

# Managing Short Life-Cycle Products

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Many companies have found that supply chain management initiatives have greatly increased their profitability, reduced inventory, and improved their ability to match supply with demand. But short lifecycle products -- like fashion apparel or toys -- are a cutting-edge challenge in supply chain management. Complex, long-term forecasts may have little meaning, while even the conventional wisdom of experienced retailers may have limited relevance in a unique and rapidly changing market environment. Use of an eclectic and flexible planning program such as Accurate Response may hold the key.

## INTRODUCTION

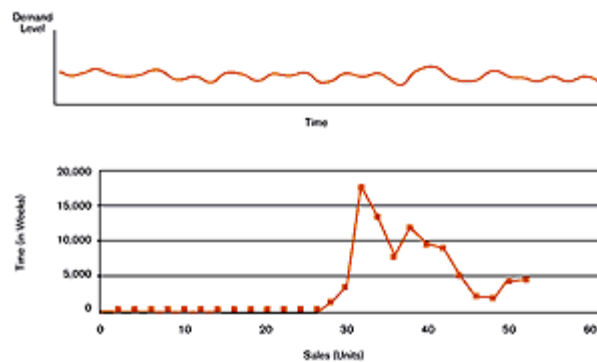
### Supply Chains in the 1990's: Good News and Bad News

The 1990s have witnessed substantial progress in supply chain management for fast moving consumer products like food and basic apparel as companies recognized the value of sharing information and working together with their channel partners. The results in many cases have been outstanding food companies like Campbell Soup and Barilla, a pasta manufacturer in Italy, have doubled inventory turns for their retail customers while maintaining or increasing fill rates<sup>1</sup>. Barilla, for example, increased fill rates from 98.8 % of sales to 99.8 % of sales at selected distribution centers by changing information flow and partnerships in the supply chains.

While these results are impressive, they have dealt exclusively with "functional" products<sup>2</sup> with long lifecycles and demand that is reasonably easy to predict. Examples of functional products besides Barilla pasta and Campbell Soup include most other food products and basic apparel such as socks and non-fashion underwear. The same success has not been achieved for "innovative" products like fashion apparel, consumer electronics, personal computers, toys, jewelry, books, and CD's, that have short life cycles and unpredictable demand.

The challenge in managing supply chains for short lifecycle products is to ensure product availability while keeping product obsolescence low. The ability to respond to market signals as well as the ability to develop accurate demand forecasts and update them based on recent information is critical.

Supply chain management for short lifecycle products is more challenging than supply chain management for fashion products for three reasons. First, the demand patterns for these

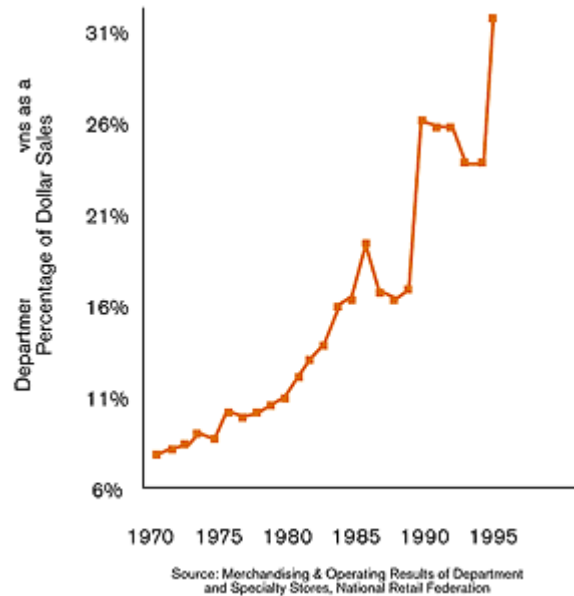


**Figure 1.** Textbook image of finished good demand patterns (top graph), versus real demand patterns (bottom graph).

products make estimation of demand and demand variability extremely difficult. Textbooks on forecasting/inventory management and supply chain management models assume the kind of demand pattern shown in Figure 1, either stable with limited variability or with demand rising quickly with large spikes in between, as in the case of short lifecycle products. Understandably, it is harder to predict demand for these products. Second, traditional forecast methods usually assume at least one year of demand history is available, which is not possible for short life cycle products since they generally have a life cycle that's less than one year. Finally, the cost of carrying inventory is much higher for short lifecycle products because of the risk of obsolescence. This necessitates inventory planning algorithms that are more precise than those that have been developed for functional products.

The need for better approaches to manage supply chains of innovative, short lifecycle products has never been more urgent. The rate of product innovation has increased dramatically in many industries making it hard to forecast demand at the SKU level. Even industries that traditionally had long lifecycle products and low product variety (e.g. telephones and computers), now have to deal with short lifecycles, high product variety, and the resulting product obsolescence which occurs because each new generation of product (e.g. Pentium PC) renders the older version obsolete.

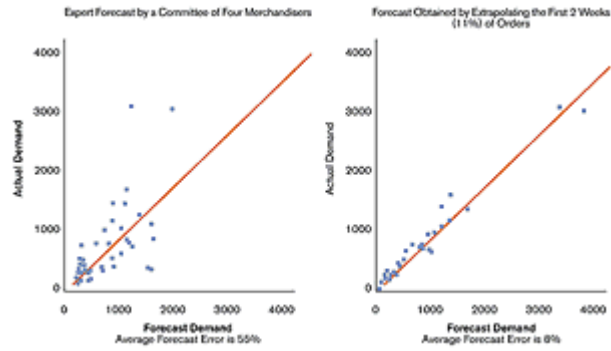
There is abundant evidence of the havoc that this has wreaked on companies' ability to match supply with demand. Figure 2 shows that department store markdowns, a key indicator of how well what is supplied by department stores matches what customers want to buy, have grown from 8% of sales in 1971 to 33% in 1995. But despite this huge oversupply, consumers aren't finding what they want in stock. For example, the 1998 Kurt Salmon Associates Annual Consumer Outlook Survey reported that 70% of apparel consumers enter a store with a clear idea of an item they want to buy, but 49% leave without buying because they can't find what they want. Of these, 67% can't find the item in their size. In some industries, the combined cost of stockouts and obsolescence even exceeds the cost of manufacturing.



**Figure 2.** Markdowns have Skyrocketed

Managing supply of innovative products is analogous to financial gambles in the stock market. Demand forecasts, like stock market prices, are impossible to predict exactly in advance. A supplier has to make production and inventory commitments quite like the portfolio planner in the stock market who has to decide what stocks to buy. Moreover, just as the portfolio planner may buy options on various stocks, merchandisers can preposition fabrics and reserve production capacity. Optimizing supply quantities also involves estimating the margin of error in demand forecasts for different products and factoring these estimates into production planning decisions.

In our research over the last decade, we have developed a planning paradigm for innovative products called Accurate Response which blends new forecasting techniques, innovative production and inventory planning algorithms, and greater supply chain responsiveness. We have also developed techniques to quantify the risk associated with carrying inventory of particular products and to use these risk measures in production sequencing decisions. A managerial description of Accurate Response is provided in Fisher, Hammond, Obermeyer and Raman, 'Making Supply Meet Demand in an Uncertain World', Harvard Business Review, May-June 1994 and a technical description in Fisher and Raman, 'Reducing the Cost of Demand Uncertainty through Accurate Response to Early Sales,' Operations Research, 1996.

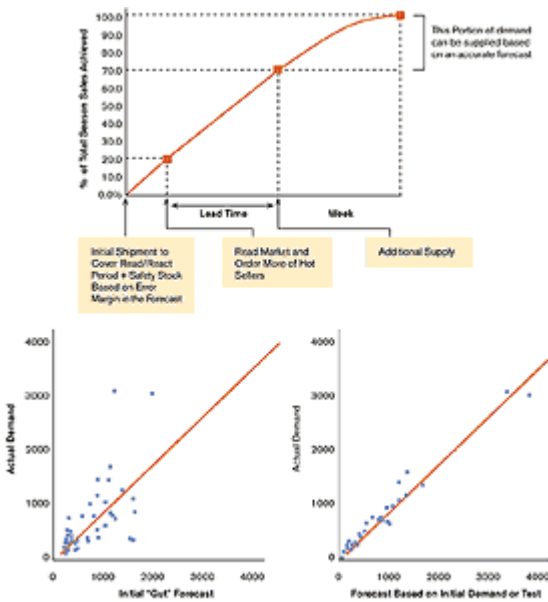


**Figure 3.** Early Sales Data is an Accurate Predictor of Lifecycle Demand

Since publication of these papers we have worked with a number of suppliers and retailers of innovative products such as fashion apparel, consumer electronics, personal computers, toys, jewelry, books and CDs. This paper provides an overview of Accurate Response using one of these examples, some insights on implementation subtleties we have learned in our case histories, and a description of how a leading Japanese retailer of fashion apparel has effectively enhanced Accurate Response. The paper concludes with a brief synopsis of ongoing research to deal with these issues in retailing.

### What is Accurate Response?

We can most clearly describe Accurate Response with an example. The example we use concerns a set of women's apparel sold by a cataloger<sup>3</sup>. Their challenge is to determine supply quantities for these products in support of a particular catalogue or 'book.' Typically, a team of expert merchants will forecast the life-cycle sales of each item prior to their introduction and prior to any sales experience. The left graph in figure 3 shows these forecasts. Each dot relates to a particular apparel style and color and shows the forecast developed by the expert merchants and the actual demand for this product. Actual demand is known by catalogers even if they stock out of a product, because customers usually order, and their order is recorded, before the inventory position of an item is checked. Many customers will also backorder items that are temporarily stocked out.



**Figure 4.** Accurate Response to Market Signals

The average forecast error for this example is 55%, which is typical of other short lifecycle products we've seen. Generally we've found that expert forecasts like these made in advance of any sales information have average errors ranging from 50% to 100%. The right most graph shows life-cycle forecasts for the same products developed by a simple extrapolation of the first two weeks of demand. This cataloger has found

that in the first two weeks after a book is issued they typically receive 11% of the eventual life-cycle orders. Thus, if a product sells 11 units in the first two weeks, we would predict sales of 100 over its lifecycle.

This simple extrapolation of a small amount of early sales provides forecasts that are dramatically more accurate than the initial 'gut' forecasts, in this case having an average forecast error of just 8%. This is one of the most robust empirical findings of our work on short life-cycle products. In all cases, we have found that the initial forecasts, derived using subjective judgment, are quite poor, while forecasts developed from intelligent interpretation of a small amount of initial sales data are dramatically more accurate.

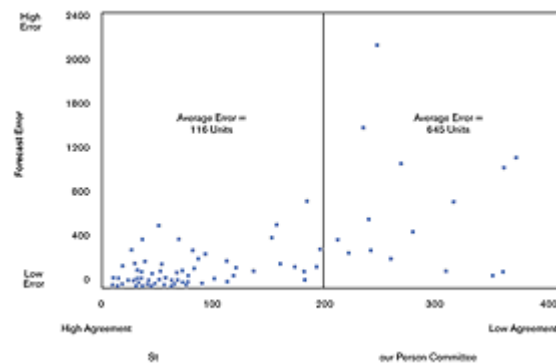
This suggests an obvious strategy for managing supply, which is illustrated in figure 4. The graph shows the percent of total life cycle sales for the complete set of products that we expect to have

Product	Anna	Laurie	Julie	Kim	Committee Average	Committee Standard Deviation	Actual Demand	Forecast Error
Navy Turtleneck	89	86	102	102	95	8	85	-10
Red Cardigan	63	76	152	51	86	46	199	113
Blue Vest	30	91	183	76	95	64	29	-66

**Figure 5.** Forecast Committee Results

occurred at each point in time. This graph would be developed using sales history for similar products in a prior season. There is no way to avoid the need to position initial supply based on the inaccurate expert forecasts. But after a brief period (two weeks) to read the market based on early sales, we can order additional quantities as warranted based on the highly accurate early demand forecasts. Replenishment quantities arrive after a lead-time. The shorter this lead time, the greater the proportion of demand that can be supplied based on the accurate forecasts, and the better we can match supply with demand over the life of the products.

The initial shipment should be big enough to cover the expected demand over the 'read' period and the replenishment lead-time, plus a hedge to protect against stock-outs given the highly inaccurate initial forecasts. Notice that the bigger the hedge quantity, the more of the products we can cover that had demand in excess of the forecast, but it would take a very big hedge to protect against all stock-outs. In this example, the largest forecast error occurs for a product on which the forecast is about 1,100 and actual demand is about 3,000.



**Figure 6.** The Committee Process is a Powerful Way Determine What You Can and What You Cannot Predict

The fraction of cases we hedge sufficiently to prevent a stock-out depends on the relative value of two costs, the cost we incur if demand exceeds supply and we stock-out, and the cost if supply exceeds demand. The first cost depends on the probability that a customer encountering a stock-out won't backorder, in which case we lose a sale and the cost we incur is the lost margin on the sale. Even if a customer backorders, there is an inconvenience which reduces customer satisfaction and may cost us future sales. Usually excess supply is sold eventually at a deep discount, but having to carry the merchandise for a long time before it sells combined with the discount usually results in a loss. All three of these key quantities, the probability a customer will backorder, the lost margin on a lost sale and the loss on excess inventory, can be estimated from historical data.

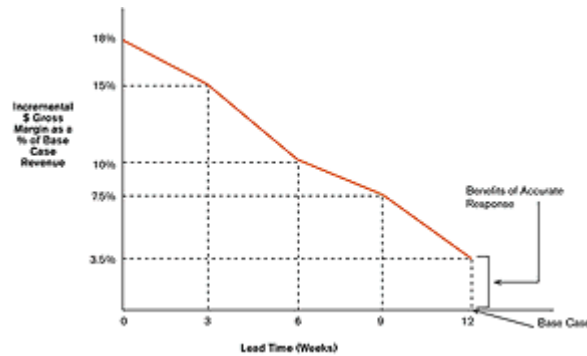
The fraction of stock-outs we can protect against with a given hedge quantity depends on the average forecast error. The bigger the error, the bigger the hedge required for a given level of

protection.

But how can we determine the likely margin of error on a forecast of an item with which we have no sales experience? We estimate the likely margin of error in the forecast of an item by asking each of the expert merchants to independently forecast each item and using the dispersion in their forecasts as a measure of the forecast error. Figure 5 shows these forecasts for three items.

Notice that the forecasts are close to each other for the first item, and that this item has a relatively small forecast error. Conversely, the forecasts vary widely for the other two items and both of these have large forecast errors. When the merchants agree, they tend to be more accurate, as shown in figure 6.

We thus use the standard deviation of forecasts across the expert forecasters as a way to estimate the likely forecast error for each item in determining its optimal hedge.

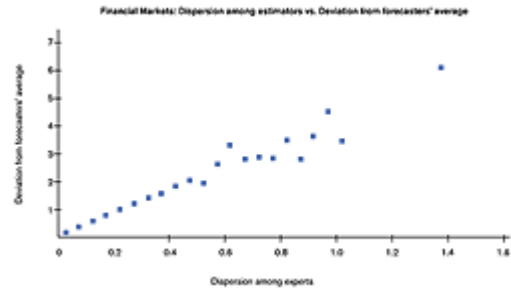


**Figure 7.** Accurate Response increases Gross Margin and Provides a Tool to Evaluate the Impact of Lead Time Reduction

Figure 7 shows that this process can have a significant financial impact. Compared to the process that was being followed by this cataloger to determine supply quantities, the process we have just described added 3.5% of sales to total gross margin, enough to increase bottom line profit by at least 50%. This increase resulted from additional gross margin earned in incremental sales generated by reducing stockouts of some items and by reduced losses due to reducing overstock on other items. These improvements resulted from taking an optimal inventory hedge and from choosing the optimal time to reorder, trading off the fact that if we reorder later we have more sales data on which to base a decision, but less of the season left for that decision to have an impact. The figure also shows the value of lead-time reductions. The graph was developed by rerunning our model on demand history for different assumed lead times. We have found this analysis to be very useful to companies that otherwise have trouble quantifying the value of lead-time reduction.

In applying this approach we have found a number of complexities that arise in practice. In the example we were able to accurately predict lifecycle sales by simply extrapolating early sales. Often this step is more complicated because the seasonal timing of sales differs by product or from year to year, and because other factors such as price or the set of competing products influence demand and change over the life of the product. In these instances it may be necessary to group products based on their demand seasonality, to look at multiple years in estimating seasonality factors (we know one retailer that uses seven different seasonality patterns depending on which day of the week Christmas falls on) and to develop a causal model of demand that includes early sales as one of the independent variables.

We have also verified the correlation between agreement and accuracy for a group of independent forecasters using other contexts, including financial data from stock market analysts. Multiple stock market analysts periodically predict quarterly earnings-per-share (eps) for a large number of companies that they are studying. We classified the company stocks in our sample based on the dispersion among experts that were predicting eps for it. After actual eps was known, we were able to obtain the error in a forecast equal to the average of the analysts' individual forecasts and hence, estimate the standard deviation of the error distribution for this forecast of eps for those stocks. Each point in figure 8 represents a set of stocks for which the analysts had approximately the same level of agreement as measured by the standard deviation of their individual forecasts, and plots this standard deviation against the standard deviation of errors. The dispersion among analysts' forecasts was clearly a very good predictor of the standard deviation of forecast errors. A more elaborate and rigorous analysis of these data can be found in A. Raman and M. L. Fisher, 'Estimating Uncertainty in Judgmental Forecasts', Harvard Business School Working Paper, 1997.



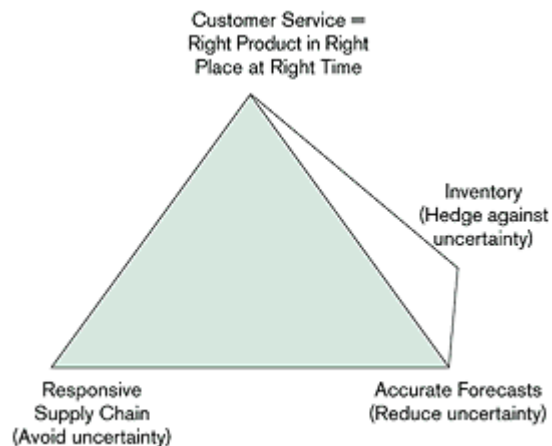
**Figure 8.** Financial Markets: Dispersion Among Estimators vs. Deviation from Forecasters' Average

### A Framework for Thinking about Accurate Response Capabilities

The three steps in the Accurate Response process align with three capabilities that are crucial in achieving excellent customer service, as depicted in figure 9: the ability to use information to create Accurate Forecasts; a fast, flexible Responsive Supply Chain that can produce and deliver in small quantities with a short lead-time; and the analysis tools to optimize Supply and Inventory decisions at each point in the supply chain.

We can think of these three capabilities as complementary ways of coping with the inherent uncertainty concerning which products customers will demand. Accurate forecasts reduce uncertainty while if our supply chain is responsive enough to produce products as they sell, we can avoid the consequences of uncertainty even if we can't accurately predict demand. Finally, once we have reduced and avoided uncertainty as much as possible, we can hedge against the residual uncertainty with inventory.

Note that the three capabilities trade-off. If we have highly accurate forecasts, we can operate effectively even with a slow supply chain. Conversely, if our supply chain is so fast that we can produce products as they sell, then forecasts don't have to be highly accurate. Of course, we can always achieve a high level of customer service with enough inventory, but at a very high cost and risk of inventory obsolescence.



**Figure 9.** Excellent Customer Service is Supported by Three Capabilities

Figure 10 shows a classic graph that is often quoted in textbooks that plots inventory levels against the level of customer service. The implication of the graph is that a firm needs to carry higher inventory to offer higher customer service. However, the methods we propose in this paper

seek to shift the firm to a more favorable inventory/serve level tradeoff curve in addition to ensuring that we are on the right point on this curve.

## World Co., Ltd: An Application of Accurate Response

Retailers measure their inventory performance with a concept called Gross Margin Return on Inventory Investment (GMROII). GMROII is equal to the total dollar gross margin earned on sales in a year divided by the average value of inventory carried to support those sales. The retailer in a study we are conducting with a group of leading edge retailers (see next section) with the highest value of GMROII is World Co., Ltd, a \$1.2 billion Japanese fashion apparel retailer and wholesaler with 7000 stores throughout Japan. While a number of retailers in our study have achieved excellence in various dimensions, we will use World as an example of what the best retailers are doing. Our description is based on a one-week visit with World in Japan in July of 1998 in which we observed their operations and met with their managers.



**Figure 10.** Shifting the Inventory/Service Level Take-Off

World has managed to achieve an incredibly responsive supply chain. They can replenish existing styles in one to two weeks and can introduce new styles in three to six weeks. By contrast, most apparel retailers measure replenishment time in months and the time to introduce new styles in years. World achieves this speed through a blend of pre-positioning of long lead-time materials, reservation of capacity with key suppliers and local production in Japan of replenishment quantities of fashion sensitive products. They also believe that empowerment is key to speed. For example, while in Japan, we observed a team in a factory preparing a new style for production. They were on the phone with designers in the head office numerous times to gain approval of design changes to make the style easier to produce or to substitute a different type of button because the requested one was stocked out. We have not seen a system that pushes design decisions to such a low level or makes them so quickly.

World uses Accurate Response to plan their production. The process of buying a new line begins with 20 sales people from a representative sample of stores evaluating items. These sales people are chosen by the store manager to be as much as possible like the target customer for items in age and other personal qualities. They meet in Tokyo at a mockup of what the store will look like with items and examine the items carefully. Each person independently scores the items on a scale from 1 to 7. World uses both the average and standard deviation of the scores in their purchase decisions. Items that everybody likes are bought aggressively, while items that nobody likes are dropped from the line. Those items that received mixed reviews are the most interesting, because they involve the greatest risk, but an also potentially high reward. World buys these items cautiously while simultaneously positioning supply of capacity and raw materials to be able to react if the item takes off. Within the first week of sales, they know whether the item will be a hit or miss and react accordingly.

A few weeks into the season, World also examines those items that are selling well and looks for common features of the hot sellers. Then they introduce new styles within the season of items that share those common features.

The World Company sees effective supply chain management as the answer to the question, "How to succeed in the SPA (specialty apparel) business?" Accurate Response is a crucial tool used by the company in achieving effective supply chain management.

### Accurate Response in Retailing

Not surprisingly, much of the interest in our work has come from retailers of products, who struggle with high inventory and markdown costs even while experiencing substantial stockouts.

In response to the initial enthusiasm among retailers, we launched a study of retail inventory management practices a few years ago. Armed with a research grant from the Alfred P. Sloan foundation in New York, we invited retailers in selected short lifecycle product categories like apparel and footwear, personal computers and consumer electronics, and books and music to join our study. The response from retailers was overwhelming, Table 1 lists the retailers that have already joined our study. As part of the study, we interviewed each retailer for roughly two days on key aspects of supply chain management and asked them to fill a survey on specific aspects of the topic. The results from the interview and the questionnaire are being summarized for publication. In addition, we are currently working with selected retailers on specific research problems that interest them. For example, we are working with some retailers on developing rigorous techniques for estimating demand and lost sales at their stores.

The retailers we have spoken to (including the ones that joined our study) are active proponents of what we term "Information-based Forecasting". Yet, most of the retailers in our study have made only limited progress towards achieving the vision that they and we believe in. The "average" retailer in our study is, to say the least, not very advanced in adopting the principles of information-based forecasting. Most retailers in our study are not very sophisticated users of historical sales data even though all of them capture detailed sales data through their point-of-

### Key Elements of the Accurate Response Method

1. Use a small amount of sales data early in the life of the product to update forecasts. We've found that effective use of early sales data typically reduces the forecast error margin from +/- 50-100% to about +/- 10%.
2. At any point in time and at each point in the supply chain, choose inventory levels for a given product to maximize over the life of the product, total dollar gross margin less the cost of inventory carrying and obsolescence. Among other things, this requires estimating a margin of error on the forecast and to help do this we ask several forecasters to independently predict demand and use the dispersion of their forecasts as a measure of risk.
3. Use various approaches to reduce lead-time to be better able to react to early sales information.

sale systems routinely. Similarly, inventory-planning systems are often woefully inadequate at most retailers. Finally, the response times for purchasing certain products at some companies is often substantially higher than what has been achieved at other companies that produce identical products.

While the average retailer does not use the principles of information-based retailing extensively, the exceptional retailers such as World Company in Japan demonstrate that the principles are applicable. The average retailer, we believe and most retail executives agree, needs to change the way it is managing its supply chain for short lifecycle products. Our mission in this project is to help the participating retailers achieve this transition as quickly as possible.

TABLE 1	<b>Harvard/Wharton Merchandising Effectiveness Project Retailers</b>		
<b>Apparel/Footwear</b>	<b>Consumer Electronics and PCs</b>	<b>Books, CDs, Theme stores</b>	<b>Other Product Categories and Multiple Product Categories</b>
<ul style="list-style-type: none"> <li>* David's Bridal</li> <li>* Federated (Macy's)</li> <li>* Gap Inc. (Old Navy)</li> <li>* JC Penney</li> <li>* The Limited</li> <li>* Philips Van Heusen (GH Bass)</li> <li>* Maurices</li> <li>* Zara</li> <li>* Nine West Group</li> <li>* Footstar (Meldisco)</li> </ul>	<ul style="list-style-type: none"> <li>* the good guys!</li> <li>* Staples</li> <li>* Tandy (Radio Shack)</li> <li>* Tweeter etc.</li> <li>* CompUSA</li> <li>* Office Depot</li> </ul>	<ul style="list-style-type: none"> <li>* Borders Group</li> <li>* Warner Bros. Studio Stores</li> <li>* The Warehouse</li> <li>* World Co.</li> <li>* Zany Brainy</li> <li>* The Disney Store</li> </ul>	<ul style="list-style-type: none"> <li>* Sears</li> <li>* Tiffany &amp; Co.</li> <li>* QVC</li> <li>* Marks &amp; Spencer</li> <li>* Iceland Frozen Foods</li> <li>* HE Butt</li> <li>* Christmas Tree Shops</li> <li>* CVS</li> <li>* Ahold</li> </ul>

### About the Author

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Marshall Fisher is the Stephen J. Heyman Professor of Operations and Information Management at the Wharton School of the University of Pennsylvania and co-director of the Fishman-Davidson Center for Service and Operations Management.

In 1965 he earned an SB in electrical engineering from MIT and joined the Boston Manufacturing and Distribution Sales office of IBM where he worked until returning to MIT for an MBA and a PhD in operations research.

After teaching assignments at the University of Chicago and Cornell University, Dr. Fisher joined the faculty of the Wharton School in 1975. His pioneering research in logistics and supply chain coordination in the more than 21 years he has been at the Wharton School has been implemented by many companies and recognized by numerous awards.

In the late 1970's, Dr. Fisher began to address the problems faced by private truck fleet operators as they endeavored to deliver their products with increased efficiency and a high level of service. This research led to both theoretical breakthroughs and successful implementations at several

companies. In 1981, he co-founded Distribution Analysis, Research and Technology, Inc., a consulting company that provided optimization software and strategy consulting, based on this research, to major clients such as Frito Lay, Exxon and Anheuser Busch. He served as chairman of the board of directors of this company until 1990, at which point the company had grown to 35 people and was merged with Manugistics Inc.

In 1990, Dr. Fisher turned his attention to supply chain coordination, focusing particularly on environments with rapid introduction of new products and a high degree of demand uncertainty. With various co-workers he developed Accurate Response, an integrated framework linking operational changes and planning approaches to improve a firm's ability to match supply with the demand for new products. Accurate Response was initially implemented at Sport Obermeyer, a leading fashion skiwear firm which credits the approach with doubling profits and significantly improving customer service.

He is currently engaged in a multi-year study funded by the Sloan Foundation to investigate how retailers are exploiting information technology and flexible manufacturing to improve the merchandising of fashion products.

In 1994, Dr. Fisher was elected a member of the National Academy of Engineering. He also served as president of the Institute of Management Science during 1988-89 and as departmental editor of Management Science from 1979 to 1983. He is a recipient of the 1977 Lanchester prize for the best paper in operations research in that year, the 1983 Edelman Prize from the Institute of Management Science for development of a large-scale logistics planning model for a major industrial gas firm, the E. Grosvenor Plowman Award from the Council of Logistics Management for contributions to logistics, and the 1995 and 1996 Wharton School MBA Core Curriculum Cluster Award for teaching excellence. He has been a consultant to many companies, including Ahold, Air Products and Chemicals, Americold, BMG, Campbell Soup, DEC, Dupont, Edward Don, Exxon, Frito Lay, IBM, Lutron, Scott Paper and Spiegel, Inc.

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Ananth Raman, associate professor in the Technology and Operations Management area, has been on the HBS faculty since 1993. He has written a number of papers, book chapters, and case studies on supply chain management. He is currently a Director of the Harvard-Wharton Merchandising Effectiveness Project that involves over 30 leading retailers. Raman has taught a number of courses in Operations Management and Supply Chain Management to MBA students and executives. He has also consulted and taught at a number of companies.

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**Footnotes**

1. See G. Cachon and M. L. Fisher, "A case study of vendor managed inventory: Campbell Soup's continuous product replenishment program", 1995 and Campbell Soup Company: A Leader in Continuous Replenishment Innovations, Harvard Business School case study 9-195-124 and Barilla Spa (A), Harvard Business School Case study 9-694-046.
  2. See M. L. Fisher, 'What is the right supply chain for your product?', Harvard Business Review, March-April 1997.
  3. This application was conducted with Professor Kumar Rajaram of UCLA's Andersen School of Management. Additional details can be found in M. L. Fisher, K. Rajaram and A. Raman, "Accurate Replenishment of Retail Fashion Merchandise: Methodology and Application", Wharton School Operations and Information Management Department Working Paper.
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