Measure, *Then* Manage

Is the forecast really "always wrong"? Or is there a better way to go about this process?

At-a-Glance

- Sustained forecast bias creates tremendous inventory problems.
- Forecasts will never quite match actual data; rather than ignore forecasts completely, measure and then manage the forecast to improve the forecasting process.
- Statistical knowledge is needed to measure the forecasting process.
- Forecast measures should be meaningful, actionable, and robust.
- Reward (pay) forecasters and their managers based on forecast accuracy.

By Steve Kakouros, Dorothea Kuettner, and Brian Cargille

Everyone agrees that forecasting is broken, which gives rise to two questions: Can it be fixed? If so, how? The answers are yes it can—by measuring, and then managing. The case studies we'll examine here demonstrate that measuring forecast accuracy and making corrections are processes that offer great benefits.

Even newcomers to supply chain management are quick to understand the impact of demand forecasting. There is no shortage of supply chain horror stories about forecasts that turn out to be several times higher than actual demand and of the resulting tremendous costs (especially in high-tech businesses) of obtaining parts and capacity that were never used. Supply chain veterans also tell of promises made by proponents of so-called new forecasting techniques—perhaps new software or a new type of exponential smoothing—that are intended to fix the problem. Furthermore, promises made by proponents of state-of-the-art forecasting software packages often fail to match reality. Sadly, the solution to erroneous forecasting is rarely that simple, and sustained forecast improvements are even more elusive.

This situation has led to a popular piece of wisdom: "Demand forecasts are always wrong." It's true that pointing to the inevitable differences between forecasts and actuals can prove this axiom. But it is also misleading, because it blames the forecasting process rather than the inherent variability of specific markets. Consumer demand is variable; we certainly cannot treat forecasts as known information and base our operations on it without planning for deviations (forecast errors).

But that doesn't mean there is nothing we can do to improve our forecasts.

Consider this more useful piece of wisdom: "Measure, and then manage." What this means is that by correctly measuring the accuracy of our forecasts, we can make appropriate adjustments to the forecasts and forecasting process. Doing this not only improves asset utilization, but also moves economic value-added numbers and stock prices in the right direction.

To get the most out of our forecasts, we must first understand how the forecasting process fits into the overall picture. Forecasting plays a critical role as a key input in the demand planning process, as shown in Figure 1. We see here that the demand matching process includes two main cycles, forecasting and demand planning.

Within the forecasting process, forecast evaluation is critical to ensuring that the best possible information is provided to demand planning, and that this information contains a mechanism for feedback obtained from actual data over time.

In fact, forecast evaluation has a very specific place in the demand planning process. The forecasting process consists of two distinct cycles. One occurs on a strategic level, and the other on an operational level. On the strategic level, decisions include how to use the forecasts, which products or product groups will be forecasted, and which forecast methodology will be used to generate the forecasts. The operational level of forecasting consists of data gathering, forecast generation, and—in our process—the ongoing evaluation of the forecasts.

Let's look at the first of two case studies using our forecast measurement methodology.

Case study 1: Success with LaserJet printing

THE INTERNET IMAGING AND Printing Systems (iIPS) Connectivity business at Hewlett-Packard manufactures network cards that turn dedicated HP printers into networked, shared printers. In 1997, the iIPS division wanted to optimize the inventory in its regional depots. Although the division's efforts were quite successful, iIPS noticed something strange while testing the new techniques: Although the algorithms seemed to be recommending reasonable stocking targets, subsequent factory simulations predicted immense inventory levels.

It turned out the problem lay within the forecasting process itself, rather than the algorithm used. At iIPS, many forecasts were positively biased, meaning the forecast consistently predicted higher sales than actual. As a consequence, inventory grew in each period until Hewlett-Packard implemented the measurement system and changed organizational responsibilities.

With heightened sensitivity to the problem, the planners at iIPS realized that the forecasting process is like any other process: Left unmanaged and unchecked, it was likely to spiral out of control. After an investigation, the planners determined that their organization did not measure forecast accuracy or hold anyone accountable for the quality of the forecasts. Management focus was on meeting financial goals, not in generating accurate forecasts for individual products.

The planning organization decided to define a set of forecast metrics as the first step to measuring and managing the process. The principles it used were as follows:

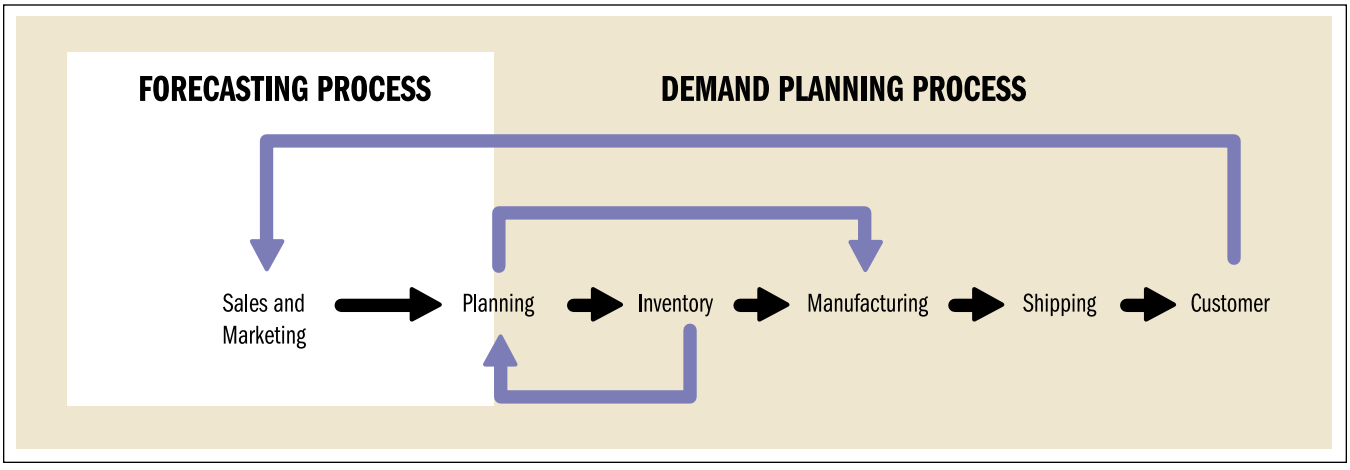
- Forecast metrics should be meaningful throughout the organization, in this case the iIPS forecasting and planning community.
- The metrics should be actionable, meaning users could take corrective actions to improve the forecast, based on the values of the metrics.
- The metrics should be robust, meaning they should perform well in a range of situations. In order to be robust, the measurement system should consist of a set of metrics, rather than one absolute measure.

Starting from these principles, the iIPS planning organization worked with its marketing colleagues and with HP's Strategic Planning and Modeling (SPaM) team to develop a forecast measurement system that could detect the source of the forecast error, quantify its magnitude, and indicate how to correct it.

What SPaM came up with was a set of four metrics, called the 4M system. The 4M system consists of the following metrics:

- **Percent error:** measures the percentage by which the forecast is off from actual values, rather than actual units as in a standard error chart.
- **Standard deviation of the percent error:** compares forecasted with actual values, measures the standard deviation of the errors, and indicates whether this deviation is within a certain acceptable limit.

Figure 1: **Demand planning process**



- **Error control:** determines whether errors fall within defined allowable limits based on past performance.
- **Bias indicator:** indicates whether there is a consistent positive or negative bias.

In the case of iIPS, the problem lay in biased forecasts. This forecast bias turned out to be a symptom of a larger problem, namely, that the forecasting and the supply chain processes were owned by two different HP organizations—marketing and planning. These organizations were measured and rewarded using different performance criteria.

The marketing organization owned the forecast. Marketing was measured on product availability, which was defined by the percentage of the time that a network card was available for purchase by a customer. However, the marketing organization was not penalized for any excess inventory that might develop as a result of production's reliance on marketing's forecasts. Although those forecasts were based on market conditions, they were at the same time heavily influenced by quota and revenue expectations. Because of this, the marketing group consistently generated forecasts with optimistic numbers to ensure the product availability that would enable it to meet its revenue targets.

On the other hand, the planning group was measured both on product availability and excess inventory. The group used statistical methods to buffer against uncertainties and were highly motivated to keep the forecasts accurate and unbiased.

Using the forecast metrics just described, the planning team was able to demonstrate the need for changes in the forecasting process. The team led a series of monthly meetings with the marketing team and management to monitor forecast accuracy.

A clear bias emerged when monthly forecast periods were examined. For each period, the bias measurement is one of three possibilities: higher than actual, exactly matches actual (a rare occurrence), and lower than actual. If data points are consistently higher or lower than actual, particularly over several consecutive months, a forecast is biased.

A forecast that is positively biased results in another problem: inventory excess that worsens over time. This was the cause of the immense inventory levels shown by the factory simulations described earlier.

After three of these meetings, the marketing manager agreed to let the planning team take over the forecasting process. Since that time, the planning group has eliminated bias from its forecasts, resulting in a 20 to 30 percent reduction of inventory while still maintaining high levels of product availability. The results of the iIPS Connectivity group continuing to apply these techniques are shown in Figure 2.

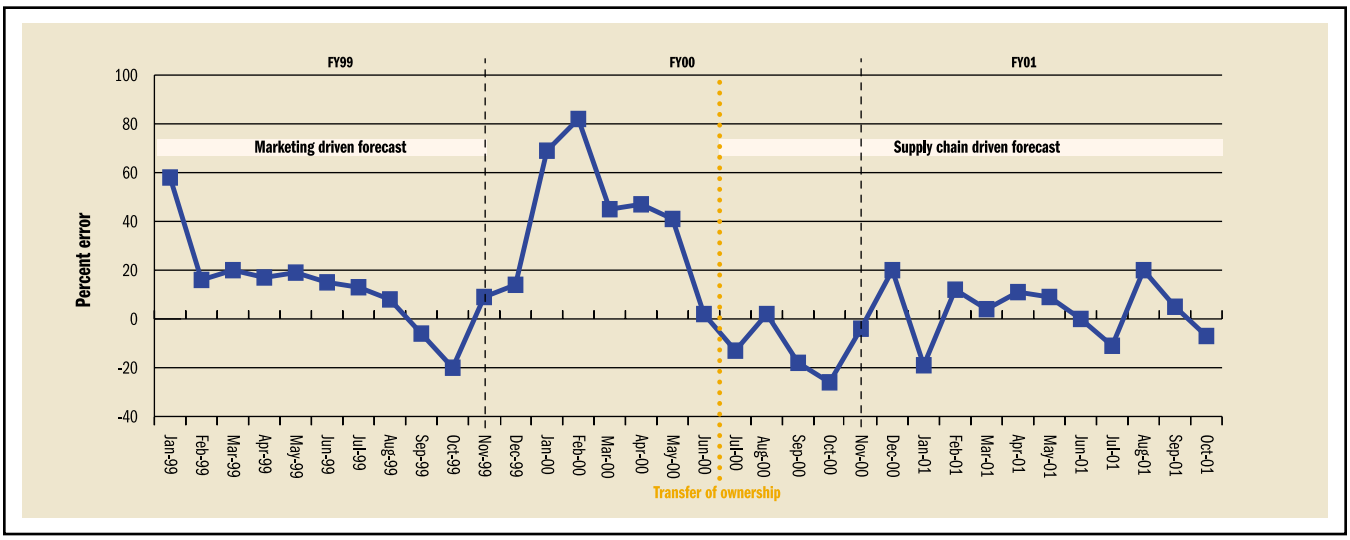
Figure 2 shows the results both before and after the planning group took over the forecasting process and began using the forecasting metrics. It also demonstrates both the direction and magnitude of forecast error over a three-year period for a sample product. The y, or vertical, axis measures the percent of forecast error. The X, or horizontal, axis is zero—where forecast matches actual orders. An unbiased forecast should show approximately equal distributions above and below the X axis over time. Figure 2 shows a clear improvement in the middle of fiscal year 2000, which is when the transition from marketing to planning took place.

Currently, the iIPS Connectivity team is within +/- 10 percent of its goals for forecast accuracy. Its measurement tools and processes enable the organization to monitor forecasts more frequently, and thus respond more quickly to changes in the market.

Case study 2: The 4M process applied to storage products

AFTER THE INITIAL IIPS pilot, these forecast measurement techniques were extended to HP's storage business, where management had identified forecast inaccuracy as the number

Figure 2: **Actual orders as a percentage of 3 month ahead forecasts**



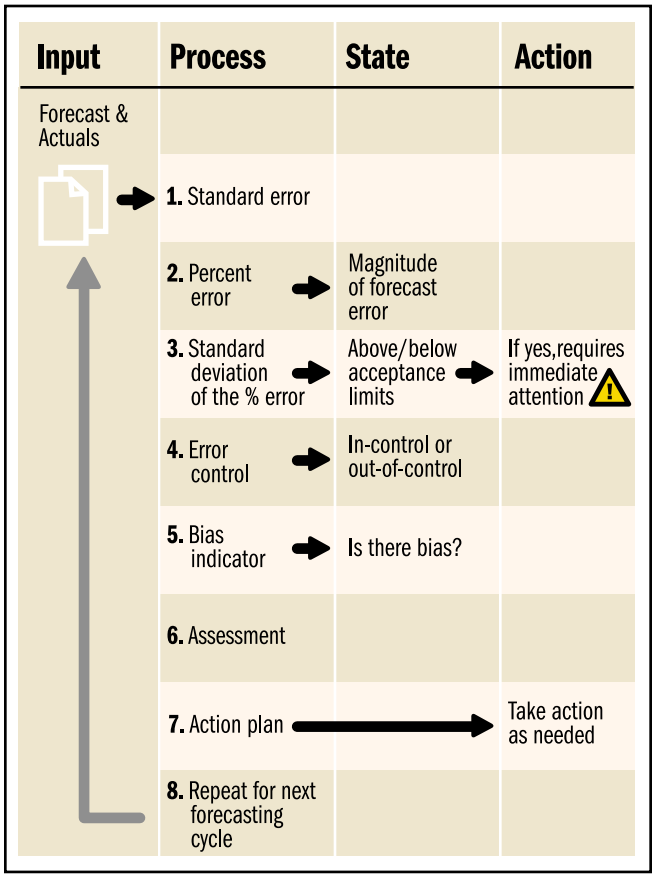
one driver of its growing inventory problem. Management wanted improvement, as well as a process for more effective communication between marketing and supply chain management.

Based on the first solution, the SPaM team generated a more robust process (see Figure 3), designed for a bigger organization with many users. In this process, the four metrics are combined with a process that enables the user (in this case, the forecaster) to quickly spot severely out-of-control conditions that require immediate action and to distinguish them from other conditions that can be addressed more gradually.

Distinguishing between serious and mild forms of forecast error is important. Some forecast correction methods overemphasize the "noise" caused by a certain inevitable amount of variability in actual sales. That, combined with a short-term historical view, can lead to chasing one's own tail where the revised forecast over-corrects for the errors from the previous month. Although demand fluctuations are unavoidable, they can be adjusted for by using statistical methods and by using data over an appropriate time frame.

As shown in Figure 3, the 4M metrics are applied in order, starting from the simplest and moving to the more complex. Each metric measures a particular aspect of forecast accuracy. The overall state of the forecast is determined using the combined input of each of the metrics.

Figure 3: **4M forecast evaluation process**



The steps in 4M are as follows:

1. Compare last period's forecast with last period's actual demand to generate a standard error chart.
2. Convert the standard error chart into a percent error chart. This gives a better picture of the magnitude of the error.
3. Calculate the standard deviation for the percent error chart. If this is outside acceptance limits, immediate attention is required.
4. Use the standard error chart to calculate the error control.
5. Calculate bias indicator chart, also using standard error.
6. Use the results of Step 2, Step 3, Step 4, and Step 5 to determine the overall state of the forecast.
7. Assess the forecast to identify areas of greatest concern.
8. Based on the state of the forecast, formulate an appropriate plan for taking corrective action, if needed.
9. Repeat this process in the following cycle.

Corrective actions are taken based on the state of the forecast. Although the states themselves are fairly unequivocal, there is a fair amount of subjectivity in areas such as when and whether to act upon them, and also in the setting of certain practical limits used within the metrics themselves.

The evaluation process is performed every forecasting cycle. A forecasting period can be of any length—monthly, weekly, or even daily—with more frequent periods being useful for generating the historical data points that are necessary for the correct use of these metrics.

In our first example (iIPS case) it was the forecast bias that was out of control, while the forecast variability was within acceptance limits. The solution was to examine the forecasting process and determine the root cause of the sustained forecast bias. By changing ownership for the forecasting process, the bias was eliminated.

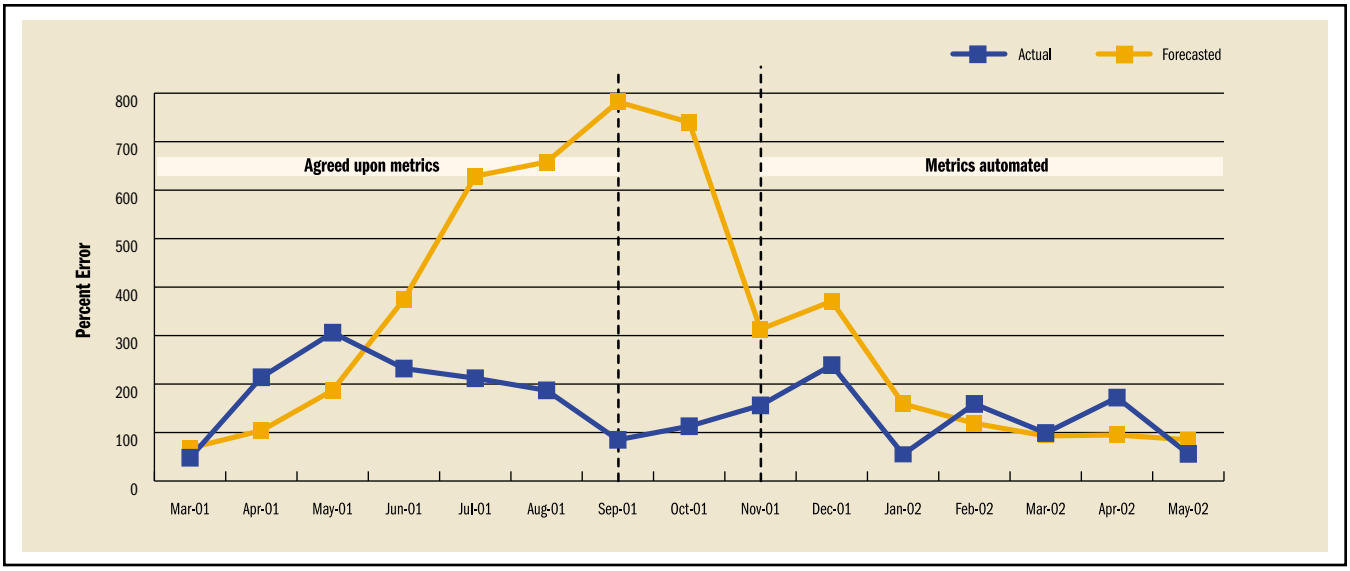
In the case of HP's storage business, not only was the bias out of control but also variability was sometimes outside the acceptance limits. In this case, improvement was realized without changing the ownership for the forecasting process. Creating measures with the marketing team, implementing the measures, and holding the marketing organization accountable—especially the most senior marketing managers—was the solution.

As can be seen in Figure 4, forecast bias was dramatically reduced, coinciding with the introduction of the new forecast measurement techniques. Continued performance is expected at this new level, and forecast bias should no longer be a problem for this business.

Key factors for successful use

CHOOSING THE RIGHT FORECAST metrics is only the start. In order to realize the benefits of more accurate, usable forecasts, a business must be prepared to implement the processes that best support forecast improvement. Following are some guidelines.

Figure 4: **World-wide actual versus forecast for HP storage product**



Prepare. Ensure that your organization is ready for, and aware of, the benefits to be gained from improved forecasting and forecast measurement. The bottom line is that the only way to get lasting results is to link the metrics to people's compensation. Therefore, you may need to institute new performance criteria to reflect new priorities. You will need firm commitment from opinion leaders and managers in the marketing, planning, and supply chain teams.

Define. Carefully consider what is being forecasted and where your forecast and actual data will come from.

- Clarify ambiguity regarding what is forecasted and what will be measured: Orders? Shipments? Revenue? Products? Bundles? Focus on improving forecasts that will improve asset management. For example, improving revenue forecasts may have very little effect on asset management, whereas improving forecasts of products ordered could have a huge effect. This is especially important if the forecasting process is spread across different teams.
- Define what forecast and actual data will be gathered. Compare forecasts created at key component lead time (the forecast used for purchasing decisions) vs. actual orders by requested shipment or build date.

Model. Build a model of the proposed metrics using historical data. Test and fine-tune the metrics. Involve both management and individual contributors who are opinion leaders.

- Use the model to demonstrate the benefit of the new metrics versus the existing ones (if any), using what-if scenarios drawn from historical events.
- Document the metrics and capture information linkages that provide the model with data (i.e., forecasts at key component lead time come from database X). These will be useful when integrating the metrics into the enterprise application systems.
- Get management commitment to proceed with the next stage and secure IT resources for piloting and implementing the measurement system.

Pilot. Custom development or links to a specialized software program may be required. Start with one product group or division to test and fine tune the new measurement system. Statistical measurement methods can be tedious and current advanced planning and optimization software often does not support this type of forecast measurement methodology.

Automate. After successfully piloting the new system, roll it out to the entire organization, continue to monitor the processes over time, and measure and document your success.

Lower inventory costs and increased responsiveness

SUPPLY CHAIN MANAGERS AND product planners don't have to accept poor forecasts as a limitation. Using straightforward techniques, they can measure forecast accuracy and begin managing their forecasting process more effectively. This can enable them to contain inventory costs and increase responsiveness to customer demand.

The effort required may seem daunting, but it can pay off quickly.

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