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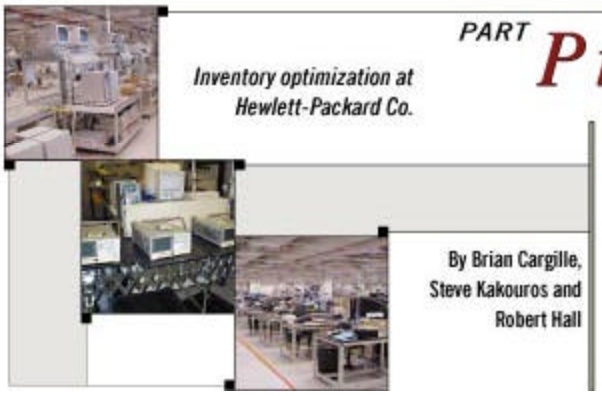

Inventory optimization at Hewlett-Packard Co.

By Brian Cargille, Steve Kakouros and Robert Hall

The cost of inventory is a major concern to many businesses. The Hewlett-Packard Company (HP) is no exception. While some product divisions have improved inventory management through investment in information technology, there remains enormous potential for inventory optimization across HP. This article describes how a small team of OR professionals capitalized on this opportunity.

HP is a highly decentralized company comprising more than 100 distinct businesses that manufacture computers, related products and a wide variety of instrumentation devices. These divisions are responsible for designing, marketing and manufacturing their own products and as such, each has its own unique inventory problems to solve. The Strategic Planning and Modeling team at HP develops leverage opportunities across these businesses.

The team was formed 10 years ago with the goal of developing practical OR/MS solutions and disseminating them broadly across HP's businesses. In support of this goal we adopted a consulting business

model, expecting our internal customers at HP businesses to cover the full cost of our efforts. This model encourages the development of technical solutions and project work only when the business impact is sufficient to justify the investment.

The team has grown slowly over time — ensuring greater demand for its services than capacity. A few principles guide the work:

- focus on the creation of intellectual assets,
- turn down projects with high risk of failure or low ROI,
- concentrate on recruiting.

Although these principles worked well for strategic initiatives, answering questions like, "Where should we put the next factory?," it was not until we developed efficient delivery mechanisms for our innovations that we were able to transfer this success to operational projects.

Involvement in Supply Chain Management

For most of its history, our team has been very active in the area of supply chain management, which saw a dramatic increase in popularity over the same period. In collaboration with Prof. Hau Lee at Stanford University, this involvement commenced with the development of a multi-echelon inventory modeling capability.

We used this capability to complete numerous analyses for HP businesses facing strategic decisions. The models that were developed incorporated all relevant supply chain costs (e.g., freight, duties, production and distribution costs, and an array of inventory-driven costs) and allowed management to choose among a set of alternative strategies.

For many of these projects, the inventory cost category outweighed all others in terms of impact on the decision. At most HP businesses, inventory-driven costs (which include devaluation, obsolescence, price protection and financing) are now the biggest control lever that the manufacturing organization has on business performance, measured in terms of ROA (return on assets) or EVA (economic value added). In the highly competitive electronics and computer industry, where product life cycles are short and commodity prices erode quickly, inventory is a tremendous cost driver and the most variable element on the balance sheet.

An Operations Research Approach to the Problem

The most common inventory control method that OR students find in textbooks is that of economic order quantity (EOQ) and its variations. In EOQ the basic idea is that the inventory is reviewed continuously; when it reaches a certain level an order of fixed size is placed. The calculations of when and how much to order are based on cost parameters, and the

goal is to minimize the inventory management cost. Deterministic EOQ type inventory control methods are good for introducing students to the concepts of inventory control, but they are not applicable to our problem. In a world of uncertain demand and supply, stochastic modeling of inventory is required.

The most well-known stochastic inventory control method is that of "the newsboy problem." In this approach demand is modeled as a random variable, and overage and underage costs are used to derive an optimal order quantity, thereby minimizing the total inventory cost. The method is inadequate in our case for two reasons: a) uncertainties around replenishment are not modeled, and b) it is a single period approach. Our solution for the HP problem was to develop a periodic review inventory control method using part availability targets, and to include as many uncertainty considerations as possible.

The foundations of this method are discussed in Davis' article, "Effective Supply Chain Management" in *Sloan Management Review*. The fundamental concept is that safety stock (extra inventory) is kept on hand as a buffer against stockouts due to demand and supply uncertainties. By using the uncertainties of both supply and demand we calculate the safety stock required to achieve a desired availability target. Establishing these availability targets requires management judgment to trade off the cost of stocking out against that of holding excess inventory.

Our inventory control approach is implemented in sets of macros that we refer to as the inventory calculation engine (ICE), written in Microsoft Excel. As Grossman describes in the April 1999 issue of *OR/MS Today*, spreadsheet flexibility and versatility makes Excel an appropriate platform for designing generic models that can be easily customized to the needs of a specific problem. Our team used this approach successfully in implementing activity-based costing (ABC) emulation models for more than six years. The success of ICE in these models and the accuracy and validity of the results was an indication that it could be used in a more operational way on a day-to-day basis.

The Tactical Inventory Management Problem

While the strategic projects certainly provided value to the businesses, the team realized that the actual inventory present within HP supply chains was often far greater than that predicted by its mathematical models. Most organizations were inefficient, carrying more than they needed in order to achieve a desired level of product delivery performance. In many cases it was clear that the planning and procurement organizations in the operating divisions simply lacked the knowledge and tools to set inventory levels appropriately for their large arrays of parts. They often used simplified approaches (e.g., ABC analysis) to set their buffer stocks without regard to supply or demand uncertainty, part commonality or uniqueness, or desired part availability or cost.

Although we had some success both in teaching inventory management

concepts and in providing highly specific models to the businesses, it became clear that we would need a more efficient method of disseminating our approach to have an impact on inventory level settings within existing supply chains. We realized that the planning and procurement communities needed access to a simple and inexpensive tool that they could easily load with their own part and product information and maintain over time. It was imperative that the results generated by the tool be easily understandable and credible. And the tool needed to be easily configured, in order to meet the varied needs of the customer base. Finally, it had to be technically sound.

Challenges

When we considered putting our inventory control technology in the hands of buyers and planners, we were faced with some new challenges. ICE was designed to recommend optimal inventory levels based on uncertainties, as well as operational characteristics, such as availability targets, review period and delivery frequency. But the approach was static. The ICE inputs represent what is mathematically necessary to make a decision about inventory. Unfortunately, our potential customers often saw the world differently!

We had to come up with a method that would bridge the gap between our theory and their real-world needs. For example, the ICE calculations assume one universal time unit, but our customers measured different parameters in many different ways (i.e. units per month for demand and weeks for lead-time). We needed a flexible tool that could incorporate both time units. This situation was repeated across each parameter.

We placed ourselves in a difficult position by envisioning a process that would enable us to build tools completely customized to our customer's needs. Customization had to take place not only on a higher mathematical level, but also in every small detail; and we wanted to deliver tools quickly and economically. In effect, we needed a manufacturing process for these tools that allowed mass customization, while requiring minimal time and resources from our team.

Solution is the 'PITs'

The solution was to design a software wizard that was able to build customized tools that were at least 90 percent complete. With the wizard we have the ability to map the business situation to the ICE inputs, and the ICE outputs to the customer requirements. These connections are not trivial and sometimes take the form of complicated algorithms, but by using modular macros we are able to develop tools very quickly. Tools generated by the wizard are equipped with a complete user interface, making them user friendly and efficient. We found that users didn't mind spending the necessary time to learn about the new tool, because they could incorporate all of Excel's functionality to conduct their own analysis and generate reports for management.

Once we had the wizard, we focused on developing a step-by-step

process to lead inventory optimization projects with the product lines. Now, everyone on our OR/MS team can lead one of these projects, even newer members. By using the wizard, we are more efficient in guiding and educating our customers. We have also developed a better focus on their needs than if we had to perform the costly and time consuming development of the tool from scratch for every customer.

We call the tools that result from this process part inventory tools (PITs). Inventory optimization projects are successful because each PIT is designed to accommodate the needs of both the product line and individual users. As a bonus, there is less resistance to the new tools when users help to build their own versions — this encourages rapid implementation and acceptance by the businesses.

Results

Customized versions of PIT are in place across a wide variety of HP product lines and geographies; from Penang, Malaysia to Fort Collins, Colo. — on parts for everything from LaserJet printers to microwave test accessories. Without exception, the product lines now have more efficient operations. Results vary; teams use the tool to improve what is most important to their business. At one division, backorders that had been a problem for years vanished within three weeks of implementing the new approach with no increase in inventory levels. Shipments had been constrained by inventory stockouts. When parts become available instruments can be built on demand, shortening the lead-time to customers and improving on-time delivery.

From Repeated Stock Outs to Statistically Controlled Inventory

When parts are available, products can be built on demand and backlog vanishes!

At HP's Integrated Circuit Manufacturing Division, planners cut finished goods inventory (which is a huge driver of costs) by $1.6 million. They made this reduction while simultaneously improving on-time delivery performance from 93 percent to 97 percent. Those circuits are now available more often for assembly into partner's HP products, enabling these partners to reduce their inventories because the upstream IC supplier is more reliable. Along with results like these come benefits that are less visible but equally valuable. Examples include less expediting, fewer disagreements about operating policy, and more control of the production system.

Most importantly, the tool diffusion process builds users' capabilities. The current focus on investments in information technology can make us easily forget that someone is responsible for setting and managing inventory levels for each part. PIT helps users perform better in their jobs; they make tradeoffs that they haven't in the past. For example, they can better negotiate with suppliers by quantifying what a supplier's "lateness" costs HP in terms of extra inventory necessary to buffer

against unreliability. They can quantify what it would be worth to review and send build plans more frequently, or to get a supplier to deliver twice a week instead of once every two weeks. It is very gratifying as an OR professional to hear of achievements like these (from a growing constituency). PITs help people get a little smarter and quite a bit more effective in managing the strategic as well as tactical aspects of their operations.

We also hear that conversations with management have taken a different tone. When a materials manager comes to a planner and requests a 99 percent fill rate, the planner can now say, "Great idea, let me show you what our increase in inventory investment will be to achieve that fill rate." This is a very different (and more analytical) discussion than they would have likely had in the past.

A nice additional benefit is seeing how divisions manage both sides of the business cycle (growth and decline). In the past, there was a significant delay between shifts in customer demand and a corresponding change in inventory levels — people were continuing to apply the same rules to a dramatically different situation. Now the decision on stocking levels is dynamically linked to demand. As the business changes the actions of the inventory owners change as well — keeping the weeks of supply in the system constant.

Implementation Across a Decentralized Business

While people working in manufacturing at different HP divisions don't often talk with each other, a friendly rivalry certainly exists. We counted on being able to capture the interest of businesses across the company by helping one pilot program manager succeed, documenting the value to their business and advertising their success. Not a new method, most of us know that "nothing succeeds like success"; what may have been different is how it happened in this case.

We were lucky enough to work with a very competent individual contributor — a procurement specialist fresh out of an MBA program. We helped him go to his management to ask for the resources (money and the time of their people) to staff the pilot.

The division he worked in, while very profitable, was not recognized as a leader in supply chain management at HP. This was a great benefit. We avoided conclusions of, "That business is already so enlightened, of course inventory optimization is easy for them to implement. At my business it would be impossible." Although they did not pay for all of our time, the division paid for our work. Charging for our work was important, to confirm they were serious and to get management's attention. We secured approval from our own management to invest in this pilot, promising future returns from selling the "soon to be proven" approach to other divisions.

Once the pilot division conquered their backorder problem they weren't shy about sharing the news. This made selling the process to other

businesses relatively easy. We made the story available, sent it out on internal e-mail messages, encouraging people to talk to the now promoted program manager from the pilot division if they had questions. The requests started coming in soon after, and once the process was proven successful at three very different businesses, we saw even more interest.

The price for the tool and process is modest, but enough to require sign off by at least two levels of manufacturing management. Just enough to cover our time, and get the attention and commitment of the divisions that are working with us. At HP, committing the time of people is one thing — money is an entirely different matter. At the end of the year, someone is going to ask the manufacturing manager what return she got for that investment. As a result the business team will be very motivated to measure and communicate the success of their implementation.

What we learned

- Pick a platform that people are using every day and enable the required functionality, but keep the technology relatively invisible to the user.
- Instead of trying to develop a "universal" approach, create a generic tool that can be customized for use with individual users in specific businesses.
- Pick a competent, grass-roots champion for your pilot site. Get management to pay for the development time so you have their attention.
- Measure the value of the improvement, direct interested "customers" to the pilot leader (not your team) for information about the approach, and use friendly rivalry to encourage diffusion.

While sacrifices must be made in performance and development time, creating a tool and a process that works on a widely available platform yields returns that are well worth the investment — lower implementation cost, improved flexibility, accelerated diffusion and smarter people. Management often spends a lot on IT systems hoping to improve operations management. In this case a few OR professionals using existing tools (Excel and a PC) are delivering quite a bit of value across very different businesses in a large, decentralized company.

The Microwave Instruments Division: Success at Inventory Control

The Microwave Instruments Division (MID) is an example of HP's traditional "technical monopolist" business. It develops highly engineered products that sell in relatively low volumes, but have

traditionally commanded high profit margins. In recent years, however, the business has seen increasing competitive pressure from products with less functionality and similar costs, but better availability.

MID's supply chain is highly vertically integrated (other HP divisions and operations make the ASICs, PCAs and subassemblies that make up its products). By focusing on their own operational metrics, these upstream operations have historically been very lean on inventory and have demonstrated poor delivery performance to their customers (who are, after all, only internal organizations).

Since the MID manufacturing organization is responsible for delivering products to HP customers, it is very interested in maintaining high product availability. It has thus been forced to carry inordinately high levels of inventory to compensate for the lack of component availability from its internal suppliers. Furthermore, its inventory is in the form of FGI (finished goods inventory) or nearly complete products. This is clearly the most expensive place to hold inventory in the supply chain.

Recognizing this problem, a project team from the site procurement organization identified the opportunity to use statistically based safety stocks to determine appropriate stocking levels at points throughout the supply chain. Customized tools were created to meet the specific needs of each inventory controller. Someone setting the number of "bins" in a KanBan loop needs a very different tool and different output than a buyer managing raw stock from a vendor with long lead-times and high economic order quantities (EOQs).

Results

Within three weeks of implementing the new approach to inventory control, MID experienced remarkable availability improvements, with no increase in inventory investment. Backorders vanished. Shipments were unconstrained by part availability, resulting in shorter lead times to customers and improved delivery performance.

And at what cost? No large IT system was required; just smart people using data that was already available and a stand-alone tool to make informed decisions.

References

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