A and SARKER S (2002), Unearthing Some Causes of BPR Failure: An Actor network Theory Perspective, School of Accounting, Information Systems and Business Law, Washington State University.

SIEGEL J, DUBROVSKY V, KIERLER S and MCGUIRE TW (1986) Group processes in computer-mediated communication. *Organizational Behavior and Human Decision Processes* 37, 157-187.

VENKATESH V and DAVIS FD (2000) A Theoretical Extension of The Technology Acceptance Model: Four Longitudinal Field Studies. *Management Science* 46, 186-204.

VIDGEN R.and MCMASTER T (1996). Black boxes, non-human stakeholders and the translation of IT though mediation. In *Information Technology and Changes in Organizational Work* (DeGross JI ,Ed) Chapman and Hall, London.

WALSHAM G (1995). Interpretive case-studies in research - nature and method. *European Journal of Information Systems* 4, 74-81.

WALSHAM G (1997). Actor-network theory and IS research: Current status and future prospects. In *Information Systems and Qualitative Research* (DeGross JI , Ed), Chapman and Hall, London.

WALSHAM G and SAHAY S (1999). GIS for district-level administration in India: Problems and opportunities. *MIS Quarterly* 23, 39-66.

ZACKARIASSON P and WILSON T (2004). Internetworked after-sales service. *Industrial Marketing Management* 33, 75-86.

ZUBOFF S (1988) *In the Age of the Smart Machine*, Basic Books, New York.

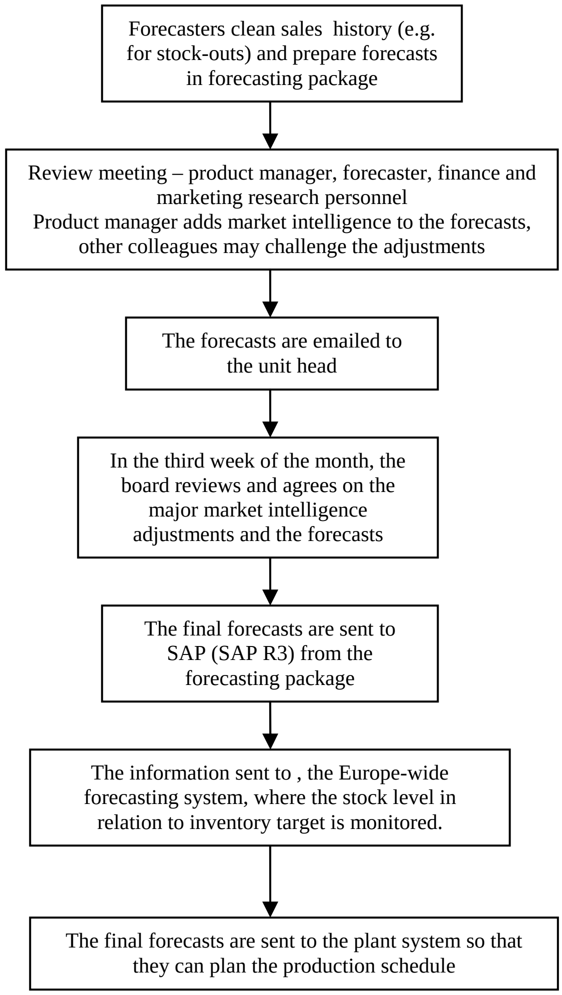

Figure 1 The company's forecasting process

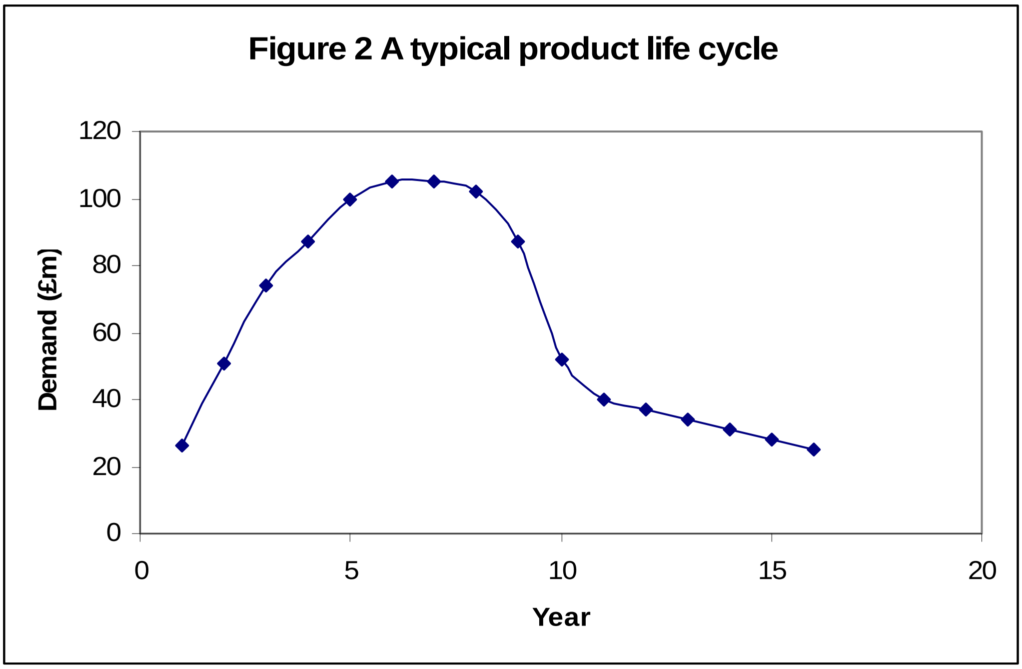
Figure 2 A typical product life cycle
120
100
80
60
40
20
0
Demand (£m)
0
5
10
15
20
Year

Percentages	**Size of adjustment**			
Effect in forecast accuracy	Less than first quartile	Between first quartile & median	Between median & third quartile	Greater than third quartile
Reduced accuracy	55.01	52.95	44.88	41.85
Improved accuracy	44.99	47.05	55.12	58.15
Total	100.00	100.00	100.00	100.00

Table 1 Size of adjustment to baseline forecast and effect on final forecast accuracy

Table 2: An Analysis of the Actors' Interests

Actors	Rational	Interests Organisational	Individual
Senior managers*	Ensure forecasts are received which are useful for monitoring business and supporting plans and decisions i.e. forecasts which are accurate, timely, cost-effective and complete. Ensure forecasts minimise chances of stockouts without excessive safety stocks Balance purchase cost of software and associated training costs with benefits	Exercise control over forecasting process. Ensure forecasting are seen to be using 'modern' methods. Ensure all relevant people are involved in forecasting. Minimise chances of conflict between middle managers. Retain existing software to avoid disruption through change	
Marketing & Product managers	Achieve high sales and high quality of service to customers - minimise chances of stock outs	Ensure forecasts are high enough to minimise chances of stockouts. Maintain some control over forecasts. Understand limitations of baseline forecasts	Demonstrate expertise relating to product.Maximise sales commission Maintain good personal relationships with customers. Make sure forecasts are not too high as they will look good if they exceed forecasts. Adjust forecasts without documentation of rationale. Avoid being seen to manipulate forecasts in one's own interests. Avoid large forecast errors - given joint responsibility. Be associated with introduction of system that will impress senior managers.
Accountants	Minimise costs resulting from forecast errors Minimise inventory costs	Counter Product Managers when they push for higher forecasts & more safety stocks, but still minimise chances of stockout. Have some control over forecasts	Avoid large forecast errors -given joint responsibility

Continued/

Table 2: An Analysis of the Actors' Interests (continued)

	Interests		
Actors	**Rational**	**Organisational**	**Individual**
Logistics managers who produce 'baseline forecasts	Produce accurate forecasts	Counter conflicting tendencies of Product managers and accountants for over and under forecasting. Be seen to be making forecast in professional manner by using an advanced software package. Keep Product Managers on board as their MI is crucial for forecast accuracy.	Share responsibility for significant forecast errors. Minimise work involved in producing base line forecasts by having easy to use software. Maintain image of competence by producing 'baseline' forecasts that look intutively reasonable at review meetings. Avoid significant conflict at review meetings. Demonstrate expertise in use of software. Maintain control over forecasts given responsibility. Minimise documentation of forecasts' rationale. .Stay with current package to minimise changeover costs and effort..Be associated with a system that will impress senior managers.
Software vendors*	Maximise profit derived from sales and support of forecasting software, Employ robust forecasting methods capable of widespread use across many companies and industries -rather than industry specific methods. Maintain loyalty of customers through user conferences	Advertise accuracy and sophistication of software's statistical methods but provide facilities for judgmental overrides. Ensure that software is easy to use. Allow easy use by non-forecasting experts. Ensure continued customer loyalty. Minimise costs of writing and providing software	Maximise sales. Avoid responsibility for any forecast inaccuracy
The software*	Maximise reputation and number of users	Ensure continued use. Maximise user satisfaction and ease of use. Provide displays capable of being used in meetings. Maximise analytical power and flexiblity of software. Outshine rivals	