the value of the closed-form analysis with a binomial lattice calculation. Do the following exercises, answering the questions that are posed:

1. Solve the expansion option problem manually using a 10-step lattice and confirm the results by generating an audit sheet using the software.
2. Rerun the expansion option problem using the software for 100 steps, 300 steps, and 1,000 steps. What are your observations?
3. Show how you would use the *Closed-Form American Approximation Model* to estimate and benchmark the results from an expansion option. How comparable are the results?
4. Show the different levels of expansion factors but still yielding the same expanded asset value of $800. Explain your observations of why, when the expansion value changes, the *Black-Scholes* and *Closed-Form American Approximation* models are insufficient to capture the fluctuation in value.
   a. Use an expansion factor of 2.00 and an asset value of $400.00 (yielding an expanded asset value of $800).
   b. Use an expansion factor of 1.25 and an asset value of $640.00 (yielding an expanded asset value of $800).
   c. Use an expansion factor of 1.50 and an asset value of $533.34 (yielding an expanded asset value of $800).
   d. Use an expansion factor of 1.75 and an asset value of $457.14 (yielding an expanded asset value of $800).
5. Add a dividend yield and see what happens. Explain your findings.
   a. What happens when the dividend yield equals or exceeds the risk-free rate?
   b. What happens to the accuracy of closed-form solutions like the *Black-Scholes* and *Closed-Form American Approximation Model* models for use as benchmarks?
6. What happens to the decision to expand if a dividend yield exists? Now suppose that although the firm has an annualized volatility of 35 percent, the competitor has a volatility of 45 percent. This means that the expansion factor of this option changes over time, comparable to the volatilities. In addition, suppose the implementation cost is a constant 120 percent of the existing firm's asset value at any point in time. Show how this problem can be solved using the Multiple Asset SLS. Is there option value in such a situation?

CONTRACTION, EXPANSION, AND ABANDONMENT OPTION

The *Contraction, Expansion, and Abandonment Option* applies when a firm has three competing and mutually exclusive options on a single project to choose from at different times up to the time of expiration. Be aware that this is a mutually exclusive set of options. That is, you cannot execute any combinations of expansion, contraction, or abandonment at the same time. Only one option can be executed at any time. That is, for mutually exclusive options, use a single model to compute the option value as seen in Figure 10.16 (example file used: *Expand Contract Abandon American and European Option*). However, if the options are nonmutually exclusive, calculate them individually in different models and add up the values for the total value of the strategy.

Figure 10.17 illustrates a Bermudan Option with the same parameters but with certain blackout periods (example file used: *Expand Contract Abandon Bermudan Option*), while Figure 10.18 (example file used: *Expand Contract Abandon Customized Option I*) illustrates a more complex Custom Option where during some earlier period of vesting, the option to expand does

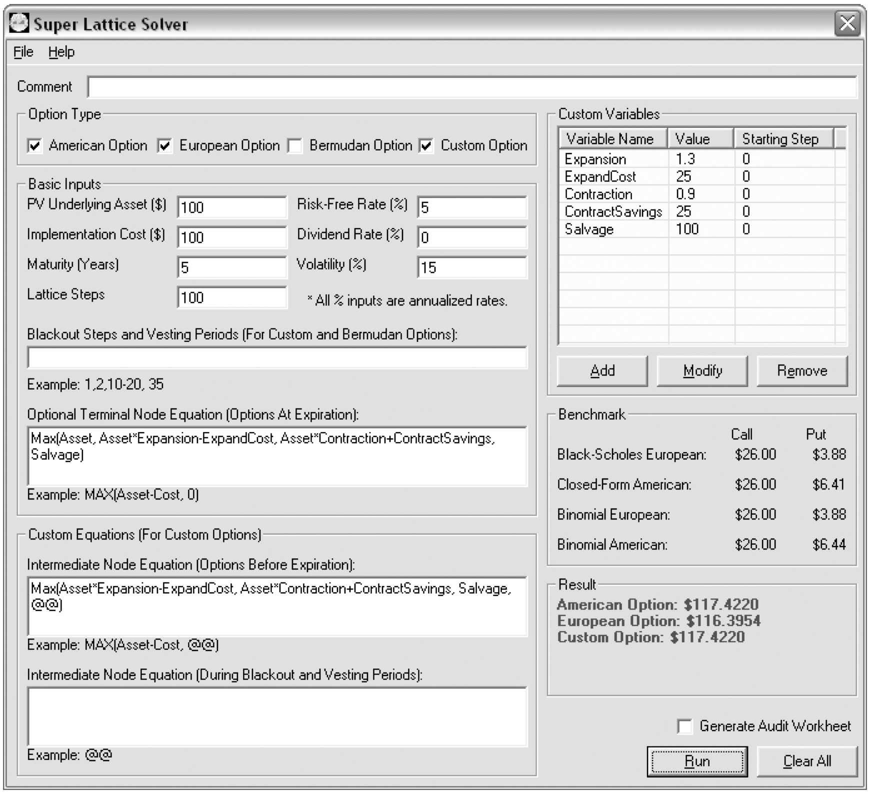

FIGURE 10.16 American, European, and Custom Options to Expand, Contract, and Abandon

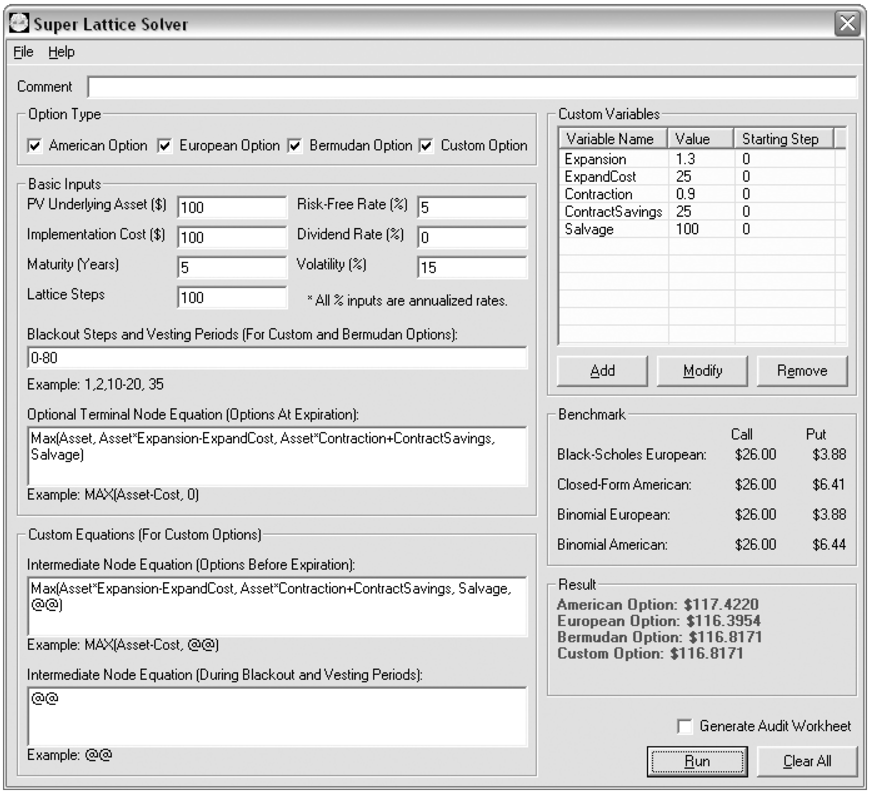

FIGURE 10.17 Bermudan Option to Expand, Contract, and Abandon

not exist yet (perhaps the technology being developed is not yet mature enough in the early stages to be expanded into some spin-off technology). In addition, during the postvesting period but prior to maturity, the option to contract or abandon does not exist (perhaps the technology is now being reviewed for spin-off opportunities), and so forth. Figure 10.19 uses the same example in Figure 10.18 but now the input parameters (salvage value) are allowed to change over time perhaps accounting for the increase in project, asset, or firm value if abandoned at different times (example file used: *Expand Contract Abandon Customized Option II*).

Exercise: Option to Choose—Contraction, Expansion, Abandonment (Dominant Option)

Suppose a large manufacturing firm decides to hedge itself through the use of strategic options. Specifically, it has the option to choose among three

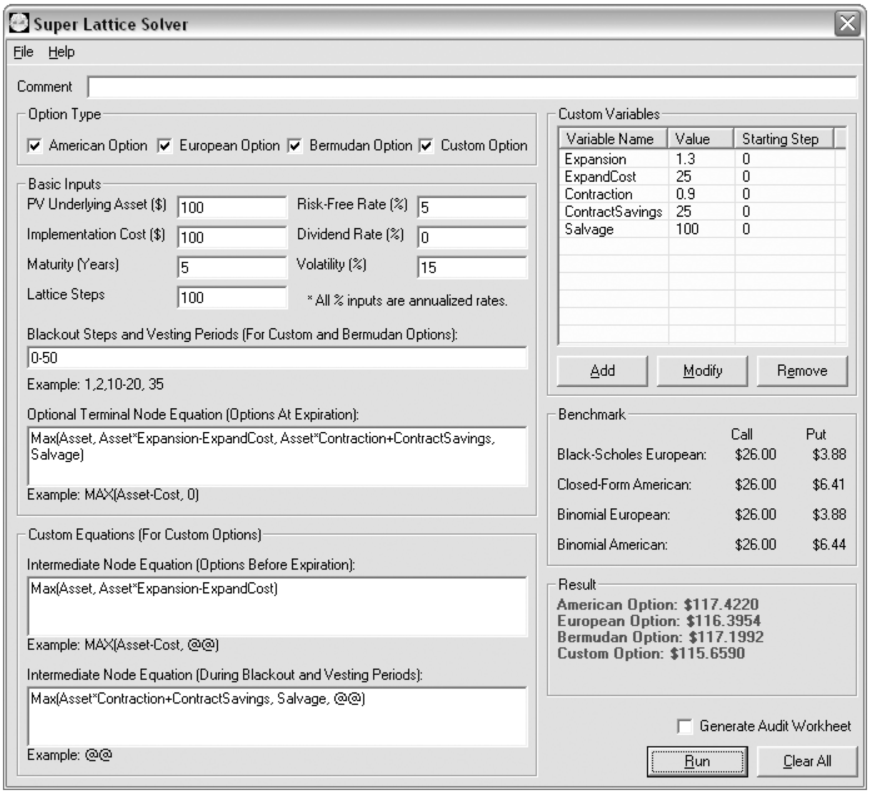

FIGURE 10.18 Custom Options with Mixed Expand, Contract, and Abandon Capabilities

strategies: expanding its current manufacturing operations, contracting its manufacturing operations, or completely abandoning its business unit at any time within the next five years. Suppose the firm has a current operating structure whose static valuation of future profitability using a DCF model (in other words, the present value of the future cash flows discounted at an appropriate market risk-adjusted discount rate) is found to be $100 million.

Using Monte Carlo simulation, you calculate the implied volatility of the logarithmic returns on the projected future cash flows to be 15 percent. The risk-free rate on a riskless asset for the next five years is found to be yielding 5 percent annualized returns. Suppose the firm has the option to contract 10 percent of its current operations at any time over the next five years, thereby creating an additional $25 million in savings after this contraction. The expansion option will increase the firm's operations by 30 percent, with a $20 million implementation cost. Finally, by abandoning its operations,

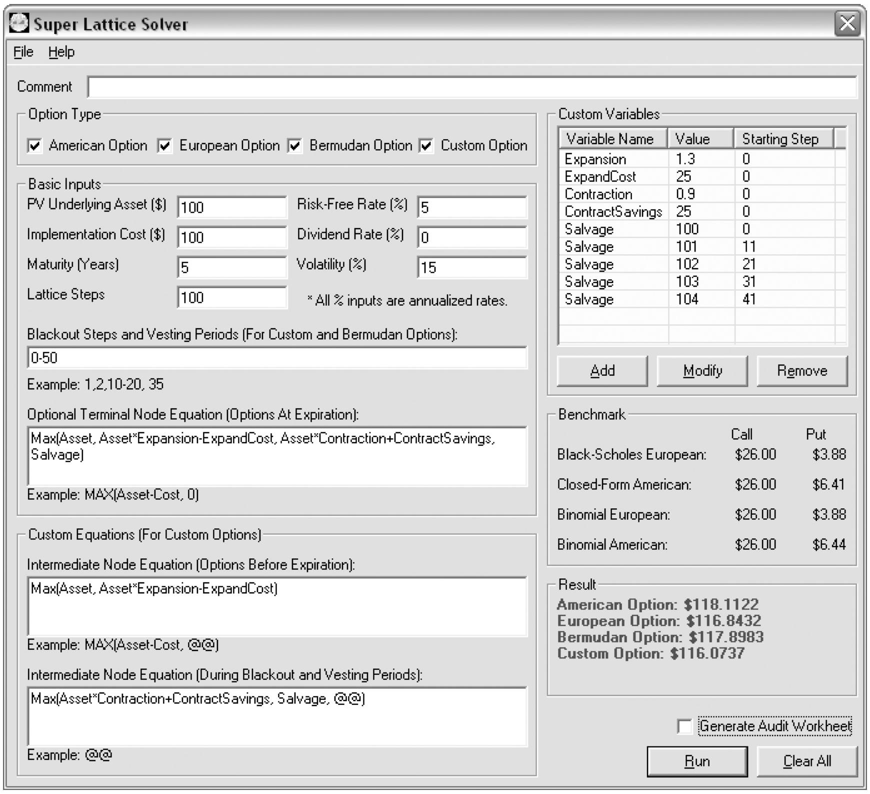

FIGURE 10.19 Custom Options with Mixed Expand, Contract, and Abandon Capabilities with Changing Input Parameters

the firm can sell its intellectual property for $100 million. Do the following exercises, answering the questions that are posed:

1. Solve the chooser option problem manually using a 10-step lattice and confirm the results by generating an audit sheet using the SLS software.
2. Recalculate the option value in question 1 accounting only for an expansion option.
3. Recalculate the option value in question 1 accounting only for a contraction option.
4. Recalculate the option value in question 1 accounting only for an abandonment option.
5. Compare the results of the sum of these three individual options in questions 2 to 4 with the results obtained in question 1 using the chooser option.

a. Why are the results different?
b. Which value is correct?

6. Prove that if there are many interacting options, if there is a single dominant strategy, the value of the project's option value approaches this dominant strategy's value. That is, perform the following steps, then compare and explain the results.
   a. Reduce the expansion cost to $1.
   b. Increase the contraction savings to $100.
   c. Increase the salvage value to $150.
   d. What inferences can you make based on these results?
7. Solve the following Contraction and Abandonment option: Asset value of $100, five-year economic life, 5 percent annualized risk-free rate of return, 25 percent annualized volatility, 25 percent contraction with a $25 savings, and a $70 abandonment salvage value.
8. Show and explain what happens when the salvage value of abandonment far exceeds any chances of a contraction. For example, set the salvage value at $200.
9. In contrast, set the salvage value back to $70, and increase the contraction savings to $100. What happens to the value of the project?
10. Solve just the contraction option in isolation. That is, set the contraction savings to $25 and explain what happens. Change the savings to $100 and explain the change in results. What can you infer from dominant option strategies? Solve just the abandonment option in isolation. That is, set the salvage value to $70, and explain what happens. Change the salvage value to $200, and explain the change in results. What can you infer from dominant option strategies?

BASIC AMERICAN, EUROPEAN, AND BERMUDAN CALL OPTIONS

Figure 10.20 shows the computation of basic American, European, and Bermudan Options without dividends (example file used: *Basic American, European, versus Bermudan Call Options*), while Figure 10.21 shows the computation of the same options but with a dividend yield. Of course, European Options can only be executed at termination and not before, while in American Options, early exercise is allowed, versus a Bermudan Option where early exercise is allowed except during blackout or vesting periods. Notice that the results for the three options without dividends are identical for simple call options, but they differ when dividends exist. When dividends are included, the simple call option values for American ≥ Bermudan ≥ European in most basic cases, as seen in Figure 10.21. Of course this generality can be applied only to plain-vanilla call options and do not necessarily apply to other