Monte Carlo Analyses Aids Negotiations

BY V. WALT BRATIC, BRYAN K. BENOIT and JAMES D. WOODS*

Computer modeling techniques can enhance accuracy, assure agreement is profitable to both parties

Increases in international trade have led to increased levels of competition among the world's largest corporations. As this competition has increased, many corporate managers have realized that the ultimate determinate of corporate success is often the development and exploitation of intellectual property. Real assets, capital, and labor can often be purchased, rented, or otherwise obtained and employed to accomplish the goals of the corporation. However, without some competitive advantage, corporate owners have little hope of earning anything greater than a "normal" rate of return on their invested capital. Often, a firm that earns above normal profits owns or has the rights to IP that provides a competitive advantage.

Companies must make a variety of decisions to determine how to maximize firm value through their IP. These decisions must be made in the same context as decisions involving more traditional corporate resources such as real property and capital. The decisions should be based on sound financial modeling and should reflect the overall strategy of the firm. This paper uses a fictitious case study to examine several of the choices available to firms owning IP and to outline the application of various techniques that can be used to estimate the financial implications of these choices.

The case is based on a fictional product, *EtherAC* which would allow companies to communicate over standard AC wires. *EtherAC* would also provide home automation features such as the ability to turn on and off lights at predetermined times and would provide home security features including intrusion, smoke and fire detection. We assume that *EtherAC* would have been developed by a small firm that has limited manufacturing capacity.

SHOULD WE MANUFACTURE *ETHERAC?*

Our first question is, "Should we manufacture *EtherAC* or should we allow others to manufacture the product using our IP instead?" Manufacturing the product provides many benefits, but it also entails numerous risks. If we manufacture the product, we will earn the entire gross margin on sales and we will be able to control exactly how our IP is employed. However, manufacturing the product means that we must obtain capital and the expertise to manufacture and market a product. Alternatively, we could license the IP behind the product and allow others to market *EtherAC*. Licensing the IP provides a relatively safe income stream, but this stream is significantly smaller than the product's gross margin, and we lose some control over how our IP is sold in the marketplace.

Given the above benefits for manufacturing or licensing/selling *EtherAC*, how should we decide which is the better opportunity? Since the overall goal of corporate managers is to maximize the value of the firm, it follows that we should select the option that maximizes firm value. This is usually determined by selecting the option that is expected to provide the greatest net present value (NPV) of expected cash flows.

Calculating NPV is conceptually simple. One estimates the inflows and outflows related to the project and discounts these cash flows to the present time period. However, this explanation overlooks certain difficulties encountered in actually applying the NPV framework.

The first major difficulty is estimating the cash flows related to the project. One must make a complete set of assumptions to construct a

ASSUMPTIONS FOR MANUFACTURING *ETHERAC*

Entry Expenditures		**Possibly Expansion**	
Plant construction	$3,000,000	Plant Construction	$3,000,000
Initial working capital	1,500,000		
	$4,500,000		
75% of construction costs depreciable for tax purposes		100% depreciable for tax purposes	
Projected Gross Profits		**Projected Advertising Costs**	
Price	$66	$750,000 per year and	
Production costs	30	15% of sales	
Gross profits	$36		
Projected Unit Sales		**Other Assumptions**	
Year 1	75,000	Year 1 capacity is 200,000 units	
Year 2	203,000	Expansion would meet all demand	
Year 3	375,000	Fixed costs are $2,000,000	
Year 4	631,000	Cost of capital is 30%	

Table 1

* *Price Waterhouse LLP, Houston, Texas; paper based on presentation of Walter Bratic and Bryan Benoit at LES (USA & Canada) Winter Meeting, Newport Beach, California.*

a model of what the cash flows will be from manufacturing or licensing the technology. Second, one must determine an appropriate discount rate, one that reflects the risk inherent in the cash flows expected to be produced from our decision.

In this paper we will examine the discount rate selection problem. However we will construct a simple cash flow model for each alternative, and we will introduce and explain a method of incorporating uncertainty into our model. First, we create the cash flow model.

Table 1 shows our basic assumptions for manufacturing *EtherAC*. The figure shows that we expect to invest $4.5 million dollars to establish a plant with an annual capacity of 200,000 units. We also anticipate an expenditure of $3 million to expand plant capacity during the second year to meet demand. The expenditure for the expansion is contingent upon demand in the second year exceeding 200,000 units.

NPV FOR MANUFACTURING *ETHERAC*
(in thousands)

	Year 0	Year 1	Year 2	Year 3	Year 4
Plant construction	($3,000)		($3,000)		
Change in working capital	(1,500)				1,500
Cash flows		607	1,048	4,650	9,308
Total	($4,500)	$607	($1,052)	$4,650	$10,808
	($4,500)				
	467				
	(622)				
	2,116	30% Discount Rate			
NPV	3,784				
	$1,245				

Table 3

Although the estimated NPV is important data, it only tells us about the expected value of the project. We know that the assumption we have made and potential errors in our estimates affect our decision, but the expected NPV value does not provide any insight into how these assumptions and errors affect our estimated NPV.

Traditionally, managers have resorted to a "Best," "Worst," and "Most Likely" case analysis to attempt to capture these features of the model. Table 4 shows what the NPV would be if the sales in Year 1 were $5.4 million, the best case, or $4.5 million, the worst case. Also in Table 4 we can see the NPV for the best case and worst case for sales growth from Year 1 to Year 2. Table 4 shows that the expected NPV varies from −$0.8 million to $3.4 million, for different levels of Year 1 sales growth, but it provides no information on the interaction between the level of sales in Year 1 and differing sales growth rates. In other words, this type of sensitivity analysis examines each variable independently of the other variables. Additionally, the cases are discrete. We gain information on only the three values assumed for each variable. We know little about the expected NPV for levels of sales and sales growth not listed on the figure.

Another potential complication is illustrated by the specific facts assumed in this simple case study. If first year sales exceed 200,000 units, then we anticipate expanding capacity. How does this potential plant expansion affect our NPV analysis? Using traditional methods, we would estimate the NPV with and without the plant expansion and then estimate the probability

CASH FLOWS FROM MANUFACTURING *ETHERAC*
(in thousands)

	Year 1	Year 2	Year 3	Year 4
Sales	$4,961	$13,395	$24,781	$41,632
Cost of goods sold	2,255	6,089	11,264	18,923
Gross profits	2,706	7,306	13,517	22,708
Advertising expense	1,494	2,759	4,467	6,995
Other fixed expenses	500	2,000	2,000	2,000
Depreciation	450	1,050	1,050	2,700
Contribution before taxes	262	1,497	6,000	11,013
Taxes	105	599	2,400	4,405
Contribution after taxes	157	898	3,600	6,608
Add back depreciation	450	1,050	1,050	2,700
Cash flow contribution	$607	$1,948	$4,650	$9,308

Table 2

Table 2 shows the estimated cash flows for four years. In order to keep the analysis tractable, and given that this is a high-technology product in a quickly-evolving field, we have limited the analysis to a four-year horizon.

Table 3 shows the NPV calculation. This project is relatively risky. Therefore, a discount rate of 30% is assigned. Given our assumptions and estimates, we anticipate the production of *EtherAC* to generate a positive NPV of $1.2 million. This implies that manufacturing and marketing *EtherAC* is at least a viable alternative.

SENSITIVITY ANALYSIS
(in thousands)

Effect of changes in Sales in Year 1

	Case: Worst	Most Likely	Best
Sales in Year 1	$4,514	$4,961	$5,397
Resulting NPV	**$399**	**$1,245**	**$1,988**

Effect of changes in the Growth rate from Year 1 to 2

	Case: Worst	Most Likely	Best
Sales Growth from Year 1 to 2	130%	170%	200%
Resulting NPV	**−$801**	**$1,245**	**$3,384**

Table 4

of expanding capacity and calculate a final NPV. However, this method becomes difficult if there are multiple contingencies.

For example, how much capacity we build or whether we subcontract out production may depend on the level of sales realized in prior years. Advertising budgets and new product introductions could also depend on the level of sales realized in prior years. Advertising budgets and new product introductions could also depend on the level of success the product meets in the market. These types of contingencies are difficult to model using traditional methods. Due to the large number of possible outcomes, it is difficult to list out all the potential paths and calculate individual NPVs. Additionally, if one did, it would be difficult to summarize this information into a meaningful result.

MONTE CARLO ANALYSIS

One technique that can be used to address the problems discussed above is called Monte Carlo analysis. Monte Carlo analysis allows the decision-maker to examine scenarios that reflect variation in all of the variables. These scenarios are developed from assumptions about the probability distributions for the variables rather than assuming discrete values representing each case.

The technique was developed during World War II to aid in the development of the first atomic weapons. Scientists could not mathematically solve the equations needed to predict how a nuclear chain reaction occurs. However, they could create equations that describe the process. Rather than solving the equations, they simuted a chain reation using the equations that describe the process. Random values were placed in the equations and the results were tabulated. From this process the scientists could estimate the probability of a chain reaction occurring given a set of initial starting conditions.

Clearly, our problem does not involve nuclear physics, but the same technique can be used. Instead of assuming three values for the possible price, we could assume that the possible price is distributed randomly between two limits. We then instruct the computer to randomly choose a price and calculate the profit repetitively. The profit from randomly selected prices are then averaged to form an expected profit assuming the price is distributed randomly between the two limits.

Table 5 shows the assumptions used in the Monte Carlo analysis. These assumptions are linked to the original model. Then the model is run through multiple iterations. In this case study we ran the model 5,000 times. During each run a new value is drawn from the probability distributions and each time an NPV is calculated. All 5,000 NPVs are then accumulated and summarized. Figure 1 provides a graphic representation of the Monte Carlo process.

The resulting graph shown in Figure 2 provides information on the expected value of the NPV as well as the level of variability in the NPV, given our assumptions. The x-axis shows the NPV while the y-axis shows the probability of that NPV occurring. From this graph, we get a representation of the entire distribution of possible NPV outcomes. In this case, we can clearly see that the upside potential exceeds the low side, but it appears two NPVs are "more likely" than other values.

Figure 2 implies that we can expect NPVs near $446,000 or about $2 million since the graph shows two distinct "humps" around these values. Further investigation reveals that these two values result from the decision to expand capacity. If first year volume is too low, we can expect the NPV to be close to $446,000, but if we are able to expand capacity, then the NPV is closer to $2 million.

Since the model indicates that the decision to expand is a critical variable, we should refine our assumptions concerning variables related to the expansion. If we assume that fixed costs related to the expansion are normally distributed with a mean of $1.5 million and that we will reduce advertising expenses if we do not expand production, then our model produces Figure 3.

Figure 3 indicates an upside potential similar to the earlier model, but now the dual "humps" are not as obvious. The modifications in our assumptions has reduced the contrast between the cases where we expand capacity and where we do not expand capacity. If our assumptions are unreasonable, then it appears that the production of *EtherAC* is a positive NPV project with significant upside potential regardless of our selection of plant capacity.

This information is valuable during licensing negotiations. We have a model that graphically shows the range and probabilities of the outcomes from producing *EtherAC*. We could use this information to encourage a potential licensee to manufacture our product by showing their potential profits or we could keep this information private and use it as a benchmark to evalu-

ASSUMPTIONS USED IN MONTE CARLO ANALYSIS

First year sales	• Drawn from a normal distribution with mean 75,000 units and a standard deviation of 10,000 units.
First year growth rate	• For above-average first-year sales, drawn from a normal distribution with mean 200%
	• For below average first-year sales, drawn from a normal distribution with mean 135%
	• Both distributions have a standard deviation of 15%
Other fixed costs	• Without an expansion in capacity, $500,000
	• With an expansion in capacity, $2,000,000

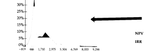
Table 5

USING MONTE CARLO SIMULATION TO ESTIMATE NPV

	Year 1	Year 2	Year 3	Year 4
Sales	4,961	13,394	24,778	41,628
Cost of Goods Sold	2,255	6,088	11,263	18,922
Gross Profits	2,706	7,306	13,515	22,706
Advertising Expenses	1,494	2,759	4,467	6,994
Other Fixed Expenses	1,500	1,500	1,500	1,500
Depreciation	450	1,050	1,050	2,700
Contribution before tax	(738)	1,997	6,499	11,512
Tax	(295)	799	2,599	4,605
Contribution after tax	(443)	1,198	3,899	6,907
Add back Depr.	450	1,050	1,050	2,700
Cashflow	7	2,248	4,949	9,6073

Run 5,000 times

Accumulate NPVs from each run to build graph

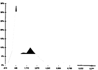


	Year 0	Year 1	Year 2	Year 3	Year 4
Plant Expenditures	(3,000)		(3,000)		
Change in NWC	(1,500)				1,500
CFs		7	2,248	4,949	9,607
	(4,500)	7	(752)	4,949	11,107

	(4,500)
	5
	(445)
	2,253
	3,889
NPV	1,202
IRR	38%

Figure 1

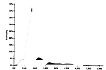
NPVs FROM PRODUCING *ETHERAC*



NPVs in Thousands of Dollars

Figure 2

REFINED NPVs FROM PRODUCING *ETHERAC*



NPV in Thousands of Dollars

Figure 3

ate various licensing alternatives.

LICENSE VALUE

Now that we have an estimate of the value created by manufacturing *EtherAC* ourselves, we must estimate the revenues from licensing the technology behind *EtherAC*. At the most basic level, the revenues we receive from licensing depend on the number of units sold and the royalty rate. However both of these numbers depend on the structure, terms, and participants of the li-

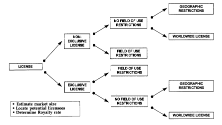


Figure 4

cense agreements.

Generally, licenses that are non-exclusive and contain geographical and field-of-use restrictions are much less valuable, and therefore the royalty rates are lower than exclusive licenses without restrictions. This is usually the case because the restrictions and possibility of competition usually limits either the price that can be charged for the product or the number of units that can be sold. It is important to note that if an IP owner sells all rights to the IP, he has effectively sold the property. In these cases, the IP owner needs to ensure that the financial terms of the license agreement reflect this "virtual" sale of the property.

Figure 4 depicts a subset of the possible license paths. To determine which path provides the largest NPV, the decision maker must estimate the market size, the number of licensees and the royalty rate at each node. A model similar to the one used earlier to estimate the NPV from manufacturing *EtherAC* is created for each node on the chart. Table 6 shows three of the nodes and the relevant assumptions. The models are adjusted so they report the licensing fees paid to the IP owner rather than the cash flows to the manufactures. For a reasonableness check, it is a good idea to estimate the NPV for the licensees. Performing this calculation ensures that your assumptions indicate the project will be profitable for your licensees. If your calculations indicate the licensees will not earn positive NPVs, then it is unlikely you will be able to successfully negotiate an agreement.

Once the basic models are set up, tested, and run we can add probability distributions to selected variables. Then we can run the

ASSUMPTIONS BEHIND EACH LICENSING NODE

	Exclusive	Field of Use		Geographical Restrictions		
		Home	Business	U.S.	Asia	EU
Number of Licensees	1	12	8	8	15	7
Units/Licensee						
Mean	90,000	30,000	26,000	38,000	33,000	40,000
Standard deviation	12,000	12,000	15,000	10,000	12,000	15,000
Sales Growth						
Mean	170%	175%	220%	200%	150%	150%
Standard deviation	15%	15%	50%	15%	60%	25%

Table 6

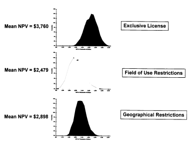


Figure 5

model using Monte Carlo analysis as before and accumulate the present value of the royalty stream into graphs. Figure 5 shows the results for the *EtherAC* product.

The charts illustrate that an exclusive license would provide the highest revenue stream to the owners of *EtherAC*. Not only is the mean NPV greatest for the exclusive license node, but the figure shows that for the exclusive case, the lowest expected NPV exceeds the lowest expected NPV for the other two alternatives. The analogous situation exists for the largest expected NPV.

LICENSE NEGOTIATIONS

The analysis presented suggests that the exclusive license node is better than manufacturing and the other license options. Therefore, the IP owners should begin to prepare for license negotiations. The models developed thus far can be adopted to estimate the NPV that will be earned by the potential licensee. Table 7 shows the assumptions made about this potential licensee.

The potential licensee will be investing more money in plant capacity than the IP owners. Additionally, we assume the potential licensee will charge a higher price by incorporating more features into the product. The potential licen-

ASSUMPTIONS FOR MANUFACTURER OF *ETHERAC*

Entry Expenditures

Plant construction	$ 8,500,000
Initial working capital	3,000,000
	$11,500,000

75% of construction costs depreciable for tax purposes.

Projected Advertising Costs

$1,000,000 per year and 10% of sales

Projected Gross Profits

Price	$80
Production costs	30
Gross profits	$50

Other Assumptions

Plant meets all capacity needs
Fixed costs are $1,500,000
Cost of Capital is 25%

Projected Unit Sales

Year 1	90,000
Year 2	236,000
Year 3	390,000
Year 4	605,000

Table 7

LICENSEE NPV WITH A 6% ROYALTY PAYMENT

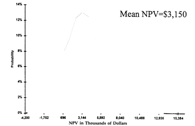


Figure 6

see will also develop the manufacturing capacity for products related to the *EtherAC* product. These add-on sales are included in the analysis. We assume a 6% royalty rate on the *EtherAC* product and no royalty on the add-on products.

When we run the Monte Carlo analysis, Figure 6 is generated. Due to the large investment in production facilities, there is a significant probability that the licensee will be accepting a negative NPV project. Our model indicates that the risk is about 10%. This relatively large risk will encourage the licensee to attempt to negotiate down the license rate. For example, if he is successful in negotiating a 4% royalty, his chance of a negative NPV project drops to about 7%.

We may be willing to accept this lower rate since our model indicates that at a 4% royalty rate we will still earn an NPV in excess of the production NPV (Results not presented.) However, rather than simply reducing the royalty rate, we may prefer to negotiate an up-front payment to compensate for the lower royalty. We could adjust the models and run the Monte Carlo analysis to show how this would affect the potential licensee's expected NPV. If the deal is negotiated properly, we should be able to entice the licensee to make the up-front payment in exchange for high payoffs associated with high profits and lower royalties for a successful product.

CONCLUSION

This stylized fictional case study demonstrates a variety of licensing concepts and techniques. The interplay between the two parties in a licensing negotiation is complex, but certain features are clearly demonstrated. During the negotiations, wealth and risk sharing are both important. The licensee will prefer to reduce his risk of negative NPV projects by ensuring that the royalty rate is low, and by avoiding up-front or milestone payments. However, the licensor will desire high royalty rates and lump-sum payments to attempt to capitalize on and recoup the R&D spending invested in the IP.

Ultimately, a licensing agreement must be carved out that meets the needs of both parties. The terms of this agreement should be based on valuation techniques and sound legal advice to ensure that the agreement is profitable for both parties. Monte Carlo and other computer modeling techniques can be used to enhance accuracy and demonstrate the effects of uncertainty.