Summary Results	Strategy A	Strategy B	Strategy C
PV Option Cost (Year 1)	$348,533	$1,595,697	$1,613,029
PV Option Cost (Year 2)	$4,224,487	$3,043,358	$4,494,950
PV Option Cost (Year 3)	$3,688,994	$10,105,987	$8,806,643
PV Revenues	$24,416,017	$33,909,554	$48,420,096
PV Operating Costs	$16,220,188	$16,765,513	$9,951,833
PV Net Benefit	$8,195,829	$17,144,041	$28,868,264
PV Cost to Purchase Option	$425,000	$169,426	$72,611
Maturity in Years	3.00	3.00	3.00
Average Risk-Free Rate	3.54%	3.54%	3.54%
Dividend Opportunity Cost	0.00%	0.00%	0.00%
Volatility	26.49%	29.44%	15.04%
Total Strategic Value with Options	$1,386,355	$4,466,540	$15,231,813

FIGURE 14.15 Summary real options analysis results.

deploying the CCOP systems to support the intelligence needs of the naval commanders and other intelligence gathering and analysis agencies in the federal government.

CASE STUDY: MANUFACTURING AND SALES IN THE AUTOMOTIVE AFTERMARKET

This case study was written by Andy Roff and Larry Blair with modeling assistance from the author. Both Andy and Larry are executives from the automotive aftermarket who have owned and managed several businesses. They each have 30 plus years of experience, specifically in the provision of information systems for the shared benefit of both suppliers and distributors. They can be contacted at larblair2@aol.com.

Background and History of the Automotive Aftermarket

The automotive aftermarket (AAM) started soon after the first horseless carriage made its way on to the world's roads more than a century ago. It happened perhaps within a couple of days when the original dog-clutch gave in to the abuse of its erstwhile horse-driving operator! And thus, the AAM was born the moment the first screw needed replacement. Over time, as makes and models of automobiles multiplied, so did the manufacturers of parts to repair and keep them running—some commissioned by the auto makers—with various manufacturing "pattern" parts of varying quality and durability. As of the time of writing, the world APA is approximately $800 billion per year, with a 3 percent expected growth rate going forward.

With so many different parts and suppliers, there was a need for reference books to identify the correct item, so giving birth to the parts catalog. Nothing much changed until the introduction of the microfiche in the 1960s, and that was used almost exclusively by the car makers' service and parts network. In skilled hands, this quasi-electronic database brought efficiency and speed to the parts sales and automotive repair processes. However, the wealth and complexity of the largely graphic-based content made its adoption by the competitive aftermarket nonviable.

Instead, the ubiquitous personal computer became a natural tool for the advent of electronic cataloguing in the early 1980s. A major hurdle that still had to be overcome was that the various proprietary systems demanded a high level of specific data formatting, which was an extremely costly exercise to undertake and conflicted with the existing print-oriented legacy practices of the catalog authors. Also, there was little point in the major aftermarket suppliers each devising and installing their own e-catalog versions when each one would demand a separate hardware platform to run on. Worse, these platforms could not integrate with the computerized point-of-sale (PoS) tills that were introduced in the late 1970s.

This demand vacuum was just too big, both conceptually and given the constraints of the available technology. The first European attempt concentrated on providing a standalone terminal, bringing together parts from multiple providers in a "bookcase" format. There was a common drill-down of available car makes and models with access to information compiled by each aftermarket supplier and designed for dissemination by trade associations. This system originated in the Netherlands and was also licensed for use in the United Kingdom during the early 1990s.

Although eventually a commercial failure, this system's introduction forced the parts suppliers and manufacturers to focus on e-data provision and begin the shift from a print-centric catalog-building mentality. This shift was reinforced by the ambitions of national parts distribution chains to provide "tied" e-catalogs and the leading PoS providers to add e-cataloguing capabilities to their terminals. Both initiatives increased the demands for e-data from suppliers and manufacturers.

In the United States, a national PoS provider decided on a massive investment in 1984, leading to the introduction of a dedicated, integrated e-catalog in 1985, followed by a European version 5 years later.

So the manufacturers' primary "shop window" took the form of these third-party e-cataloguing systems. They were forced to become less possessive about their data, had less control of timeliness and accuracy in the way it was presented to the marketplace, and had to provide multiple versions of the e-catalogs for the various national chains and third-party providers. In some cases, they were even obliged to pay to have it placed on display.

The Issues Facing the Industry

There is a silver lining to this particular cloud. Given that the formats of the data are now becoming increasingly common and indexed to an industry standard—in the United States, industry-sponsored lists are available—data will become increasingly consistent with a faster time to market. Now that technology is more advanced, graphics and illustrations on the part's characteristics, its location on the car, fitting tips, and other key information can all be linked into such a catalog. All of these improvements will help to increase the quality of the buying experience and enable individual manufacturers the ability to distinguish their offerings.

And there's more. Manufacturers' products can be accurately linked to a list of cars and that list of cars can be linked to state-provided car population statistics. Now production and distribution strategies can be subjected to risk analysis, simulation, forecasting, optimization, and real options analysis. When all the possible components impacting on a decision to manufacture or source the supply of a given replacement part are taken into consideration, it shows just how fragile and error-prone traditional decision-making methods must be.

The Analytical Complexity

An example case study is based on Casky Automotive Electrics, Inc., a theoretical private company specializing in the design and manufacturing of automotive products in support of the original equipment manufacturing (OEM) sector of the automotive industry. Casky's specialty is rotating electrics, commonly known as *alternators* and *starters*. The company has close ties with both Ford and General Motors (GM), and these firms have provided Casky with a basis for growing their business in both North America and Europe. As a development partner to two of the world's largest automotive manufacturers, Casky has supported the development programs of both manufacturers with engineering expertise that has led to manufacturing contracts for starter motors for some of the most recognized car models on the road. Those relationships have also led to contracts for some of the newest hybrid models in which fuel efficiency is maximized. These models place an even greater burden on the starter motor and therefore increase its cost and complexity. Casky has won a contract for the starter motor for the hypothetical new Phalynx hybrid minivan that was introduced by GM in 2005. GM has placed orders for the units that will be fitted to the cars during their assembly. However, Casky has also won the contract for the service support of the dealer network for replacement of starters as required by service demands. The automotive manufacturing industry is one of the largest (considering both economic value and employment) in those countries having a high vehicle registration. Certainly North America and Europe account for most of the vehicle registrations in the world and highest per capita ratios of car registrations in comparison to the general population.

Initial total sales of the Phalanx are predicted at 100,000 per year, rising to 150,000 in year 2 and reducing to 100,000 in year 3. Sales predictions for similar models in the past have been accurate to ±5 percent. The vehicle will be manufactured in mainland Europe and primarily marketed in Europe and North America. The eventual population of the model will vary across the European and North American states but will aggregate 55 percent and 45 percent in the two markets. Vehicle population statistics will be available annually from various external suppliers. A face-lift, as opposed to an all-new, model will be marketed in year 4, and sales are predicted to recover to 150,000 before declining steadily to 75,000 in year 5 prior to an all-new model launch. The total predicted model population will therefore be 575,000 with an annual scrap rate—attrition through either insurance total loss or being uneconomical to repair—of 2 percent compounded annually. There are two gasoline and one diesel versions with a prediction of equal demand for all three engine variations across the model range, with these engines serving both the original and face-lift versions, but not the all-new model.

Caskey is chosen to provide the starting motor for all three engines. They supply only new, as opposed to reconditioned, units both to GM and the automotive aftermarket (AAM). Each starting motor unit is different, having been specifically designed for a specific model, and has different wear characteristics with a minimum time before failure (MTBF) of 100,000 miles for the smaller gas engine, 85,000 miles for the larger gas engine, and 100,000 miles for the diesel version. The average annual user mileage is predicted at 12,000 for the smaller gas engine and 15,000 for both the larger gas engine and the diesel. There is a 2-year warranty on the units sold in mainland Europe and 3 years in the United Kingdom, Ireland, and North America.

There is a demand from GM of sufficient stock on hand for 1 week's production with a zero failure rate at fitting. The unexpected failure rate (that is, before MTBF and therefore resulting in a warranty claim) is 1:10,000. GM's retail service network has 250 outlets in Europe and 150 in North America, and each must hold at least two of each unit at the model launch. Caskey has three European and two North American distribution warehouses that service both GM's retail network and the AAM through both independent and chain parts retailers. The margin is the least on sales to the GM, +20 percent to the national chains, and +25 percent to the independents.

Caskey expects to supply 90 percent of units sold through GM's service network outside of warranty claims, but competes from the 4th year onward with other new unit manufacturers and in the 5th year onward with unit reconditioners. There is a single European new unit manufacturer with a distribution network in North America that introduces a modified starting motor, which also fits another model with an existing and out-of-warranty model with a similar population and engine mix. This new unit manufacturer expects to gain an initial 10 percent of the market for the new model, rising by 2 percent compound and 50 percent of the additional model where it was one of two vehicle parts manufacturers (VPMs) selected for the original equipment. Two unit reconditioners enter the market in North America and three in Europe, each expecting a 5 percent share of the market and each distributing only to the AAM. The reconditioners' ability to service the market is directly related to the return of worn units which in the first year of their operation (year 5 of production) is 100 percent from GM, reducing in subsequent years as more units from the other new unit VPM wear out. The MTBF for the reconditioned units is only 66 percent of that for the all-new units.

The Analytical Framework Applying Risk Analysis, Simulation, Forecasting, and Optimization

Setting up and solving the problem is not a trivial task, requiring facility with Risk Simulator's Monte Carlo simulation, forecasting, and optimization routines. Figure 14.16 illustrates a forecast model of the automobile demand based on the assumptions listed previously. Minimum, maximum, and most likely value ranges are also listed and each of the period's demand values is simulated (Figure 14.17); that is, the European and U.S. demands for each quarter are simulated such that the expected values of each year are in line with the foregoing assumptions of 100, 150, 100, 150, and 75 thousand vehicles, respectively.

Figure 14.18 illustrates the modeling of the additional requirements and restrictions of the demand forecasts, such as failure rates of the parts, scrap rates of the automobile model, and average miles driven per year. Note that all the highlighted cells in Figures 14.16 and 14.18 are simulation assumptions and each value is simulated thousands of times in the model. Next, an optimization model is developed based on these uncertainties in demand levels, as shown in Figure 14.19. In this model, we see that the decision variables are the quantity to manufacture; that is, to find the optimal quantity to manufacture given the uncertainty-based forecasted demand levels. Price per unit, failure rates, and average driving distance per year for a vehicle are all accounted for in the model. The analysis provides the optimal quantity to manufacture such that the total net profits are maximized, subject to excess costs of surplus and shortages in quantity on hand.

						Possible Ranges for Actual Auto Demand					
Period	Europe	USA	Total	Running Total	Annual Totals	Minimum Europe	Most Likely Europe	Maximum Europe	Minimum USA	Most Likely USA	Maximum USA
Year 1 Q1	11,001	8,996	20,000	20,000		10,451	11,001	11,551	8,546	8,996	9,445
Year 1 Q2	13,767	11,242	25,000	45,000		13,079	13,767	14,455	10,680	11,242	11,804
Year 1 Q3	19,266	15,763	35,000	80,000		18,303	19,266	20,230	14,974	15,763	16,551
Year 1 Q4	10,998	8,999	20,000	100,000	100,000	10,448	10,998	11,547	8,549	8,999	9,449
Year 2 Q1	16,497	13,504	30,000	130,000		15,672	16,497	17,322	12,828	13,504	14,179
Year 2 Q2	20,615	13,504	37,500	167,500		19,584	20,615	21,646	16,057	16,902	17,747
Year 2 Q3	28,892	23,629	52,500	220,000		27,447	28,892	30,336	22,448	23,629	24,810
Year 2 Q4	16,499	13,503	30,000	250,000	150,000	15,674	16,499	17,324	12,828	13,503	14,178
Year 3 Q1	10,997	8,995	20,000	270,000		10,447	10,997	11,547	8,546	8,995	9,445
Year 3 Q2	13,746	11,246	25,000	295,000		13,059	13,746	14,434	10,684	11,246	11,809
Year 3 Q3	19,253	15,737	35,000	330,000		18,290	19,253	20,216	14,951	15,737	16,524
Year 3 Q4	11,004	9,007	20,000	350,000	100,000	10,453	11,004	11,554	8,557	9,007	9,458
Year 4 Q1	16,500	13,498	30,000	380,000		15,675	16,500	17,325	12,823	13,498	14,173
Year 4 Q2	20,619	16,890	37,500	417,500		19,588	20,619	21,650	16,046	16,890	17,735
Year 4 Q3	28,882	23,637	52,500	470,000		27,438	28,882	30,326	22,455	23,637	24,819
Year 4 Q4	16,487	13,504	30,000	500,000	150,000	15,663	16,487	17,311	12,828	13,504	14,179
Year 5 Q1	8,246	6,757	15,000	515,000		7,834	8,246	8,658	6,419	6,757	7,094
Year 5 Q2	10,307	8,433	18,750	533,750		9,792	10,307	10,823	8,012	8,433	8,855
Year 5 Q3	14,434	11,802	26,250	560,000		13,712	14,434	15,156	11,212	11,802	12,392
Year 5 Q4	8,255	6,746	15,000	575,000	75,000	7,843	8,255	8,668	6,409	6,746	7,083
Grand Total	316,266	258,790	575,000			300,452	316,266	332,079	245,850	258,790	271,729

FIGURE 14.16 Automobile demand forecast.

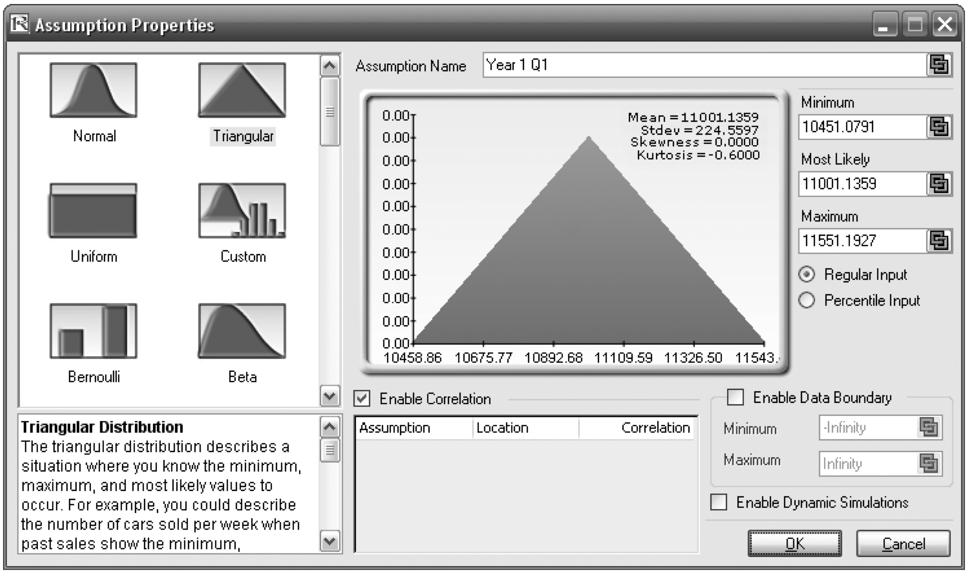


FIGURE 14.17 Monte Carlo simulation of demand forecast.

Initial Projected Scrap Rate	1.99%		(Range is from 1.50% to 2.5% per year)
Postwarranty Scrap Rate	10.82%		(Range is from 8% to 15% per year)
Projected Miles Driven Per Year		12,000	(Range is from 10,000–14,000 for small petrol engines)
		15,000	(Range is from 13,000–17,000 for large petrol engines)
		14,989	(Range is from 13,000–17,000 for diesel engines)
Average Warranty		100,000 (miles)	
Prewarranty Failure Rate	0.01%		(Range is from 0.01% to 0.02% per week)
Postwarranty Failure Rate	0.15%		(Range is from 0.05% to 0.20% per week)

FIGURE 14.18 Additional requirements.

For instance, say we have a marginal holding or carrying cost of $1.00 for each surplus unit manufactured versus a cost of $1.20 marginal excess net losses in sales if there is a shortage in manufactured parts with respect to sales demand. In addition, at least 800 units must be available within the first 6 months to cover the two-unit minimum per outlet for the 400 outlets worldwide. Finally, the manufactured output cannot exceed 1.50 times the forecasted values per year, to prevent any glut in the market. Monte Carlo simulation and forecasting methodologies were applied as well as dynamic

Expected Period	Auto Parts Europe	Demand USA	Forecast Total	Miles Driven		Quantity to Manufacture	Required Min	Required Max	Shortage or Surplus	Marginal Cost	Total Sales	Price Unit	Min Price	Max Price	Stochastic Sales
Year 1 Q1	83	68	152	3,747		400	200	500	248	$ (248.21)	$ 11,384.55	$ 74.88	$ 50.00	$100.00	$ 11,291.05
Year 1 Q2	188	154	342	7,495		400	200	500	58	$ (58.46)	$ 25,615.24	$ 74.78	$ 50.00	$100.00	$ 25,539.16
Year 1 Q3	334	273	607	11,242		224	200	500	–383	$ (459.81)	$ 18,800.00	$ 75.06	$ 50.00	$100.00	$ 16,812.41
Year 1 Q4	417	342	759	14,989		225	200	500	–534	$ (640.76)	$ 16,875.00	$ 74.65	$ 50.00	$100.00	$ 16,795.51
Year 2 Q1	543	444	987	18,736		977	300	2,000	–10	$ (11.59)	$ 109,912.50	$ 112.31	$ 75.00	$150.00	$109,729.00
Year 2 Q2	699	527	1,271	22,484		978	300	2,000	–293	$ (351.93)	$ 110,025.00	$ 112.00	$ 75.00	$150.00	$109,540.33
Year 2 Q3	918	751	1,670	26,231		978	300	2,000	–692	$ (830.08)	$ 110,025.00	$ 112.55	$ 75.00	$150.00	$110,078.79
Year 2 Q4	1,044	854	1,897	29,978		978	300	2,000	–919	$ (1,103.31)	$ 110,025.00	$ 111.30	$ 75.00	$150.00	$108,853.36
Year 3 Q1	1,127	922	2,049	33,725		1,586	500	4,000	–463	$ (555.86)	$ 237,900.00	$ 148.90	$100.00	$200.00	$236,163.21
Year 3 Q2	1,231	1,008	2,239	37,473		1,586	500	4,000	–653	$ (783.55)	$ 237,900.00	$ 151.04	$100.00	$200.00	$239,546.39
Year 3 Q3	1,378	1,127	2,505	41,220		1,586	500	4,000	–919	$ (1,102.32)	$ 237,900.00	$ 147.99	$100.00	$200.00	$234,717.81
Year 3 Q4	1,461	1,195	2,656	44,967		1,586	500	4,000	–1,069	$ (1,283.27)	$ 238,050.00	$ 148.44	$100.00	$200.00	$235,580.13
Year 4 Q1	1,586	1,298	2,884	48,715		2,251	500	4,000	–633	$ (759.70)	$ 337,650.00	$ 149.12	$100.00	$200.00	$335,671.99
Year 4 Q2	1,743	1,426	3,169	52,462		2,252	500	4,000	–917	$ (1,100.04)	$ 337,800.00	$ 152.04	$100.00	$200.00	$342,396.00
Year 4 Q3	1,961	1,605	3,567	56,209		2,252	500	4,000	–1,315	$ (1,578.19)	$ 337,800.00	$ 150.20	$100.00	$200.00	$338,241.96
Year 4 Q4	2,087	1,708	3,795	59,956		2,252	500	4,000	–1,543	$ (1,851.42)	$ 337,800.00	$ 150.49	$100.00	$200.00	$338,897.62
Year 5 Q1	2,150	1,759	3,909	63,704		2,782	500	4,000	–1,127	$ (1,352.04)	$ 417,300.00	$ 151.17	$100.00	$200.00	$420,552.35
Year 5 Q2	2,228	1,824	4,051	67,451		2,782	500	4,000	–1,269	$ (1,522.80)	$ 417,300.00	$ 150.71	$100.00	$200.00	$419,276.61
Year 5 Q3	2,338	1,913	4,250	71,198		2,782	500	4,000	–1,468	$ (1,761.88)	$ 417,300.00	$ 150.03	$100.00	$200.00	$417,384.52
Year 5 Q4	2,400	1,964	4,364	74,946		2,782	500	4,000	–1,582	$ (1,898.49)	$ 417,300.00	$ 148.95	$100.00	$200.00	$414,391.63
Year 6 Q1	2,353	1,925	4,277	78,693		2,786	500	4,000	–1,491	$ (1,789.63)	$ 417,900.00	$ 151.00	$100.00	$200.00	$420,674.40
Year 6 Q2	2,306	1,887	4,192	82,440		2,786	500	4,000	–1,406	$ (1,687.63)	$ 417,900.00	$ 149.22	$100.00	$200.00	$415,723.94
Year 6 Q3	2,260	1,849	4,109	86,187		2,787	500	4,000	–1,322	$ (1,546.46)	$ 418,050.00	$ 148.80	$100.00	$200.00	$414,703.62
Year 6 Q4	2,215	1,812	4,027	89,935		2,787	500	4,000	–1,240	$ (1,488.47)	$ 418,050.00	$ 148.93	$100.00	$200.00	$415,055.05
Year 7 Q1	2,171	1,776	3,947	93,682		3,947	500	4,000	0	$ (0.43)	$ 592,050.00	$ 149.16	$100.00	$200.00	$688,741.26
Year 7 Q2	2,128	1,71	3,869	97,429		3,869	500	4,000	0	$ (0.08)	$ 580,338.17	$ 150.50	$100.00	$200.00	$582,285.22
Year 7 Q3	9,871	8,076	17,948	101,176	*Warranty Expires*	4,000	500	4,000	–13,948	$ (16,737.06)	$ 600,000.00	$ 248.15	$100.00	$200.00	$593,796.91
Year 7 Q4	8,804	7,203	16,006	104,924		4,000	500	4,000	–12,006	$ (14,407.69)	$ 600,000.00	$ 150.91	$100.00	$200.00	$603,657.11
Year 8 Q1	7,851	6,424	14,275	108,671		4,000	500	4,000	–10,275	$ (12,330.26)	$ 600,000.00	$ 151.07	$100.00	$200.00	$604,279.89
Year 8 Q2	7,002	5,729	12,731	112,418		4,000	500	4,000	–8,731	$ (10,477.52)	$ 600,000.00	$ 150.93	$100.00	$200.00	$603,708.20
Year 8 Q3	6,245	5,109	11,354	116,166		4,000	500	4,000	–7,453	$ (8,825.16)	$ 600,000.00	$ 149.51	$100.00	$200.00	$598,020.37
Year 8 Q4	5,569	4,557	10,126	119,913		4,000	500	4,000	–6,126	$ (7,351.51)	$ 600,000.00	$ 151.25	$100.00	$200.00	$604,988.39
Year 9 Q1	4,967	4,064	9,031	123,660		4,000	500	4,000	–5,031	$ (6,037.25)	$ 600,000.00	$ 150.33	$100.00	$200.00	$601,315.42
Year 9 Q2	4,430	3,624	8,054	127,407		4,000	500	4,000	–4,054	$ (4,865.13)	$ 600,000.00	$ 150.79	$100.00	$200.00	$603,151.05
Year 9 Q3	3,951	3,232	7,183	131,155		4,000	500	4,000	–3,183	$ (3,819.79)	$ 600,000.00	$ 150.17	$100.00	$200.00	$600,671.48
Year 9 Q4	3,523	2,883	6,406	134,902		4,000	500	4,000	–2,406	$ (2,887.50)	$ 600,000.00	$ 149.10	$100.00	$200.00	$596,392.93
Year 10 Q1	3,142	2,571	5,713	138,649		3,858	500	4,000	–1,856	$ (2,226.45)	$ 578,700.00	$ 150.14	$100.00	$200.00	$579,252.36
Year 10 Q2	2,802	2,293	5,095	142,396		3,858	500	4,000	–1,237	$ (1,484.93)	$ 578,700.00	$ 149.96	$100.00	$200.00	$578,548.04
Year 10 Q3	2,499	2,045	4,544	146,144		3,859	500	4,000	–685	$ (822.40)	$ 578,850.00	$ 150.89	$100.00	$200.00	$582,296.17
Year 10 Q4	2,229	1,824	4,053	149,891		3,859	500	4,000	–194	$ (232.61)	$ 578,850.00	$ 148.00	$100.00	$200.00	$571,137.56
Year 11 Q1	1,988	1,627	3,614	153,638		2,531	500	4,000	–1,083	$ (1,300.20)	$ 379,650.00	$ 149.92	$100.00	$200.00	$379,435.92
Year 11 Q2	1,773	1,451	3,224	157.496		2,531	500	4,000	–693	$ (831.08)	$ 379,650.00	$ 150.23	$100.00	$200.00	$380,226.69
Year 11 Q3	1,581	1,294	1,875	161,133		2,532	500	4,000	–343	$ (411.50)	$ 379,800.00	$ 150.56	$100.00	$200.00	$381,210.00
Year 11 Q4	1,410	1,154	2,564	164,880		2,532	500	4,000	–32	$ (38.37)	$ 379,800.00	$ 148.24	$100.00	$200.00	$375,336.46
Year 12 Q1	1,258	1,029	2,287	168,627		2,000	300	2,000	–287	$ (344.00)	$ 300,000.00	$ 150.02	$100.00	$200.00	$300,038.57
Year 12 Q2	1,122	918	2,039	172,375		1,661	300	2,000	–378	$ (454.02)	$ 249,150.00	$ 150.70	$100.00	$200.00	$250,312.34
Year 12 Q3	1,000	818	1,819	176,122		1,661	300	2,000	–158	$ (189.34)	$ 249,150.00	$ 149.70	$100.00	$200.00	$248,656.93
Year 12 Q4	892	730	1,622	179,869		1,322	300	2,000	–300	$ (360.08)	$ 198,300.00	$ 150.56	$100.00	$200.00	$199,034.29
Year 13 Q1	796	651	1,447	183,617		500	200	500	–947	$ (1,135.96)	$ 75,000.00	$ 151.45	$100.00	$200.00	$ 75,726.91
Year 13 Q2	710	581	1,290	187,364		500	200	500	–790	$ (948.20)	$ 75,000.00	$ 150.21	$100.00	$200.00	$ 75,106.59
Year 13 Q3	633	518	1,151	191,111		500	200	500	–651	$ (780.76)	$ 75,000.00	$ 149.66	$100.00	$200.00	$ 74,829.28
Year 13 Q4	564	462	1,026	194,858		500	200	500	–526	$ (631.42)	$ 75,000.00	$ 150.37	$100.00	$200.00	$ 75,186.06

FIGURE 14.19 Optimization model.

optimization techniques. The actual part quantities that should be manufactured that maximize net profits, minimize excess losses, and are all the while subject to the relevant minimum and maximum manufactured parts are illustrated in Figure 14.19 and charted in Figure 14.20. As can be seen in the chart, it is optimal to start with a small quantity initially when the Phalanx is introduced, and gradually but with a stepwise progression, increase the number of parts as the car gets older. The quantity peaks between years 7 and 10 when warranties expire and when the parts are most needed, and then gradually decreases over time as the cars are decommissioned, sold, or scrapped.

Using these advanced risk analysis techniques, we are able to predict the optimal manufacturing output and the life cycle of a specific part based on historical data and simulating thousands of potential outcomes and scenarios in an optimization model. In fact, we can take this one step further and on completion of the optimization analysis, reapply simulation and obtain the probabilities of the net revenues for this particular part, as seen in Figures 14.21, 14.22, and 14.23.

However, we require two parts per outlet for 250 outlets
in Europe and 150 outlets in the United States.
So, the first period requires 800 units.

Assumed Cost of a Surplus unit: $1.00 (Additional carrying cost losses per unit)
Assumed Cost of a Shortage unit: $1.20 (Additional sales loss per unit)

Constraints:
1. First 6 months must be at least 800 units: 800
2. Each year we cannot manufacture more than 1.5 times the forecasted demands:

Year	Manufactured	Limit
1	1,249	1,859
2	3,911	5,825
3	6,345	9,449
4	9,007	13,415
5	11,128	16,574
6	11,146	16,606
7	15,816	41,770
8	16,000	48,487
9	16,000	30,675
10	15,434	19,406
11	10,126	12,277
12	6,644	7,767
13	2,000	4,914

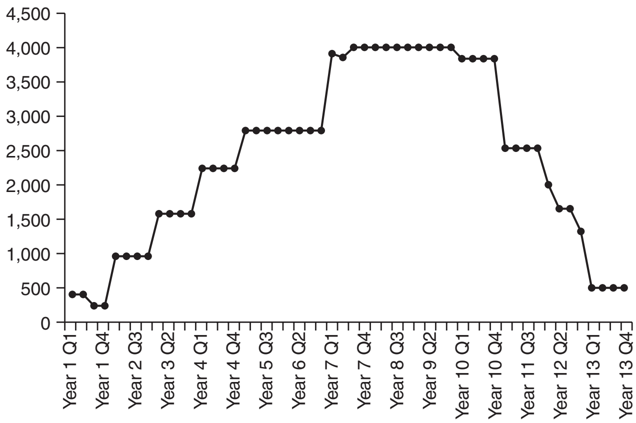


FIGURE 14.20 Optimal quantity and manufacturing constraints.

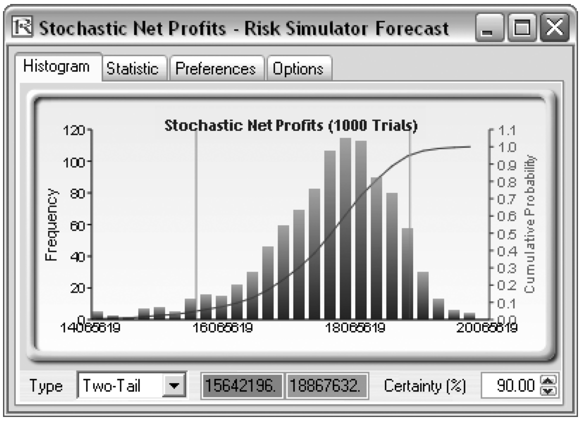
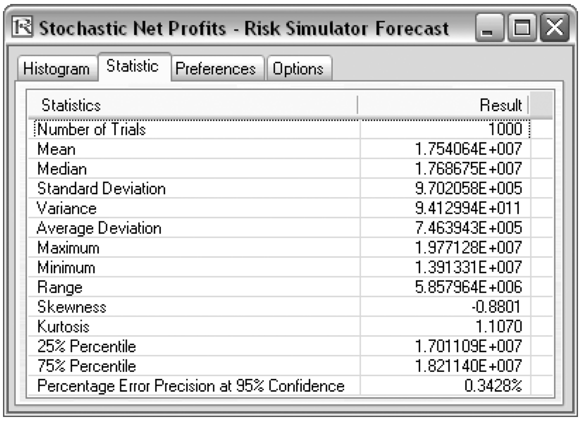


FIGURE 14.21 The 90 percent confidence interval.


Stochastic Net Profits - Risk Simulator Forecast

Histogram | Statistic | Preferences | Options

Statistics	Result
Number of Trials	1000
Mean	1.754064E+007
Median	1.768675E+007
Standard Deviation	9.702058E+005
Variance	9.412994E+011
Average Deviation	7.463943E+005
Maximum	1.977128E+007
Minimum	1.391331E+007
Range	5.857964E+006
Skewness	-0.8801
Kurtosis	1.1070
25% Percentile	1.701109E+007
75% Percentile	1.821140E+007
Percentage Error Precision at 95% Confidence	0.3428%

FIGURE 14.22 The simulated statistics.

Figure 14.21 shows that the 90 percent confidence interval of the net profits for this particular part is between $15.64 and $18.87 million over its lifetime. In fact, the expected value or mean net profit is $17.54 million (Figure 14.22). Finally, using the simulated results, we can compare the profitability of one part versus another. For instance, suppose we have an alternative part that the company is deciding on manufacturing and the expected net profit payoff is $15.0 million. We can determine that by manufacturing the current parts, there is a 91.20 percent probability that this current part's net profits will exceed the alternative business line.

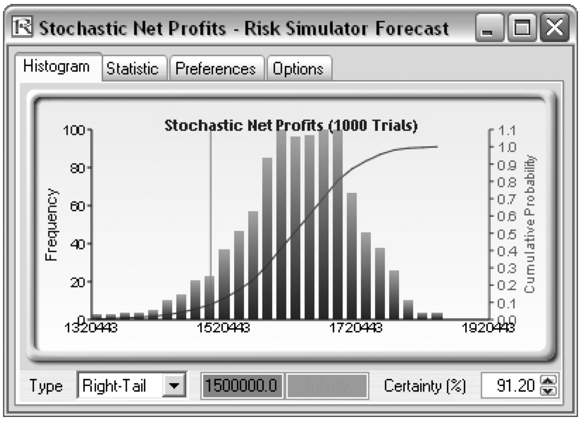


FIGURE 14.23 Sample breakeven points.

In contrast, had optimization and simulation risk analysis not been performed, the results would have been a highly suboptimal set of results. For instance, based on the required minimum and maximum production required in each period, say we manufacture at the average of the forecasted values; the total net profits would have been $13.43 million or manufacturing at the required minimum required values returns $0.71 million in net profits. Therefore, given such huge swings in values, running optimization guarantees the maximum possible net profits of $17.54 million subject to the uncertainties and risks inherent in the demand forecasts.

To conclude, Monte Carlo simulation, forecasting, and optimization are crucial in determining the risk elements and uncertainties of pricing and demand levels. In addition, the analysis provides a set of valid optimal quantities to manufacture given these uncertainty demand levels, all the while considering the risk of the business line. Thus, using risk analysis, decision makers can not only decide which business lines or parts to manufacture, but how much to manufacture, when to manufacture them, and if required, to decide the optimal price points to sell the parts, maximize profits, and minimize any losses and risks.

CASE STUDY: THE BOEING COMPANY'S STRATEGIC ANALYSIS OF THE GLOBAL EARTH OBSERVATION SYSTEM OF SYSTEMS

This case study was written by Ken Cobleigh, Dan Compton, and Bob Wiebe, from The Boeing Company in Seattle, Washington, with assistance from the author. This is an actual consulting project performed by Ken,