CHAPTER THREE

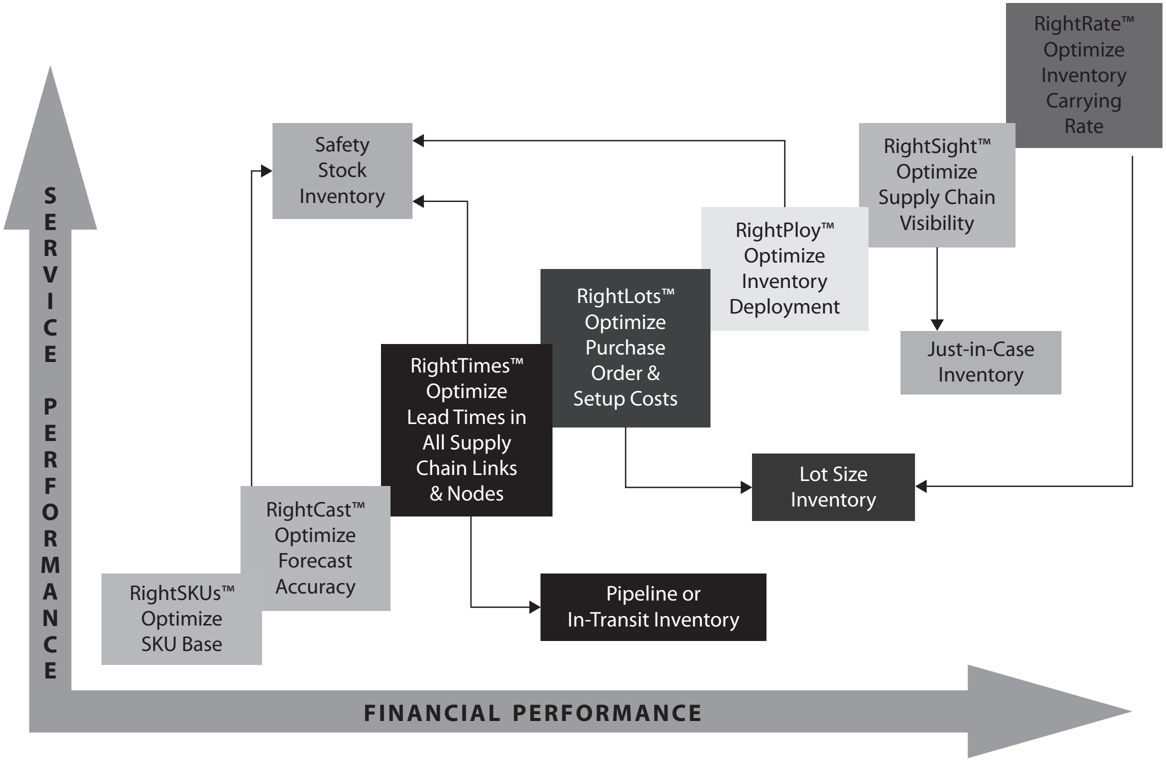
INVENTORY OPTIMIZATION

3.1 RightSKUs: SKU Optimization
3.2 RightCast: Forecast Optimization
3.3 RightTimes: Lead Time Optimization
3.4 RightLots: Lot Size Optimization
3.5 RightPloy: Inventory Deployment Optimization
3.6 RightSight: Inventory Visibility Optimization
3.7 RightRate: Inventory Carrying Rate Optimization
3.8 RightStock: Inventory Optimization

I developed the RightStock (Figure 3.1) inventory strategy model as a part of our RightChain framework to help professionals work through the complexities, intricacies, and trade-offs of inventory decision making. The model is based on over 30 years of consulting, research, and development in inventory and supply chain strategy. RightStock is influencing the inventory strategies of some of the world's most successful supply chains, including Abbott Laboratories, Coca-Cola, Disney, Colgate, Hallmark, Honda, Nutrisystem, Pratt & Whitney, and Procter & Gamble, to name a few. So far the model has been responsible for more than $3 billion in profit improvements.

RightStock is quantitative, logical, and methodical. It is not a philosophy unless you consider not having a philosophy a philosophy or call objectively putting numbers to decisions a philosophy. The model is unique in that it

Figure 3.1 RightStock Inventory Model



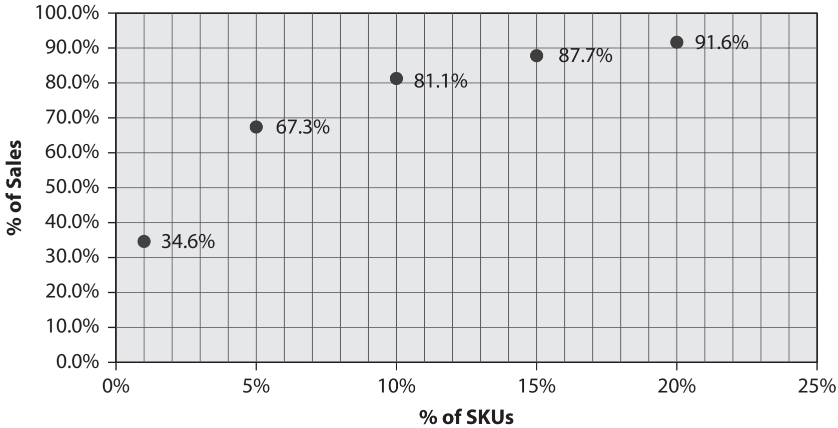
works from the SKU level up. We begin by determining optimal SKU-level inventory strategies, and then we aggregate them into category, business unit, and/or geographic strategies.

RightStock is a seven-step journey designed to optimize—not minimize—inventory levels. The optimal inventory level is the one that achieves the required service level and yields the best result on the selected financial performance metric. After the establishment of those financial and service performance metrics, the journey begins. The first step in the journey is *SKU optimization* (RightSKUs): the search for the portfolio that balances financial performance with customer needs for service and variety. The second step is *forecast optimization* (RightCast): establishing forecast accuracies that improve decision making across the entire supply chain. The third step is *lead time optimization* (RightTimes): the computation and implementation of lead times that balance purchase prices, transportation costs, and inventory levels. The fourth step is *lot size optimization* (RightLots™): establishing lot sizes across the supply chain that balance inventory carrying costs with manufacturing setup and procurement purchase order costs. The fifth step is *deployment optimization* (RightPloy™): defining the inventory allocation to facilities that optimizes inventory carrying costs, redeployment costs, and response times to customers. The sixth step is *visibility optimization* (RightSight™): defining and implementing the level and form of inventory visibility that yields the highest return on investment. The final step is *inventory carrying rate optimization* (RightRate): measuring and then optimizing the opportunity cost of capital, storage and handling, loss and damage, obsolescence and markdowns, and insurance and taxes.

3.1 RIGHTSKUs: SKU OPTIMIZATION

SKU optimization, which is often referred to as SKU rationalization or SKU portfolio management, is one of the first, best, and most important steps in inventory strategy development. When we begin RightStock projects, we

Figure 3.2 Pareto's Law at Work in Biotech SKU Revenue



usually find that about a third of the SKUs are profitable, about a third are breaking even, and about a third are losing money. If you could take only one of the steps recommended in this book, this would be the one.

This section provides several examples of Pareto's law at work in SKU revenue and profitability. Figure 3.2 is from a RightSKUs analysis of a biotechnology company in which 5% of the SKUs yield the first 67% of revenue, 10% yield 81%, and 20% yield 92%.

Another example is shown in Figure 3.3. This example is from a large service parts organization. Note that 427 (8.8%) of the SKUs yield 99% of the

Figure 3.3 RightSKUs Analysis for a Large Service Parts Organization

	% of Revenue	No. of SKUs	% of SKUs	On Hand $s	% On Hand $s	On Order $s	% On Order $s
A	50%	38	0.8%	$ 4,039,410	16.0%	$49,172,393	52.5%
B	80%	143	3.0%	$ 4,062,673	16.1%	$12,720,699	13.6%
C	90%	153	3.2%	$ 2,866,522	11.4%	$5,676,796	6.1%
D	95%	165	3.4%	$ 2,531,909	10.1%	$4,370,671	4.7%
E	99%	427	8.8%	$ 2,942,393	11.7%	$2,929,997	3.1%
F	Remainder	3,901	80.8%	$ 8,732,685	34.7%	$18,755,643	20.0%

revenue. Lamentably, 34.7% of the inventory investment—$8,732,685—was in the SKUs that yielded the last 1% of the company's revenue. Worse yet, over $18 million worth of new product was on order for the same bottom-dwelling SKUs.

You SKUs, You Lose Another example of the phenomenon is illustrated in Figure 3.4, which shows a deliverable from a recent client engagement that was focused on SKU strategy in the food and beverage industry. Note that 28% of the SKUs yielded the first 90% of total operating profit, 39% of the SKUs yielded the first 95% of operating profit, and 28% of the SKUs yielded a return on invested capital lower than the corporate threshold of 10%.

This company's hope, as in many organizations, was that more SKUs would translate to more sales and profit. In Figure 3.5 you can see that the introduction of new SKUs did not yield more sales but spread the same sales over more SKUs. Maintaining sales may seem like a victory; however, the introduction of the additional SKUs and their related complexity worked against supply chain, inventory, and profit performance. In this case, inventory investment grew from $22.3 million to $48.5 million: a 35% increase in inventory investment that came with a 44% increase in SKUs (Figure 3.6). To make matters worse, because the same demand was spread over more SKUs, forecast accuracy declined, resulting in significantly higher out of stock levels, which grew from a low of 2% to a high of 7%: a 250% increase in out of stock rates (Figure 3.7).

The additional warehousing space, warehouse congestion, longer pick lines, increased planning cycles, and shorter run lengths all resulted in a 27% increase in total supply chain cost per case from a low of $2.56 to a high of $3.26 (Figure 3.8). In this case, turning back the clock to the good old days of $2.56 per case was worth in excess of $50 million per year in supply chain cost savings. Finally, without an increase in sales, with higher inventory levels, and with reduced gross margins as a result of higher supply chain costs, GMROI declined from a high of 2648% to a low of 1205%, a 54% decrease (Figure 3.9). I coined the phrase "You SKUs, you lose" to help the company remember the performance burden of more underperforming SKUs.

Figure 3.4 RightSKUs Analysis in the Food and Beverage Industry

Operating Profit	SKUs	% SKUs	Cum SKUs	Cum% SKUs	Inventory $s	Cum Inv$s	Total Supply Chain Cost
Negative	49	12.66%	49	12.66%	$ 1,565,462	$ 1,565,462	$ 29,540,720
0% to 5%	22	5.68%	71	18.35%	$ 1,457,217	$ 3,022,678	$ 33,483,000
6% to 10%	15	3.88%	86	22.22%	$ 1,317,098	$ 4,339,776	$ 38,401,000
11% to 15%	32	8.27%	118	30.49%	$ 2,524,189	$ 6,863,965	$ 42,000,000
16% to 20%	43	11.11%	161	41.60%	$ 2,793,378	$ 9,657,343	$ 21,339,333
21% to 30%	95	24.55%	256	66.15%	$ 12,272,727	$ 21,930,070	$ 34,888,211

IVA	SKUs	% SKUs	Cum SKUs	Cum% SKUs	Inventory $s	Cum Inv$s	Total Supply Chain Cost
Negative	26	6.72%	26	6.72%	$ 270,497	$ 270,497	$ 27,991,299
$0 to $1,000	25	6.46%	51	13.18%	$ 224,322	$ 494,818	$ 31,099,543
$1,000 to $5,000	30	7.75%	81	20.93%	$ 374,084	$ 868,902	$ 33,099,798
$5,000 to $10,000	24	6.20%	105	27.13%	$ 366,336	$ 1,235,238	$ 41,222,908
$10,000 to $25,000	47	12.14%	152	39.28%	$ 1,680,720	$ 2,915,958	$ 52,772.939

GMROI	SKUs	% SKUs	Cum SKUs	Cum% SKUs	Inventory $s	Cum Inv$s	Total Supply Chain Cost
Negative	5	1.29%	5	1.29%	$ 82,853	$ 82,853	$ 27,991,299
0's	45	11.63%	50	12.92%	$ 2,420,399	$ 2,503,252	$ 31,099,543
1's	14	3.62%	64	16.54%	$ 1,839,287	$ 4,342,538	$ 33,099,798
2's	26	6.72%	90	23.26%	$ 2,890,469	$ 7,233,007	$ 41,222,908
3's	9	2.33%	99	25.58%	$ 602,301	$ 7,835,308	$ 52,772,939
4's	11	2.84%	110	28.42%	$ 411,224	$ 8,246,531	$ 28,882,221
5's	19	4.91%	129	33.33%	$ 1,517,483	$ 9,764,014	$ 17,333,119

ROIC	SKUs	% SKUs	Cum SKUs	Cum% SKUs	Inventory $s	Cum Inv$s	Total Supply Chain Cost
Negative	49	12.7%	49	12.7%	$ 1,565,462	$ 1,565,462	$ 29,540,720
0% to 5%	42	10.9%	91	23.5%	$ 3,027,972	$ 4,593,434	$ 25,342,000
6% to 10%	30	7.8%	121	31.3%	$ 4,404,671	$ 8,998,105	$ 60,285,000

Figure 3.5 Case Volume Versus Number of SKUs

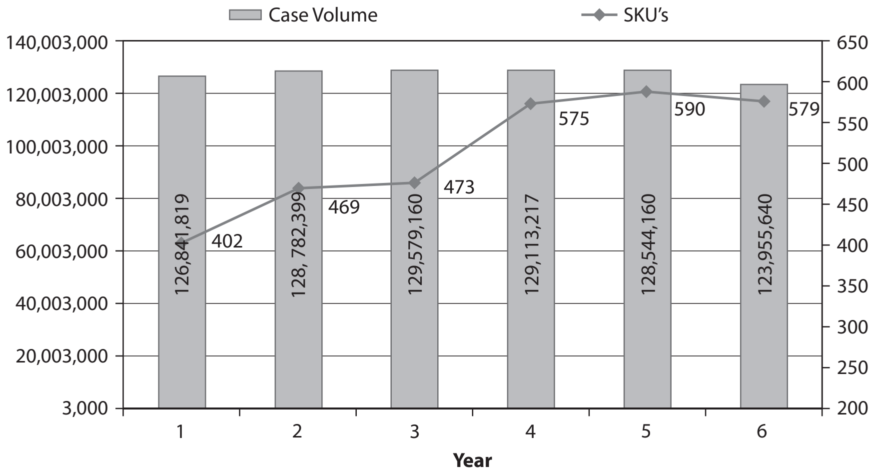


Figure 3.6 Inventory Investment Versus Number of SKUs

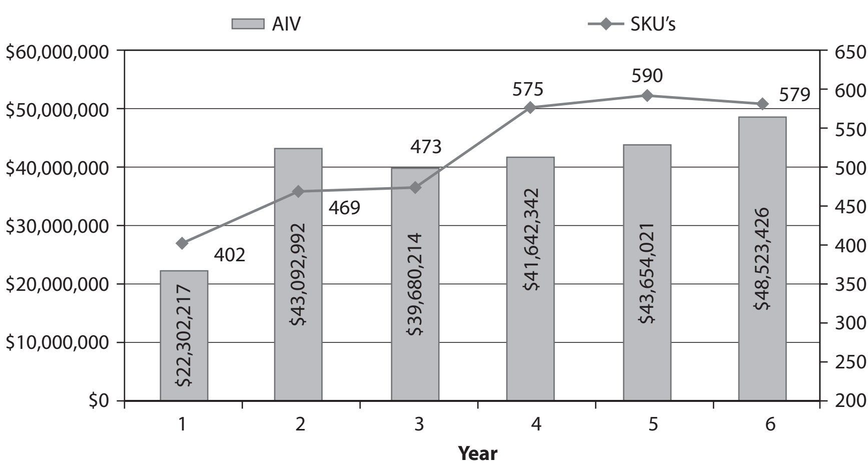


Figure 3.7 Out of Stocks Versus Number of SKUs

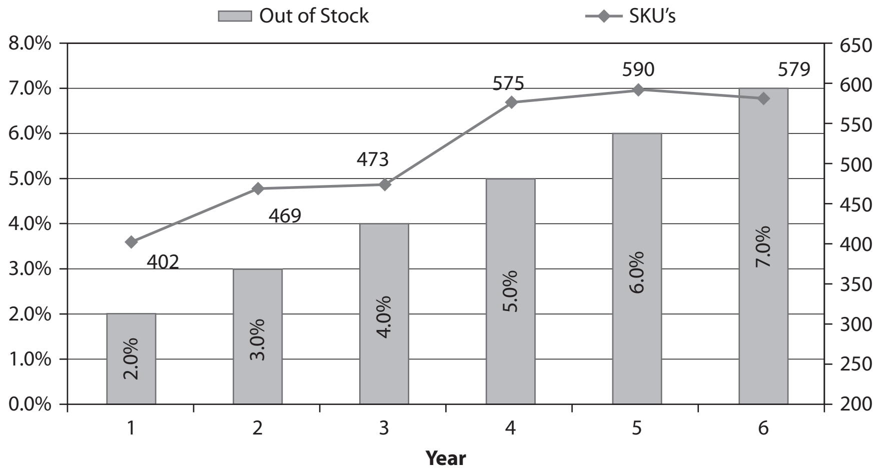


Figure 3.8 Total Supply Chain Cost per Case Versus Number of SKUs

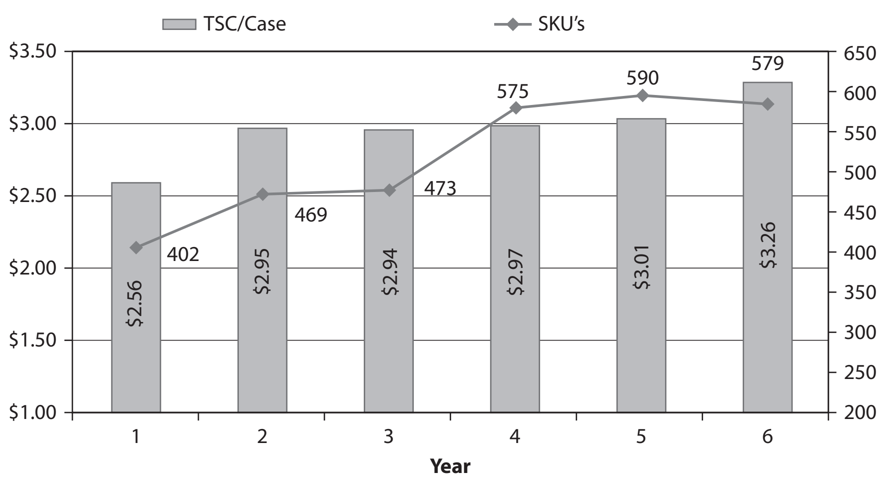
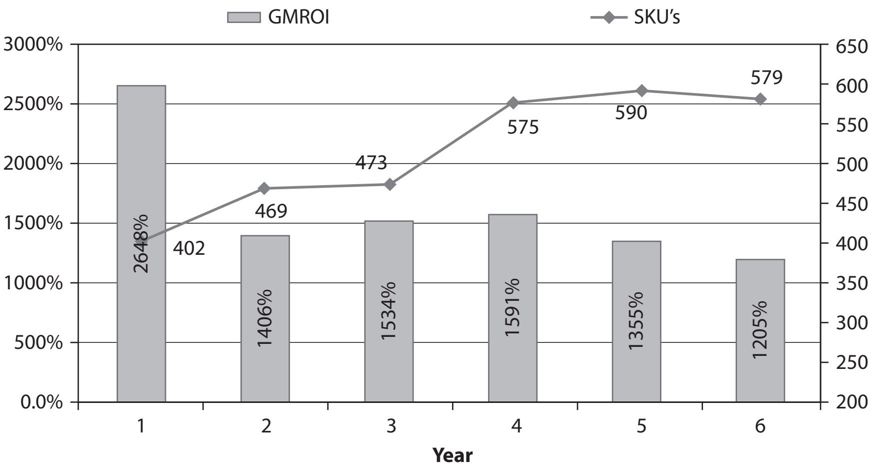


Figure 3.9 GMROI Versus Number of SKUs



But It's Just an SKU The impact of a single SKU on a supply chain is greatly underestimated. In this client example we established that each "little" SKU was

- Ordered 1,934,000 times per year . . .
  - There were 1,212,000,000 SKU orders in a year that cost $30,000,000, or $.04 per SKU order. Removing one SKU would potentially save $60,000; ten SKUs $600,000.
- Delivered 1,815,358 times per year . . .
  - There were 907,679,000 SKU deliveries in a year that cost $91,000,000, or $.10 per SKU delivery. Removing one SKU would potentially save $182,000; ten SKUs $1,820,000.
- Merchandised 1,063,463 times per year . . .
  - There were 500,908,801 SKU pulls in a year that cost $55,246,000, or $.09 per SKU pull. Removing one SKU would potentially save $110,000; ten SKUs $1,100,000.
- Picked in warehouses 120,000 times per year . . .
  - There were 12,000,000 SKU picks in a year that cost $65,000,000, or $5.42 per SKU pick. Removing one SKU would potentially save $130,000; ten SKUs $1,300,000.

- Made or bought 60,000 times per year . . .
    - There were 6,000,000 SKU lots in a year that cost $47,000,000 per year. Removing one SKU would potentially save $96,000; ten SKUs, $9.600,000.
- Handled in some way 7,000,000 times per year.
    - Removing one SKU could potentially save up to $480,000 per year; removing 10 SKUs could save $4,800,000 per year; and removing 100 SKUs could save $48,000,000 per year.

Pruning for Profit In my experience, the most fruitful first step to take in developing an inventory strategy is to remove *non-value-added SKUs*: SKUs that are more trouble than they are worth. With those SKUs removed, the same inventory or less is much more profitably allocated to the remaining SKUs. Forecasting becomes more accurate because the same forecasting resources are focused on fewer, more forecastable SKUs. Fill rate and market share increase as a result.

The forecast accuracy for an SKU you don't have is perfect. The lead time for an SKU you don't have is zero. The inventory investment in an SKU you don't have is $0. The cube occupied by an SKU you don't have is zero. The length of the pick line for an SKU you don't have is zero. The planning time required for an SKU you don't have is zero.

According to the dictionary, *pruning* means "to reduce, especially by eliminating superfluous matter, to remove as superfluous, to cut off or cut back parts of for better shape or more fruitful growth, to cut away what is unwanted or superfluous." Pruning focuses available resources on the healthiest limbs and branches to maximize the quantity and quality of the fruit.

One of the best examples of the profitability of pruning comes from an unexpected source. We have a franchise of our business in Japan through a joint venture with a division of Mitsubishi. I travel there once or twice a year to teach a series of seminars, consult with clients, and check on the business. During one of my first trips, my Japanese partner promised to take me to one of the best places to eat in Tokyo: the basement of a department store near our office. I didn't understand until I got to the produce section. There, he showed me some of the most beautiful fruit and vegetables I have ever seen. They were also the most expensive I have ever seen. A small bunch of grapes cost $14. One cantaloupe was $120. A single strawberry was $5. Three peaches were $9. I asked my partner why the fruit was so expensive. He explained that when the fruit is newly budding on a plant, the farmers identify the most promising 10% and prune the other 90%. The full resources of the plant are then focused on the best 10% of the fruit.

The fruit was so expensive that I didn't buy any. I could only imagine what it tasted like until a client invited us into his home for dessert. My wife and two children were with me. We sat on the floor in his dining room, and he proceeded to serve what I estimate was $1,000 worth of fresh fruit. It was the best fruit I have ever eaten, so good that it was as if I had never eaten fruit before.

This is obviously an extreme example of the power of pruning, but the point is the same: when it comes to SKUs, less is usually more.

One of our major food industry clients recently brought to our attention the fact that in the short time we had been working with it, the most effective initiative we had put in place was RightSKUs. That initiative had reduced its total SKU base from 3,000 to 2,000 (a 33% reduction), and over that time the gross margin return on inventory, fill rate, and market share had increased substantially. The increase in the overall earnings before interest and taxes (EBIT) was in the multimillions.

Many organizations have initiated SKU rationalization projects, but many of those projects have died on the vine. The only means we have found to successfully carry out a pruning project is to follow a facilitated methodology and *make the project a process*. We have developed a formal methodology for SKU rationalization called RightSKUs. By using the RightSKUs methodology we develop formal criteria for evaluating the value of an SKU. The project team assigns a weight to each SKU valuation criterion, and all the SKUs are given a valuation ranking. That ranking is used and updated in an ongoing process and series of RightChain meetings (Figure 4.15) that institutionalize the pruning process.

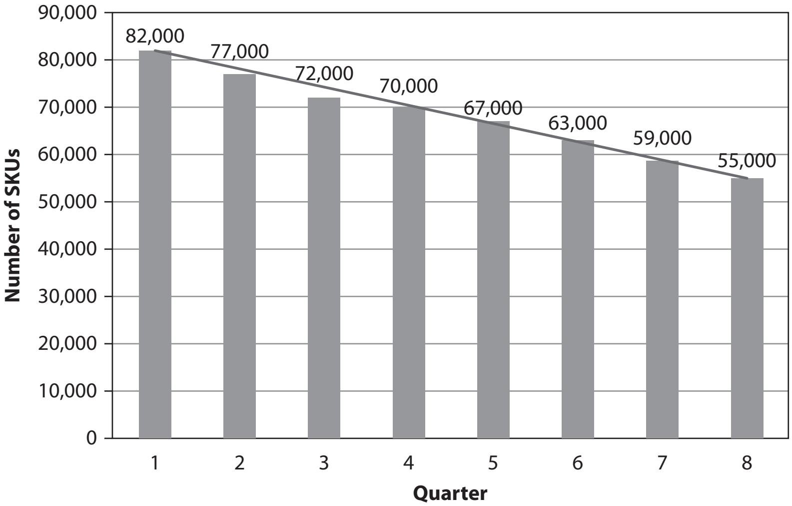
A recent SKU valuation we completed for a major plastics company is shown in Figure 3.10. In this analysis we included pounds sold, EBIT, EBIT per pound, and EBIT % in the most valuable SKU rankings. We sometimes call this valuation a Most Valuable SKUs ranking. The ABCD categories are used in the customer service policy, with service levels differentiated for A, B, and C SKUs. D SKUs are pruned.

Step by Step Pruning is painful. You probably know that from times in your personal life when you had to cut out certain activities or certain relationships that were not profitable or were even harmful. It comes up in supply chain strategy when someone in marketing and/or product development has to face the fact that his or her SKU is no longer valuable. Simplification is rarely easy or popular. It challenges the status quo. It is in vogue in many organizations to boast about the complexity of the work even if that complexity is non-value-added and self-inflicted. In contrast, simplification is profitable and is one of the key common denominators of successful supply chain organizations.

Instead of radical SKU reductions, some of our clients have had success piloting and implementing SKU optimization incrementally. An incremental SKU optimization from the CPG industry is shown in Figure 3.11. The program yielded a $7 million increase in profitability.

Once the ideal portfolio has been developed, diligence is required to maintain it. With one retail client we implemented a simple rule requiring that every new SKU introduction be accompanied by the SKU that would be pruned as a result.

Figure 3.11 Incremental RightSKUs Implementation



3.2 RIGHTCAST: FORECAST OPTIMIZATION

A few years ago we assisted a major sporting goods company with its inventory strategy. On the basis of my observations of the company's inventory and supply chain, I made a strong recommendation that it implement forecasting. The CIO interrupted my presentation and strongly disagreed. He said, "We are not going to do forecasting!" I was taken aback by the interruption and the forcefulness of his rebuke. I asked him, "Why are you not going to forecast?" He said, "Because the forecast will be wrong." I wanted to say "Duhhhh" but restrained myself and instead said, "You are right. There is only one source of perfect forecasting Whom I know, but He does not work for most supply chains. However, wouldn't you like to know how far off your forecast is, in what direction, and if it is getting better or worse?"

The CIO's strong reaction to my recommendation that the company implement forecasting may sound unusual, but I didn't find it that far from the norm. The vast majority of organizations don't forecast at all, forecast at such a high level that it is practically irrelevant for inventory planning purposes, and/or don't hold anybody accountable for it, which is tantamount to not forecasting at all.

Forecasting plays a pivotal and vital role in determining required inventory levels. Forecasting also influences nearly every supply chain decision. As a result, the degree to which forecasting is in error foreshadows the error in all supply chain decision making.

Even a small improvement in forecast accuracy can yield substantial inventory savings. In a recent project with a major engine manufacturer we found that every 10% improvement in forecast accuracy yielded a 5% reduction in inventory (Figure 3.12). In that particular case the reduction was worth more than $5 million in safety stock inventory.

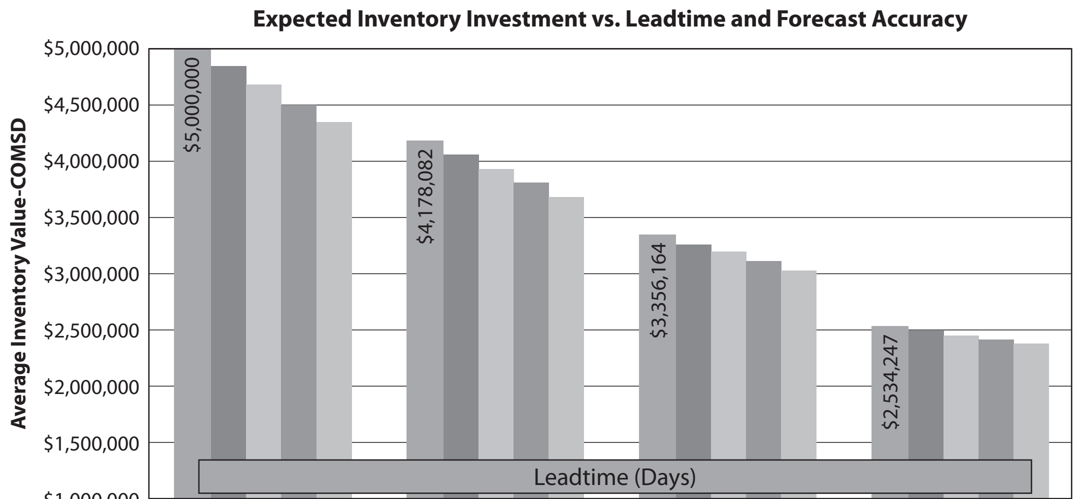
RightCast Simulation A simulation of the benefits of forecast optimization for a single SKU at a large toy company is presented here. The baseline inventory profile for the SKU was shown in Figure 2.24.

Suppose we implement a few RightCast practices such as forecast bias identification and minimization, individual accountability and dedication to forecast accuracy, back casting, and rapid error correction. In this case those practices helped reduce forecast error from 140% to 80% (Figure 3.13). What is the ripple effect (Figure 3.14)?

As you would expect, less safety stock inventory is required to support the same target fill rate of 92%. In this case safety stock inventory value (SSIV) declines from $60,630 to $34,646, a savings of $25,984. Average inventory value (AIV) declines by the same amount. The resulting inventory carrying cost declines from $42,632 to $30,680, a savings of $11,953 per year. Inventory turn rate increases from 1.24 to 1.72, an increase of 39%. GMROI increases from 144% to 200%, a 39% increase. Inventory Value Added (IVA) increases from $90,768 to $102,721, a 13% increase. Inventory Policy Cost™ (IPC) declines from $49,112 to $37,160, a 24% decrease.

Is a 43% reduction in inventory investment, a 39% increase in inventory turns, an increase in GMROI from 144% to 200%, a 13% increase in Inventory Value Added, and a 24% decrease in Inventory Policy Cost worth the

Figure 3.12 Forecast Accuracy and Inventory Savings



Leadtime Forecast Error %	100	75	50	25
100%	$5,000,000	$4,178,082	$3,356,164	$2,534,247
95%	$4,835,353	$4,054,268	$3,273,182	$2,492,097
90%	$4,672,023	$3,931,770	$3,191,517	$2,451,264
85%	$4,507,376	$3,807,956	$3,109,852	$2,410,432
80%	$4,342,729	$3,684,141	$3,026,870	$2,369,600

Figure 3.13 RightCast Simulation for a Large Toy Company

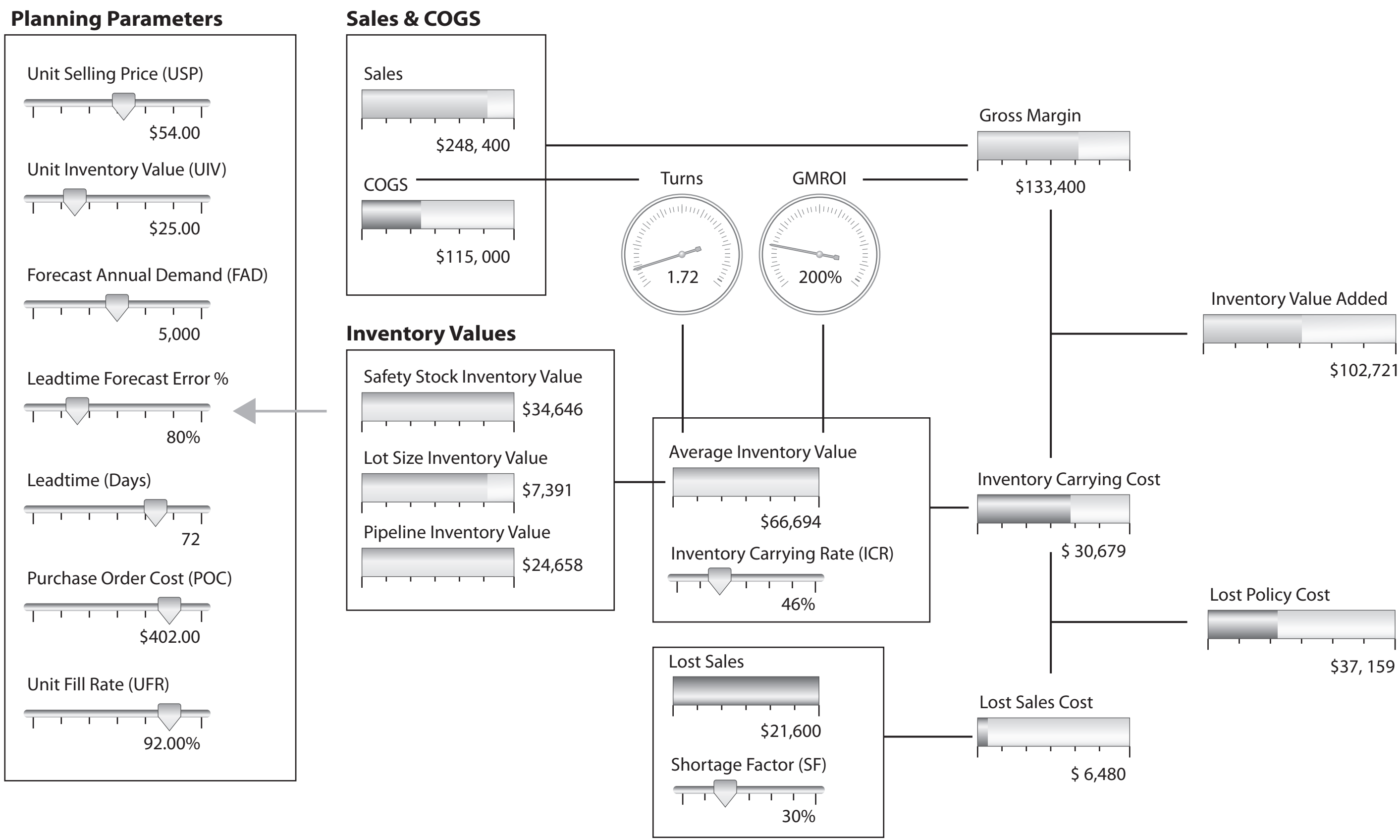


Figure 3.14 RightCast Simulation Results for a Large Toy Company

	Baseline		RightCast™		Improvement		%
Unit Selling Price (USP)	$	54.00	$	54.00			
– Unit Inventory Value (UIV)	$	25.00	$	25.00			
Unit Gross Margin (UGM)	$	29.00	$	29.00			
× Forecast Annual Demand (FAD)		5,000		5,000			
Gross Margin Potential (GMP)	$	145,000.00	$	145,000.00			
× Unit Fill Rate (UFR)		92.00%		92.00%			
Gross Margin (GM)	$	133,400.00	$	133,400.00			
Leadtime Forecast Error % (LFEP)		**140%**		**80%**		60%	43%
Leadtime (Days)		72		72			
Purchase Order Cost (POC)	$	402.00	$	402.00			
Safety Stock Inventory Value (SSIV)	**$**	**60,630**	**$**	**34,646**	$	25,984	43%
+ Lot Size Inventory Value (LSIV)	$	7,391	$	7,391			
+ Pipeline Inventory Value (PIV)	$	24,658	$	24,658			
Average Inventory Value (AIV)	**$**	**92,679**	**$**	**66,695**	$	25,984	28%
× Inventory Carrying Rate (ICR)		46%		46%			
Inventory Carrying Cost (ICC)	**$**	**42,632**	**$**	**30,680**	$	11,953	28%
Inventory Turn Rate (ITR)		**1.24**		**1.72**		0.48	39%
GMROI		**144%**		**200%**		56%	39%
Inventory Value Added™	**$**	**90,768**	**$**	**102,721**	$	11,953	13%
Lost Sales (LS)	$	21,600	$	21,601			
Shortage Factor (SF)		30%		30%			
Lost Sales Cost (LSC)	$	6,480	$	6,480			
Inventory Policy Cost (IPC)	**$**	**49,112**	**$**	**37,160**	$	11,953	24%

effort? Most likely. In fact, we have yet to conduct a project in which there was not an overwhelming business case for pursuing a RightCast initiative.

3.3 RIGHTTIMES: LEAD TIME OPTIMIZATION

There is a nearly maniacal emphasis on lead time reduction in many organizations. A few years ago we completed a supply chain benchmarking project with a large company in the computing industry. I met a group of engineers there unlike any I had ever met before: the velocity engineering group. I asked what they did, and they explained that their entire purpose was to reduce cycle times in all the processes in the company. They all spoke like auctioneers and lived in their own secretive subculture, kind of like a secret society of cycle time ninjas. They were not the kind of people I like to hang out with, but they were very effective at taking time out of processes.

Another company recently called and asked how they could reduce their cycle time in aircraft engine repair. I asked them how long it currently took them. They said it required seven days, including the round trip to Europe. In light of how short the cycle time already was, I was stunned that they were even asking. They insisted that I consider the question. I asked them what the cycle time had been before it was reduced to seven days. They said it had been 21 days. I asked them how they had condensed the cycle time to seven days. They said they value stream mapped the process into daily buckets and found opportunities to work activities in parallel and eliminate wasted time. I encouraged them to repeat the process but to use hourly buckets and look specifically at which days in the week and which hours in the day each activity would be performed. They took my suggestion and are now working the international process in 4.5 days.

Lead time often plays a dominant role in the inventory required to support a supply chain strategy. It contributes directly to pipeline inventory and safety stock inventory.

In safety stock inventory, lead time has a multiplicative effect. My friend at Honda, Chuck Hamilton, uses a golf analogy to explain the effect. If a golfer hits a ball 100 yards off the tee with the face off center by 10%, the ball will be only 10 yards off center at the end of its flight and still on the fairway. If a golfer hits a ball 200 yards off the tee with the face off center by 10%, the ball will be 20 yards off center at the end of its flight and barely on the fairway. If a golfer hits a ball 300 yards off the tee with the face off center by 10%, the ball will be off center by 30 yards at the end of its flight and in the rough, probably the deep rough. The longer the lead time, the greater the impact of forecast errors.

In a recent project with a large food company we found that every day of lead time reduction was worth approximately $5 million (Figure 3.15).

In light of these results, the logical assumption is that shorter lead times are better. At the risk of appearing being a contrarian, I would say that *the right lead time is better*. Many customers do not value speed but prefer lead time consistency. Many customers, suppliers, and internal systems are not equipped to accommodate reduced lead times. Also, lead time reductions have a price tag. Some lead times are shortened by moving product more frequently with more expensive transportation modes (air versus ocean, truck versus rail, etc.). Some lead times are reduced by purchasing from local suppliers at a higher price. Some lead times are reduced through the use of forward stocking nearer the point of consumption, requiring extra inventory. Some lead times are reduced by investing in material handling automation to speed product through warehouses, distribution centers, ports, and factories. Those investments must be weighed against the benefits associated with the lead time reductions they bring.

RightTimes Simulation Determining the appropriate investment in lead time reduction is the purpose of RightTimes optimization and simulation. A RightTimes simulation for a single SKU at a large toy company is shown in Figure 3.16. In this case, a variety of lead time reduction options were under consideration, including alternative transportation modes, alternative transportation schedules, near sourcing, and receiving automation. Those options had the potential to reduce lead time from the baseline of 72 days (see Figure 2.24) to 40 days. What is the ripple effect (Figure 3.17)? How much could be justifiably invested in the options?

First, notice that safety stock inventory value drops from $60,330 to $33,683, a reduction of $26,947, or 44%. Pipeline inventory investment drops from $24,650 to $13,699, a reduction of $10,951, or 44%. Total inventory investment drops from $92,679 to $54,773, a reduction of $37,906, or 41%. Inventory carrying cost drops from $42,632 to $25,196, a reduction of $17,436 per year. Inventory turns increase from 1.24 to 2.10, a 69% increase. GMROI

Figure 3.15 Inventory Investment Versus Days of Lead Time for a Food Client

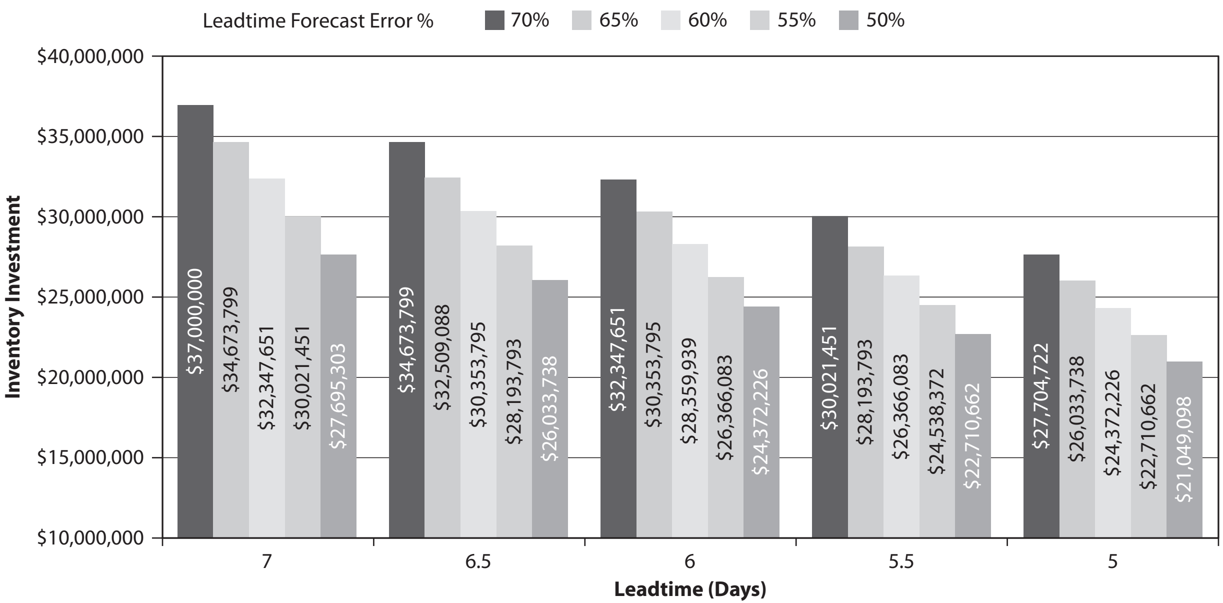


Figure 3.16 RightTimes Lead Time Simulation for a Large Toy Company

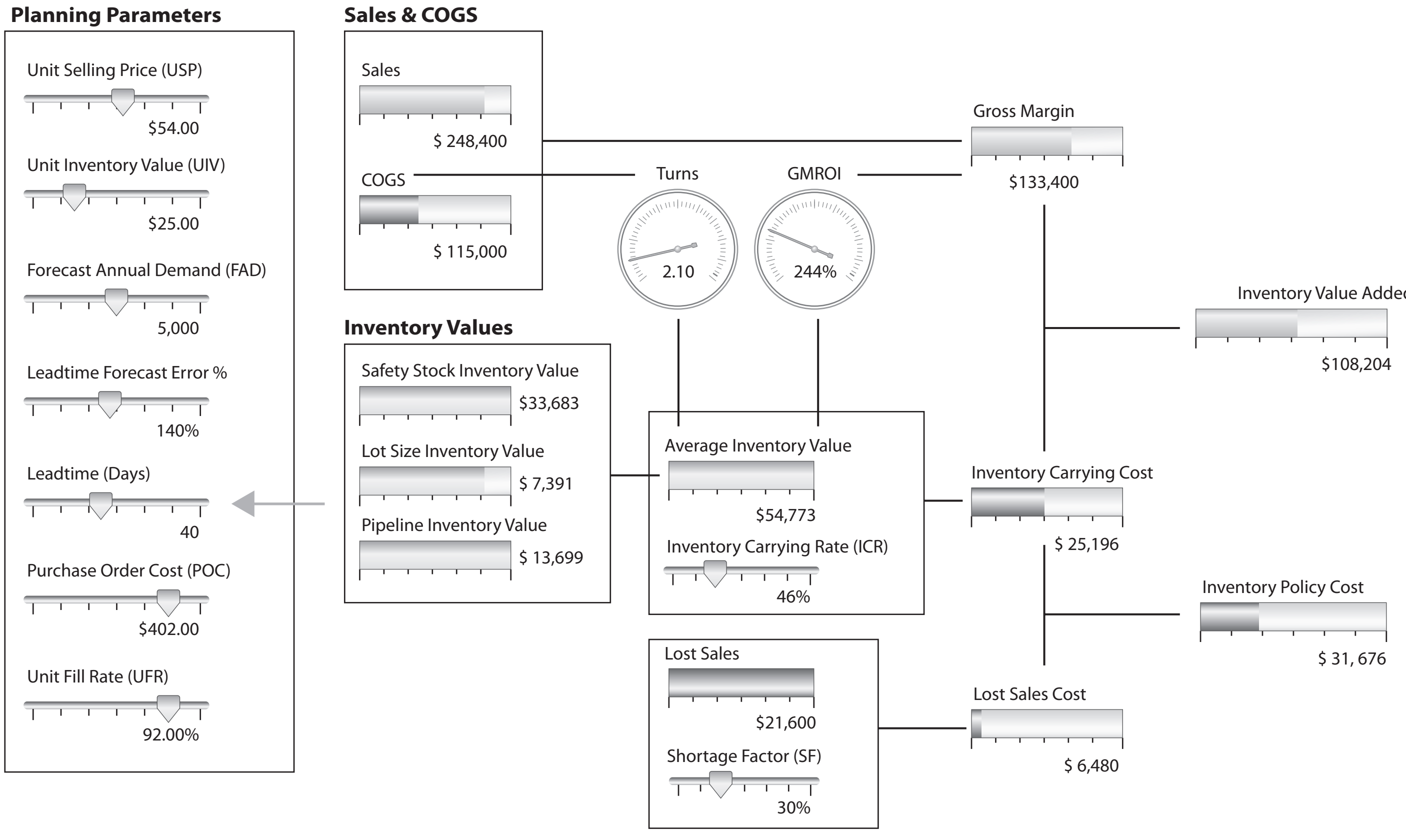


Figure 3.17 RightTimes Simulation Results for a Large Toy Company

Factor	Baseline		RightTimes™		Improvement		%
Unit Selling Price (USP)	$	54.00	$	54.00			
– Unit Inventory Value (UIV)	$	25.00	$	25.00			
Unit Gross Margin (UGM)	$	29.00	$	29.00			
× Forecast Annual Demand (FAD)		5,000		5,000			
Gross Margin Potential (GMP)	$	145,000.00	$	145,000.00			
× Unit Fill Rate (UFR)		92.00%		92.00%			
Gross Margin (GM)	$	133,400.00	$	133,400.00			
Leadtime Forecast Error % (LFEP)		140%		140%			
Leadtime (Days)		**72**		**40**		**32**	**44%**
Purchase Order Cost (POC)	$	402.00	$	402.00			
Safety Stock Inventory Value (SSIV)	**$**	**60,630**	**$**	**33,683**	**$**	**26,947**	**44%**
+ Lot Size Inventory Value (LSIV)	$	7,391	$	7,391			
+ Pipeline Inventory Value (PIV)	**$**	**24,658**	**$**	**13,699**			
Average Inventory Value (AIV)	**$**	**92,679**	**$**	**54,773**	**$**	**37,906**	**41%**
× Inventory Carrying Rate (ICR)		46%		46%			
Inventory Carrying Cost (ICC)	**$**	**42,632**	**$**	**25,196**	**$**	**17,436**	**41%**
Inventory Turn Rate (ITR)		**1.24**		**2.10**		**0.86**	**69%**
GMROI		**144%**		**244%**		**100%**	**69%**
Inventory Value Added™	**$**	**90,768**	**$**	**108,204**	**$**	**17,436**	**19%**
Lost Sales (LS)	$	21,600	$	21,601			
Shortage Factor (SF)		30%		30%			
Lost Sales Cost (LSC)	$	6,480	$	6,480			
Inventory Policy Cost (IPC)	**$**	**49,112**	**$**	**31,676**	**$**	**17,436**	**36%**

increases from 144% to 244%. Inventory Value Added increases from $90,768 to $108,204, a $17,436 increase, or 19%. Inventory Policy Cost drops from $49,112 to $31,676, a reduction of $17,436, or 36%.

Is a 41% reduction in inventory investment, a 69% increase in inventory turns, a 100% increase in GMROI, a 19% increase in Inventory Value Added, and a 36% reduction in Inventory Policy Cost worth the investment? In this case those percentages when applied to the entire SKU base yielded a $20 million reduction in inventory, an $8 million per year reduction in inventory carrying costs, turns increasing from 1.2 to 2.0, an increase in

GMROI from 150% to 250%, and an increase in Inventory Value Added of over $17 million. The investments in the alternative transportation modes and routes, near sourcing, and automated logistics and material handling systems required to accomplish the lead time reduction totaled approximately $4.5 million, yielding a payback against inventory carrying cost savings of 0.56 year.

3.4 RIGHTLOTS: LOT SIZE OPTIMIZATION

When I teach lot size optimization, I like to use an example that is close to home. Suppose you live in Georgia and there is only one ATM machine in that state. The single ATM is in a small, remote town in southern Georgia. The ATM is open only during the last week of July. To get whatever cash you need, you endure a trip down heavily congested country roads through swarms of gnats in humidity so thick that you need an umbrella and heat so intense that you think you are in a sauna; you put up with all this to stand in lines so long that you think you are at Disney World. One last thing: when you finally get your turn at the ATM, the fee to withdraw your money is $1,000. How much money will you withdraw? Yep. All of it. While it is not in the bank, it is not earning interest. It is likely to get lost or stolen, and if you are like me, you are much more likely to spend it.

The sum total of the hassle, the pain, and the withdrawal fee equates to the transaction cost. In general, the higher the transaction cost is, the fewer times a person wants to endure the transaction.

In manufacturing and production contexts, the transaction cost related to lot sizing is the cost, hassle, and time of setting up or changing over a production line. The higher the cost, the longer the time, and the greater the hassle, the fewer times we want to execute the transaction. Thus, when we get the line set up, we should run it for a while. The result may be a lot of inventory. (No wonder it's called a lot size.)

In the purchasing and procurement context, the cost related to the time, telecommunications, planning, and execution of a purchase order is the transaction cost. As was the case with production, the higher the cost, the longer the time, and the greater the hassle, the fewer times we want to execute the transaction. Therefore, when it comes time to place a purchase order, we are going to order a lot.

Now, let's run the southern Georgia ATM tape back and fast-forward to another time. Suppose there is an ATM machine within arm's reach wherever you are. It is open 7 × 24 × 365. There is no withdrawal fee (amazingly, you access your own money for free). How much will you withdraw each time? Yes, just enough for the next few minutes or until some more cash is needed.

In manufacturing, if it's free and requires no time to set up or change over a line, we can afford as many setups as we wish. Manufacturing lot size inventory in those cases should be minimal. In procurement, if it's cost- and hassle-free to place a purchase order, we can afford to place as many as we like. Procurement lot size inventory in those cases should be minimal.

Transaction costs should go a long way toward determining the size of the transaction. Surprisingly, not many supply chain organizations can tell you the true cost of their most important supply chain transactions: setup costs, changeover costs, purchase order costs, freight bill payment costs, transportation setup costs, and so on. As a result, lot sizing is often overlooked as an opportunity to improve inventory and supply chain performance. Lot sizing has become a lost science in supply chain optimization. Even the economic order quantity is one of the babies thrown out with the bathwater.

In an attempt to reinstitute lot sizing in supply chain strategy, we developed and now execute lot size deviation analyses as part of most supply chain assessments. We typically find that lot sizes are off in one direction or another by 100 to 300%. An example from a large food and beverage company is shown in Figure 3.18. Note that the lot sizes for 86.5% of the SKUs were undersized to the tune of 50% of the optimal lot size. Once this

Figure 3.18. RightLots Lot Size Deviation Analysis in a Food and Beverage Company

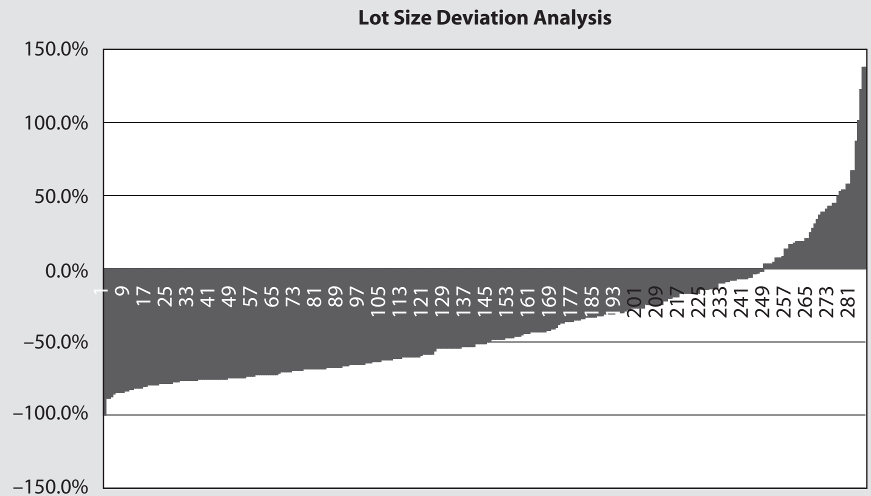
LRI's RightStock™
Inventory Optimization System™

Number of SKUs Overbuilt	39
% SKUs Overbuilt	13.5%
Avg. % Deviation When Overbuilt	35.8%

249	Number of SKUs Underbuilt
86.5%	% SKUs Underbuilt
–51.5%	Avg. % Deviation When Underbuilt

Lot Size Deviation Analysis

The Lot Size Deviation Analysis compares current purchase and run quantities with optimal purchase and run quantities. A 0% deviation means that the current purchase or run quantity is optimal. A deviation above the line indicates a purchase or run quantity that is too large.



was corrected, total supply chain costs were reduced by more than $10 million, with the majority of those savings accruing from higher manufacturing productivity.

RightLots Simulation As the prevailing trade press winds have blown toward lower and lower inventory, they have carried with them a move toward smaller and smaller lot sizes, highly flexible production cells, mixed-model rapid changeovers, and lot sizes approaching one. In many cases and for many SKUs there is a high return on investment for reducing lot sizes, and in many cases there is not. Computing and implementing optimal lot sizes for manufacturing run lengths and purchasing lot sizes is the focus of RightLots lot size optimization. A lot size simulation is shown in Figures 3.19 and 3.20.

In the example, procurement process mapping, e-procurement, blanket ordering, and receiving automation were all under consideration. In combination those initiatives were estimated to reduce the purchase order cost from $402 per purchase order to $100 per purchase order. As one would expect, the optimal lot size inventory is significantly reduced, dropping from $7,391 to $3,686, a 50% reduction in lot size inventory value. However, since lot size inventory represents only a small portion of total inventory in this case, the reduction in lot size inventory yielded only a 4% reduction in expected total inventory investment. The related percentage improvements in inventory carrying rate, turns, GMROI, Inventory Value Added, and Inventory Policy Cost are on a similar negligible scale, ranging from 2% to 4%.

As a result, in this situation, the effort to reduce purchase order and setup cost should take a backseat to higher-priority work on safety stock and pipeline inventory. That is not always the case. In many projects we engage in, lot size inventory constitutes the majority of total inventory value and excess inventory. In those cases, lot size inventory should be the focal point for inventory optimization.

Figure 3.19 RightLots Simulation for a Large Toy Company

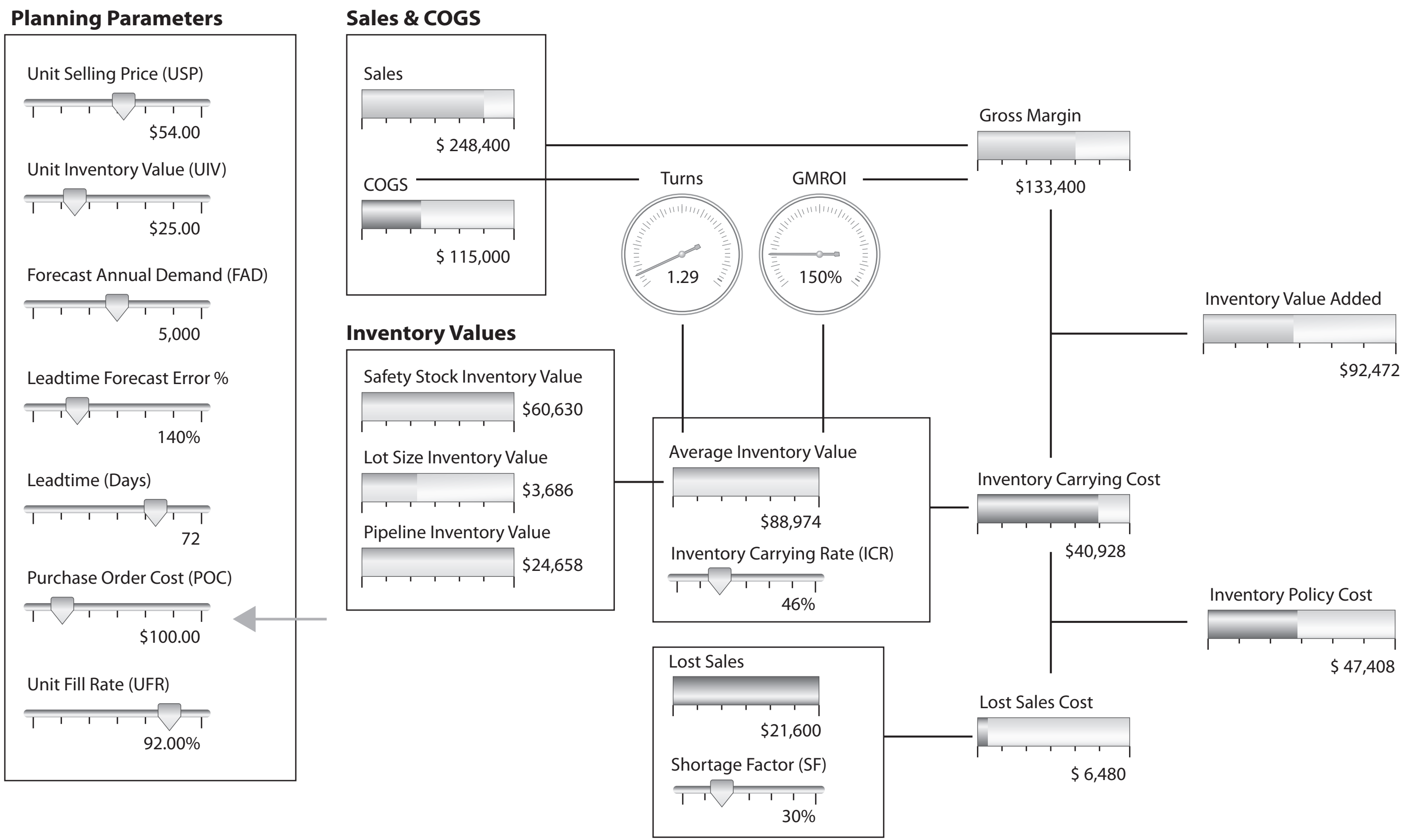


Figure 3.20 RightLots Simulation Results for a Large Toy Company

Factor	Baseline		RightLot™		Improvement		%
Unit Selling Price (USP)	$	54.00	$	54.00			
– Unit Inventory Value (UIV)	$	25.00	$	25.00			
Unit Gross Margin (UGM)	$	29.00	$	29.00			
× Forecast Annual Demand (FAD)		5,000		5,000			
Gross Margin Potential (GMP)	$	145,000.00	$	145,000.00			
× Unit Fill Rate (UFR)		92.00%		92.00%			
Gross Margin (GM)	$	133,400.00	$	133,400.00			
Leadtime Forecast Error % (LFEP)		140%		140%			
Leadtime (Days)		72		72			
Purchase Order Cost (POC)	**$**	**402.00**	**$**	**100.00**			
Safety Stock Inventory Value (SSIV)	$	60,630	$	60,630			
+ Lot Size Inventory Value (LSIV)	**$**	**7,391**	**$**	**3,686**	**$**	**3,705**	**50%**
+ Pipeline Inventory Value (PIV)	$	24,658	$	24,658			
Average Inventory Value (AIV)	**$**	**92,679**	**$**	**88,974**	**$**	**3,705**	**4%**
× Inventory Carrying Rate (ICR)		46%		46%			
Inventory Carrying Cost (ICC)	**$**	**42,632**	**$**	**40,928**	**$**	**1,704**	**4%**
Inventory Turn Rate (ITR)		**1.24**		**1.29**		**0.05**	**4%**
GMROI		**144%**		**150%**		**6%**	**4%**
Inventory Value Added™	**$**	**90,768**	**$**	**92,472**	**$**	**1,704**	**2%**
Lost Sales (LS)	$	21,600	$	21,600			
Shortage Factor (SF)		30%		30%			
Lost Sales Cost (LSC)	$	6,480	$	6,480			
Inventory Policy Cost (IPC)	**$**	**49,112**	**$**	**47,408**	**$**	**1,704**	**3%**

3.5 RIGHTPLOY: INVENTORY DEPLOYMENT OPTIMIZATION

Sometimes it's not the amount of inventory but where it is located that makes the difference. The allocation and assignment of inventory to multiple locations is called inventory deployment. It is one of the most complex inventory strategy decisions because it opens up interdependencies with customer response times, transportation costs, and redeployment costs and concerns. I always advise our clients that all things being equal, fewer stocking locations is better than more.

What is the likelihood of a misdeployment if there is only one facility? Zero. Once the deployment can of worms is opened, the range of options is nearly endless, running from a single central facility to consigned inventory in every customer location. Determining where to land in that spectrum is called deployment optimization.

The range of deployment scenarios is nearly infinite. We recommend a rigorous process to narrow the options to a few high-potential candidate deployment scenarios for evaluation. The process includes collecting and analyzing a comprehensive database to support the decision making, brainstorming to identify candidate deployment scenarios and scenario evaluation criteria, and doing rigorous analytic modeling. We have been down those roads a few times. The best way to teach deployment optimization may be to share a few examples.

Everybody Wants a Warehouse A few years ago we developed a supply chain strategy for the spares group in a large semiconductor company. The catalyst for the project was a request from the company's sales group to provide each customer with his or her own spares warehouse inside his or her facility. That's great customer service but very expensive. It was an easy thing for sales to request since that department was not paying for inventory or supply chain expenses.

We were engaged to help the company determine the conditions under which customers "earned" their own warehouses. We developed a deployment simulation system to help the company answer that question on an ongoing basis (Figure 3.21).

We began by working with finance to develop a return on asset threshold for customer warehouses. Using estimated revenue, inventory consumption, and location logistics, we estimated return on assets (ROA) for on-site stocking for each customer. Customers were assigned on-site inventory on the basis of their predicted ROA. Customers who did not qualify for the on-site spares program were given the option to increase their volume to qualify.

Sales and marketing accepted the responsibility of the additional supply chain costs of supporting on-site inventories. The key was having finance, sales, and supply chain collaborating to work through the decision with reliable data and a real-time decision support tool.

Predeploy It One of our clients is a large food company that delivers on a direct store delivery (DSD) basis to grocery chains around the Southeast. Its historical deployment strategy had been to centralize and hold inventory, delaying deployment for as long as required delivery windows would permit. The approach was based on the lean principle of inventory postponement: holding back inventory in a central location until an order is received. It could be called delayed deployment or deploy to order.

After looking at the company's outbound transportation cost I suspected that that approach might be overly expensive. They were willing to have a look at some other options. The resulting analysis is shown in Figure 3.22. The figure is a screen shot from our Multi-Echelon Inventory Optimization System. The system considers multiple network configuration options for each SKU. Network configuration options are defined as the number of central warehouses, the number of regional warehouses, and the number of local warehouses. In the example a single central warehouse serves 12 sales centers that each serve 17 small depots. After one minimizes the total logistics cost, including transportation, inventory carrying, and lost sales costs, an optimal inventory deployment emerges. The key is to understand the optimal allocation and assignment of inventory for each type of SKU. In this case the recommended deployment is 20/30/50: 20% of the inventory held centrally, 30% held regionally, and 50% deployed in depot locations near large customers. The previous deployment had been 60/20/20. The revised deployment was worth $12 million in total logistics cost savings.

Serving the World from Cleveland Sometimes it goes the other way. A few years ago one of our industrial supplies clients asked us to help it with a global network strategy. The company was headquartered in Cleveland, Ohio, and served all of Europe and Asia from there. Its Asian business had grown quite rapidly, and it suspected that an Asian distribution hub might be necessary and beneficial to improve customer service and reduce supply chain costs. That intuition was logical. Certainly it would be faster and less expensive to serve Asia from Asia. Not necessarily!

As we normally do, we developed a few candidate scenarios. Since over half the company's Asian business was in Japan, one candidate scenario was to have a Japan hub. It turned out that because of poor schedules out of Japan for their cargo and excellent schedules provided by their carrier in Cleveland, it would take longer to serve their Asian clients from Japan than from Cleveland. In addition, because of the high cost of Japanese space and labor and the extra handling step required to add a hub, supply chain costs were higher.

Since Singapore was their second largest Asian market and is an excellent logistics hub, a Singapore hub was the other option we considered. The Singapore option turned out to offer slightly better service—a half day closer in the worst case—but was still more expensive: $500,000 additional per year. Is a half a day better service in the worst case worth $500,000? That's an answer the executives have to provide. In this case I suggested that they pilot a small DC with a third-party logistics provider (3PL) and monitor the results. So far, Cleveland is looking better and better.

Supply chain logistics is nonlinear and often counterintuitive. The more interdependencies there are, the more nonlinear and counterintuitive it becomes. That's why it is so important to work with comprehensive and holistic analytical models in considering each unique supply chain situation.

3.6 RIGHTSIGHT: INVENTORY VISIBILITY OPTIMIZATION

To a large extent, inventory levels are about trust. Since we tend to not trust what we can't see, any blind spots or poor visibility in the supply chain will be places where excess inventory accumulates. The value of visibility is *replacing information about inventory for inventory*.

During a project with a home improvement company I sat with one of the buyers for an hour to get familiar with his work. Early in the hour he placed a large order for a replenishment of lumber. Toward the end of the hour he placed the same order for the same quantity with the same vendor. I asked why. He explained that if he did not receive electronic notification from the vendor that it had received the order, he reordered. I asked him if he canceled the original order. He said no. I asked why he had not canceled the original order. He said that he wanted to make double sure the vendor received the order. I asked him if he was afraid of having too much inventory. He said no, explaining that the person in his position before him had been fired for running out. The lack of visibility, which in this case was the lack of an electronic acknowledgment from the supplier, led to excess inventory.

Inventory accuracy is a major contributor to inventory visibility. Suppose you are a buyer for a retailer and you get to keep your job if the stores in your region do not run out of stock. However, the warehouse for your region has an inventory accuracy of 60%, as was the case in a recent engagement of ours. How much extra inventory will you procure? At least 40% but potentially more. If the accuracy is that poor, it is difficult to trust any number reported by that DC.

The appetite for inventory visibility in the supply chain is nearly insatiable. With bar codes, quick response (QR) codes, radio-frequency identification (RFID) tags, and Global Postioning Systems (GPS), nearly any level of inventory visibility is feasible. The difficult issue is determining what level and what type of visibility are valuable. Just as in other investment decisions, there are marginal returns toward the tail end of the benefits curve. The proper approach is to develop progressively more comprehensive visibility scenarios, estimate the return and investment for each, and choose a visibility path forward. We call that RightSight: determining the most appropriate points, transactions, and types of inventory visibility in the supply chain.

Our RightSight scenario generation template is shown in Figure 3.23. We consider each document, each transaction, each node, and each link in the supply chain and recommend the optimal level and type of visibility. We measure the degree of visibility as the percentage of SKUs and the percentage of supply chain transactions in compliance with the visibility program.

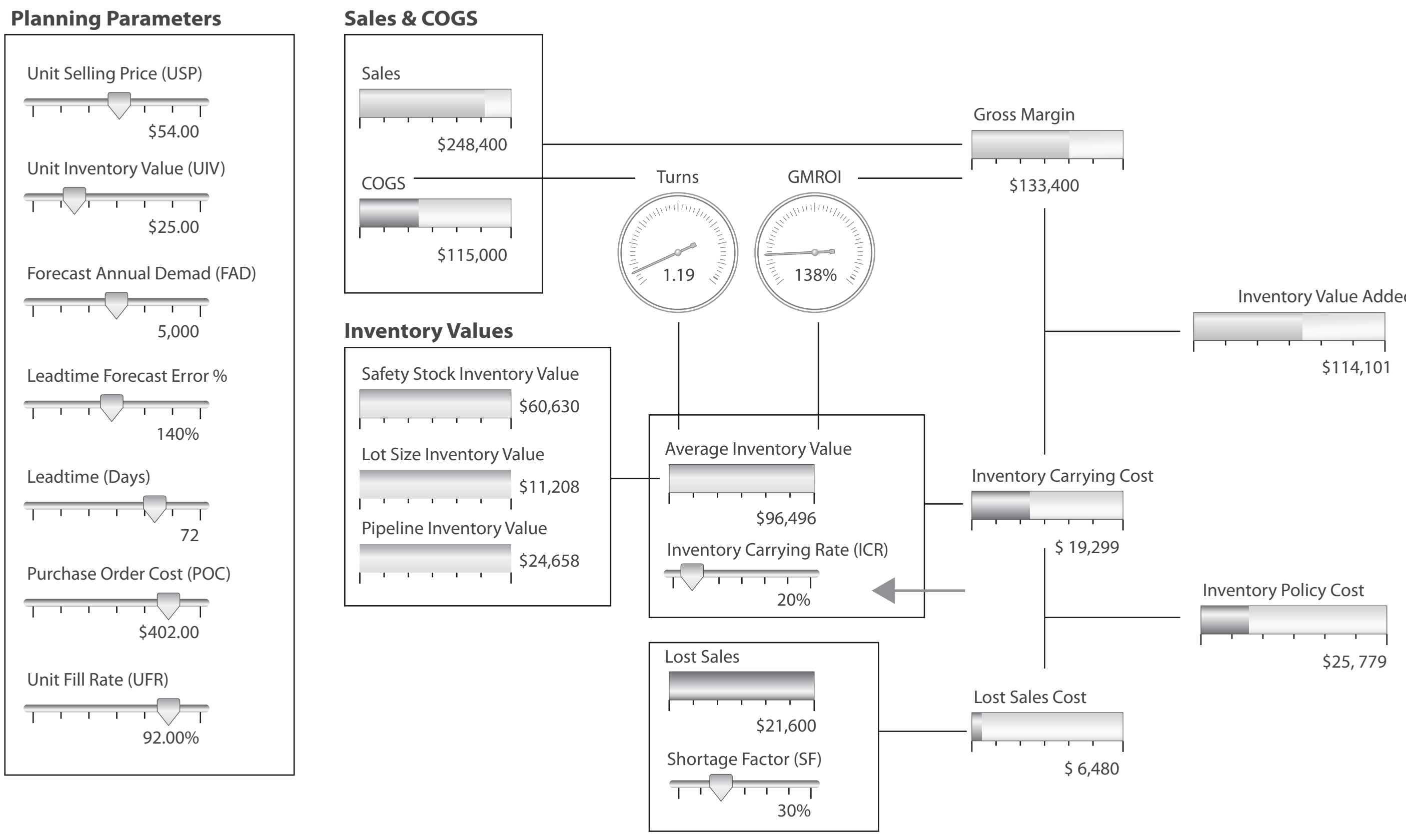
3.7 RIGHTRATE: INVENTORY CARRYING RATE OPTIMIZATION

The inventory carrying rate is the cost of carrying a dollar of inventory for one year. It includes the opportunity cost of capital, the cost of storage and handling, loss and damage, obsolescence and markdowns, and insurance and taxes. The rate determines the financial viability of holding inventory. If it is inexpensive to carry inventory, it becomes less expensive to provide higher fill rates and shorter response times. The inventory carrying rate is a critical factor in nearly all inventory calculations, yet very few organizations recognize it or compute it.

Since few organizations have an inventory carrying rate, there is very little understanding of its impact on inventory strategy. Even when companies have an inventory carrying rate, they assume that it is fixed. They overlook the fact that it, like forecast accuracy, lead time, purchase order cost, setup cost, and so forth, plays a major role in inventory optimization. The inventory carrying rate should be evaluated as a potential source for process improvement and investment. For example, warehouse process improvements and related material handling equipment (MHE) and WMS investments typically yield higher warehouse labor productivity, higher warehouse storage density, higher levels of inventory accuracy, and lower damage and loss rates. As a result, storage and handling costs can be significantly reduced, yielding a much lower inventory carrying rate. In addition, relocating to locales with lower interest, tax, and duty rates results in lower inventory carrying rates. One of our industrial supplies clients moved its distribution operations three blocks and paid for the move and a fully automated DC with the savings it achieved in inventory carrying costs. The savings accrued from a lower inventory carrying rate that was a result of lower inventory taxes in the adjacent county and the free trade zone status available in the new facility.

RightRate Simulation An inventory strategy considering relocation and DC automation was being considered in the example shown in Figure 3.24. It was thought that there was the potential to reduce the inventory carrying

Figure 3.24 RightRate Simulation for a Large Toy Company



rate from 46% to 20% per year. The expected inventory investment increases slightly by 4%; however, the cost to carry the inventory drops dramatically by 55%, yielding a 26% increase in Inventory Value Added and a 48% decrease in Inventory Policy Cost. In this case, those percentages represented savings in excess of $7 million per year in inventory carrying and total supply chain costs and an increase of over $3 million per year in Inventory Value Added and economic value added (EVA) for the client. Those savings easily paid for the $2.5 million investment required for warehouse process improvements and MHE/WMS investments (Figure 3.25).

Figure 3.25 RightRate Simulation Results for a Large Toy Company

Factor	Baseline		RightRate™		Delta		%
Unit Selling Price (USP)	$	54.00	$	54.00			
– Unit Inventory Value (UIV)	$	25.00	$	25.00			
Unit Gross Margin (UGM)	$	29.00	$	29.00			
× Forecast Annual Demand (FAD)		5,000		5,000			
Gross Margin Potential (GMP)	$	145,000.00	$	145,000.00			
× Unit Fill Rate (UFR)		92.00%		92.00%			
Gross Margin (GM)	$	133,400.00	$	133,400.00			
Leadtime Forecast Error % (LFEP)		140%		140%			
Leadtime (Days)		72		72			
Purchase Order Cost (POC)	$	402.00	$	402.00			
Safety Stock Inventory Value (SSIV)	$	60,630	$	60,630			
+ Lot Size Inventory Value (LSIV)	**$**	**7,391**	**$**	**11,208**	**$**	**(3,817)**	**–52%**
+ Pipeline Inventory Value (PIV)	$	24,658	$	24,658			
Average Inventory Value (AIV)	**$**	**92,679**	**$**	**96,496**	**$**	**(3,817)**	**–4%**
× Inventory Carrying Rate (ICR)		**46%**		**20%**			
Inventory Carrying Cost (ICC)	**$**	**42,632**	**$**	**19,299**	**$**	**23,333**	**55%**
Inventory Turn Rate (ITR)		**1.24**		**1.19**		**(0.05)**	**–4%**
GMROI		**144%**		**138%**		**–6%**	**–4%**
Inventory Value Added™	**$**	**90,768**	**$**	**114,101**	**$**	**23,333**	**26%**
Lost Sales (LS)	$	21,600	$	21,600			
Shortage Factor (SF)		30%		30%			
Lost Sales Cost (LSC)	$	6,480	$	6,480			
Inventory Policy Cost (IPC)	**$**	**49,112**	**$**	**25,779**	**$**	**23,333**	**48%**

3.8 RIGHTSTOCK: INVENTORY OPTIMIZATION

Because they are synergistic in their effect, a well-developed inventory strategy should consider all seven RightStock principles—SKU assortment, forecast accuracy, lead time, lot sizing, deployment, visibility, and inventory carrying rate—together. That was our recommendation for this client. The results are shown in Figures 3.26 and 3.27. Forecast error was reduced from 140% to 80%. Lead time was reduced from 72 days to 40 days. Purchase order cost was reduced from $402 to $100 per transaction. Inventory carrying rate was reduced from 46% per year to 20% per year. As a result, every type of inventory was reduced dramatically, yielding an overall reduction in total inventory investment of 58%. Inventory carrying cost for the simulated SKU was reduced from $42,632 per year to $7,707 per year, an 82% decrease. Inventory turns increased from 1.24 to 2.98, a 140% increase. GMROI increased from 144% to 346%. Inventory Value Added increased from $90,768 to $125,693, a 38% increase. Inventory Policy Cost declined from $49,112 to $14,187, a 71% decline.

Is a 58% reduction in inventory, an 82% reduction in inventory carrying cost, a 140% increase in inventory turns, an increase in GMROI from 144% to 346%, a 38% increase in Inventory Value Added, and a 71% decrease in Inventory Policy Cost with no decrease in an already optimized service level worth the time, effort, and investment? In this case that combination of numbers represented over $40 million worth of inventory, $10 million per year savings in inventory carrying cost, $6.5 million in Inventory Value Added, and $10 million in Inventory Policy Cost reductions, easily paying for the $3.5 million investment required to accomplish them.

Figure 3.26 RightStock Simulation for a Large Toy Company

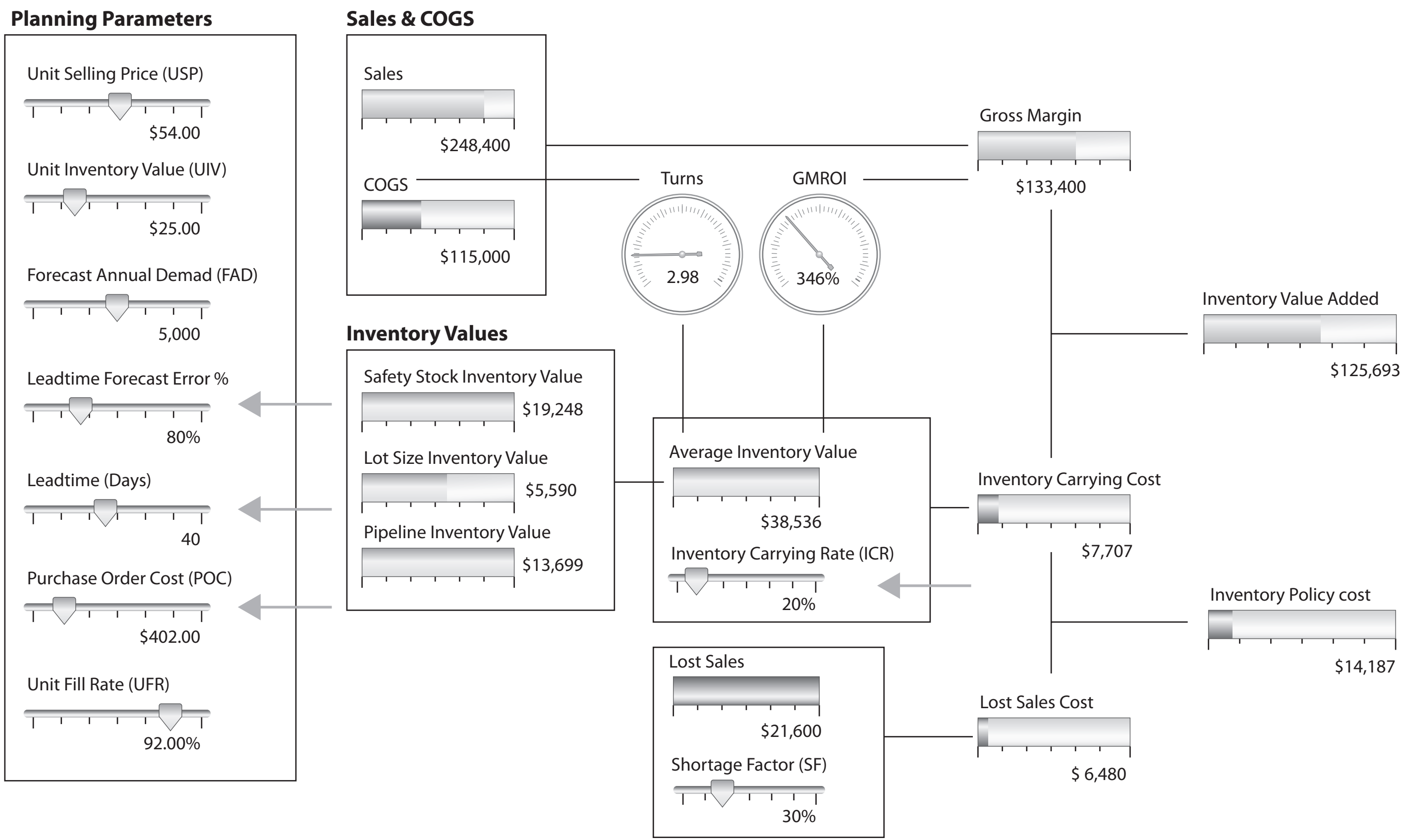


Figure 3.27 RightStock Simulation Results for a Large Toy Company

Factor	Baseline	RightStock™	Improvement	%
Unit Selling Price (USP)	$ 54.00	$ 54.00		
– Unit Inventory Value (UIV)	$ 25.00	$ 25.00		
Unit Gross Margin (UGM)	$ 29.00	$ 29.00		
× Forecast Annual Demand (FAD)	5,000	5,000		
Gross Margin Potential (GMP)	$ 145,000.00	$ 145,000.00		
× Unit Fill Rate (UFR)	92.00%	92.00%		
Gross Margin (GM)	$ 133,400.00	$ 133,400.00		
Leadtime Forecast Error % (LFEP)	**140%**	**80%**	60%	43%
Leadtime (Days)	**72**	**40**	32	44%
Purchase Order Cost (POC)	**$ 402.00**	**$ 100.00**	$ 302	75%
Safety Stock Inventory Value (SSIV)	**$ 60,630**	**$ 19,248**	$ 41,382	68%
+ Lot Size Inventory Value (LSIV)	**$ 7,391**	**$ 5,590**	$ 1,801	24%
+ Pipeline Inventory Value (PIV)	**$ 24,658**	$ **13,699**	$ 10,959	44%
Average Inventory Value (AIV)	**$ 92,679**	**$ 38,537**	$ 54,142	58%
× Inventory Carrying Rate (ICR)	**46%**	**20%**	26%	57%
Inventory Carrying Cost (ICC)	**$ 42,632**	**$ 7,707**	$ 34,925	82%
Inventory Turn Rate (ITR)	**1.24**	**2.98**	1.74	140%
GMROI	**144%**	**346%**	202%	140%
Inventory Value Added™	**$ 90,768**	**$ 125,693**	$ 34,925	38%
Lost Sales (LS)	$ 21,600	$ 21,601		
Shortage Factor (SF)	30%	30%		
Lost Sales Cost (LSC)	$ 6,480	$ 6,480		
Inventory Policy Cost (IPC)	**$ 49,112**	**$ 14,187**	$ 34,925	71%