Chapter 1 : An Overview of Forecasting Methods

Read chapter 2 Existing Technology Forecasting Methodologies: Technological innovations are key causal agents of surprise and disruption. In the recent pa.

Judgmental or Intuitive Methods Judgmental methods fundamentally rely on opinion to generate a forecast. Typically the opinion is from an expert or panel of experts having knowledge in fields that are relevant to the forecast. In its simplest form, the method asks a single expert to generate a forecast based on his or her own intuition. The potential for bias may be reduced by incorporating the opinions of multiple experts in a forecast, which also has the benefit of improving balance. This method of group forecasting was used in early reports such as Toward New Horizons von Karman, Forecasts produced by groups have several drawbacks. First, the outcome of the process may be adversely influenced by a dominant individual, who through force of personality, outspokenness, or coercion would cause other group members to adjust their own opinions. Second, group discussions may touch on much information that is not relevant to the forecast but that nonetheless affects the outcome. Lastly, groupthink 4 can occur when forecasts are generated by groups that interact openly. The shortcomings of group forecasts led to the development of more structured approaches. The Delphi Method The Delphi method is a structured approach to eliciting forecasts from groups of experts, with an emphasis on producing an informed consensus view of the most probable future. The Delphi method has three attributesâ€"anonymity, controlled feedback, and statistical group response 5 â€"that are designed to minimize any detrimental effects of group interaction Dalkey, In practice, a Delphi study begins with a questionnaire soliciting input on a topic. Participants are also asked to provide a supporting argument for their responses. Last accessed June 11, Persistent Forecasting of Disruptive Technologies. The National Academies Press. This process continues for several rounds, until the results reach predefined stop criteria. These stop criteria can be the number of rounds, the achievement of consensus, or the stability of results Rowe and Wright, The advantages of the Delphi method are that it can address a wide variety of topics, does not require a group to physically meet, and is relatively inexpensive and quick to employ. Delphi studies provide valuable insights regardless of their relation to the status quo. In such studies, decision makers need to understand the reasoning behind the responses to the questions. A potential disadvantage of the Delphi method is its emphasis on achieving consensus Dalkey et al. Some researchers believe that potentially valuable information is suppressed for the sake of achieving a representative group opinion Stewart, Because Delphi surveys are topically flexible and can be carried out relatively easily and rapidly, they are particularly well suited to a persistent forecasting system. One might imagine that Delphi surveys could be used in this setting to update forecasts at regular intervals or in response to changes in the data on which the forecasts are based. Extrapolation and Trend Analysis Extrapolation and trend analysis rely on historical data to gain insight into future developments. This type of forecast assumes that the future represents a logical extension of the past and that predictions can be made by identifying and extrapolating the appropriate trends from the available data. This type of forecasting can work well in certain situations, but the driving forces that shaped the historical trends must be carefully considered. If these drivers change substantially it may be more difficult to generate meaningful forecasts from historical data by extrapolation see Figure Trend extrapolation, substitution analysis, analogies, and morphological analysis are four different forecasting approaches that rely on historical data. Trend Extrapolation In trend extrapolation, data sets are analyzed with an eye to identifying relevant trends that can be extended in time to predict capability. Tracking changes in the measurements of interest is particularly useful. Several approaches to trend extrapolation have been developed over the years. Gompertz and Fisher-Pry Substitution Analysis Gompertz and Fisher-Pry substitution analysis is based on the observation that new technologies tend to follow a specific trend as they are deployed, developed, and reach maturity or market saturation. This trend is called a growth curve or S-curve Kuznets, Gompertz and Fisher-Pry analyses are two techniques suited to fitting historical trend data to predict, among other things, when products are nearing maturity and likely to be replaced by new technology Fisher and Pry, ; Lenz, Analogies Forecasting by analogy involves identifying past situations or technologies similar to the one of current interest and using historical data to project future developments. Research has shown that the accuracy of this forecasting technique can be improved by using a structured approach to identify the best analogies to use, wherein several possible analogies are identified and rated with respect to their relevance to the topic of interest Green and Armstrong, Green and Armstrong proposed a five-step structured judgmental process. The first step is to have an administrator of the forecast define the target situation. An accurate and comprehensive definition is generated based on Page 22 Share Cite Suggested Citation: When feasible, a list of possible outcomes for the target is generated. The next step is to have the administrator select experts who are likely to know about situations that are similar to the target situation. Based on prior research, it is suggested that at least five experts participate Armstrong, Once selected, experts are asked to identify and describe as many analogies as they can without considering the extent of the similarity to the target situation. Experts then rate how similar the analogies are to the target situation and match the outcomes of the analogies with possible outcomes of the target. Predefined rules promote logical consistency and replicability of the forecast. An example of a rule could be to select the analogy that the experts rated as the most similar to the target and adopt the outcome implied by that analogy as the forecast Green and Armstrong, Page 23 Share Cite Suggested Citation: The technique lends itself to forecasting in that it provides a structured process for projecting the future attributes of a present-day technology by assuming that the technology will change in accordance with the Laws of Technological Evolution, which may be summarized as follows: Increasing degree of ideality. Decreasing price and improving benefits result in improved performance, increased functionality, new applications, and broader adoption. The evolution of GPS from military application to everyday consumer electronics is an example of this law. Nonuniform evolution of subsystems. The various parts of a system evolve based on needs, demands, and applications, resulting in the nonuniform evolution of the subsystem. The more complex the system, the higher the likelihood of nonuniformity of evolution. The development rate of desktop computer subsystems is a good example of nonuniform evolution. Processing speed, disk capacity, printing quality and speed, and communications bandwidth have all improved at nonuniform rates. Transition to a higher level system. This law can be used at the subsystem level as well, to identify whether existing hardware and components can be used in higher-level systems and achieve more functionality. As a technology moves from a rigid mode to a flexible mode, the system can have greater functionality and can adapt more easily to changing parameters. Shortening of energy flow path. The energy flow path can become shorter when energy changes form for example, thermal energy is transformed into mechanical energy or when other energy parameters change. The transmission of information also follows this trend Fey and Rivin, An example is the transition from physical transmission of text letters, newspapers, magazines, and books , which requires many transformational and processing stages, to its electronic transmission tweets, blogs, cellular phone text messaging, e-mail, Web sites, and e-books , which requires few if any transformational or processing stages. Transition from macro- to microscale. System components can be replaced by smaller components and microstructures. This stage involves studying the history of a technology to determine its maturity. Analysis of these curves can help to predict when one technology is likely to be replaced by another. This is the application of the above laws to forecast specific changes innovations related to the technology. The engineering problems that must be addressed to realize the evolutionary changes predicted in the roadmapping stage are then identified. It is in this stage that technological breakthroughs needed to realize future technologies are specified. Many forecasts would terminate in the problem formulation stage since it is generally not the purpose of a forecast to produce inventions. In spite of this, TRIZ often continues. This last stage involves an attempt to solve the engineering problems associated with the evolution of a technology. Although the attempt might not result in an actual invention, it is likely to come up with valuable information on research directions and the probability of eventual success in overcoming technological hurdles. Models These methods are analogous to developing and solving a set of equations describing some physical phenomenon. The use of computers enables the construction and solution of increasingly complex models, but the complexity is tempered by the lack of a theory describing socioeconomic change, which introduces uncertainty. The specific forecast produced by the model is not as important as the trends it reveals or its response to different inputs and assumptions. The following sections outline some model-based techniques that may be useful for forecasting disruptive technology. Some of them were used in the past for forecasting technology, with varying success. Theory of Increasing Returns Businesses that produce traditional goods may suffer from the law of diminishing returns, which holds that as a product becomes more commonplace, its marginal opportunity cost the cost of foregoing one more unit of the next best alternative increases proportionately. This is especially true when goods become commoditized through increased competition, as has happened with DVD players, flat screen televisions, and writable compact discs. Applying the usual laws of economics is often sufficient for forecasting the future behavior of markets. However, modern technology or knowledge-oriented businesses tend not to obey these laws and are instead governed by the law of increasing returns Arthur, , which holds that networks encourage the successful to be yet more successful. The value of a network explodes as its membership increases, and the value explosion attracts more members, compounding the results Kelly, A better product is usually unable to replace an older product immediately unless the newer product offers something substantially better in multiple dimensions, including price, quality, and convenience of use. Although the law of increasing returns helps to model hi-tech knowledge situations, it is still difficult to predict whether a new technology will dislodge an older product. This is because success of the newer product depends on many factors, some not technological. Arthur mentions that people have proposed sophisticated techniques from qualitative dynamics and probability theory for studying the phenomenon of increasing returns and, thus, perhaps to some extent, disruptive technologies. Chaos Theory and Artificial Neural Networks Clement Wang and his colleagues propose that there is a strong relationship between chaos theory and technology evolution Wang et al. They claim that technology evolution can be modeled as a nonlinear process exhibiting bifurcation, transient chaos, and ordered state. What chaos theory reveals, especially through bifurcation patterns, is that the future performance of a system often follows a complex, repetitive pattern rather than a linear process. They further claim that traditional forecasting techniques fail mainly because they depend Page 25 Share Cite Suggested Citation: The authors then report that existing methods for technology forecasting have been shown to be very vulnerable when coping with the real turbulent world Porter et al. Chaos theory characterizes deterministic randomness, which indeed exists in the initial stages of technology phase transition. It will have a material impact, it will incrementally improve the status quo, or it will fail and go into oblivion. A particular technology exists in one of three states:

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There are four basic learning points: Overview â€” Applications and Basic Steps Forecasting is the prediction of future events and conditions and is a key element in service organizations, especially banks, for management decision-making. There are typically two types of events: The need for forecasting stems from the time lag between awareness of an impending event or need and the occurrence of that event. Organizations constantly try to predict economic events and their impact. The following are a few applications for forecasting modules: Forecasting utilization rates for credit cards: Model loss rates of a group of home equity lines of credit as a function of time. An independent system operator, organized for monitoring the electrical grid, has a need to predict electrical usage â€" the volatility of the daily usage can be thought of as a blend of day-ahead-market volatility and monthly volatility, where the month can be one or more months forward. There are some basic steps for creating a forecast: How will the forecasts be used, who needs the forecast and what is the voice of the customer VOC? Gather the necessary information by obtaining historical mathematical data and utilizing the accumulated judgment and expertise of key personnel. Determine what graphical plots will best benefit management and design a preliminary analysis. Choose and fit models by using and evaluating a forecast model for decision making. Forecast errors and management response. Forecasting System A forecasting system consists of two primary functions: Forecast generation includes acquiring data to revise the forecasting model, producing a statistical forecast and presenting results to the user. Forecast control involves monitoring the forecasting process to detect out-of-control conditions and identifying opportunities to improve forecasting performance. Figure 1 shows a visualization of a forecasting system and process. Forecasting System There are a number of common terms when discussing forecasting models: Conversely, in-sample data refers to the data used to construct the model. Users should fit the model to the in-sample data. Hold out x percent of most recent rule of thumb is 10 percent â€" usually for longitudinal data Hold out x percent but randomly throughout the entire data set â€" usually for cross-sectional data Use all data and wait for future values: There are three commonly used statistical measures used in forecasting: If Yt is the observed value at period t and Ft is the forecasted value at period t Figure 2: Forecasting Formulas Table 1: Examples of Forecast Error Measures Period.

Chapter 3 : Time Series Analysis for Business Forecasting

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Important aspects[edit] "I think we have a cultural affinity for technology that reflects optimism, but we all make poor forecasts. The forecast does not have to state how these characteristics will be achieved. Secondly, technological forecasting usually deals with only useful machines, procedures or techniques. This is to exclude from the domain of technological forecasting those commodities, services or techniques intended for luxury or amusement. Rational and explicit methods[edit] The whole purpose of the recitation of alternatives is to show that there really is no alternative to forecasting. The virtues of the use of rational methods are as follows: They can be taught and learned, They can be described and explained, They provide a procedure followable by anyone who has absorbed the necessary training, and in some cases, These methods are even guaranteed to produce the same forecast regardless of who uses them. The virtue of the use of explicit methods is that they can be reviewed by others, and can be checked for consistency. Furthermore, the forecast can be reviewed at any subsequent time. Technology forecasting is not imagination. Methods of technology forecasting[edit] Combining forecasts[edit] Studies of past forecasts have shown that one of the most frequent reasons why a forecast goes wrong is that the forecaster ignores related fields. A given technical approach may fail to achieve the level of capability forecast for it, because it is superseded by another technical approach which the forecaster ignored. Another problem is that of inconsistency between forecasts. Because of these problems, it is often necessary to combine forecasts of different technologies. Therefore rather than to try to select the one method which is most appropriate, it may be better to try to combine the forecasts obtained by different methods. If this is done, the strengths of one method may help compensate for the weaknesses of another. Reasons for combining forecasts[edit] The primary reason for combining forecasts of the same technology is to attempt to offset the weaknesses of one forecasting method with the strengths of another. In addition, the use of more than one forecasting method often gives the forecaster more insight into the processes at work which are responsible for the growth of the technology being forecast. Trend curve and growth curves[edit] A frequently used combination is that of growth curves and a trend curve for some technology. Here we see a succession of growth curves, each describing the level of functional capability achieved by a specific technical approach. An overall trend curve is also shown, fitted to those items of historical data which represent the currently superior approach. The use of growth curves and a trend curve in combination allows the forecaster to draw some conclusions about the future growth of a technology which might not be possible, were either method used alone. With growth curves alone, the forecaster could not say anything about the time at which a given technical approach is likely to be supplanted by a successor approach. With the trend curve alone, the forecaster could not say anything about the ability of a specific technical approach to meet the projected trend, or about the need to look for a successor approach. Thus the need for combining forecasts. Identification of consistent deviations[edit] Another frequently used combination of forecasts is that of the trend curve and one or more analogies. We customarily consider the scatter of data points about a trend curve to be due to random influences which we can neither control nor even measure. However, consistent deviations may represent something other than just random influences. Where such consistent deviations are identified, we may have an opportunity to apply an analogy. Typical events which bring about deviations from a trend are wars and depressions. Thus the purpose of combining analogies with a trend forecast is to predict deviations from the trend deviations which are associated with or caused by external events or influences. As with other uses of analogy, it is important to determine the extent to which the analogy between the event used as the basis for the forecast, and the historical model event, satisfies the criteria for a valid analogy. Forecasts of different technologies[edit] Combining forecasts of different technologies may be even more important than combining the forecasts of the same technology. One reason for this is the fact that technologies may interact or be interrelated in some fashion. Another reason for this is that of consistency in an overall picture or scenario. One of the simplest examples of interacting trends is the projection to absurdity, i. For instance, if one simply projects recent rates of growth of world population, one arrives at some fantastic conclusions about the density of population in a particular place by various dates in the next millennium. Some other trends which can confidently be expected to not continue indefinitely are: Annual production of scientific papers. Number of automobiles per capita. Kilowatt hours of electricity generated annually. Another instance of interacting trends was in the case of the number of scientists in the U. Since the s through the s, science as an activity in the United States grew exponentially. If projected indefinitely, these two curves would give the result that eventually every person in the U. Thus it is clear that the scientific discipline of technology forecasting is not mere trend extrapolation but also involves combining forecasts. Uses in manufacturing[edit] Almost all modern manufacturing firms utilize the services of a technological forecaster. Thus technological forecasting is not mere astrology or palmistry, but a scientific and well defined procedure adopted by a technological forecaster or a consultancy for the forecasting of a particular technology. Even though technological forecasting is a scientific discipline, some experts are of the view that "the only certainty of a particular forecast is that it is wrong to some degree.

Chapter 4 : Business Forecasting: Practical Problems and Solutions | calendrierdelascience.com

Practical technology forecasting: concepts and exercises, with notes on anticipating sociopolitical interactions with technology. Responsibility by James R. Bright.

Financial Statements Financial Forecasting Methods There are a number of different methods by which a business forecast can be made. All the methods fall into one of two overarching approaches: Qualitative forecasts can be thought of as expert-driven, in that they depend on market mavens or the market as a whole to weigh in with an informed consensus. Market Research Polling a large number of people on a specific product or service to predict how many people will buy or use it once launched. Asking field experts for general opinions and then compiling them into a forecast. For more on qualitative modeling, read " Qualitative Analysis: What Makes a Company Great? These approaches are concerned solely with data and avoid the fickleness of the people underlying the numbers. They also try to predict where variables like sales, gross domestic product , housing prices and so on, will be in the long-term, measured in months or years. The indicator approach depends on the relationship between certain indicators, for example, GDP and unemployment rates , remaining relatively unchanged over time. By following the relationships and then following indicators that are leading, you can estimate the performance of the lagging indicators , by using the leading indicator data. This is a more mathematically rigorous version of the indicator approach. Instead of assuming that relationships stay the same, econometric modeling tests the internal consistency of datasets over time and the significance or strength of the relationship between data sets. Econometric modeling is sometimes used to create custom indicators that can be used for a more accurate indicator approach. However, the econometric models are more often used in academic fields to evaluate economic policies. For a basic explanation on applying econometric models, read " Regression Basics for Business Analysis. This refers to a collection of different methodologies that use past data to predict future events. The difference between the time series methodologies is usually in fine details, like giving more recent data more weight or discounting certain outlier points. By tracking what happened in the past, the forecaster hopes to be able to give a better than average prediction about the future. How Does Forecasting Work? There is a lot of variation on a practical level when it comes to business forecasting. However, on a conceptual level, all forecasts follow the same process. A problem or data point is chosen. This can be something like "will people buy a high-end coffee maker? Theoretical variables and an ideal data set are chosen. This is where the forecaster identifies the relevant variables that need to be considered and decides how to collect the data. To cut down the time and data needed to make a forecast, the forecaster makes some explicit assumptions to simplify the process. A model is chosen. The forecaster picks the model that fits the dataset, selected variables, and assumptions. Using the model, the data is analyzed and a forecast made from the analysis. The forecaster compares the forecast to what actually happens to tweak the process, identify problems or in the rare case of an accurate forecast, pat himself on the back. Problems With Forecasting Business forecasting is very useful for businesses, as it allows them to plan production, financing and so on. However, there are three problems with relying on forecasts: The data is always going to be old. It is impossible to factor in unique or unexpected events, or externalities. Assumptions are dangerous, such as the assumptions that banks were properly screening borrowers prior to the subprime meltdown. And black swan events have become more common as our dependence on forecasts has grown. This is a conceptual knot. In a worst-case scenario, management becomes a slave to historical data and trends rather than worrying about what the business is doing now. The Bottom Line Forecasting can be a dangerous art, because the forecasts become a focus for companies and governments, mentally limiting their range of actions, by presenting the short to long-term future as already being determined. Interested in more methods employed in financial modeling? Read " Style Matters in Financial Modeling. Get a free 10 week email series that will teach you how to start investing. Delivered twice a week, straight to your inbox.

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Chapter 5 : The Basics Of Business Forecasting | Investopedia

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Chapter 6 : Technological Forecasting and Social Change - Journal - Elsevier

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Excerpts from Survival Statistics - an applied statistics book for graduate students. Most people view the world as consisting of a large number of alternatives. Futures research evolved as a way of examining the alternative futures and identifying the most probable. Forecasting is designed to help decision making and planning in the present. Forecasts empower people because their use implies that we can modify variables now to alter or be prepared for the future. A prediction is an invitation to introduce change into a system. There are several assumptions about forecasting: There is no way to state what the future will be with complete certainty. Regardless of the methods that we use there will always be an element of uncertainty until the forecast horizon has come to pass. There will always be blind spots in forecasts. We cannot, for example, forecast completely new technologies for which there are no existing paradigms. Providing forecasts to policy-makers will help them formulate social policy. The new social policy, in turn, will affect the future, thus changing the accuracy of the forecast. Many scholars have proposed a variety of ways to categorize forecasting methodologies. The following classification is a modification of the schema developed by Gordon over two decades ago: Genius forecasting - This method is based on a combination of intuition, insight, and luck. Psychics and crystal ball readers are the most extreme case of genius forecasting. Their forecasts are based exclusively on intuition. Science fiction writers have sometimes described new technologies with uncanny accuracy. There are many examples where men and women have been remarkable successful at predicting the future. There are also many examples of wrong forecasts. The weakness in genius forecasting is that its impossible to recognize a good forecast until the forecast has come to pass. Some psychic individuals are capable of producing consistently accurate forecasts. Mainstream science generally ignores this fact because the implications are simply to difficult to accept. Our current understanding of reality is not adequate to explain this phenomena. Trend extrapolation - These methods examine trends and cycles in historical data, and then use mathematical techniques to extrapolate to the future. The assumption of all these techniques is that the forces responsible for creating the past, will continue to operate in the future. This is often a valid assumption when forecasting short term horizons, but it falls short when creating medium and long term forecasts. The further out we attempt to forecast, the less certain we become of the forecast. The stability of the environment is the key factor in determining whether trend extrapolation is an appropriate forecasting model. The concept of "developmental inertia" embodies the idea that some items are more easily changed than others. Clothing styles is an example of an area that contains little inertia. It is difficult to produce reliable mathematical forecasts for clothing. Energy consumption, on the other hand, contains substantial inertia and mathematical techniques work well. The developmental inertia of new industries or new technology cannot be determined because there is not yet a history of data to draw from. There are many mathematical models for forecasting trends and cycles. Choosing an appropriate model for a particular forecasting application depends on the historical data. The study of the historical data is called exploratory data analysis. Its purpose is to identify the trends and cycles in the data so that appropriate model can be chosen. The most common mathematical models involve various forms of weighted smoothing methods. Another type of model is known as decomposition. This technique mathematically separates the historical data into trend, seasonal and random components. A process known as a "turning point analysis" is used to produce forecasts. ARIMA models such as adaptive filtering and Box-Jenkins analysis constitute a third class of mathematical model, while simple linear regression and curve fitting is a fourth. The common feature of these mathematical models is that historical data is the only criteria for producing a forecast. One might think then, that if two people use the same model on the same data that the forecasts will also be the same, but this is not necessarily the case. Mathematical models involve smoothing constants, coefficients and other parameters that must decided by the forecaster. To a large degree, the choice of these parameters determines the forecast. It is vogue today to diminish the value of mathematical extrapolation. Makridakis one of the gurus of quantitative forecasting correctly points out that judgmental forecasting is superior to mathematical models, however, there are many forecasting applications where computer generated forecasts are more feasible. For example, large manufacturing companies often forecast inventory levels for thousands of items each month. It would simply not be feasible to use judgmental forecasting in this kind of application. Consensus methods - Forecasting complex systems often involves seeking expert opinions from more than one person. Each is an expert in his own discipline, and it is through the synthesis of these opinions that a final forecast is obtained. One method of arriving at a consensus forecast would be to put all the experts in a room and let them "argue it out". This method falls short because the situation is often controlled by those individuals that have the best group interaction and persuasion skills. A better method is known as the Delphi technique. This method seeks to rectify the problems of face-to-face confrontation in the group, so the responses and respondents remain anonymous. The classical technique proceeds in well-defined sequence. In the first round, the participants are asked to write their predictions. Their responses are collated and a copy is given to each of the participants. The participants are asked to comment on extreme views and to defend or modify their original opinion based on what the other participants have written. Again, the answers are collated and fed back to the participants. In the final round, participants are asked to reassess their original opinion in view of those presented by other participants. The Delphi method general produces a rapid narrowing of opinions. It provides more accurate forecasts than group discussions. Furthermore, a face-to-face discussion following the application of the Delphi method generally degrades accuracy. Simulation methods - Simulation methods involve using analogs to model complex systems. These analogs can take on several forms. A mechanical analog might be a wind tunnel for modeling aircraft performance. An equation to predict an economic measure would be a mathematical analog. A metaphorical analog could involve using the growth of a bacteria colony to describe human population growth. Game analogs are used where the interactions of the players are symbolic of social interactions. Mathematical analogs are of particular importance to futures research. They have been extremely successful in many forecasting applications, especially in the physical sciences. In the social sciences however, their accuracy is somewhat diminished. The extraordinary complexity of social systems makes it difficult to include all the relevant factors in any model. Clarke reminds us of a potential danger in our reliance on mathematical models. As he points out, these techniques often begin with an initial set of assumptions, and if these are incorrect, then the forecasts will reflect and amplify these errors. One of the most common mathematical analogs in societal growth is the S-curve. The model is based on the concept of the logistic or normal probability distribution. All processes experience exponential growth and reach an upper asymptopic limit. Modis has hypothesized that chaos like states exist at the beginning and end of the S-curve. The disadvantage of this S-curve model is that it is difficult to know at any point in time where you currently are on the curve, or how close you are to the asymtopic limit. The advantage of the model is that it forces planners to take a long-term look at the future. Another common mathematical analog involves the use of multivariate statistical techniques. These techniques are used to model complex systems involving relationships between two or more variables. Multiple regression analysis is the most common technique. Unlike trend extrapolation models, which only look at the history of the variable being forecast, multiple regression models look at the relationship between the variable being forecast and two or more other variables. Multiple regression is the mathematical analog of a systems approach, and it has become the primary forecasting tool of economists and social scientists. The object of multiple regression is to be able to understand how a group of variables working in unison affect another variable. The multiple regression problem of collinearity mirrors the practical problems of a systems approach. Paradoxically, strong correlations between predictor variables create unstable forecasts, where a slight change in one variable can have dramatic impact on another variable. In a multiple regression and systems approach, as the relationships between the components of the system increase, our ability to predict any given component decreases. Gaming analogs are also important to futures research. Gaming involves the creation of an artificial environment or situation. Players either real people or computer players are asked to act out an assigned role. The "role" is essentially a set of rules that is used during interactions with other players. While gaming has not yet been proven as a forecasting technique, it does serve two important functions.

Chapter 7 : Forecasting & Technology Drive Spares Supply Chain | Applied Materials

Consists of "the bulk of the substantive material" in the Practical Technology Forecasting workbook first published in and revised in "Because of the deleted exercises, there are gaps in the page numbering"--Preface.

General considerations Measurements and ideas as the basis for weather prediction The observations of few other scientific enterprises are as vital or affect as many people as those related to weather forecasting. With such information they must have enjoyed greater success in the search for food and safety, the major objectives of that time. In a sense, weather forecasting is still carried out in basically the same way as it was by the earliest humansâ€"namely, by making observations and predicting changes. The modern tools used to measure temperature , pressure, wind, and humidity in the 21st century would certainly amaze them, and the results obviously are better. Yet, even the most sophisticated numerically calculated forecast made on a supercomputer requires a set of measurements of the condition of the atmosphere â€"an initial picture of temperature, wind, and other basic elements, somewhat comparable to that formed by our forebears when they looked out of their cave dwellings. The primeval approach entailed insights based on the accumulated experience of the perceptive observer, while the modern technique consists of solving equations. Although seemingly quite different, there are underlying similarities between both practices. Because observations are so critical to weather prediction, an account of meteorological measurements and weather forecasting is a story in which ideas and technology are closely intertwined, with creative thinkers drawing new insights from available observations and pointing to the need for new or better measurements, and technology providing the means for making new observations and for processing the data derived from measurements. The basis for weather prediction started with the theories of the ancient Greek philosophers and continued with Renaissance scientists, the scientific revolution of the 17th and 18th centuries, and the theoretical models of 20th- and 21st-century atmospheric scientists and meteorologists. In synoptic meteorology , simultaneous observations for a specific time are plotted on a map for a broad area whereby a general view of the weather in that region is gained. Since the midth century, digital computers have made it possible to calculate changes in atmospheric conditions mathematically and objectivelyâ€"i. The widespread adoption of numerical weather prediction models brought a whole new group of playersâ€"computer specialists and experts in numerical processing and statisticsâ€"to the scene to work with atmospheric scientists and meteorologists. Moreover, the enhanced capability to process and analyze weather data stimulated the long-standing interest of meteorologists in securing more observations of greater accuracy. Technological advances since the s have led to a growing reliance on remote sensing, particularly the gathering of data with specially instrumented Earth-orbiting satellites. By the late s, forecasts of weather were largely based on the determinations of numerical models integrated by high-speed supercomputers, except some shorter-range predictions, particularly those related to local thunderstorm activity, were made by specialists directly interpreting radar and satellite measurements. Practical applications of weather forecasting Systematic weather records were kept after instruments for measuring atmospheric conditions became available during the 17th century. Undoubtedly these early records were employed mainly by those engaged in agriculture. Planting and harvesting obviously can be planned better and carried out more efficiently if long-term weather patterns can be estimated. In the United States, national weather services were first provided by the Army Signal Corps beginning in These operations were taken over by the Department of Agriculture in By the early s free mail service and telephone were providing forecasts daily to millions of American farmers. Weather Bureau established a Fruit-Frost forecasting Service during World War I , and by the s radio broadcasts to agricultural interests were being made in most states. Its application in this area gained in importance after Francis W. Reichelderfer was appointed chief of the U. Weather Bureau in During World War II the discovery of very strong wind currents at high altitudes the jet streams, which can affect aircraft speed and the general susceptibility of military operations in Europe to weather led to a special interest in weather forecasting. One of the most famous wartime forecasting problems was for Operation Overlord , the invasion of the European mainland at Normandy by Allied forces. An unusually intense June storm brought high seas and gales to the

French coast, but a moderation of the weather that was successfully predicted by Col. Stagg of the British forces after consultation with both British and American forecasters enabled Gen. Eisenhower , supreme commander of the Allied Expeditionary Forces, to make his critical decision to invade on June 6, The second half of the 20th century saw unprecedented growth of commercial weather-forecasting firms in the United States and elsewhere. Marketing organizations and stores commonly hire weather-forecasting consultants to help with the timing of sales and promotions of products ranging from snow tires and roofing materials to summer clothes and resort vacations. Many oceangoing shipping vessels as well as military ships use optimum ship routing forecasts to plan their routes in order to minimize lost time, potential damage, and fuel consumption in heavy seas. Similarly, airlines carefully consider atmospheric conditions when planning long-distance flights so as to avoid the strongest head winds and to ride with the strongest tail winds. International trading of foodstuffs such as wheat , corn maize , beans, sugar, cocoa, and coffee can be severely affected by weather news. For example, in a severe freeze in Brazil caused the price of coffee to increase substantially within just a few weeks, and in a freeze in Florida nearly doubled the price of frozen concentrated orange juice in a matter of days. Weather-forecasting organizations are thus frequently called upon by banks, commodity traders, and food companies to give them advance knowledge of the possibility of such sudden changes. The cost of all sorts of commodities and services, whether they are tents for outdoor events or plastic covers for the daily newspapers, can be reduced or eliminated if reliable information about possible precipitation can be obtained in advance. Forecasts must be quite precise for applications that are tailored to specific industries. Gas and electric utilities, for example, may require forecasts of temperature within one or two degrees a day ahead of time, or ski-resort operators may need predictions of nighttime relative humidity on the slopes within 5 to 10 percent in order to schedule snow making. History of weather forecasting Early measurements and ideas The Greek philosophers had much to say about meteorology, and many who subsequently engaged in weather forecasting no doubt made use of their ideas. Unfortunately, they probably made many bad forecasts, because Aristotle , who was the most influential, did not believe that wind is air in motion. He did believe, however, that west winds are cold because they blow from the sunset. The scientific study of meteorology did not develop until measuring instruments became available. Its beginning is commonly associated with the invention of the mercury barometer by Evangelista Torricelli , an Italian physicist-mathematician, in the midth century and the nearly concurrent development of a reliable thermometer. Galileo had constructed an elementary form of gas thermometer in , but it was defective; the efforts of many others finally resulted in a reasonably accurate liquid-in-glass device. A succession of notable achievements by chemists and physicists of the 17th and 18th centuries contributed significantly to meteorological research. During the 19th century, all of these brilliant ideas began to produce results in terms of useful weather forecasts. The modern approach to weather forecasting, however, can only be realized when many such observations are exchanged quickly by experts at various weather stations and entered on a synoptic weather map to depict the patterns of pressure, wind, temperature, clouds, and precipitation at a specific time. Such a rapid exchange of weather data became feasible with the development of the electric telegraph in by Samuel F. Morse of the United States. Synoptic weather maps resolved one of the great controversies of meteorologyâ€”namely, the rotary storm dispute. By the early decades of the 19th century, it was known that storms were associated with low barometric readings, but the relation of the winds to low-pressure systems, called cyclones, remained unrecognized. William Redfield , a self-taught meteorologist from Middletown, Conn. The American meteorologist James P. Espy subsequently proposed in his Philosophy of Storms that air would flow toward the regions of lowest pressure and then would be forced upward, causing clouds and precipitation. Both Redfield and Espy proved to be right. The air does spin around the cyclone, as Redfield believed, while the layers close to the ground flow inward and upward as well. Further, the inflow is associated with clouds and precipitation in regions of low pressure, though that is not the only cause of clouds there. In Europe the writings of Heinrich Dove , a Polish scientist who directed the Prussian Meteorological Institute, greatly influenced views concerning wind behaviour in storms. Unlike the Americans, Dove did not focus on the pattern of the winds around the storm but rather on how the wind should change at one place as a storm passed. It was many years before his followers understood the complexity of the possible changes.

Establishment of weather-station networks and services Routine production of synoptic weather maps became possible after networks of stations were organized to take measurements and report them to some type of central observatory. As early as , U. Army Medical Corps personnel were ordered to record weather data at their posts; this activity was subsequently expanded and made more systematic. Actual weather-station networks were established in the United States by New York University , the Franklin Institute , and the Smithsonian Institution during the early decades of the 19th century. Buys Ballot in the Netherlands. Other such networks of weather stations were developed near Vienna, Paris, and St. It was not long before national meteorological services were established on the Continent and in the United Kingdom. The first national weather service in the United States commenced operations in , with responsibility assigned to the U. The original purpose of the service was to provide storm warnings for the Atlantic and Gulf coasts and for the Great Lakes. Within the next few decades, national meteorological services were established in such countries as Japan, India, and Brazil. The importance of international cooperation in weather prognostication was recognized by the directors of such national services. The proliferation of weather-station networks linked by telegraphy made synoptic forecasting a reality by the close of the 19th century. Yet, the daily weather forecasts generated left much to be desired. Many errors occurred as predictions were largely based on the experience that each individual forecaster had accumulated over several years of practice, vaguely formulated rules of thumb e. Progress during the early 20th century An important aspect of weather prediction is to calculate the atmospheric pressure patternâ€"the positions of the highs and lows and their changes. Modern research has shown that sea-level pressure patterns respond to the motions of the upper-atmospheric winds, with their narrow, fast-moving jet streams and waves that propagate through the air and pass air through themselves. Frequent surprises and errors in estimating surface atmospheric pressure patterns undoubtedly caused 19th-century forecasters to seek information about the upper atmosphere for possible explanations. The British meteorologist Glaisher made a series of ascents by balloon during the s, reaching an unprecedented height of nine kilometres. At about this time investigators on the Continent began using unmanned balloons to carry recording barographs, thermographs, and hygrographs to high altitudes. During the late s meteorologists in both the United States and Europe used kites equipped with instruments to probe the atmosphere up to altitudes of about three kilometres. Notwithstanding these efforts, knowledge about the upper atmosphere remained very limited at the turn of the century. The situation was aggravated by the confusion created by observations from weather stations located on mountains or hilltops. Such observations often did not show what was expected, partly because so little was known about the upper atmosphere and partly because the mountains themselves affect measurements, producing results that are not representative of what would be found in the free atmosphere at the same altitude. Fortunately, a large enough number of scientists had already put forth ideas that would make it possible for weather forecasters to think three-dimensionally, even if sufficient meteorological measurements were lacking. In William H. Dines , a British meteorologist, published data that showed how the upper atmosphere compensates for the fact that the low-level winds carry air toward low-pressure centres. Dines recognized that the inflow near the ground is more or less balanced by a circulation upward and outward aloft. Indeed, for a cyclone to intensify, which would require a lowering of central pressure, the outflow must exceed the inflow; the surface winds can converge quite strongly toward the cyclone, but sufficient outflow aloft can produce falling pressure at the centre. Meteorologists of the time were now aware that vertical circulations and upper-air phenomena were important, but they still had not determined how such knowledge could improve weather forecasting. Then, in , the Norwegian meteorologist Jacob Bjerknes introduced what has been referred to as the Norwegian cyclone model. This theory pulled together many earlier ideas and related the patterns of wind and weather to a low-pressure system that exhibited fronts â€"which are rather sharp sloping boundaries between cold and warm air masses. Here, the winds are from the lower latitudes, and the warm air, being light, glides up over a large region of cold air. Widespread, sloping clouds spread ahead of the cyclone; barometers fall as the storm approaches, and precipitation from the rising warm air falls through the cold air below. Where the cold air advances to the rear of the storm, squalls and showers mark the abrupt lifting of the warm air being displaced. Thus, the concept of fronts focused attention on the action at air mass boundaries. The Norwegian cyclone model could be called the frontal model, for the idea of warm air masses being lifted over cold air along their edges fronts became a major forecasting tool. The model not only emphasized the idea but it also showed how and where to apply it.

Chapter 8 : Use Forecasting Basics to Predict Future Conditions

It is this relative continuity in a technology's technical and economic characteristics and potential applications which makes technological forecasting possible.

One recent offering from Applied Materials is a Forecast Parts Management FPM model, in which customers sit down with managers from AGS to develop forecasts of the parts and quantities that will be needed over a given period see figure 1. Forecast Parts Management FPM is designed to help minimize customer fab disruptions and ensure the highest quality parts, at competitive costs. In turn, Applied Materials can use the combined forecasts from our FPM customers to improve the efficiency of the entire supply chain. This means the benefits of FPM allow greater assurance of supply, with more efficient use of inventory, which translates into savings for customers. FPM is becoming a partnership platform, where customers and Applied Materials establish an ongoing working model, built around a forecast, that puts fab performance as the top priority. Through FPM, Applied Materials helps customers minimize fab disruptions and ensure they receive the highest-quality parts, at costs that enable them to remain competitive. Lee noted that other programs are also evolving to help customers continuously improve efficiency and performance, and achieve lower cost of ownership for their Applied Materials equipment. TKM programs provide customers with a steady flow of clean kits to eliminate kit shortages and spending spikes, and often include industry-leading advanced coatings that extend part lifetimes, reduce particles and lengthen mean time between cleans. If a supplier had issues with a dimension, or needed to qualify a new computer numerical control CNC machine, we would send out an engineer and go through the qualification process. The wafer process window would not be impacted if the dimensional spec of the part had a wider range in limits. Today, however, the part dimensional spec must be much tighter because even a minor deviation will impact the wafer performance. Together, they are developing an upfront understanding of components, cleaning requirements, chamber matching, and health-monitoring techniques. AGS has been qualifying parts suppliers located closer to major customers, often in less costly regions. Flying spares from a parts manufacturer in one country, to a cleaning specialist in another, and then to a parts center in a third country, often involves unnecessary logistics and costs. Intelligent components are needed to match chamber-to-chamber and system-to-system, a key demand from fab managers that must ensure Angstrom-level performance. And mass flow controllers also had selfcalibration capabilities. With chamber matching we have to make every wafer, every die, feel and see the same thing. Much of this metrology work is done at the chamber and system levels, partly to avoid driving up the cost of individual components. To determine the number of radicals generated by a remote plasma source, for example, AGS relies on internal chamber metrology. Everyone is under a lot of pressure to drive down costs, and anything we ask of the supplier side results in added costs. While Applied has been engaged in custom engineering for more than 20 years, over the past few years the group has grown to more than AGS engineers working with customers. In some cases, Cho said, the original tool might be equipped with parts that exceed the performance needs of a particular customer. In that case, less expensive parts are sourced and tested. Lee said this custom engineering work extends to mm fabs. Having solutions to help our mm customers continue to run profitable operations is a critical capability we want to expand. Ensuring available spare parts is our number one priority. Accomplishing that goal requires optimizing spares inventory at locations around the globe. That global logistics system goes beyond the capabilities of small companies that in some cases re-engineer Applied parts, supplying them on a piece-part basis.

Chapter 9 : Practical technology forecasting: James Rieser Bright: calendrierdelascience.com: Books

Technology forecasting describes a group of techniques that predict, in quantifiable terms, the direction, character, rate, implication, and impact of technical advance. This management guide details technology forecasting techniques that contribute to better decision making.

Advertisement In Brief Stronger or more frequent weather extremes will likely occur under climate change, such as more intense downpours and stronger hurricane winds. Then the blackened sky over Joplin, Mo. Winds exceeding miles per hour tear a devastating path three quarters of a mile wide for six miles through the town, destroying schools, a hospital, businesses and homes and claiming roughly lives. Nearly 20 minutes before the twister struck on the Sunday evening of May 22, , government forecasters had issued a warning. A tornado watch had been in effect for hours and a severe weather outlook for days. The warnings had come sooner than they typically do, but apparently not soon enough. Although emergency officials were on high alert, many local residents were not. The Joplin tornado was only one of many twister tragedies in the spring of A month earlier a record-breaking swarm of tornadoes devastated parts of the South, killing more than people. April was the busiest month ever recorded, with about tornadoes. At fatalities, was the fourth-deadliest tornado year in U. The stormy year was also costly. The intensity continued early in ; on March 2, twisters killed more than 40 people across 11 Midwestern and Southern states. Tools for forecasting extreme weather have advanced in recent decades, but researchers and engineers at the National Oceanic and Atmospheric Administration are working to enhance radars, satellites and supercomputers to further lengthen warning times for tornadoes and thunderstorms and to better determine hurricane intensity and forecast floods. The Power of Radar Meteorologist doug forsyth is heading up efforts to improve radar, which plays a role in forecasting most weather. Radar works by sending out radio waves that reflect off particles in the atmosphere, such as raindrops or ice or even insects and dust. By measuring the strength of the waves that return to the radar and how long the round-trip takes, forecasters can see the location and intensity of precipitation. The Doppler radar currently used by the National Weather Service also measures the frequency change in returning waves, which provides the direction and speed at which the precipitation is moving. This key information allows forecasters to see rotation occurring inside thunderstorms before tornadoes form. They noted very strong outbound velocities right next to very strong inbound velocities in the radar data. The visual appearance of those data was so extraordinary that the researchers initially did not know what it meant. These data enabled longer lead times for tornado warnings, increasing from a national average of 3. Although Doppler radar has been transformative, it is not perfect. It leaves meteorologists like Forsyth blind to the shape of a given particle, which can distinguish, say, a rainstorm from a dust storm. Ironically, the trajectory of his career path changed when a failed eye exam led him from U. Air Force pilot ambitions to a career in meteorology. Since then, Forsyth has focused on radar upgrades that give forecasters a better view of the atmosphere. One critical upgrade is called dual polarization. This technology allows forecasters to differentiate more confidently between types of precipitation and amount. Although raindrops and hailstones may sometimes have the same horizontal widthâ€”and therefore appear the same in Doppler radar imagesâ€”raindrops are flatter. Knowing the difference in particle shape reduces the guesswork required by a forecaster to identify features in the radar scans. That understanding helps to produce more accurate forecasts, so residents know they should prepare for hail and not rain, for example. Information about particle size and shape also helps to distinguish airborne bits of debris lofted by tornadoes and severe thunderstorms, so meteorologists can identify an ongoing damaging storm. Particle data are especially important when trackers are dealing with a tornado that is invisible to the human eye. If a tornado is cloaked in heavy rainfall or is occurring at night, dual polarization can still detect the airborne debris. The National Weather Service is integrating dual-polarization technologyâ€”which is also helpful for monitoring precipitation in hurricanes and blizzardsâ€”into all Doppler radars across the nation, expecting to finish by mid At the same time, NOAA personnel are training forecasters to interpret the new images. During that storm, dual-polarization radars proved more accurate in detecting precipitation rates, and therefore predicting flooding, than conventional Doppler radars farther north. The improved capabilities surely saved lives in the Carolinas; farther up the coast, without this technology, Hurricane Irene was deadlier despite early warnings, claiming nearly 30 lives. Navy to detect and track enemy ships and missiles has great potential to improve weather forecasting as well. Heinselman leads a team of electrical engineers, forecasters and social scientists at the National Weather Radar Testbed in Norman, Okla. Current Doppler radars scan at one elevation angle at a time, with a parabolic dish that is mechanically turned. Once the dish completes a full degree slice, it tilts up to sample another small sector of the atmosphere. After sampling from lowest to highest elevation, which during severe weather equates to 14 individual slices, the radar returns to the lowest angle and begins the process all over again. Scanning the entire atmosphere during severe weather takes Doppler radar four to six minutes. In contrast, phased-array radar sends out multiple beams simultaneously, eliminating the need to tilt the antennas, decreasing the time between scans of storms to less than a minute. Ideally, the phased-array system would have four panels that emitted and received radio waves, to provide a degree view of the atmosphereâ€”one each for the north, south, east and west. Researchers in Norman have made only one-panel systems operable for weather surveillance, and it is likely to be at least a decade before phased arrays become the norm across the country. Eyes in the Sky Of course, even the best radars cannot see over mountains or out into the oceans, where hurricanes form. Forecasters rely on satellites for these situations and also rely on them to provide broader data that supplement the localized information from a given radar. To improve the delivery of this essential environmental intelligence, NOAA will deploy a range of new technologies in the next five years. Without more detailed satellite observations, extending the range of accurate weather forecastsâ€”especially for such extreme events as hurricanesâ€—would be severely restricted. Monitoring weather requires two types of satellites: Using loops of pictures taken at minute intervals, forecasters can monitor rapidly growing storms or detect changes in hurricanes but not tornadoes. Polar satellites, which orbit the earth from pole to pole at an altitude of approximately miles, give closer, more detailed observations of the temperature and humidity of different layers of the atmosphere. A worldwide set of these low Earth orbit LEO satellites covers the entire globe every 12 hours. Their data will be used in computer models to improve weather forecasts, including hurricane tracks and intensities, severe thunderstorms and floods. This level of outlook is reserved for the most extreme cases, with the least uncertainty, and is only used when the possibility for extremely explosive storms is detected. The new LEO satellites should allow such predictions as much as five to seven days before a storm. Geostationary satellites will improve, too. Advanced instruments that will image the earth every five minutes in both visible and infrared wavelengths will be onboard the GOES-R series of satellites to be launched in They will increase observations from every 15 minutes to every five minutes or less, allowing scientists to monitor the rapid intensification of severe storms. The lightning mapper will help forecasters detect jumps in the frequency of in-cloud and cloud-to-ground lightning flashes. Research suggests that these jumps occur up to 20 minutes or more before hail, severe winds and even tornadoes. Billions of Data Each of the new radar technologies and satellites could improve warning times by several minutes, but incorporating the data derived from all these systems into forecasting computer models could provide even more time. Warnings for tornadoes, for example, could be issued up to an hour in advance. That is the kind of lead time that would have made a big difference in Joplin. Forecasting models are based on physical laws governing atmospheric motion, chemical reactions and other relationships. They crunch millions of numbers that represent current weather and environmental conditions, such as temperature, pressure and wind, to predict the future state of the atmosphere. Imagine another one a few hundred feet above thatâ€”and another and another, in layer after layer, all the way to the top of the stratosphere some 30 miles up. Millions of lines of code are needed to translate the billions of grid points under observation. A typical forecast model today uses grids at the surface that run about five to 30 miles square. Processing more data points, however, requires faster supercomputers. Advances in modeling also require talented people who can integrate all these data and interpret them. But Lapenta believes faster speeds are possible, which will allow the models to run at even smaller scales. For example, grids of just one mile square would enable models to simulate the small-scale conditions that catapult a routine thunderstorm or hurricane into a monster. Lapenta hopes such high-resolution models might begin to appear by Lapenta foresees a day in the next decade when the increasing capabilities of new radars and satellites will be coupled with an evolving generation of finely detailed weather-prediction models running in real time on computers at speeds exceeding a quintillion computations a second. To make them a reality, scientists such as Lapenta are working on the mathematical, physical and biogeochemical relations that need to be encoded in a way that enables those relations to work together seamlessly. Instead they will be able to issue tornado, severe thunderstorm and flash-flood warnings based on highly accurate model forecasts produced well in advance, giving the public 30 to 60 minutes to take safety precautions. Better Science, Better Decisions With all these improvements, meteorologists such as Gary Conte in the New York City Weather Forecast Office will be able to predict more accurately, with longer lead times, weather hazards that can shut down the city, such as storms with snow and ice. Severe weather outlooks will extend beyond five days, hurricane forecasts beyond seven days, and the threat of spring floods will be known weeks in advance. This vision for a weather-ready nation is motivated by the desire to avoid the unmitigated disasters of The goal is that by the rebuilt and thriving city of Joplin would receive a severe tornado warning more than an hour in advance. Families would have more time to gather and get to a safe room. Nursing homes and hospitals would be able to transfer residents and patients to shelter. Retailers would have time to get employees to safety and close up shop. Cell phones would thrum with multiple messages to seek shelter while local meteorologists broadcast similar warnings on television and radio. The clarion call of tornado sirens would reinforce the urgency of these warnings. She is a marine ecologist and environmental scientist, with expertise in oceans, climate change and interactions between the environment and human well-being. He is responsible for the preparation and delivery of weather warnings and predictions to government, industry and the general public.