Getting Things Done

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New graphic and analytic techniques improve understanding of an old management problem

While new manufacturing and production systems like JIT and MRP have begun to revolutionize factories, age-old problems of inventory management persist. The author of this article, who draws on his practical experience dealing with finished goods inventories, describes several simple techniques to help understand inventory performance and to suggest where it can be improved. When "snapshots" of current inventory are added to "moving pictures" of past performance and combined with some straightforward calculations, managers will get a much sharper picture of inventory problems.

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Inventories constitute the second largest asset category of all U.S. manufacturing corporations, exceeded only by plant and equipment and followed by receivables. Although inventories account for such a large portion of corporate assets and a great deal of research has been done on production and inventory control, improvements in inventory productivity and performance have been less than spectacular for most companies. Consider the following:

☐ As reported in the *Economic Report of the President*, for a long time the ratio of nonfarm inventories to final sales in constant dollars has changed little. This ratio was 2.64 in 1954, 2.61 in 1964, 3.11 in 1974, and 2.69 in 1984.

☐ A constant flow of success stories and descriptions of various inventory and production operations systems used in companies has appeared in the management literature. Studies show, however, that most companies that have installed these techniques have not achieved the results they expected. For example, International Data Systems estimates that only 25% of materials requirements planning systems (MRP) have achieved installation objectives.[1]

☐ Mathematical techniques for inventory control have become so esoteric and complex that some are either unusable or can be easily misused. According to a recent article in *Interfaces*, research into an exponential smoothing formula used in a personal computer forecasting package that had been proven incorrect turned up 23 instances of formula errors in books and articles on forecasting going back to 1965.[2]

Despite all the efforts and resources people have devoted to inventory management and forecasting tools over the years, for most companies—and for the economy in general—progress in this area has not occurred.

This article is addressed to managers who are dissatisfied or uneasy about inventory performance and are looking for ways to improve it. The techniques described here are straightforward and logical. They are not mathematically complex. They are designed to provide insight into inventory and product performance in ways that allow comparisons between and among inventory segments, measurement of profit contribution, and identification of exceptions.

These techniques apply primarily to the management of finished goods inventory in a make-to-stock manufacturing environment where order backlogs exist. I focus on finished goods inventory because it contains the products customers buy. With improved forecasting and management of finished goods, traditional systems like MRP can be employed to improve the management of work-in-process (WIP) and raw materials inventory.

I do not ask questions about whether products should be made to stock or to order; whether inventory should be held as finished goods, WIP, or raw materials; or where inventory should be managed. Answers to these questions depend on many conditions that are company and industry specific. Likewise, each organization has logical places where inventory can be managed. The important first step is to identify and assign accountability to a specific individual or group.

While the tools presented here are based on these limitations, in

Editor's note: All references are listed at the end of the article.

many cases they can be adapted to other inventories and other environments.

Inventory balance

Managers must make tradeoffs between customer service and inventories. A study published by the National Council of Physical Distribution Management, *Customer Service: Meaning and Measurement,* identified inventory availability as the single most important element in the mix of customer service elements.[3]

Inventory availability translates into inventory investment. The rule of thumb holds that if a company wants to improve customer service or inventory availability, it must raise its inventory investment.

This rule is commonly represented graphically, as *Exhibit I* illustrates, by moving from point A to point B on the curve. But this exhibit depicts an ideal situation. The points on the curve represent perfect inventory balance: the right inventory mix to provide the correct availability for a desired level of customer service.

In reality, most companies operate somewhere inside the curve, such as at point C. Here the inventory is out of balance: too much inventory exists for some items and not enough for others. While the total inventory investment should provide the desired service level, it does not.

The further point C lies inside the curve, the greater the imbalance and hence the potential for improvement through inventory management. To improve its inventory balance, a company has three choices. It can reduce inventory investment while maintaining service levels; it can improve service without increasing inventory investment; or it can improve service while reducing investment.

If the composition of the inventory can be adjusted so that more of it fulfills current needs, then it will turn over faster, customer service will be better, inefficiency costs will be lower, and the inventory investment can be lower. These are clearly desirable outcomes.

Unfortunately, in too many companies, a lack of good information on the details may hide the realization that inventory is out of balance. Companies normally act in one of two ways: management gives general orders to improve the balance and six months later, after much planning, sweat, pain, and frustration, point C has moved only slightly from its previous position (the imbalance is the same, it has only been rearranged); or nothing happens.

Snapshots & moving pictures

One of the clearest and most direct ways to increase visibility and improve the performance of inventories is through the use of graphics that highlight balance and performance. As the old adage has it, "A picture is worth a thousand words."

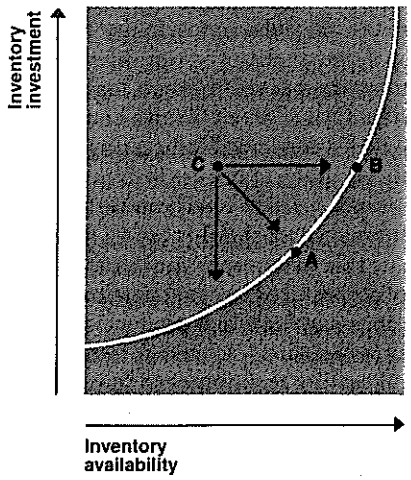
Traditional inventory performance measures include inventory levels measured in units and dollars, turnover rates, and, on occasion, service levels achieved. But two other measures are important to the operation of the business and the satisfaction of customer needs: the fill rate (percent fill) and the utilization rate (percent utilization) of the inventory to meet the current needs of the business.

As the buffer between production and customer demand, inventory must satisfy current demand. To have good inventory balance (and move closer to the ideal balance on the curve), a company's inventories must fill current demands effectively and be used efficiently.

In the following analysis, I discuss two types of inventory graphs, "snapshots" and "moving pictures." (The information used to create these graphs is generally available from computerized inventory and order reporting systems and can be analyzed and graphed by machine or by hand.)

A snapshot shows what the inventory looks like at a certain point in terms of its ability to satisfy current demand (percent fill) and how well it is being used (percent utilization)—see *Exhibit II.* The moving picture shows the same attributes over time, expressed in stock or sales units (since companies sell and ship units, not dollars). The moving picture highlights trends and historical relationships and may suggest questions managers can ask to help them better understand their situations and make good decisions about inventory plans and policies.

Exhibit I **The inventory balance**



Fill and utilization rates are subjective assessments that each company must determine based on its own particular needs. In the example shown in *Exhibit III,* management decided to set the target fill rate in the range of 60% to 80% and the target utilization rate at 40% to 60% for each product line. The reason for this is that current demand included demand to be shipped over the next several weeks. Since the total current demand was not being shipped immediately, the fill rate could be less than 100%, assuming that production could meet requirements before the expected shipment date. The utilization rates are lower because the company also had a short customer lead time with immediate demand that the order backlog did not reflect. The lower utilization percentages indicate that inventory was available as safety stock or a buffer.

Managers must always evaluate inventory with regard to current demand. They must always satisfy this demand to meet customer requirements, to keep them happy, and to generate repeat business.

Current demand is short-term demand. How management defines this period depends on the nature

of the business and the reporting capabilities of the company's information system. In most cases, this period should not exceed four to six weeks.

Forecasting is an imperfect mix of art and science. In my experience, the quality and timeliness of many item-level forecasts leave much to be desired. Even when a company makes a concerted forecasting effort, the accuracy of results is frequently not measured or reported. Yet forecast accuracy data should play an important role in determining the inventory levels required to cover demand fluctuations and order and production lead time variations, as well as to refine forecasting techniques to improve accuracy.

The graphic technique of the moving picture provides a vivid picture of history as well as of the consequences of past decisions. This picture can then be used to make forecasts and improve the quality of future decisions.

Examples of snapshots and moving pictures are shown in *Exhibits II* to *V*. These exhibits reflect the orders placed with the company for delivery in the future. The reporting system captures the demand information in monthly installments. The graphs were created on a weekly basis. Current demand is generally defined as demand for the current month. If less than two weeks is left in the current month, current demand includes demand remaining this month plus demand for the next month.

These exhibits are based on the following information for each product line:

1 Total available inventory by product line in units

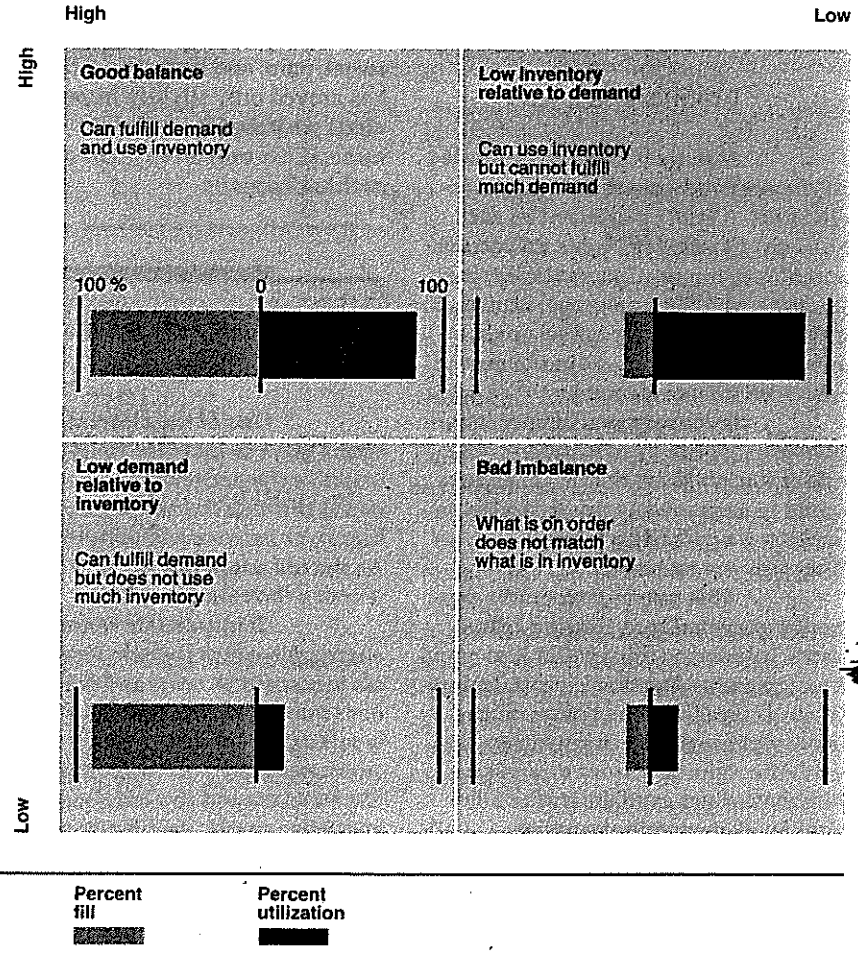
2 Current demand for the product line in units

3 Current demand that available inventory cannot satisfy by item within the product line (called the "production requirement")

4 Quantity fill equals current demand minus production requirement

5 Percent fill equals quantity fill divided by current demand

Exhibit II **Fill rate, utilization rate, and inventory balance**



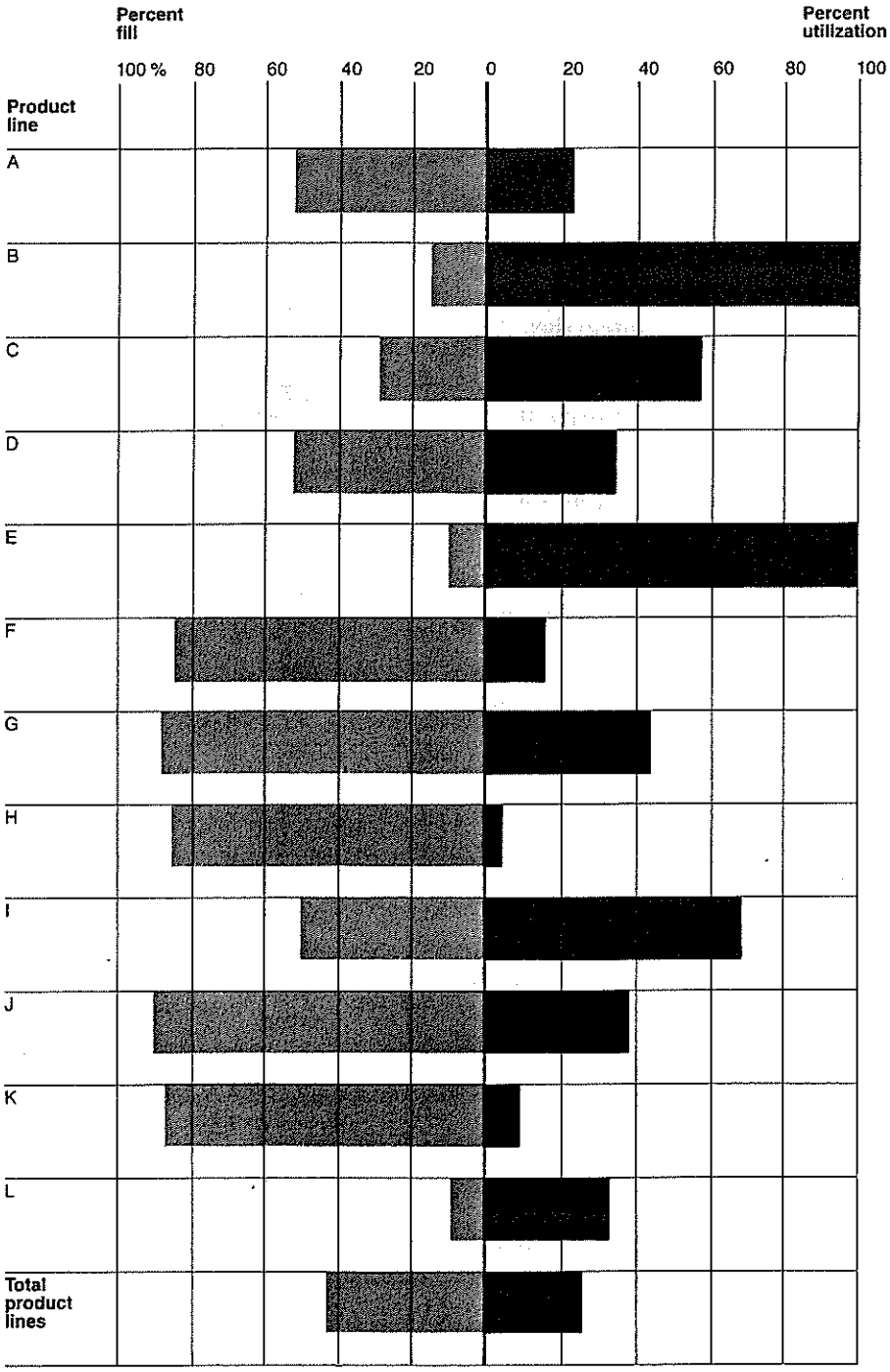
6 Percent utilization equals quantity fill divided by total inventory

These quantities are graphed using the snapshot and moving picture formats. The results are graphs available on a timely basis that can give managers insight into their inventory balance. The snapshot shows the entire inventory, product line by product line, at any time. The moving picture shows each product line over long periods and allows managers to analyze trends and balance patterns, and to ask "what if" questions. The insights they gain from such analysis can extend far beyond inventory implications (see *Exhibit V*).

Graphs developed for each product line strike a good balance between a picture of the inventory in total and of the inventory of individual items. The product line graphs are put together by aggregating the information about line items. The product lines can be compared with each other and evaluated against the graphs for total inventory and with regard to corporate goals. Moreover, details within each product line can expose problems and exceptions.

In industries without significant order backlogs, assumptions regarding current demand can probably be modified to reflect the nature of the business. For example, wholesalers or distributors who service most of their orders in a day or less might accumulate and evaluate weekly totals for demand that was filled (quantity fill) and back-ordered (production requirement) by product line against the available inventory that existed at the beginning of the weekly period. While this step

Exhibit III **Snapshot of fill rate and utilization rate by product line**



would preclude action to correct imbalances for the demand measured, the moving pictures would provide trend and balance information on which managers could base future decisions.

Many employees may be involved in formulating, managing, and performing inventory and customer service activities for a company. Snapshot and moving-picture graphs are an easy way to communicate targets, goals, and performance throughout the organization in a timely, concise, and understandable manner.

Reporting and graphing inventory balances helps managers identify problem areas for corrective action. Inventory balance improves as a company moves closer to the balance curve and its rewards.

Measuring profitability

Inventory, like any other asset, should make a contribution to return on investment. One method of measuring ROI in inventory is a "turn and earn" calculation of gross margin return on inventory investment (GMROI).[4]

GMROI can be used to ascertain the amount of gross profit earned for each dollar invested in inventory. It is computed according to the following formula:

$$\text{GMROI} = \frac{\$\text{ Gross profit}}{\$\text{ Sales}} \times \frac{\$\text{ Sales}}{\$\text{ Average inventory at cost}}$$

The *earn* term in the formula is simply the gross profit margin (GPM) percentage.

The *turn* term should not be confused with the inventory turnover rate.

Inventory turnover measures sales at cost divided by average inventory at cost. A derivation of the turnover rate can be made, however, which can then be used in the GMROI calculation. With the derivation, the *turn* term becomes

$$\frac{\text{Turnover rate}}{1-\text{GPM\%}}$$

where GPM is the gross margin percentage.

GMROI can then be computed as follows:

$$GMROI = GPM\% \times \frac{\text{Turnover rate}}{1 - GPM\%}$$

where GPM% is expressed as a decimal.

As an example, an item has a GPM% of 41% and a turnover rate of 4.9 turns.

$$\text{Its GMROI} = .41 \times \frac{4.9}{.59} = 3.41$$

In other words, for every dollar invested in inventory for this item, the company earned $3.41 in gross profit.

This technique has several applications. For example, by calculating the profitability of each item, the item's performance can be measured. It is important to remember that profitability is the combination of the profit contribution (GPM%) and the intensity of asset utilization (turnover). Items with low profit contributions can be winners if they have high turnover rates. And items with high GPM% can support a lower turnover rate. Also, by establishing a target GMROI for the company based on its goals, such things as individual products, product lines, and geographical and organizational units can all be measured against the performance targets. As a result, managers can identify products that are not pulling their weight and those that are doing more than their share, and they can take action accordingly.

Managers should keep two warnings in mind when using this technique. First, items with high turnover rates give high GMROIs. This technique does not account for penalty costs associated with high turnover rates that tend to reduce the GPM%. These penalty costs can derive from expediting, extra paperwork and handling, and the intangible costs related to stockouts, potential lost sales, and customer dissatisfaction.

My second warning concerns data collection systems that may be inadequate. Most companies do not measure average inventory at the item level. One possible solution to this problem is to incorporate a simple weighted moving average into existing computer stock status routines. This would allow the calculation of a reasonable approximation of the average inventory over the course of a year.

GMROI is useful for the simple reason that it measures performance in the purest of forms – return on investment. Granted, valid reasons exist for not relying on this measure absolutely, such as decisions to carry items as loss leaders or to meet service and repair needs. Managers should be aware, however, of the inventory performance implications and the reasons behind these decisions.

Putting it all together

The final step in sharpening inventory management is to put the analytic pieces together so that both importance and performance are connected. A technique known as ABC analysis allows segmentation of the inventory based on distribution by sales value.

In ABC analysis, the inventory is ranked in descending order of value with certain parts of the distribution categorized as A, B, or C, depending on some user-defined criteria. Two reasons justify this ranking. First, the 80–20 rule, also known as Pareto's Law, is pervasive in business: 20% of a company's customers account for 80% of sales; 20% of the product line accounts for 80% of sales; 20% of the items in the product line account for 80% of the inventory (this is a different 20% from those items that account for 80% of the sales); and 20% of orders account for 80% of volume sold. The 80–20 rule focuses attention on the few but important items that account for the bulk of the company's volume.[5]

Second, within each segment, different stocking and service policies may be appropriate. By segregating the inventory, items are ranked according to their sales contribution. As a result, managers can apply policies and control techniques specific to each classification.

The ranking criteria are simple. First, compute the unit sales or dollar sales for each item; then list the items in descending order. Finally, compute the cumulative dollars or units sold and cumulative percentage of sales. This method of ranking is slightly different from the method usually applied to raw materials in a manufacturing environment. For those situations, the ranking is based on inventory value or projected usage. The decision rules in manufacturing are applied to keep tight control on the A items.

With finished goods, the ranking is based on sales volume. The decision rules are designed to make sure the A items are in stock and do not run out.

Exhibit IV **Moving picture of inventory use**

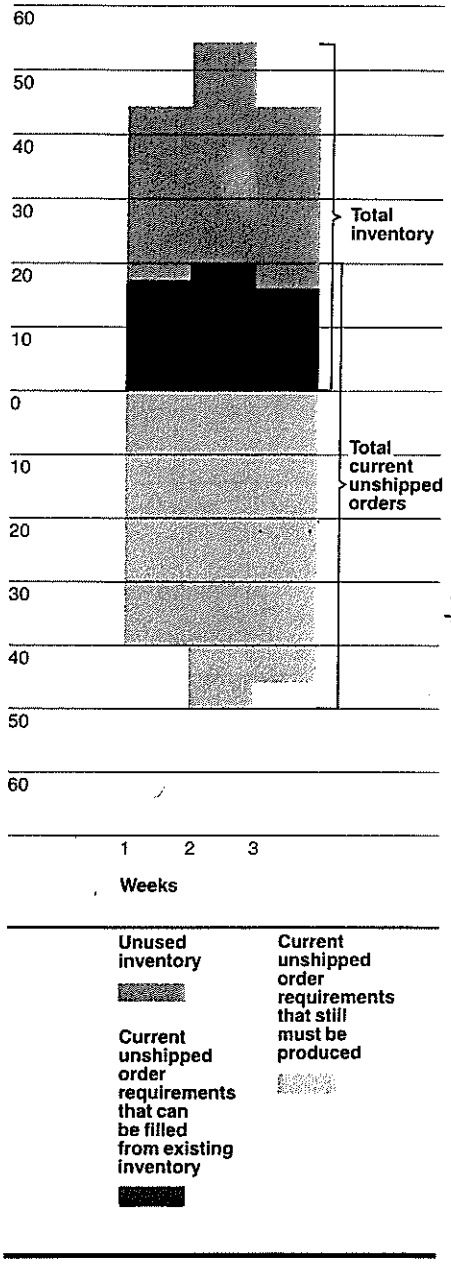
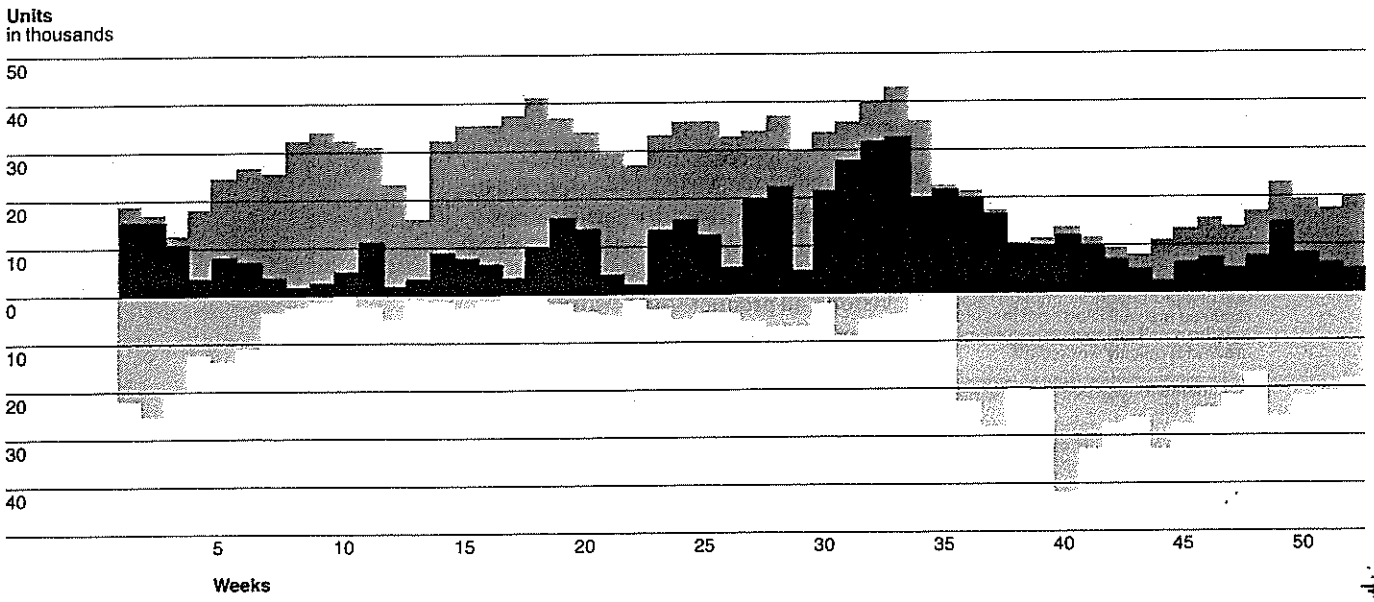
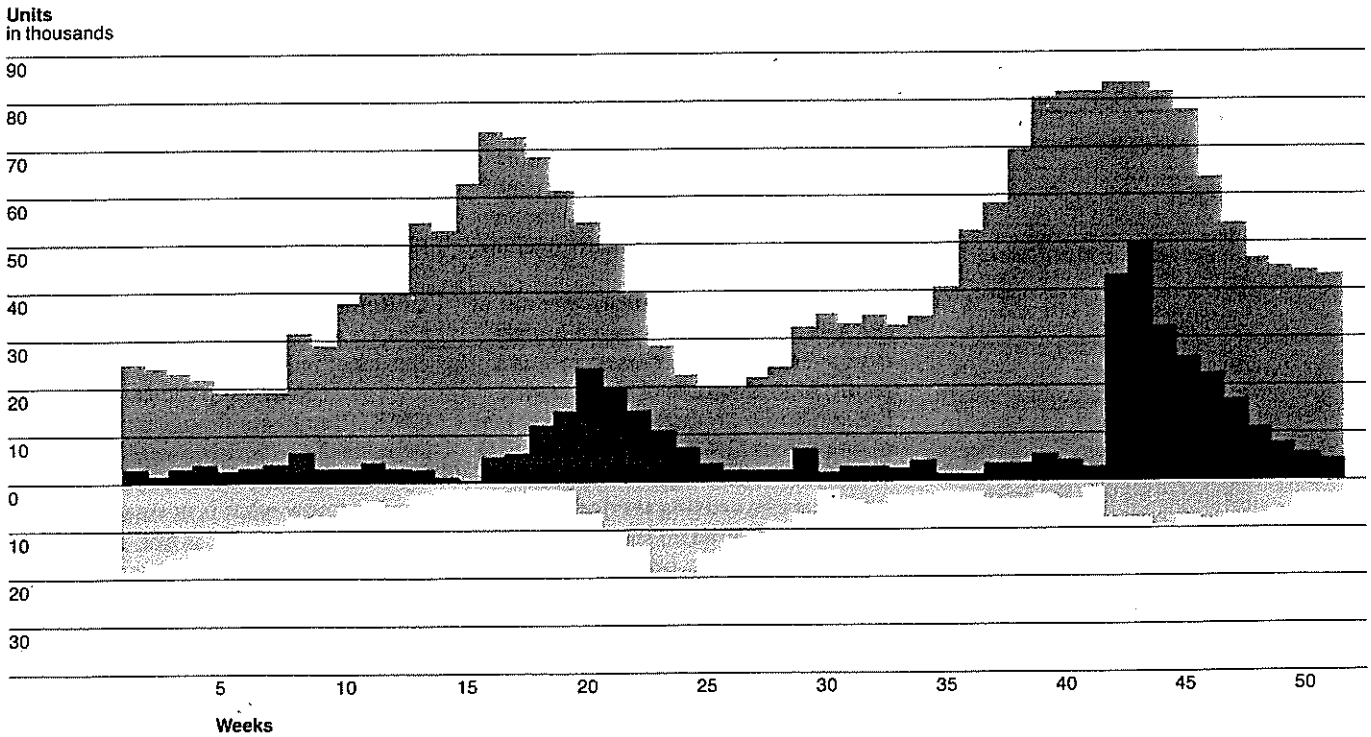


Exhibit V **Moving picture of inventory use by product line**

Product line C



Product line J



Analysis of moving pictures of product lines C and J

The moving pictures contain a tremendous amount of information. An analysis follows:

Product line C consists of eight items, the top-selling items in the company's total product line.

Weeks	Comment
1–6	Significant production requirement worked off.
5–30	Adequate inventory maintained, but slight increases in production requirement occurring in periods 22–30.
30–33	Total inventory increases in anticipation of a promotion. Promotion orders received are well filled from inventory, and the small production requirement created is quickly worked off.
34	Shipments reduce both inventory and quantity fill.
35	Additional shipments reduce inventory. Because inventory was balanced, quantity fill fully uses inventory (100% utilization and 100% fill) as additional orders come in.
36	A new month is added to current demand. The demand was either not forecast or production schedules were not met. The production requirement is substantial.
36–52	Inventory continues to be shipped. Current production makes some progress in reducing the production requirement, but inventory is not balanced. Unneeded inventory increases starting in period 38. By period 52, the inventory is seriously out of balance with both low fill and utilization rates.

Product line J is a seasonal line.

Weeks	Comment
1–7	There is a serious imbalance of inventory with low fill and utilization. Current demand (not backlog) is drawing down inventory. An increased production rate to build for a seasonal promotion is actually being used to reduce the outstanding production requirement.
8–16	Inventory rises in anticipation of the promotion.
16–25	The promotion-driven orders draw down inventory. The total forecast at the product line level was accurate, but the mix was off. The amount of extra inventory is the same as the production requirement. (Or the production requirement is for the products produced in periods 1–8 that were used to satisfy a previous backlog.)
25–30	Production requirement worked off.
35–43	Inventory buildup for promotion.
44–51	Shipments are made with a relatively small production requirement. The year-end inventory is almost double the inventory existing at the start of the year.

Once the ranking is completed, it is a simple matter to break the product line into the A, B, and C categories. The A items are those that account for the top 50% of cumulative sales. The C items are the bottom 50% of the total items. The Bs are the items left. *Exhibit VI* illustrates this classification. Many arbitrary schemes exist for ABC classifications using different percentages. This one is simple, direct, and easy to remember.

By combining the ABC analysis with GMROI, inventory needs (demand) and inventory performance come into sharp perspective. When summarized by ABC classification, division and product line performance differences are clear.

Such information helps spell out inventory management needs, policies, and direction. For example, many companies measure performance only at the product line level. Using the ABC analysis, the performance of individual products becomes apparent. In one company, a product line that managers thought was the top group had sales roughly 20% greater than the line they believed was number two. There were more than 30 items in the first line and only 8 in the second, however, and the average sales dollars generated by an item in the second line were more than three times those of the average item in the first line. By performing ABC analysis, management found that items from product line number two occupied the first five places and all eight items from that line were in the top 5% – and the company had not known it!

Another interesting result of the ABC analysis is the much higher than average turnover rates (and, as a result, high GMROIs of the A items). For consumer products, a turnover rate of more than 12% is an indication that the items are moving too fast. These items may be causing service levels lower than desired on the balance graph. The C items, on the other hand, will likely have very low turnover rates and low GMROIs. These items tie up investment in inventory and cause low overall inventory turnover rates.

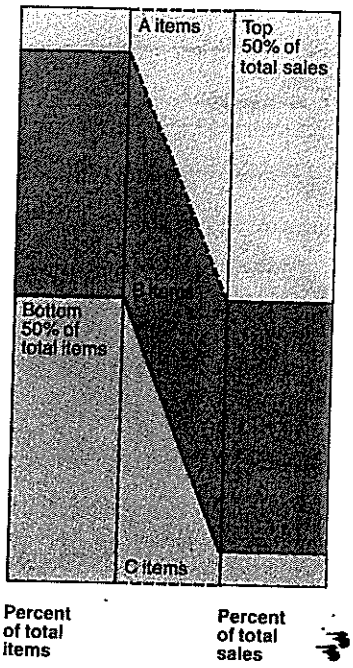
To deal with such problems, a company has several options. For example, it may reduce the turnover in As, thereby increasing inventory investment but also improving availability and service, and improve the turnover in Cs, thereby reducing inventory investment. Because the As constitute a relatively small number of items and the Cs a relatively large number, the effect of these actions will be a net reduction in inventory.

Because they target particular items for a specific reason, such policies are more effective than broad policies like "reduce inventory by 10%."

To develop the graphs and GMROI, analysts should start at the item level and build upward. To deal with exceptions, moreover, managers need to know what is normal for their companies and what is not. To develop the programs and computer analysis necessary to trap and report the abnormal items, analysts should develop an understanding of the appropriate data about the business, inventory, and sales environments.

Exhibit VII provides a detailed example of an ABC analysis, and *Exhibit VIII* gives examples of a product line summary and product line detail comparisons.

Exhibit VI **Ranking by ABC analysis**



Items ranked in descending order by unit or dollar sales.

Exhibit VII **ABC distribution**
Items ranked by net sales during a specific period

	Rank	Product line	Item	Net sales in thousands	Cumulative sales in thousands	Cumulative sales	Unit sales in thousands	Average monthly inventory in units	GPM	Inventory turnover	GMROI	ABC category
	1	C	C2295	$ 1,390	$ 1,390	1.7%	348	13,411	46.5%	25.9	22.51	**A items** Items in top 50% of cumulative sales
	2	C	C1736	1,257	2,647	3.2	341	17,286	43.4	18.2	13.96	
	3	C	C1248	1,248	3,895	4.8	332	19,837	45.7	16.8	14.14	
	4	C	C1103	1,233	5,128	6.3	339	16,244	44.4	20.2	16.13	
	5	A	A1334	1,148	6,276	7.7	250	14,883	44.5	16.8	13.47	
	66	J	J2276	345	40,042	49.1	89	17,895	22.9	5.0	1.49	
	67	A	A1979	343	40,385	49.6	137	20,812	37.1	6.6	3.89	
	68	K	K0195	343	40,728	50.0	66	17,512	39.5	3.7	2.42	
	69	K	K1724	342	41,070	50.4	140	28,470	33.4	4.9	2.46	**B items**
	70	K	K1695	340	41,410	50.8	96	20,117	38.8	4.8	3.04	
	71	J	J1003	333	41,743	51.2	124	11,799	27.3	11.3	4.24	
	377	J	J2477	34	77,861	95.6	15	6,601	17.0	2.2	.45	
	378	H	H1462	33	77,894	95.6	17	9,437	40.2	1.8	1.21	
	379	Q	Q1365	33	77,927	95.6	13	7,659	33.2	1.7	.84	
	380	K	K0135	33	77,960	95.7	12	30,672	39.4	.4	.26	**C items** Bottom 50% of total items
	381	K	K1221	33	77,993	95.7	18	27,543	38.8	.7	.44	
	382	K	K2221	32	78,025	95.8	18	14,878	29.1	1.2	.49	
	757	Q	Q2173	− 4	81,488	100.0	− 2	1,681	18.0	−1.0	−.22	
	758	Q	Q1300	− 4	81,484	100.0	− 1	480	30.5	−2.0	−.88	
	759	R	R0623	− 4	81,480	100.0	− 2	542	27.5	−3.3	−1.25	
Total				$ 81,480	$ 81,480	100.0%	26,584	7,406,453	38.6%	3.6	2.26	
Summary	68	A items (9.0%)		$ 40,728 (50.0%)			11,461	1,191,923	39.6%	9.6	6.29	
	311	B items (41.0%)		36,857 (45.2%)			13,465	4,692,996	37.9	2.9	1.77	
	380	C items (50.0%)		3,845 (4.7%)			1,658	1,521,534	35.3	3.6	.60	

Steps to improved inventory management

Inventory performance can be improved using a combination of graphics and detailed reporting techniques that provide insight, clarity, and visibility to inventory needs and levels. These methods can bridge the gap between inventory investment, service, and profitability goals and the detailed, item-level inventory planning tools available in this computerized age.

Executives should follow these steps to improve inventory management:

1 Recognize that inventories may be out of balance but can be managed. Implement the tools outlined in this article to identify problems and take corrective action.

2 Examine your organization and identify responsibility for inventory management and performance. In many companies, responsibility for inventory asset management is dispersed or nonexistent.

3 Establish inventory goals with respect to profitability, turnover, and customer service. Begin measuring products and performance in these terms.

4 Use different techniques for handling different classes of inventory. For A items, those that generate disproportionate shares of demand and sales, availability is paramount in importance. But for Cs, which generate little revenue and have low demand, strive to achieve a specific minimum turnover rate. Lower the levels of C-item inventory. Risk stockouts.

It is critical to stock and price C items so that they earn a reasonable rate of return. Use a target GMROI rate to arrive at the margin.

Exhibit VIII **Product line summary**

Product line	GPM	Inventory turnover	GMROI
A	34.7 %	19.1	10.15
B	36.9	10.5	6.14
C	45.4	15.1	12.56
D	40.4	6.1	4.13
E	39.0	7.2	4.60
F	34.3	4.4	2.30
G	37.8	22.9	13.92
H	33.7	6.8	3.46
I	25.6	3.4	1.17
J	22.6	4.3	1.26
K	33.9	9.1	4.60
L	34.4	8.2	4.30
All others	37.3	2.1	1.25
Total	38.6 %	3.6	2.26

Detail for product line B

ABC category	Rank	Item	GPM	Inventory turnover	GMROI
A	18	B0242	36.2 %	14.7	8.34
A	40	B1011	38.3	20.3	12.60
A	63	B2014	36.2	16.0	9.08
B	76	B2137	38.3	38.4	23.84
B	114	B1724	38.3	11.7	7.26
B	220	B1195	36.3	7.8	4.44
B	257	B2775	38.3	11.2	6.95
B	324	B2346	36.2	5.7	3.23
C	390	B2013	35.8	8.4	4.68
C	413	B1136	35.8	4.8	2.68
C	415	B1012	35.8	3.3	1.84
C	424	B2198	35.8	3.4	1.90
C	507	B1841	35.7	3.2	1.78
C	525	B1869	35.7	6.0	3.33
Total 14 items			36.9 %	10.5	6.14

5 Measure forecast accuracy. If you don't, you won't know what you forecast well and what you forecast poorly. Failure to measure forecast accuracy at the item level can lead to the "100% accuracy syndrome," in which managers and planners know that the forecast is inaccurate but they don't know where. Rather than find out (that's the other guy's job), they simply accept the forecast without question and produce or purchase to the forecast. As a result, inventory imbalances are self-perpetuating.

Robert G. Brown writes that a forecast is the sum of the mathematical model (if one exists), dependent demand, order backlog, and marketing intelligence.[6] Use graphics and GMROI techniques to improve the quality of marketing intelligence. Then improve the forecast and make it more responsive to changing conditions.

6 Improve the skills and understanding of employees responsible for making inventory decisions. Make sure they understand the concepts thoroughly. For example, people often claim that highly accurate inventories and bills of material are required for MRP systems to function properly. But so are accurate forecasts. Regardless of the bill-of-material and inventory accuracy, you will build the wrong inventory if the forecast is wrong.

In this article, I have discussed ways to improve inventory management and performance. The techniques I have advocated make common sense, they can be easily understood, and they work.

References

1 Robert E. Cole, "Target Information for Competitive Performance," HBR May-June 1985, p. 100.

2 Everette S. Gardner, Jr., "The Strange Case of the Lagging Forecasts," *Interfaces*, May-June 1984, p. 47.

3 Bernard J. La Londe and Paul H. Zinszer, *Customer Service: Meaning and Measurement* (Chicago: National Council of Physical Distribution Management, 1976).

4 Peter L. Mullins, *How to Measure Product Line and Customer Profitability* (Washington, D.C.: National Association of Wholesaler-Distributors, 1974).

5 For a discussion of Pareto's Law, see Oliver W. Wight, "Inventory Control Systems," in *The Production and Inventory Control Handbook*, ed. James H. Greene (New York: McGraw-Hill, 1970), p. 16-3.

6 Robert G. Brown, *Materials Management Systems* (New York: John Wiley, 1977).