CHAPTER 11

Real Options Case Studies

This chapter shows several actual cases and real-life applications of real options, financial options, and employee stock options, solved using the Super Lattice Solver (SLS) software and Risk Simulator software. The cases included in this chapter are:

- High-Tech Manufacturing—Build or Buy Decision
- Financial Options—Convertible Warrants with a Vesting Period and Put Protection
- Pharmaceutical Development—Value of Perfect Information and Optimal Trigger Values
- Oil and Gas—Farm Outs, Options to Defer, and Value of Information
- Valuing Employee Stock Options Under 2004 FAS 123
- Integrated Risk Modeling—Applying Simulation, Forecasting, and Optimization on Real Options
- Biopharmaceutical Industry—Valuing Strategic Manufacturing Flexibility
- Real Estate—Alternative Use and Development
- United States Navy—Strategic Flexibility in Mission Control Centers

CASE 1: HIGH-TECH MANUFACTURING—BUILD OR BUY DECISION WITH REAL OPTIONS

Microtech, Inc. is a billion-dollar high-tech manufacturing firm currently interested in developing a new state-of-the-art, high-capacity micro hard drive that fits into the palm of your hand. The problem is, the larger the capacity, the larger the magnetic disk has to be, and the faster it has to spin. Therefore, making small hard drives is hard enough, let alone a high-capacity hard drive that is reliable and state-of-the-art. The risks the firm faces include market risks—will this product sell, will it sell enough, and at what price—and private risks—will the technology work and can we develop it fast enough ahead of the competition—both of which are significant enough to yield serious disasters in the project. In performing its due diligence, the vice president of advanced emerging technologies of this firm found a small start-up firm that is also currently developing such a technology, and it is approximately three-quarters of the way there. This small start-up will initiate a patent process in the next few weeks, and Microtech would like to consider acquiring the start-up prior to the patent process starting. The start-up has shown interest in being acquired and based on preliminary discussions, requested $50M for the firm.

The question is, should Microtech acquire the firm and mitigate some development risk but still face the market risk and some residual development risk? After all, the start-up has the technology only partially completed. Then again, through the acquisition, Microtech can take a potential rival out of the picture and even mitigate the chances of its competitors acquiring this firm's technologies. How much is this firm really worth, compared to its asking price of $50M? What options exist to mitigate some of the market and development risks? Are there additional opportunities in the market that Microtech can take advantage of through the acquisition?

The finance staff at Microtech with the assistance of several external consultants began to collect all the relevant data and created a DCF model, and the best-guess present value of the benefits from the firm is $100M. This means that the NPV of buying the firm is $50M after accounting for the acquisition cost of $50M. In the DCF model, the probability of technical success is also modeled (using several binomial distributions and their relevant probabilities of success in several phases multiplied together) as well as the market positioning (triangular distributions were used to simulate the different market conditions in the future). Using the Risk Simulator software, the Monte Carlo simulation's resulting annualized volatility is found to be 25 percent, a somewhat moderate level of risk. The finance staff also created another DCF with which to compare the result. This second DCF models the scenario of building the technology in-house, and the total development cost in present value will be $40M, a lot less than the acquisition cost of $50M. At first glance, it might be better off building the technology in-house, providing an NPV of $60M. However, the volatility is found to be 30 percent as it is riskier to develop the technology from scratch than to buy a firm with the technology almost completed.

The question now becomes what, if any, strategic real options exist for Microtech to consider? Is the NPV analysis sufficient to justify doing it itself? What about all the market and private risks in the project? If acquiring the firm, are there any options to protect Microtech from failure? If building the technology itself, are there any options to mitigate the development risks?

Microtech then proceeded to perform some *real options framing exercises* with its executives, facilitated by an external real options expert consultant. The questions raised included what risks exist and how can they be reduced.

The real options consultant then put a real options framework around the discussions and came up with a preliminary *strategy tree* (Figure 11.1). For the first pass, four main options were conceived: mitigate the development risk of building themselves; mitigate the risk of the market; mitigate the risk of failure if acquiring the firm; and take advantage of the upside risks whenever possible. These options are compiled into path-dependent strategies in Figure 11.1.

Strategy A is to develop the technology in-house but the R&D risk is mitigated through a stage-gate investment process, where the total $40M required investment is spread into four steps of $10M each (in present values). At any phase of the development, the fate of the next stage is determined; that is, to

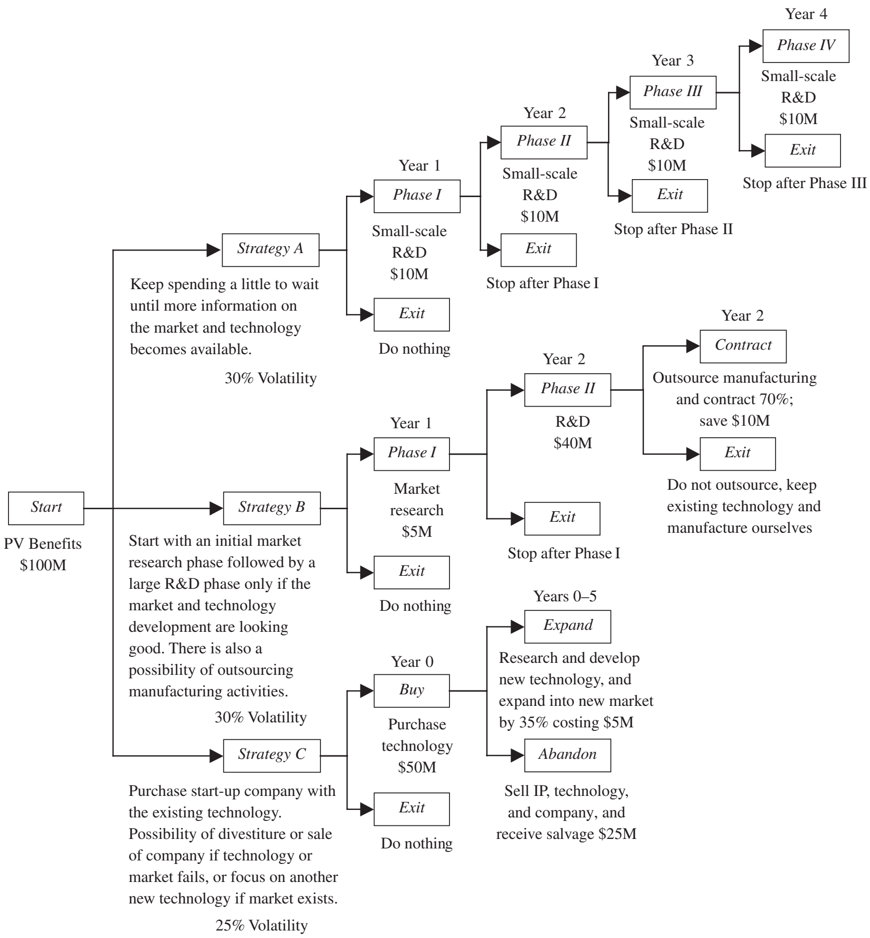

FIGURE 11.1 Strategy Tree for High-Tech Manufacturing

decide if the R&D initiative should continue depending on the outcome of the current phase. The investment can be terminated at any time, and the maximum loss will be the total investment up to that point. That is, if R&D shows bad results after one year, the initiative is abandoned, the firm exits the project, and the maximum loss is $10M, not the entire $40M as defined in the DCF model. The questions are: How much is this strategic path worth and is stage-gating the process worth it?

Strategy B is to develop the technology but the market risk is being hedged. That is, a preliminary Phase I market research is performed for $5M in the first year to obtain competitive intelligence on Microtech's competitors and to see if the market and complementary technologies exist such that the microdrive will indeed be successful. Then, depending on the results of this market research, Phase II's R&D initiative will or will not be executed. Because the market research takes an entire year to complete, further stage-gating the R&D initiative is not an option because it will significantly delay the launch of the product. So, Phase II is a full-scale R&D. In this strategic path, although the market risk is mitigated through market research, the development risk still exists. Hence, a contraction option is conceived. That is, Microtech finds another counterparty to assume the manufacturing risks by signing a two-year contract whereby at any time within the next two years, Microtech can have this counterparty firm take over the development of the microdrive's increased rotational latency and seek times during the R&D process where the counterparty shares in 30 percent of the net profits without undertaking any R&D costs. Microtech will assume the entire $40M R&D cost but ends up mitigating its highest development risks and also saves $10M (in present values) by not having to increase its own manufacturing competencies by hiring outside consultants and purchasing new equipment. The questions are: How much is this strategic path worth, is the market research valuable, and how much should Microtech share its net profits with the counterparty?

Strategy C is to purchase the start-up firm for $50M. However, by acquiring the firm, Microtech obtains additional options. Specifically, if the technology or market does not work out as expected, Microtech can sell the start-up (sell its intellectual property, patents, technology, assets, buildings, and so forth) for an estimated salvage value of $25M within the first year. As the content of the start-up's intellectual property is expected to increase over time because of added development efforts, the salvage value is expected to increase by $1M each year. If the technology is successful within the next five years, other products can be created from this microdrive base platform technology. For instance, the microdrive is not only applicable for use as in laptops but with an additional funding of $5M, the technology can be adapted into handheld global positioning system (GPS) map locators for cars and travel enthusiasts, personal pocket-sized hard drives (where an individual can carry an entire computer on his key chain and all he has to do is plug it into a monitor and the virtual computer comes up), MP3 players, and a multitude of other products, which by Microtech's estimates will increase the NPV of the microdrive by 35 percent. However, this expansion option only exists in Strategy C, as time to market is crucial for these new products and the start-up already has three-quarters of the technology completed, speeding Microtech's time to market tremendously. The questions are: How much is the start-up actually worth to Microtech and is $50M too high a price to pay for the company? Figure 11.1 shows these three strategic paths and the relevant information on each strategy branch.

Strategy A's total strategic value is worth $64.65M using the Multiple Asset SLS software with 100-step lattices as seen in Figure 11.2. The NPV is $60M, indicating that the option value is worth $4.65M. This means that there is definitely value in stage-gating the R&D initiative to hedge downside risks. To follow along, open the MSLS file: *Solution to Chapter 11—Case I Strategy A* from the accompanying CD.

However, when the annualized dividend rate exceeds 2.5 percent, the option value becomes zero and the total strategic value reverts to the NPV of $60M as seen in Figure 11.3. This means that by spending more time and putting off development through a stage-gate process, as long as the maximum losses per year (lost market share and opportunity losses of net revenues from

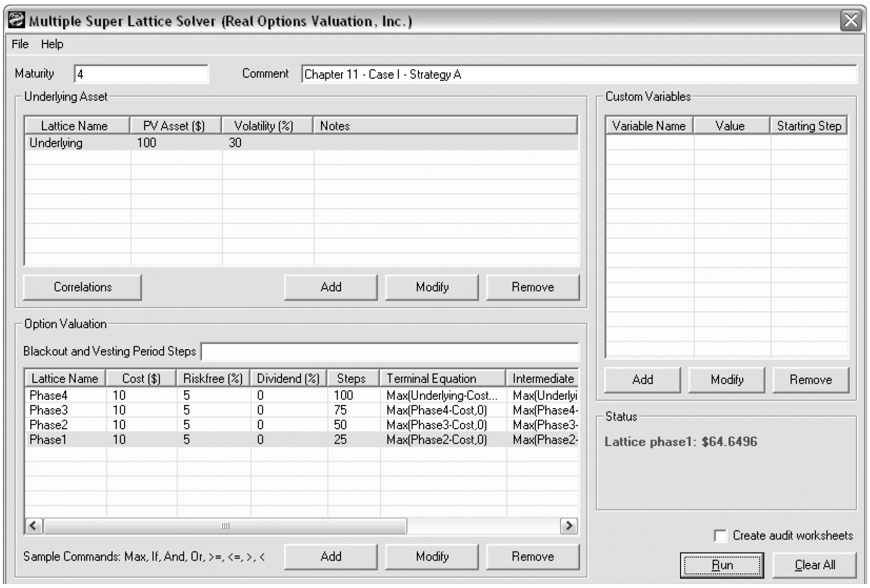

FIGURE 11.2 Value of Strategy A

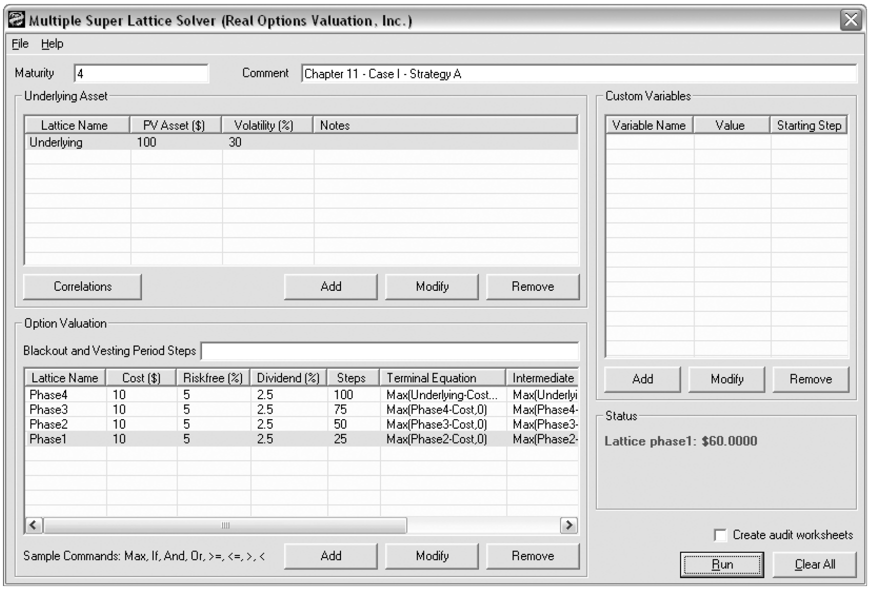

FIGURE 11.3 Strategy A's Break-Even Point

sales) do not exceed $2.5M (2.5 percent of $100M), then stage-gating is valuable. Otherwise, the financial leakage is too severe such that the added risk is worth it and the $40M should be spent immediately on a large-scale development effort. To follow along, open the MSLS file: *Solution to Chapter 11—Case I Strategy A* from the accompanying CD and progressively modify each valuation phase's dividend rate from 0 percent to 2.5 percent.

The total strategic value of Strategy B is valued at $75.90 as seen in Figure 11.4. The NPV is $55M (computed by taking $100M – $5M – $40M), which means that the options are valued at $20.90M. To follow along, open the MSLS file: *Solution to Chapter 11—Case I Strategy B* from the accompanying CD. So, thus far, Strategy B is the better strategic path, with a value of $75.90M. In addition, Figure 11.5 shows the strategic value without the contraction option, worth $59.12M ($4.12M option value to stage-gate with market research and $55M NPV). Thus, the contraction option with the counterparty to hedge the downside technical risk is worth $16.78M. A further analysis can be performed by changing the contraction factor (how much is allocated to the counterparty) and the amount of savings, as seen in Table 11.1.

Finally, the total strategic value for Strategy C is valued at $131.12 (see Figure 11.6) less $50 purchase price of the start-up company or a net strategic value of $81.12M. That is, Microtech should be willing to pay no more than

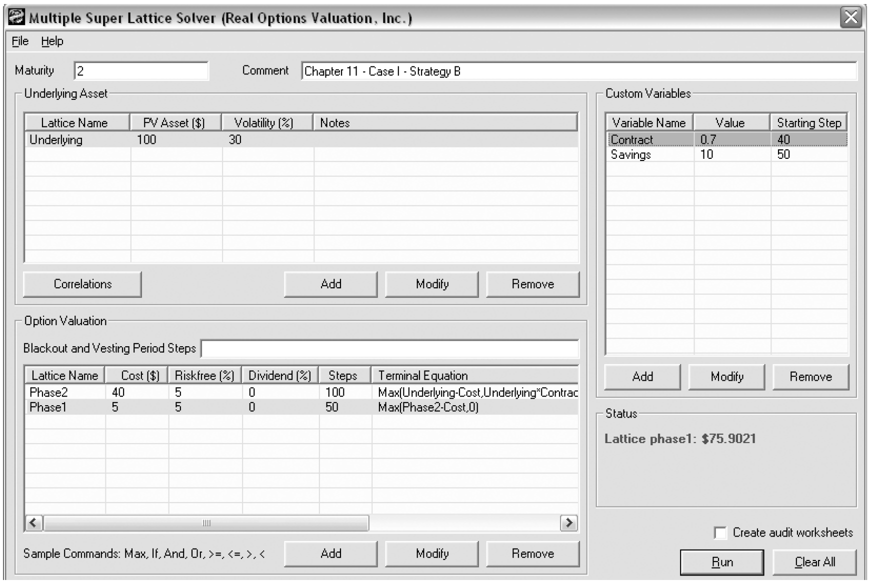

FIGURE 11.4 Value of Strategy B

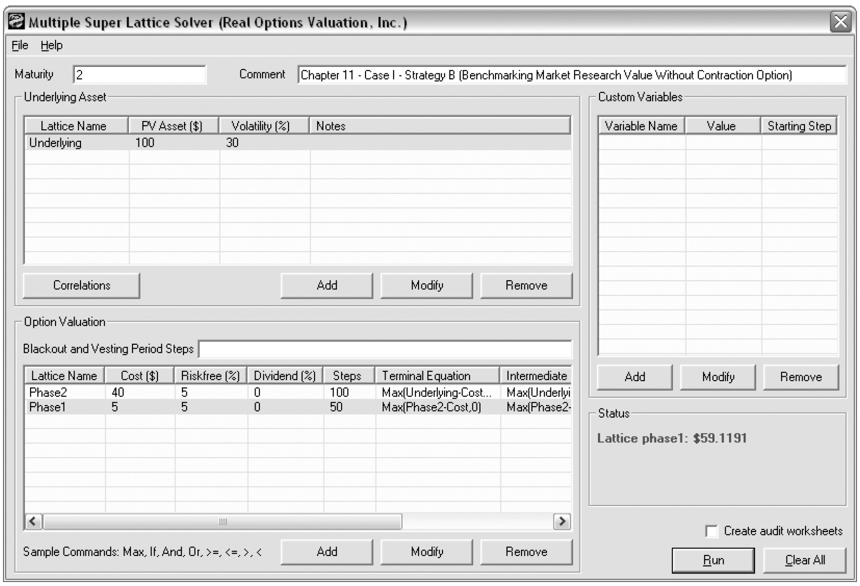

FIGURE 11.5 Strategy B without Contraction

TABLE 11.1 Decision Table on Savings and Contraction Factors

Contraction Factor	Savings										
	$0.00	$5.00	$10.00	$15.00	$20.00	$25.00	$30.00	$35.00	$40.00	$45.00	$50.00
	Strategic Option Value										
0.05	$59.15	$59.27	$59.50	$59.86	$60.39	$61.11	$62.07	$63.25	$64.67	$66.41	$68.40
0.10	59.19	59.35	59.64	60.09	60.74	61.62	62.73	64.13	65.83	67.77	69.94
0.15	59.24	59.47	59.84	60.40	61.19	62.26	63.60	65.24	67.15	69.31	71.83
0.20	59.32	59.62	60.11	60.82	61.80	63.08	64.66	66.53	68.68	71.20	73.97
0.25	59.43	59.82	60.45	61.36	62.56	64.07	65.91	68.06	70.57	73.36	76.39
0.30	59.60	60.12	60.91	62.04	63.50	65.30	67.43	69.94	72.76	75.84	79.15
0.35	59.83	60.53	61.54	62.92	64.68	66.80	69.31	72.15	75.28	78.67	82.30
0.40	60.16	61.09	62.38	64.07	66.18	68.68	71.54	74.73	78.19	81.88	85.80
0.45	60.65	61.86	63.49	65.55	68.05	70.94	74.18	77.72	81.51	85.48	89.65
0.50	61.35	62.91	64.93	67.45	70.38	73.66	77.26	81.14	85.22	89.46	93.83
0.55	62.34	64.32	66.85	69.82	73.18	76.87	80.82	84.98	89.32	93.77	98.31
0.60	63.70	66.25	69.26	72.70	76.49	80.56	84.83	89.24	93.76	98.36	103.01
0.65	65.66	68.71	72.27	76.18	80.35	84.72	89.22	93.81	98.46	103.15	107.87
0.70	68.24	71.88	75.90	80.20	84.68	89.26	93.92	98.61	103.34	108.07	112.82
0.75	71.58	75.72	80.15	84.72	89.37	94.08	98.81	103.55	108.30	113.05	117.81
0.80	75.65	80.18	84.83	89.55	94.28	99.03	103.78	108.54	113.29	118.05	122.81
0.85	80.31	85.02	89.76	94.51	99.27	104.02	108.78	113.54	118.29	123.05	127.81
0.90	85.25	90.00	94.76	99.51	104.27	109.02	113.78	118.54	123.99	128.05	132.81
0.90	85.25	90.00	94.76	99.51	104.27	109.02	113.78	118.54	123.99	128.05	132.81

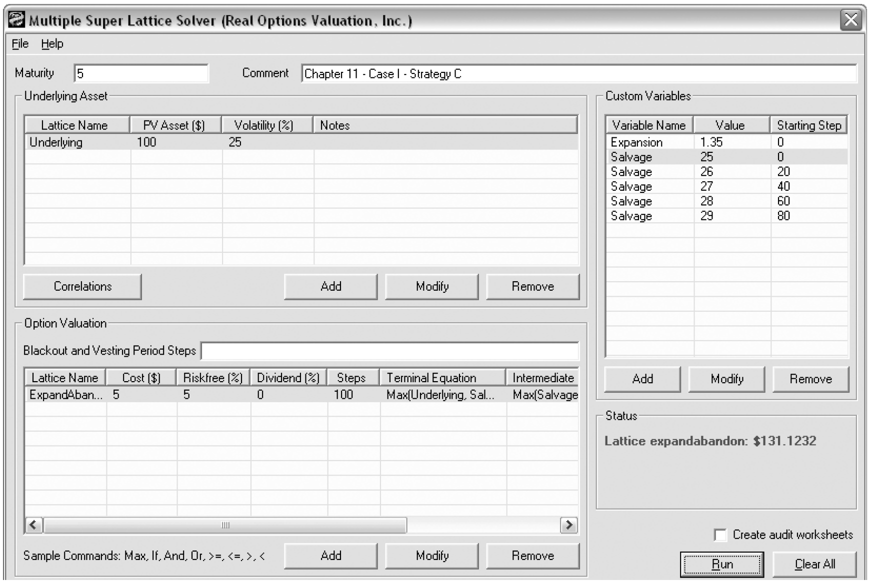

FIGURE 11.6 Value of Strategy C

$55.22M for the start-up (i.e., $50M + $81.12M – $75.90M), otherwise it is better off pursuing Strategy B and building the technology itself.

Thus, the optimal strategy is to purchase the start-up company, go to market quickly with the ability to abandon and sell the start-up should things fail, or to further invest an additional R&D sum later on to develop spin-off technologies. If real options analysis was not performed, Microtech would have chosen to develop the technology itself immediately and spend $40M. This strategy would yield the highest NPV if real options and risk mitigation options are not considered. Microtech would have made a serious decision blunder and taken unnecessary risks. By performing the real options analysis, additional spin-off products and opportunities surface, which prove to be highly valuable.

CASE 2: FINANCIAL OPTIONS—CONVERTIBLE WARRANTS WITH A VESTING PERIOD AND PUT PROTECTION

This case study provides a sample application of the Super Lattice Solver on valuing a warrant (an instrument that can be converted into a stock, similar to a call option) that has a protective put option associated with it. The analysis