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Forecasting task-technology fit: The influence of individuals, systems and procedures on forecast performance

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Abstract

This study establishes and tests a theoretically-based model of forecasting practice. Forecasting Task-Technology Fit (FTTF) addresses the relationship between forecasting support systems, the procedures that guide forecast creation, and their fit with the capabilities of the forecasting support system user. An analysis of survey responses collected from 216 forecasting practitioners confirms a positive relationship between specific forecasting support system characteristics and the system user's perceptions of system quality and access. The results also support a positive relationship between the system user's perceptions of the quality of, and their access to, procedures that guide forecast creation and their perceptions of system quality and access. Finally, the results confirm a positive relationship between the user's assessment of system quality and access and a dependent variable measuring forecast performance.

Keywords: Forecasting support systems; Forecasting management; Sales forecasting; Task technology fit; Forecasting practice

1. Introduction

Demand forecasts are employed in a wide range of business operations, including inventory management, transportation, distribution, replenishment, production, maintenance and supplier collaboration (Fildes, Goodwin, & Lawrence, 2006; Kusters, McCullough, & Bell, 2006). When used effectively, improved forecasting performance helps organizations and supply chains to adapt to changing market conditions and improve operating performance (Fildes & Beard, 1992; Gardner, 1990; Wacker & Lummus, 2002). When performance degrades, companies frequently rely on inventory assets, expedited services and other expensive actions to support operations and maintain service (Armstrong, 1988; Winklhofer, Diamantopoulos, & Witt, 1996). In the worst cases, poor forecasting performance can contribute to major financial losses. Forecasting missteps at Cisco Systems were believed

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to have contributed to a multi-billion-dollar write off of products and components during the dot-com bust in 2000 (Berinato, 2001).

Researchers have long recognized the significant role of forecasting in business practice, and forecasting journals have emphasized the need to investigate management factors that influence model development and implementation (Fildes, 2006; Makridakis, 1996; Winklhofer et al., 1996). Since its founding, the *International Journal of Forecasting* has published two editorials calling for more research into forecasting practice (Lawrence, 2000; Schultz, 1992). The volume of such research, however, has remained limited (Fildes, 2006). Schultz (1984), for example, investigated model implementation and the structures and processes related to model application. Reviewing practice-related research, Winklhofer et al. (1996) cited 35 surveys and six case studies that offered insights related to forecast design, selection/specification and evaluation.

Few studies have presented a theoretical grounding to explain how factors and relationships may influence forecast development and application (Davis & Mentzer, 2007; Fildes & Hastings, 1994; Fildes et al., 2006; Mentzer, Bienstock, & Kahn, 1999; Winlkhofer & Diamantopoulos, 2003). Proposed frameworks have considered the influence of market environment, organization, management support, and information systems on forecast performance and application. They have addressed forecasting at a departmental and individual unit of analysis. They have yet, however, to provide empirical evidence to confirm such relationships. The lack of an empirically tested model of forecasting development and application represents a significant gap in efforts to understand and improve forecasting practice.

One factor consistently represented across earlier models of forecasting is conceptualized in one form or another as the forecasting system. Schultz (1984) identified "system format" and "system quality" in his forecasting model implementation profile. Fildes and Hastings (1994) outlined what they considered to be the characteristics of an 'idealized' (quotes original) forecasting system to guide a discussion of organizational factors in market forecasting. Mentzer et al. (1999) addressed systems as being one of the four dimensions of forecasting management that impact performance. Davis and Mentzer (2007) included information technology as part of an information logistics component of their sales forecasting management (SFM) framework.

The present study emphasizes the role of systems in forecasting. It integrates research drawn from the forecasting, information systems and decision support systems literature to address the relationship between forecasting support system effectiveness and forecast performance. Fildes et al. (2006) employed the term forecasting support system (FSS) to describe a forecasting system as a type of decision support system (DSS) used to prepare forecasts. Their description of system characteristics included database capabilities used to collect demand history and related information, a range of forecasting techniques, and the ability to incorporate managerial judgments.

The study also benefits from a stream of research concerned with improving information and decision support system effectiveness. It draws on the theory of Task-Technology Fit (TTF) (Goodhue, 1995; Goodhue & Thompson, 1995) to evaluate the relationship between the skills and abilities of individuals involved in forecasting, the task and system characteristics that support forecast creation, and the resulting forecast performance, defined as an assessment of forecast accuracy.

The next section reviews the literature concerned with forecasting models and systems, as well as information systems research. The review provides a theoretical grounding to explain how factors influence the effectiveness of forecast support systems. Section 3 develops a series of hypotheses that address the relationship between the capabilities of individuals involved in forecasting, the tasks and systems that support forecasting, and forecast accuracy. Section 4 discusses the methodology for testing the hypotheses. Section 5 discusses the results, and Section 6 addresses conclusions and implications for forecasting practice and research.

2. Relevant literature

Research investigating the role of systems in forecasting practice has described the system characteristics which are useful to forecast applications in areas such as production and inventory control (Fildes & Beard, 1992), vendor managed inventory (Nachiappan, Jawahar, Parthibaraj, & Brucelee, 2005),

Table 1
Studies addressing forecasting system characteristics.

System capability/study	Fildes and Beard (1992)	Mentzer and Schroeter (1994)	Mentzer and Bienstock (1998)	Mentzer and Kent (1999)	Mentzer et al. (1999)	Fildes et al. (2006)
Method	Technique application	Case	Benchmark	Case	Benchmark study	Case
Client/server					√	
Central database					√	√
Electronic linkage/customers					√	
Developer/user access			√			
Item-level time series	√	√		√		√
History/forecast aggregation	√	√		√		√
Multiple methods	√	√	√	√	√	√
Time series	√	√	√	√	√	√
Regression	√	√	√	√	√	√
Qualitative	√	√	√	√	√	√
Performance reporting	√	√		√	√	√
User-defined reporting	√				√	√
Note capabilities				√		
Easy to use		√	√	√		√
Process driven						√
Graphics	√	√				
Item/data flagging	√		√			
Experimental module	√	√				√
Automated selection	√		√			

and parts management (Snyder, 1993). It has addressed features for facilitating management judgment (Moriarty, 1985) and event information (Webby, O'Connor, & Edmundson, 2005) during forecast creation.

Forecasting research has also identified general system features and capabilities which are considered important to forecast creation and implementation (Fildes et al., 2006; Fildes & Beard, 1992; Mentzer et al., 1999; Mentzer & Bienstock, 1998; Mentzer & Kent, 1999; Mentzer & Schroeter, 1994). These include capabilities that can help individuals with little knowledge of forecasting techniques create forecasts (Fildes et al., 2006; Kusters et al., 2006). While such capabilities could be considered helpful to practice, if it leads to system misuse they may also contribute to poor forecast performance (McCarthy, Davis, Golicic, & Mentzer, 2006; Mentzer & Cox, 1984; Mentzer & Kahn, 1995). Concern for such circumstances may have contributed to the characterization of forecasting systems as a "black box" (McCarthy et al., 2006).

The first column of Table 1 offers a list of capabilities reflected in articles that present normative discussions of the system requirements expected to help improve forecasting. The studies include case analyses of the forecasting practices in one or more companies (Mentzer & Kent, 1999; Mentzer & Schroeter, 1994) and in a particular the application domain (Fildes & Beard, 1992). They draw insights based on benchmark analyses across organizations (Mentzer & Bienstock, 1998; Mentzer et al., 1999), and, in one case, draw on elements discussed as part of a framework for guiding forecasting support system design (Fildes et al., 2006).

These studies offer a number of system recommendations, including the ability to process time series data at the lowest unit of analysis and aggregate data based on different criteria. Such a capability provides individuals in different functions with a means of reviewing forecasts at the level and unit of analysis where they are most comfortable. For example, production or logistics frequently rely on the item level or item by location level unit demand, whereas marketing may be more interested in the demand by product category, and finance may be more interested in the forecasted dollar demand rather than units.

Recommendations suggest that systems be able to draw from alternative forecasting techniques and select the best technique based on the unique demand characteristics of the product or service. This is particularly valuable as users become responsible for greater numbers of items that must be reviewed and reforecasted on a regular basis (Fildes et al., 2006). In the wholesale and retail industries, for example, individuals can be responsible for forecasting tens of thousands of items on a monthly or weekly basis.

Other recommendations include the ability to present data in graphic and tabular formats that allow for user reviews in a manner consistent with their approach to analysis, give the ability for forecast experimentation outside the production system, and provide a means of adjusting history to address unexplained demand or anticipate future demand. In addition, many indicate the need to be able to flag and record reasons for forecast changes.

To assess performance, recommendations include the automatic capture of common performance metrics such as mean squared error or mean absolute percent error, and encourage metrics related to the performance of functions that use forecasts. Some suggest that measures be captured at any point during the process where forecasts may be altered. Doing so can pinpoint where changes are made that affect performance, and may help to identify the need for training or process changes.

The majority of these studies prescribe system features and capabilities that should lead to improved forecast performance when implemented. They have, however, offered little evidence of the linkage between system capabilities, their application and forecast performance. Descriptive studies of forecasting practice suggest that system advances may not be leading to improved performance (McCarthy et al., 2006).

Acknowledging this continuing challenge to improving forecasting performance, Fildes et al. (2006) employed *decisional guidance* and *restrictiveness* (Silver, 1991) to suggest *how* the forecasting system design can improve the likelihood that appropriate techniques will be applied to demand information and result in improved forecast performance. Their system design emphasized guidance over restrictiveness, asserting that guidance is more consistent with a flexible system and promotes features that may be easier to use. Fildes et al. (2006) adopted the concept of ease of use as a key to user acceptance of forecasting tools. Their approach drew on the Technology Acceptance Model (TAM) in information systems research (Venkatesh & Davis, 2000).

The Technology Acceptance Model (Davis, 1986; Davis, Bagozzi, & Warshaw, 1989; King & He, 2006) adapts relationships outlined in the Theory of Reasoned Action (TRA) (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975). TAM posits that the perceived usefulness and perceived ease of use of a technology helps to establish an individual's attitude toward the technology, their intention to use it, and the resulting use behavior (Davis et al., 1989). TAM2 (Venkatesh & Davis, 2000), which was referenced by Fildes et al. (2006), conceptualizes perceived usefulness in terms of *system results demonstrability*, along with *ease of use*, as an antecedent to system use behavior. Forecasting, they noted, offers a means of demonstrability, using accuracy as a measure of performance.

TAM and TAM2 focus on "use" as the dependent variable. While system use is requisite to obtaining benefit from a FSS, Delone and McLean (1992) acknowledged the limitations of focusing solely on use as a measure of system success.

"Simply saying that more use will yield more benefits, without considering the nature of this use, is clearly insufficient. Researchers must also consider the nature, extent, quality, and appropriateness of the system use" (Delone & McLean, 2003, p. 16).

This observation is relevant to forecasting. Schultz (1984) acknowledged that forecasting models (a component of forecasting systems) may not improve organizational effectiveness if used incorrectly.

TAM has received considerable attention in information and decision support systems research. An alternative stream of research found in the same domain draws theoretical support from cognitive cost-benefit research (Christensen-Szalanski, 1980; Creyer, Bettman, & Payne, 1990) and organizational contingency theory (Van de Ven & Delbecq, 1974; Van de Ven & Drazin, 1985). Task-Technology Fit (TTF) (Goodhue, 1995) considers the interactions between tasks, defined as actions carried out by individuals to turn inputs into outputs; technologies, defined as the tools used by individuals in carrying out their tasks; and an individual's capabilities. The concept is based on the proposition that:

"...(a) an individual's performance is affected by how well technology options "fit" his or her task requirements, (b) fit operates through its impact on task processes, and (c) individuals can evaluate fit and choose technologies on that basis" (Goodhue, 1995, p. 1830).

Applied to forecasting practice, TTF suggests that individuals who use forecasting support systems are able to evaluate the fit between the tasks that guide forecast development and the systems that support forecasting. To the extent that these factors coincide, use of the system will lead to higher performance, which, in the case of forecasting, may be evaluated based on forecast accuracy.

Fildes et al. (2006) outlined technology features believed to support improved forecasting (see Table 1). They addressed forecasting tasks that they described as involving "the derivation of the statistical (model-based) forecasts," and "judgmental adjustment of the statistical forecast to take into account special factors and other available information" (p. 353). Their consideration for decisional guidance in forecasting system design acknowledges the importance of user capabilities as outlined in TTF. Decisional guidance offers a system-centric approach to "fitting" the capability of the users (particularly poorly trained users) with the tasks and systems that support forecasting. Where the dependent variable in TAM is the behavior of system use, the dependent variable in TTF is concerned with user perceptions of performance. In forecasting, such perceptions would receive grounding from "tangible" measures of accuracy (Fildes et al., 2006).

Goodhue (1995) confirmed that users are able to evaluate the task-technology fit of systems they employ. Goodhue and Thompson (1995) included system utilization as a behavioral construct in their Technology-to-Performance Chain (TPC) model. Their study confirmed a positive relationship between TTF and performance, as well as a relationship between utilization and performance, and indicated that TTF predicted performance better than utilization alone. The findings did not support a relationship between TTF and utilization.

Dishaw and Strong (1999) evaluated TTF and TAM both separately, and as an integrated model with technology utilization as the dependent variable. Their findings indicated the strongest support for an integrated model (51% of utilization variance explained), followed by support for TTF (41% of utilization variance explained), and finally TAM (35% of utilization variance explained). The context of their study appears more relevant to forecasting. Where Goodhue (1995) and Goodhue and Thompson (1995) investigated TTF and TPC, respectively, applied to general system applications, Dishaw and Strong (1999) focused on a specific application area involving the use of CASE tools for software maintenance. The next section adopts TTF as a means of explaining how forecasting support systems may contribute to improvements in forecast performance.

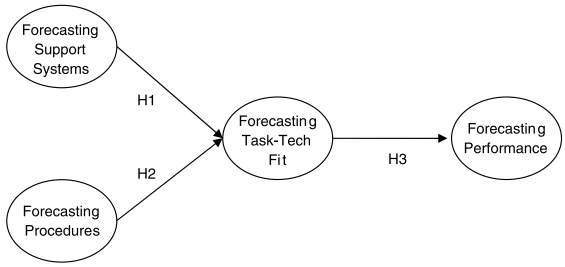

Fig. 1. The forecasting task-technology fit model.

3. Evaluating forecasting task-technology-fit (FTTF)

Fig. 1 illustrates the task-technology fit model applied to forecasting support systems and their impact on forecast performance. Within the context of forecasting, the hardware and software used to analyze demand related data and produce forecasts represent the technology characteristics of the forecasting support system, and task characteristics are represented by the procedures and activities that guide forecast development. Forecasting task-technology fit (FTTF) is based on the evaluation of the individuals responsible for preparing forecasts. Finally, forecasting performance is represented based on measures of forecast accuracy. Each of these elements and their relationships are explained in the following subsections.

3.1. Forecasting support systems

The technology characteristics of forecasting support systems are the hardware, software and network features and capabilities of the system.

Goodhue (1995) suggested that users are able to compare the characteristics of the systems they use with those prescribed as part of an idealized system. This perspective, known as profile deviation, conceptualizes the user's system assessment based on its adherence to a specified profile (Venkatraman, 1989; Zigurs & Buckland, 1998). Drawing on the characteristics reflected in normative models of forecasting support systems (Table 1), the profile of an idealized forecasting system should include attributes such as detailed demand capture and a means of aggregating demand; the ability to change the unit of measurement based on user requirements; the ability to recommend techniques; and the ability to display demand and forecast information in tabular and graphic format. Such systems should be able to capture performance information from the original forecast and at any point where forecast modifications occur. They should provide users with a means of recording reasons for demand or forecast modifications.

Goodhue (1995) relied on a separate panel of information system experts to determine the technology characteristics of the general systems being evaluated. Goodhue and Thompson (1995) employed dummy variables to assess technology characteristics. The evaluation of FSS technology is more consistent with Dishaw and Strong (1999), who focused on user assessments of the functionality and capabilities of the maintenance support software tools used. Forecasting technology characteristics are defined as the extent to which FSS technologies correspond to those of an idealized FSS. Though system characteristics may differ between companies, their support of core forecasting functionalities is likely to share common elements. By evaluating FSS user perceptions as a comparison with the features and capabilities of an "idealized" system, expert opinion regarding system design is integrated in the assessment.

3.2. *Forecasting procedures*

Forecasting procedures are the actions carried out by individuals in turning inputs, such as historical demand and information related to product and market characteristics, into outputs, in this case demand forecasts. Forecasting procedures may be influenced by a number of contingent factors, for example, organizational factors, including whether forecasting responsibility resides in a separate forecast function or within an existing function such as sales or marketing. Forecasting procedures may focus solely on historical demand data or may include qualitative input from individuals throughout the organization.

Forecasting procedures may be affected by product or service characteristics. Capital equipment forecasting may require a means of gathering input regarding the timing and probability of receiving a contract. Consumer product forecasting, on the other hand, might focus on methods of collecting more specific demand data and data concerned with the influence of promotion and competitive pricing activities.

Forecasting procedures may also be defined by market characteristics. Wholesale and retail forecasting tasks will be more focused on collecting historical demand data. Agricultural product forecasting may require the collection of weather information that can influence seasonal demand, or commodity prices that can influence the selection of crops that will be planted from year to year.

Goodhue and Thompson (1995) and Goodhue (1995) evaluated task characteristics based on dimensions of *non-routineness* and *interdependence*. Dishaw and Strong (1999) measured tasks based on user reports of the relative frequency of task activities related to planning, knowledge building, diagnosis and modification.

Support for forecasting procedures in the FTTF model draws on research concerned with the role of cognitive fit in problem-solving (Vessey, 1991; Vessey & Galletta, 1991). Cognitive fit views problem solving as "…the outcome of the relationship between the problem representation and the problem-solving task" (Vessey, 1991, p. 220). Processes (procedures) link the two factors and contribute to the individual's mental representation of the problem. When the information contained in the problem representation corresponds to the problem-solving task, common processes facilitate the individual's mental representation of the problem and contribute to the effectiveness of the solution. Vessey and Galletta (1991) extended the cognitive fit model to address the individual's problem-solving skills. In this case, when the individual's problem-solving skills correspond to both the problem representation and the problem-solving task, the problem-solving performance is expected to improve.

Viewed in a forecasting context, when the procedures that guide forecast creation are consistent with the forecast information and the task of forecasting, adherence to those procedures will contribute to the forecaster's mental representation of the forecasting problem and improve forecasting effectiveness. When the forecaster's skills match both the forecast information and the task of forecasting, the forecast performance will improve.

Forecasting procedures are operationalized along two dimensions. Procedure quality is defined as the degree to which the procedures guiding the forecasting process are perceived to assist in the creation of demand forecasts. Procedure access is defined as the degree to which the procedures guiding forecast creation are perceived to be available to assist in the creation of demand forecasts. Evaluating FSS user perceptions of procedure quality and procedure access offers a means of assessing the correspondence between the task of forecasting, the information represented in the forecasting problem and the forecaster's skills.

3.3. User evaluation of forecasting task-technology fit

Forecasting task-technology fit involves the perceptions of the FSS user regarding the extent to which the features and technologies represented in the forecasting support system "fit" or facilitate their efforts to complete the forecasting task. Goodhue (1995) confirmed the ability of system users to evaluate task-system fit. His task-system fit construct consisted of 12 dimensions. Goodhue and Thompson (1995) re-confirmed the validity and reliability of a task-technology fit instrument, and represented "user evaluations of task-technology fit" in a factor consisting of eight dimensions (quality, locatability, authorization, compatibility, ease of use/training, production timeliness, system reliability, and relationship with users).

The user evaluation of FTTF is defined as the respondent's perception of the correspondence between forecasting support system capabilities and forecasting procedures that facilitate the creation of forecasts. Rather than the 12 dimensions proposed by Goodhue (1995), the present study integrates the dimensions of right data, right detail and data accuracy (Goodhue, 1998) to establish a measure of *system quality*. *System quality* is defined as the degree to which the tools and information in the forecasting support system assist individuals to perform their forecasting related tasks.

Items drawn from the dimensions of accessibility, ease of use, and system reliability (Goodhue, 1998) were used to establish a measure of *system access*. *System access* is defined as the degree to which the tools and information in the forecasting system are available to assist individuals in performing their forecasting tasks. Combined, the construct of system quality and system access represent the factors of a higher order FTTF construct.

Forecasting research has addressed forecasting processes (Fildes & Hastings, 1994; Mentzer et al., 1999), system requirements (Fildes & Beard, 1992; Fildes et al., 2006; Mentzer & Kent, 1999) and user capabilities (Fildes et al., 2006; Goodwin, Fildes, Lawrence, & Nikolopoulos, 2007) as parts of an overall picture of forecasting practice. The FTTF model provides an opportunity to assess the roles of these three factors in an integrated fashion. Furthermore, studies support an assertion that individuals are able to evaluate the extent to which systems can help them complete their tasks successfully (Goodhue, 1995). Applied to the domain of forecasting, TTF posits that users of a forecasting support system are able to evaluate forecasting procedures and forecasting support systems, and the extent to which the correspondence between procedures and systems supports them in the successful creation of demand forecasts. These relationships lead us to our first two hypotheses.

H_1: Forecasting support system characteristics are positively related to user evaluations of forecasting task-technology fit.

H_2: Forecasting task characteristics are positively related to user evaluations of forecasting task-technology fit.

3.4. Forecast performance

Goodhue and Thompson (1995) confirmed a relationship between user perceptions of TTF and perceived performance. They also noted the importance of identifying objective measures of performance. Forecasting systems provide just such an opportunity for more "tangible" measures (Fildes et al., 2006). Traditional forecasting performance measures include statistics reflected in calculations of the mean absolute percent error (MAPE), mean absolute deviation (MAD), and similar quantifications of forecast accuracy. Each represents the comparison of the forecasted demand with the actual demand experienced. Forecasting performance is therefore defined as the extent to which demand forecasts match the actual demand for a product or service over a stated time horizon.

The technology acceptance model focuses on utilization as a dependent variable, and suggests that individuals have a choice whether or not to use the system. TAM posited that perceptions of ease of use and usefulness result in system use. If a system is well designed, its use should subsequently lead to improved performance. The information systems literature, and more specifically the forecasting literature, has recognized that the connection between use and performance is insufficient.

TTF makes a different assumption. TTF assumes that the individual will not necessarily have a choice whether or not to use the system, as use may be mandated (Goodhue, 1995). However, users are still able to assess the extent to which the technology helps them accomplish their tasks. If, for example, technologies do not effectively support task requirements, TTF posits that users may become more frustrated with their efforts, and performance will suffer.

The emphasis in forecasting research on evaluating user satisfaction with systems, along with the inherent complexity of forecasting methods and the frequency with which the forecasting task must be repeated (weekly, monthly, etc.), suggest a greater likelihood that system use may be mandated by policy or by the volume of activity. The effectiveness of the system in helping the users complete their tasks then becomes important to the creation and performance of the forecasts. This is reflected in the following hypothesis.

H_3: User evaluations of forecast task-technology fit are positively related to forecast performance.

The next section describes the method employed to evaluate these hypotheses.

4. Methodology

The study employed a non-experimental mail survey methodology (Kerlinger, 1992). Surveys were distributed to the senior person responsible for forecasting at companies that manufacture or distribute products through consumer or industrial product supply channels. The criteria guiding sample selection were broad, in hopes of achieving a moderate level of external validity (Cook & Campbell, 1979), and to contribute to the generalizability of the results. The unit of analysis was the respondent's perceptions of the system used and the procedures followed to create forecasts, and the resulting forecasting performance.

Scale development followed the procedures and guidelines recommended by Bienstock, Mentzer, and Bird (1997), Churchill (1979), Dunn, Seaker, and Waller (1994), Gerbing and Anderson (1988), Garver and Mentzer (1999) and Mentzer and Flint (1997). Existing scales provided models for the development of scales for measuring forecasting task-technology fit and the tasks that support forecast creation. Forecasting research provided guidance for developing scales to measure forecasting support system as well as forecasting performance.

Variable definitions emerged through an iterative process involving experience, literature reviews and exploratory research. Depth interviews were conducted with forecasting managers in seven companies. The interviews were unstructured and started with a discussion of the individual's role in the company and their involvement in forecasting. The goal of the process was to confirm the relationships conceptualized in the FTTF model, and ensure a precise definition of the variables to be operationalized in the survey instrument.

A new scale for measuring *forecasting support systems* was developed to tap respondent perceptions regarding the features and capabilities of their forecasting system. The features included were based on those commonly prescribed by forecasting experts.

Measures of forecasting procedure characteristics were derived from measures of task technology fit, and were adapted to address forecasting tasks along two dimensions, *procedure quality* (defined as the degree to which forecasting procedures and methods assist individuals in their forecasting tasks), and *procedure accessibility* (defined as the degree to which forecasting procedures are available to assist individuals in performing their forecasting tasks).

Measures of forecasting task-technology fit were grounded in existing scales developed by Goodhue

(1998). Rather than the original 12 dimensions, items drawn from the dimensions of right data, right detail, and data accuracy were consolidated to establish a dimension of system quality. Items drawn from the original dimensions of accessibility, ease of use and system reliability were consolidated to establish a second dimension of system access.

The dependent variable of forecasting performance was represented by a scale for evaluating forecast accuracy at different levels of aggregation (stock keeping unit by location (SKUL), stock keeping unit (SKU) and product line), over a one month time horizon.

4.1. Survey pretest

The survey plan was implemented through the procedures outlined by Dillman (1978). The survey was distributed to individuals responsible for forecasting at 280 companies. After three waves of mailings, 21 surveys were returned blank, with bad addresses, or after the cut-off date for analysis, resulting in a net mailing to 259 individuals. Of the 259 surveys, 129 usable surveys were returned, resulting in a response rate of 49.8%. The forecasting manager pretest descriptive statistics revealed no skewness or kurtosis problems with the data.

To assess a potential response bias, a comparison of responses between the first and third waves of survey returns was analyzed (Armstrong & Overton, 1977). In addition, a random sample of 26 non-respondents was contacted by phone and asked five non-demographic questions (Mentzer & Flint, 1997). The results of both analyses indicated no bias.

Confirmatory analysis was used to analyze scale unidimensionality (Gerbing & Anderson, 1988). Reviews of factor loadings, modification indices and substantive content were used to evaluate items that loaded weakly on the hypothesized factor for elimination.

The pretest asked respondents to record the forecast accuracy for their products at multiple levels of aggregation. Because of the large number of missing responses, measurement refinements could not be accomplished as part of the pretest. To improve responses, the final test instrument employed scales associated with forecast accuracy at the different levels of aggregation. Seven point scales presented ranges of accuracy, namely <70%, 70%–74%, 75%–79%, 80%–84%, 85%–89%, 90%–94%, and 95%–100%.

The reliability of first order factors was evaluated based on Cronbach's coefficient alpha (Cronbach, 1951). The reliability of the two second order factors was calculated using Nunnally's (1978) formula for the reliability of linear combinations. The reliabilities for the six first order factors, as well as the two higher order constructs, were above the recommended threshold of 0.70.

Convergent validity was assessed for each first order factor using confirmatory factor analysis. Item-to-factor loadings were all significant at the $\alpha = 0.05$ level. As a result, convergent validity was supported with regard to all first order factors.

The discriminate validity for the higher level task construct and task/technology fit construct was assessed through a comparison of three models (Bienstock et al., 1997). Model 0 proposes a structure of no factors and all traits. Model 1 proposes a structure of one factor consisting of all traits. Model 2 proposes a structure consistent with the final dimensional structure (e.g. two dimensions of forecasting task-technology fit), with each dimension being associated with its respective trait. A significant difference in the chi-square comparison of Model 0 with Model 1 provides evidence of convergent validity, and the comparison between Model 1 and Model 2 provides evidence of discriminate validity (Bienstock et al., 1997; Widaman, 1985). The evidence supported convergent validity for each construct, as well as discriminate validity among the sub-dimensions of each construct.

4.2. Final survey

The final survey was directed to the individuals responsible for forecasting at each of 289 companies. Fourteen surveys were returned incomplete or declining participation, resulting in a net mailing of 275 surveys. After three waves, 216 usable survey responses were received. The effective response rate for the final sample was 78.54%. The participants included individuals from companies ranging in size from less than \$10 million to greater than \$5 billion. The inventory approaches employed for finished goods included inventory to stock (72.2%), inventory to order (20.4%), and both methods (6.5%). Two companies did not report their inventory approach. Table 2 provides descriptive statistics for each of the final measurement items, as well as correlations between measures from the final sample. The means for the items ranged from

Table 2
Final sample descriptive statistics.

Correlation matrix										
Item	Mean	Std. Dev	Skew	Kurt.	Proced. quality	Proced. access	System quality	System access	Fcstg. support system	Fcstg. perf.
1	4.00	1.45	−0.14	−0.60						
2	3.99	1.42	−0.07	−0.75						
3	3.34	1.46	−0.17	−0.70						
4	3.76	1.47	−0.15	−0.93						
Procedure quality					1.00					
5	3.80	1.90	0.04	−1.14						
6	4.68	1.59	−0.44	−0.56						
7	4.03	1.73	−0.08	−0.95						
8	4.05	1.58	−0.13	−0.57						
9	3.91	1.66	−0.01	−0.77						
Procedure access					0.83	1.00				
10	4.62	1.71	−0.47	−0.75						
11	4.04	1.64	−0.09	−0.80						
12	3.41	1.57	−0.31	−0.96						
13	4.06	1.58	−0.17	−0.81						
System quality					0.74	0.72	1.00			
14	4.61	1.70	−0.45	−0.66						
15	4.44	1.66	−0.28	−0.75						
16	4.03	1.58	−0.20	−0.88						
17	4.58	1.72	−0.45	−0.79						
System access					0.68	0.75	0.84	1.00		
18	4.02	1.92	−0.12	−1.19						
19	4.44	2.02	−0.40	−1.18						
20	4.46	1.91	−0.35	−1.02						
21	4.25	1.82	−0.23	−1.02						
22	3.88	2.02	−0.10	−1.34						
Fcstg. support system					0.59	0.63	0.81	0.81	1.00	
23	4.74	1.47	−0.83	0.34						
24	3.89	1.71	−0.36	−0.92						
25	3.47	1.78	0.06	−1.09						
Fcstg. perf.					0.46	0.39	0.42	0.36	0.37	1.00
Fcst procedures					0.90	0.92	0.82	0.79	0.67	0.37
Fcst Task-Tech Fit					0.78	0.80	0.94	0.91	0.89	0.42

3.34 to 4.74, and the standard deviations for the items ranged from 1.42 to 2.02.

Because of the high response rate associated with the final survey of forecasting managers, the test for response bias was limited to a comparison of differences in the mean response between the first and third waves of the survey mailing for five preselected questions. No response bias was identified. The revised measures of forecast accuracy were well received in the final survey and the measures were included in the confirmatory analysis.

A confirmatory measurement model was run to assess unidimensionality (Gerbing & Anderson, 1988). The fit of the measurement model was good, with a chi square/df ratio of 1.80, a RMSEA of 0.061, which falls within the acceptable fit range of 0.05–0.08, and a CFI of 0.945, which is greater than the 0.90 value accepted as a minimum indicator of consistency with the observed data from which it was estimated. Regression weights of all items on their latent variables were in the appropriate direction and were significant at the 0.001 level. The results supported convergent validity

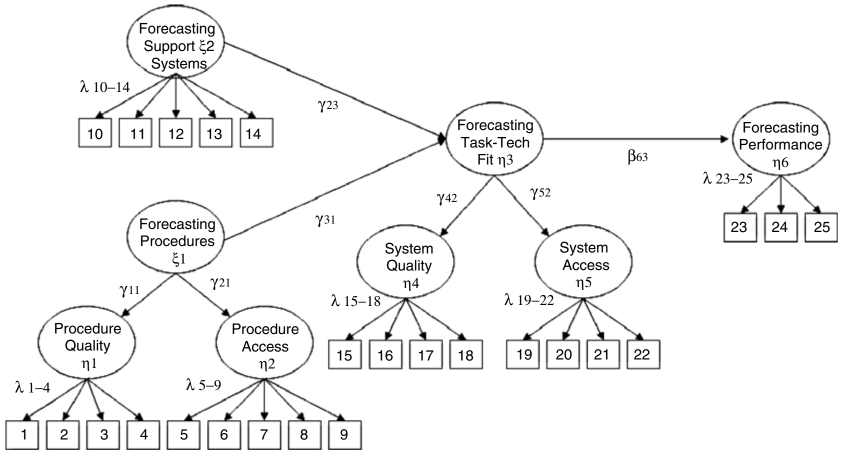

Fig. 2. Forecasting task-technology fit model.

and unidimensionality. Discriminate validity for each of the second order constructs was confirmed as outlined in the pretest section.

5. Results

The FTTF model (Fig. 2) illustrates the relationships tested in this study. Forecasting support systems ($\xi 2$) and forecasting procedures ($\xi 1$) represent exogenous variables that are proposed to influence the endogenous variable, forecasting task-technology fit ($\eta 3$). Forecasting procedures consist of two dimensions, procedure quality ($\eta 1$) and procedure access ($\eta 2$). Forecasting task-technology fit also consists of two dimensions, system quality ($\eta 4$) and system access ($\eta 5$). Forecasting task-technology fit is subsequently proposed to influence the endogenous variable of forecasting performance ($\eta 6$). Structural equation modeling was used to evaluate the FTTF model. AMOS 7.0 and SPSS version 15 software were used to conduct the analysis. The results supported a good fit of the FTTF path model (chi square/df ratio of 2.16, a RMSEA of 0.072 and a CFI of 0.921). Table 3 provides the path estimates and critical ratios associated with each of the factor measures and relationships illustrated in Fig. 2.

5.1. Hypothesis 1

Hypothesis 1 stated that forecasting support system characteristics are positively related to user evaluations of forecasting task-technology fit. Based on a path weight of 0.671 with a t-value of 8.251, the hypothesis was supported, and was significant at the 0.001 level (Table 5). Forecasting research has prescribed system capabilities that are expected to help improve forecast performance. While simulation studies support a relationship between system capabilities (e.g. multiple methods) and performance, such a relationship has not been confirmed in practice.

The present study incorporated commonly prescribed forecasting system capabilities as measures of forecasting support systems. Rather than employing the capabilities solely as a normative model of system capabilities that support improved forecasting, task-technology fit considers the user role in system assessment. Fildes et al. (2006) recognized the user role when they proposed that forecasting support systems be able to guide users with system application. From a TTF perspective, design attributes that guide forecast creation may contribute to user perceptions of system quality and access by those users who have not received forecasting training. For those with forecasting training, the extent to which system features facilitate their forecasting task may also contribute to perceptions of system quality and access.

Fildes et al. (2006) also suggested that guidance may be more important than restrictiveness in forecasting support system design. This is also reflected in the forecasting task-technology fit model. From a TTF perspective, design attributes that restrict access to data and techniques may not significantly influence

Table 3
Forecasting Task-Technology Fit model results.

Path	Estimates	Critical ratio
Fcst Procedure – Procedure Quality (γ11)	0.89	9.41
Fcst Procedure – Procedure Access (γ21)	0.92	n/a
Fcst Procedures – Fcst TTF (γ31)	0.67	7.88
Fcst TTF – System Quality (γ42)	0.90	9.48
Fcst TTF – System Access (γ52)	0.88	n/a
Fcst Support Systems – Fcst TTF (γ23)	0.67	8.25
Fcst TTF – Fcst Performance (β63)	0.38	4.76
Procedure Quality - Item 1 (λ11)	0.88	n/a
Procedure Quality - Item 2 (λ12)	0.87	17.53
Procedure Quality - Item 3 (λ13)	0.84	16.21
Procedure Quality - Item 4 (λ14)	0.81	15.41
Procedure Access – Item 1 (λ15)	0.72	n/a
Procedure Access – Item 2 (λ16)	0.76	10.67
Procedure Access – Item 3 (λ17)	0.87	12.26
Procedure Access – Item 4 (λ18)	0.81	11.40
Procedure Access – Item 5 (λ19)	0.83	11.71
System Quality – Item 1 (λ110)	0.77	n/a
System Quality – Item 2 (λ111)	0.86	12.93
System Quality – Item 3 (λ112)	0.41	5.79
System Quality – Item 4 (λ113)	0.83	12.52
System Access – Item 1 (λ114)	0.79	n/a
System Access – Item 2 (λ115)	0.88	13.90
System Access – Item 3 (λ116)	0.81	12.65
System Access – Item 4 (λ117)	0.68	10.25
Fcst Support Systems – Item 1 (λ118)	0.71	n/a
Fcst Support Systems – Item 2 (λ119)	0.76	10.11
Fcst Support Systems – Item 3 (λ120)	0.78	10.32
Fcst Support Systems – Item 4 (λ121)	0.74	9.90
Fcst Support Systems – Item 5 (λ122)	0.62	8.37
Fcst Performance – Item 3 (λ123)	0.75	n/a
Fcst Performance – Item 4 (λ124)	0.97	11.96
Fcst Performance – Item 5 (λ125)	0.72	10.83

the perception of system quality and access by users with little training in forecasting. For those with more extensive forecast training, restricting access to a limited set of data and techniques may lead to frustration with the forecasting task, and may detract from user perceptions of system quality and access.

5.2. Hypothesis 2

Hypothesis 2 stated that forecasting procedures are positively related to user evaluations of forecasting task-technology fit. Based on a path weight of 0.668 with a t-value of 7.879, this hypothesis was supported, and was significant at the 0.001 level. Goodhue (1995) and Goodhue and Thompson (1995) measured task characteristics along the dimensions of non-routineness and interdependence. Forecasting procedures generally reflect more clearly defined activities. The degree of routineness and interdependence of forecasting procedures reflects contingent factors such as the market demand characteristics, the availability of demand related information, communication requirements, and so forth. The present study evaluated forecasting procedures based on conceptual underpinnings similar to those of the FTTF construct. In this case, forecasting procedures are viewed as the "technologies" that facilitate the task of forecasting. Forecasting products with different market and demand characteristics may call for different forecasting procedures. For example, fashion products may rely on more qualitative assessments of larger market trends than grocery items, which rely more on demand history. The access to defined procedures and the perceived quality of those procedures may be expected to be related to forecaster assessments of how technologies support their forecasting efforts.

5.3. Hypothesis 3

Hypothesis 3 stated that the user evaluation of forecasting task-technology fit is positively related to forecast performance. Based on a path weight of 0.381 with a t-value of 4.775, the hypothesis was supported, and was significant at the 0.001 level. Research has generally prescribed certain system characteristics that should help to improve forecast performance. The confirmation of this third hypothesis recognizes that the individuals responsible for forecast creation play an important role in determining the extent to which processes and systems influence forecast performance.

The evaluation of the model for forecasting task-technology fit confirms the proposition that forecast support system users are able to evaluate the correspondence between the forecasting support system capabilities, the procedures that guide forecast development, and their own forecasting skills and abilities. The results of the study confirmed that there is a positive relationship between forecasting support system capabilities and user evaluations of forecasting task-technology fit; between forecasting procedures and user evaluations of forecasting task-technology fit; and between forecasting task-technology fit and forecast performance.

6. Conclusions and future directions

Drawing on forecasting, information, and decision support system research, this study empirically tested a theoretically-based model of forecasting task-technology fit. The results of the study illustrated the correspondence between forecasting system characteristics, forecast procedures, and user assessments of system quality and access which influence forecast performance.

6.1. Implications for practice

For businesses, improved forecast performances offer a means of improving the performances of systems and activities that use forecasts for planning and management. There is support for this assertion. Simulation studies have illustrated operational and financial benefits from employing more accurate forecasts (Bowersox, Closs, Mentzer, & Sims, 1979; Gardner, 1990; Zhao, Xie, & Lau, 2001). Studies of forecasting practice, however, have reflected a continuing challenge in identifying those factors that may improve forecast performance (Fildes & Hastings, 1994; McCarthy et al., 2006).

This study acknowledges the significant role the user plays in the implementation of forecasting support systems. The contribution of a forecasting support system relies on the assessment of the individuals who use the system to create forecasts – specifically, user perceptions of the extent to which the system contains the right data and the techniques they believe are needed to forecast demand, and the extent to which the system provides access to accurate data and appropriate techniques. If the forecaster perceives the support system to not contain the techniques or data they believe are needed to create forecasts, or to not provide easy access to the techniques or data, the resulting forecasts are likely to suffer in terms of accuracy.

This relationship may also be reflected by the phenomenon identified in case and benchmark studies as "Islands of Analysis" (Moon, Mentzer, & Smith, 2003, p.18). Islands of Analysis are described as the informal implementation of forecasting systems and processes in multiple, and not always authorized, locations throughout an organization. The emergence of Island of Analysis may reflect efforts on the part of forecasters to establish systems that they perceive to be of better quality or to provide better access than the official forecasting support system.

This study supports specific capabilities that are frequently recommended in forecasting support systems. Forecasting practitioners should lean toward support systems that include the following capabilities: the use of multiple forecasting techniques, the ability to display the forecast in different measurement units and at different levels of aggregation, the ability to distinguish product importance, and the ability to capture forecast adjustments. In order to support improved forecast performance, however, it is important that these features be perceived to contribute to forecaster assessments of system quality and access.

The results of this study also highlight the need to establish procedures for guiding forecast creation that are clearly documented, accessible to those responsible for forecasting, and viewed by forecasters as appropriate and easy to follow. This finding is consistent with business trends that emphasize process mapping and evaluation as part of broader continuous improvement practices.

6.2. Implications for research

Forecasting research has presented new algorithms for forecast creation and compared those models with existing methods in an effort to improve performance. Surveys have described the techniques and systems used in industry, together with the satisfaction with various techniques. Case analyses have provided a greater understanding of the complex management and organizational factors that influence forecast creation and application. Recently, studies have started to develop a grounding for theoretical frameworks that identify factors and explain relationships that illustrate the forecasting phenomena.

The present study represents one of the first empirical assessments of a theoretically based model of factors that influence forecasting performance in organizations. The FTTF model offers a means of evaluating forecasting procedures and technologies that recognize the role of the forecaster and the contingent nature of forecasting practices in different organizations. This study contributes to forecasting research by offering a series of psychometrically rigorous measures of forecasting systems, procedures and performance. A new measure of forecasting system capabilities was developed to assess the extent to which the characteristics of forecasting support systems reflect those prescribed in idealized forecasting systems. Additional measures for capturing forecaster perceptions of the quality of and access to forecasting procedures and forecasting systems were adapted from measures used in TTF research.

This study contributes to information and decision support system research by further validating the relationship conceptualized in the theory of task-technology fit. Where earlier TTF studies have relied on user evaluations of performance, this study employed more objective measures of performance based on forecast accuracy. While previous studies evaluating task-technology fit have been conducted across individuals within the same organization, this study evaluated FTTF across companies, and represents an alternative assessment of the generalizability of the concept.

Among the limitations of the study, the original conceptualization of task-technology fit incorporated 12 dimensions. The present study condensed them into two dimensions representing system quality and access. While these two dimensions appear to reflect a significant amount of the variability in forecasting performance, it will be beneficial to more thoroughly test the broader dimensions of TTF within the domain of forecasting.

Another potential limitation involves the approach taken to evaluate forecast performance. Establishing a scale for measuring forecast performance helped to ensure the capture of performance data, though perhaps at the expense of measurement variability. Future studies that include forecasting performance should attempt to establish more detailed measures of accuracy, and measures of accuracy at different forecast horizons.

6.3. Future directions

This study represents an initial investigation of the role of task-technology fit within the domain of forecasting. It would be beneficial to both decision support research and forecasting research to develop a greater depth of understanding of the variables and relationships represented in the current model. Qualitative research methods offer a means of investigating TTF within a forecasting context, will help to validate current results, and may reveal other factors that can influence forecast development and performance.

Task-technology fit is also part of a larger model referred to as the Technology to Performance Chain (TPC) model (Goodhue & Thompson, 1995). The TPC model suggests that performance feedback may influence the decision whether or not to use a technology, or the way in which the user assesses task-technology fit. Locke (1968) and others have identified feedback clarity and challenge to be important aspects which lead to improved performance. Forecasting appears to offer a clear metric to those responsible for forecast development, and should be considered in an extension of the FTTF model.

Table A.1
Respondents were asked to choose a level of agreement or disagreement with the questions based on a scale ranging from 1 (Strongly disagree) to 7 (Strongly agree).

Construct	Questions
Procedure quality the degree to which the procedures guiding the forecasting process are perceived to assist in the creation of demand forecasts.	Our forecasting procedures... ...support forecast development very effectively ...provide clear directions to guide forecast development ...are exactly what are needed to create accurate forecasts ...ensure the right methods (techniques) are used to forecast
Procedure access the degree to which the procedures guiding forecast creation are perceived to be available to assist in the creation of demand forecasts.	Our forecasting procedures... ...are documented ...ensure that forecasts are created in a timely manner ...are readily available to help guide forecast development ...are easy to follow ...are always up-to-date
Forecasting support systems the extent that forecasting support system technologies correspond to those of an idealized forecasting support system.	Our forecasting system... ...uses a number of quantitative methods (techniques) for forecasting ...can display forecasts in different measurement units that might be needed by forecast participants (e.g. units, cases, dollars, etc) ...can display forecasts at different levels of our product hierarchy that might be needed by forecast participants (product by location, product, product line, division, etc) ...gives us the ability to manage products on an ABC ranking, or other means of distinguishing product importance ...can capture forecast adjustments made by *each* forecasting participant
Forecasting system quality the degree to which information in the forecasting support system assists individuals in performing their forecasting related tasks.	Our forecasting system... ...contains data at the right level(s) of detail to support forecasting ...contains the right methods (techniques) needed to create forecasts ...contains data that is not accurate enough to create effective forecasts ...contains all the data needed to create accurate forecasts
Forecasting system access the degree to which information in the forecasting system is available to assist individuals in performing their forecasting tasks.	Our forecasting system... ...is easily accessible to those who need it to create forecasts ...makes it easy to get access to demand and forecast data ...makes it easy to access the forecasting methods (techniques) needed to develop forecasts ...is always "up" and available when forecasting participants need it
Forecast performance the extent to which demand forecasts match the actual demand for a product or service over a stated time horizon... A seven point scale with the following ranges was used to capture performance: <70%, 70%–74%, 75%–79%, 80%–84%, 85%–90%, 90%–94%, 95%–100%.	For each level of your forecast hierarchy, indicate how accurate forecasts are, based on a monthly time horizon... ...product line forecasts ...product (SKU) forecasts ...product (SKU) by location forecasts (DC level)

In addition to performance feedback, the TPC model extends the dependent variable to include the impact on organizational performance. In cases where forecasts are applied directly to decision support systems without user intervention, we might expect improved performance in those parts of the organization that apply forecasts. Simulation research, for example, has presented evidence that improved forecasting contributes to improved performance in areas such as inventory management (Gardner, 1990). In many cases, forecasts are not implemented in isolation. Forecast users have been acknowledged in cases discussed by Fildes and Hastings (1994), Mentzer et al. (1999) and Schultz (1984). Future research should investigate the connection between forecast creation and the application of forecasts in planning and management activities that include forecast users. Specifically, what factors influence the decision made by forecast users to implement the forecasts they receive?

Goodhue (1995) and Goodhue and Thompson (1995) and others have addressed more general systems and technologies in their studies of performance. The financial commitment of ERP and other office automation systems is substantial and warrants the research focus. More specific applications such as forecasting, inventory management, production planning and other decision support type systems can also have a significant impact on cost and service within supply chains. Future research should consider the adaptation of the TPC model to other specific application areas. Such research will help to further confirm the connection between task-technology fit and performance. By establishing measures of system capabilities in a manner similar to the present study, such research will provide a means of identifying domain-specific technology characteristics that contribute to system performance.

Appendix. Final survey items

See Table A.1.

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