WHITE PAPER

KINAXIS™

DEMAND PLANNING

HOW TO REDUCE THE RISK AND IMPACT OF INACCURATE DEMAND FORECASTS

SUPPLY CHAIN EXPERT SERIES

EXECUTIVE SUMMARY

Forecasts are typically a key input to your demand and supply chain operations processes. Unless the total time it takes to source, make and deliver your product is less than the time your customer is willing to wait for delivery, you will need a forecast. Actually, you will need two types of forecast: a demand forecast to help manage your operations, and a supply forecast to send to your suppliers to prepare them to respond to your requirements.

The supply forecast is a direct result of the demand forecast, so while this white paper will focus on the demand forecast, the principles discussed are equally applicable to managing supply forecasts.

As a general rule, forecasts are always inaccurate. This paper discusses two approaches which can be used to reduce the risk and impact of inaccurate forecasts:

1. Collaboration between customers and suppliers to improve the accuracy of the forecast

2. Quicker response to demand changes to reduce the impact and cost of forecast error

By improving your demand management and forecasting processes, your organization can improve customer service (by being more responsive) as well as operations performance (through better alignment of supply with demand).

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UNDERSTANDING FORECAST ERRORS AND DEMAND VARIABILITY

It is obvious why you would want an accurate forecast: If you can predict your requirements and subsequently pass that forecast to your suppliers, then you are much more likely to get what you need, when you need it.

However, demand forecasts are notoriously inaccurate. As summarized in the diagram below, from a 2005 AMR Research study[1], forecast errors in the range of 11% to 28% are typical. Since this time, product portfolios have grown, globalization has become the norm and demand volatility has increased substantially.

Forecast accuracy (AMR Benchmark Analytix data)

Forecast Error (MAPE) with One-Month Lag		
Industry	**Range**	**Median**
Bulk Chemical	24% to 10%	11%
Consumer Goods	40% to 14%	26%
High-Tech	45% to 4%	28%

Source: AMR Research, 2005

1. Lora Cecere, Eric Newmark, and Debra Hofman, "How Do I Know That I Have a Good Forecast?" AMR Research Report, January 2005, page 9.

The forecaster's dream is to develop a process that predicts the exact demand that will be received in every future period. With so many factors influencing actual demand, an exact forecast will remain just that – a dream. So it can be helpful to think of your actual demand as a combination of both a predictable portion and a random portion. Your hope is that by considering all the "right" factors in your forecasting process, the portion of your demand that is random disappears, thus greatly minimizing the risk of forecast error.

In the end, the acid test of forecast error is whether you run out of inventory or not. If your demand is very predictable, you could carry very little extra inventory and you would never have a shortage. However, as per the AMR study, demand always has an unpredictable element to it. Inventory can be used to buffer against the unpredictable demand and there are numerous costs which can be avoided by carrying just the right quantity of inventory for every part you sell.

FORECAST ERROR AND INVENTORY

The underlying mathematics of forecast error depends upon the exact nature of the demand you are forecasting. The simplest case is to treat demand in a period as a random process with an average value. Basically, your forecast represents that average or "expected" quantity of demand in that period.

The Challenge:

Your challenge is to provide a quantity of supply to satisfy your demand in a given period. Think of your supply strategy as a combination of:

- "cycle stock" (supply for the expected demand in the current period) and
- "buffer stock" (additional supply to cover the statistical variability in your demand).

If you only supply cycle stock, then half the time you will have a shortage and half the time you will have too much inventory (because you are only supplying to the average value).

Statistics can be used to calculate the probability of having enough inventory as a function of the supply provided and the variability (standard deviation) associated with your demand. The chart below illustrates this relationship.

"Cumulative" line (which shows the likelihood of having enough supply to cover all your demand in a given period) is a function of the supply quantity above or below your expected demand. The supply quantity is measured as a function of the buffer stock you carry and is expressed in terms of the expected variability (standard deviation) in your demand.

As noted in the diagram, you have a 50/50 chance of satisfying your demand if you supply to the forecast, and an 84% probability of satisfying all your actual demand if you have enough supply for the period to cover the forecast plus one standard deviation. If you have enough supply to cover the forecast plus three standard deviations, you will have enough supply to cover all your demand more than 99% of the time.

The Bottom Line:

A better forecast means less error and that predicts a smaller standard deviation, which in turn means you need to provide less buffer inventory.

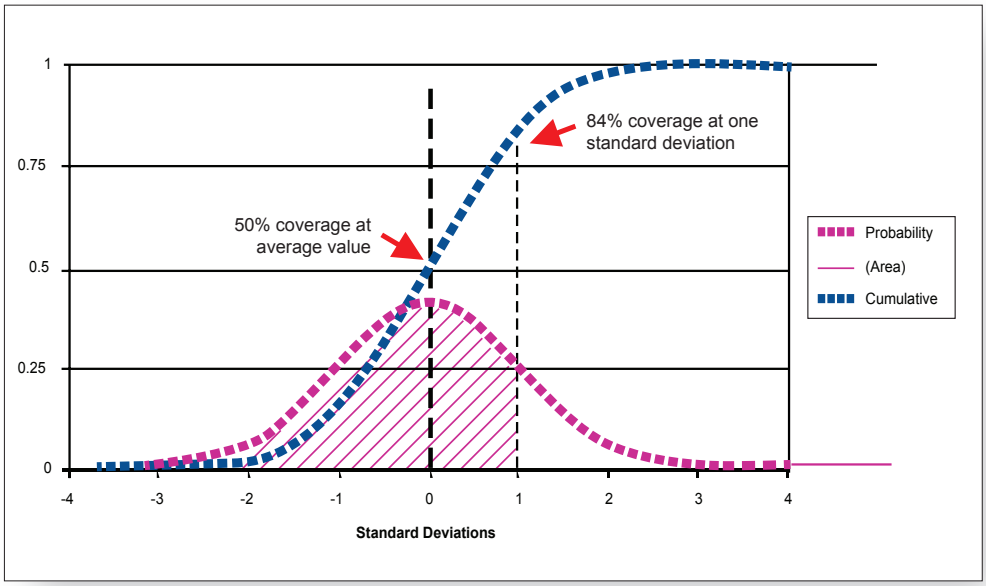
Forecast error is almost always an indicator of demand variability, when referring to actual demand versus the statistical forecast. As mentioned, the *statistical forecast* is almost always either an average or trend, and demand variation results in actuals that are different than the projected trend.

However, if you are referring to the difference between the actual and the *consensus forecast*, then the forecast error could be unrelated to demand variation (for example, my consensus forecast predicted a lower sales number this month but it turned out to be the same as last month).

Regardless, the bottom line is that by improving your forecast, you can obtain better coverage (customer service level) with the same inventory, or you can hold less inventory to achieve the same coverage.

That leads to the big question: "How can I improve my forecast accuracy?"

Normal Distribution



A FEW WORDS ABOUT MEASURING SERVICE LEVEL

There can be a lot of confusion over what is meant by the term “service level”:

• The most pessimistic measure is the ratio of:

$$\frac{\text{the \# of periods in which you satisfy ALL your demand}}{\text{the total \# of periods}} = \text{coverage}$$

• The most optimistic measure is the ratio of:

$$\frac{\text{the demand you satisfy in a period}}{\text{total demand in the period}} = \text{service ratio}$$

In each period, if your supply balance carry-over plus new supply equals your forecast demand, you will achieve 50% coverage based on the criteria of completely satisfying ALL the demand in a period. However, you will be able to satisfy a much higher percentage of your TOTAL demand resulting in a more favorable service ratio compared to coverage ratio.

To illustrate,
- assume your forecast demand is 100 units per period,
- your demand has a standard deviation of 10 units (10% standard deviation), and
- your total supply for the period is 100 units.

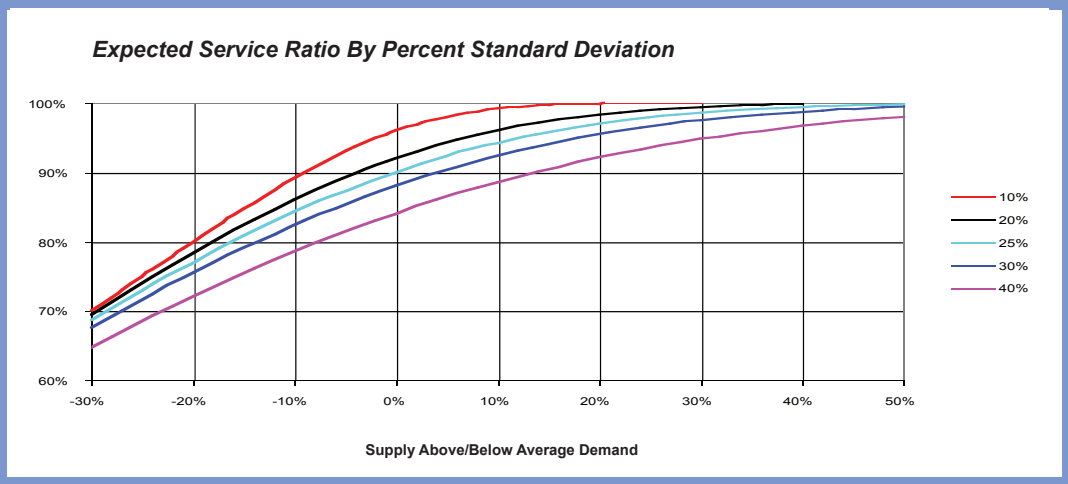
On average you will be able to satisfy about 96% of your demand (service ratio) in the period it was requested. (Remember, your coverage for the period is 50% because you are supplying to your expected demand quantity).

Now, let’s look at the two measurements when we provide supply above the expected or average demand quantity.

A buffer stock of one standard deviation (10 units in this example, meaning a total inventory available for the period of 110 units) will result in satisfying ALL your demand (coverage) in only 84% of the periods, but also means that you can satisfy an average of 99.2% of the TOTAL demand (service ratio) in each period.

Regardless of which service level measurement you use, the buffer stock you need to carry to provide a target service level depends on the standard deviation in your demand.

The diagram below shows the service ratio you would expect if you supply to a percentage of your average demand, as a function of the standard deviation in your demand. From the diagram, if your demand has a percent standard deviation of 20%, and you provide inventory of 10% above your forecast, you should expect a service ratio of approximately 96%.



IMPROVING FORECAST ACCURACY

A lot of mathematical research has been done to generate forecasts from historical demand. The assumption is that past results are a reliable predictor of the future. As world economic events continue to unfold, it is quite clear that historical demand is, at best, just one possible indicator of future demand. Therefore, in today's environment, "statistical forecasts" should be seen as just one input to the demand planning process.

In addition to using mathematics to generate a better forecast from historical data, another approach to improve forecast accuracy is collaboration. The definition of "collaboration" in Wikipedia[2] presents a strong motivation to collaborate:

> **Collaboration** is a recursive process where two or more people or organizations work together toward an intersection of common goals ... by sharing knowledge, learning and building consensus. Collaboration does not require leadership and can sometimes bring better results through decentralization and egalitarianism. In particular, teams that work collaboratively can obtain greater resources, recognition and reward when facing competition for finite resources.

If your customer is not the end user of the product, then your customer orders aren't the actual demand. Your shipments to your customer can differ from the real customer demand.

The APICS Dictionary, 12th edition[3], clearly states the purpose for collaborative forecasting:

> **Collaborative forecasting:** The process for collecting and reconciling information from within and outside the organization to come up with a single projection of demand.

A collaborative process is well-suited to creating a demand forecast that considers multiple, and sometimes competing factors such as:

- Historical demand, including trends, similar products, and seasonality
- Macro and micro economic trends
- Promotions and advertising
- New product introductions and competitor activity
- Unique insight and judgment of demand and supply chain planning participants

Typical inputs to the forecasting process include:

- Current forecasts from sales personnel, whether at the level of individual Stock Keeping Units (SKUs) or as product families. If the latter, then you also need models for disaggregating family forecasts into corresponding forecasts at the SKU level.
- Current forecasts from customers and distributors
- Actual demand history. You want to use historical data to predict future demand. Therefore, you want to be sure it is as "close" to the actual demand as possible. If your customer is not the end user of the product, then your customer orders aren't the actual demand. Note that your shipments to your customer can differ from the real customer demand.

2. Wikipedia, "collaboration": http://en.wikipedia.org/wiki/Collaboration/
3. APICS Dictionary, 12th edition, http://www.apics.org/Resources/APICSDictionary.htm

Also consider that if your customer distributes your product to the end user, the orders placed on you by your customer are not really the actual demand – it has been modified by the distributor due to inventory, shortages, policies and promotions. Your demand data will be more accurate if it comes from real point-of-sale data rather than your distributor's orders.

Recent actual demand data is also extremely useful in monitoring whether current sales are actually tracking to your forecast, regardless of the process you used to create that forecast.

- Marketing forecasts and economic trends. Your marketing department can predict overall market changes and can also predict demand transitions from one product to another.

A collaborative forecasting process will provide participants with data, such as that listed above, and through iteration and discussion will create forecasts for each part that you sell.

Companies using a collaborative forecasting process typically capture and analyze the various inputs in Microsoft Excel. However, Excel is not an efficient tool for collecting and handling large quantities of data. It was not designed for sharing data among numerous participants; nor for tracking their individual inputs to the process. The lack of an efficient, collaborative tool forces people to make many compromises in their process. For example they will:

- Run the process infrequently (once per month at best, often once per quarter)
- Bucket data by large time buckets (monthly forecast and monthly actual sales)
- Summarize data by product family or other superset of parts
- Determine forecasts for individual SKUs through disaggregation models from the level where the forecast is actually created

A process which did not suffer from the above compromises would clearly be an improvement. The process that is best for an organization is the one that results in the most accurate forecast with the least amount of effort to create and maintain it.

As such, a tool to support the improved process should offer the following capabilities:

Data collection

- Automated data collection from ERP and other systems
- Ad hoc import of data from Excel and other data sources
- Direct entry of data by authorized participants

Access

- Direct access to a single, unified database for all participants in the process
- This includes providing permission-based direct access for key external participants

Visibility and analysis

- Aggregation of data to family or other levels rather than capturing data at these aggregated levels
- Comparison of data at any level, whether aggregated or not
- Tracking of unlimited data sets (scenarios) to provide comparative views of alternative sets of input data and assumptions
- Automatic "bucketing" of data for reporting and human review and analysis (while retaining data using its original date and SKU resolution.)
- Instantaneous visibility to any data

EXTERNAL COLLABORATION

True collaboration with customers or suppliers requires a very close relationship between the participants. It takes time to develop the level of trust and supporting technology to make collaboration work. Therefore, as discussed by Cohen and Roussel in their book: "Strategic Supply Chain Management"[4], you should start by collaborating with your key customers (or suppliers). Once you have those relationships and processes working, expand to a few more. However, unless your customer base is very small, don't expect that you will ever achieve a high level of collaboration with all your customers.

Which customers represent the bulk of your business? Which customers exhibit the largest or most frequent changes in demand? Which customers provide you with the most profit? *These* are the customers you should collaborate with – assuming they are willing to participate.

There are several models of collaboration with customers and suppliers. The more common types of collaboration are:

- Purchase Orders. This is really not a collaborative model at all. The customer places purchase orders and the supplier delivers the product, usually on or after a standard lead-time for that item. The supplier often creates its own forecast in order to deliver inside its cumulative lead-time for that product.
- Periodic Forecast. Forecast data is sent to the supplier from the customer. There is neither explicit discussion nor negotiation about the forecast. The actual mechanics of the transfer can range from an automated transmission to sending emails with an Excel attachment, or even just a phone conversation. The data sent usually covers the forecast for a set of inventory parts for a specified number of time buckets. Typically, new forecasts are sent on a monthly basis, but weekly and quarterly updates are also common. The forecast is often presented in monthly or weekly buckets. In some high-volume relationships, the forecast can even be presented in daily buckets.
- Vendor (supplier) Managed Inventory (VMI). The focus is actual consumption data which is sent to the supplier and the supplier is responsible for replenishment. Forecast data (projected consumption) might also be sent to the supplier. However, the supplier has ultimate responsibility for replenishing against actual consumption and therefore has ultimate responsibility for managing the forecast.
- Forecast Acceptance and Negotiation. As in the Periodic Forecast model, forecast data is periodically sent to the supplier. However, the supplier has an opportunity to respond with the quantity and timing of the material it commits to deliver. There is often some negotiation between the supplier and the customer as to which product(s) should consume whatever scarce resources are limiting the supplier from delivering the requested quantity. In some situations, the supplier may also negotiate to deliver more than the requested quantity. This detailed collaboration can be facilitated with tools to analyze projected inventory levels, availability and consumption of the scarce resources, and the impact of pending inventory decisions.

The collaboration model which works best for each particular customer-supplier relationship depends upon the volume and volatility in demand and supply. If the customer is able to generate a reliable forecast of its demand (remember, the "customer" in this discussion could be your customer, or it could be you collaborating with your supplier) and if the volume and volatility justify the associated investment,

4. Shoshanah Cohen and Joseph Roussel, PRTM Supply Chain Innovation practice. "Strategic Supply Chain Management" McGraw-Hill, 2004. http://www.prtm.com/books/supplychain/

then the forecast acceptance and negotiation model may be appropriate. However, if the customer is not able to produce a reliable forecast, then the VMI model can be very effective. If the customer's volume or demand volatility is low, any value in collaboration (beyond purchase orders) does not justify the cost of setting up a collaborative environment.

As technology improves, it is likely that the cost of setting up a collaborative environment will diminish so, in the future, it may become practical to add collaboration to more of your customer-supplier relationships.

The next question you need to answer is "How frequently should I update my forecast?"

FORECAST MORE, REACT FASTER

It seems logical that if you could get closer to actual demand, update forecasts more frequently and instantaneously alter supply plans, the quality of your forecast would improve and the impact of inaccuracies would diminish.

Back to statistics

If your forecast error in any period is independent of the error in any other period, then statistics shows the standard deviation over several (M) periods depends upon the number of periods:

Standard deviation over M periods = $\sqrt{M}$ * (standard deviation in one period)

Thus, assuming daily demand, the standard deviation increases with the square root of the number of days in your sample period (M). The demand variability that you need to cover with buffer supply is really the variability over your measurement cycle plus your replenishment time. So, if you reflect back to the discussion about "coverage", **you could carry half as much buffer stock to cover demand variation if you detect and replenish in response to differences between projected and actual demand on a weekly rather than monthly basis! And that could decrease to 20% if you could convert your monthly forecast review and replenishment cycle to a daily process.**

The chart below summarizes the quantity of buffer stock you would need for the same service level depending upon the number of days in your forecast and replenishment cycle. The chart compares the buffer stock required for 84% coverage or 96% service ratio. That is, it assumes that the standard deviation in daily demand is 10% of the average demand.

	Daily	Weekly	Monthly
Days in Cycle	**1**	**5**	**22**
Buffer Stock, as % of average daily demand, required for same service level 10% (assuming standard deviation for 1 day)	10%	22.4%	46.9%

Let us look again at the previous Expected Service Ratio chart.

If you provide supply equal to your forecast demand (buffer is zero), and if you are able to reduce your forecast standard deviation from 40% to 20% (such as by changing your forecast review and replenishment cycle from monthly to weekly), you can improve your service ratio from 84.1% to 92.0%.

Conversely, if you target a service ratio of 99%, you could reduce your required buffer stock from 64% of your average daily demand (corresponding to a 40% standard deviation in monthly buckets) to 12.5% of your average daily demand (corresponding to a 20% standard deviation in weekly buckets).

What is an inventory reduction of 50% worth to your organization?

What is an inventory reduction of 51.5% (64.0 – 12.5) of your average daily demand worth to your organization?

This makes shortening your forecast review and replenishment cycle an attractive notion. But how can you complete a forecasting cycle more than once a month?

In most companies, the forecasting process takes a month to complete because it is based on manual collection and analysis of data, using Excel. There are even cases where a "monthly" forecast cycles takes as much as six weeks!

Think what you could do if you had automated processes to collect the data and could immediately consolidate and review it. The next table compares typical ("before") and target ("after") forecast cycle times that the authors of this paper have seen in companies that are attacking their demand planning and forecasting process.

Activity	Typical	Target
	Days	
Collecting Forecast (Customers, Marketing, Sales, etc.)	10	2
Consolidation	2	0
Comparison & Analysis	5	2
Rationalization & Review	5	1
Total	**22**	**5**

Key considerations for improving forecast cycle times:

- Note that it is not necessary to improve the cycle time for all your customers. The key is to **focus on the source of most variability in your demand** which is the main cause of your forecast error. If the unit error from a particular customer is small, then the buffer stock you carry for that customer is also small. Customers with large unit errors in their forecast are the ones that force you to carry more buffer stock – these are the ones that you should work with to improve accuracy (collaboration) and to reduce cycle time (frequent updates).

- Look at the 'Typical Days' column in the previous table. In this example, almost half the cycle time is used for collecting the forecasts. Your processes might well be different. The point is to **focus on the activity that takes the most time.** Improve your processes in that area first. Think how a "future state" process for that activity might work.
- **Run processes in parallel** if possible, and **eliminate the activity completely if it does not add value!**
- **Look for changes in processes and technology** that would eliminate the most time from your forecast and response cycle.

To reiterate the technology drivers mentioned previously, your forecasting process would be accelerated by processes using a technology which provides:

- Faster, simpler data collection
- Direct access to a unified data base, for all participants in the process
- Tracking of unlimited data sets (scenarios)
- Aggregation and disaggregation of data across families and date buckets
- Instantaneous visibility to any data

In the end, a dramatic reduction in your forecast review and replenishment cycle time will make you a more responsive, more demand-driven, organization. That will allow you to reduce your inventory levels while improving your customer service. Certainly, these are worthwhile goals!

Additional Resources and Reading

- Richard B Chase, Nicholas J. Aquilano. "Production and Operations Management" Irwin Professional Publishing, January 1989. http://www.amazon.ca/Production-Operations-Management-Richard-Chase/dp/0256069204

- David L. Anderson, Frank F. Britt, and Donavon J. Favre. "The 7 Principles of Supply Chain Management" Supply Chain Management Review, 4/1/2007. Download from: http://www.scmr.com/article/CA6432096html?q=7+principles/

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