a. What happens to the results?
b. Does a dividend yield increase or decrease the value of an abandonment option? Why?

5. Assume that the salvage value increases at a 10 percent annual rate. Show how this can be modeled using the software's *Custom Variables List*.
6. Explain the differences in results when using the *Black-Scholes* and *American Put Option Approximation* in the benchmark section of the Single Asset SLS software.

AMERICAN, EUROPEAN, BERMUDAN, AND CUSTOMIZED CONTRACTION OPTION

A *Contraction Option* evaluates the flexibility value of being able to reduce production output or to contract the scale and scope of a project when conditions are not as amenable, thereby reducing the value of the asset or project by a *Contraction Factor*, but at the same time creating some cost *Savings*. As an example, suppose you work for a large aeronautical manufacturing firm that is unsure of the technological efficacy and market demand for its new fleet of long-range supersonic jets. The firm decides to hedge itself through the use of strategic options, specifically an option to contract 10 percent of its manufacturing facilities at any time within the next five years (i.e., the *Contraction Factor* is 0.9).

Suppose that 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 expected future cash flows discounted at an appropriate market risk-adjusted discount rate) is found to be $1,000M (*PV Asset*). Using Monte Carlo simulation, you calculate the implied volatility of the logarithmic returns of the asset value of the projected future cash flows to be 30 percent. The risk-free rate on a riskless asset (five-year U.S. Treasury Note with zero coupons) is found to be yielding 5 percent.

Further, 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 $50 million in savings after this contraction. These terms are arranged through a legal contractual agreement with one of its vendors, who had agreed to take up the excess capacity and space of the firm. At the same time, the firm can scale back and lay off part of its existing workforce to obtain this level of savings (in present values).

The results indicate that the strategic value of the project is $1,001.71M (using a 10-step lattice as seen in Figure 10.7), which means that the NPV currently is $1,000M and the additional $1.71M comes from this contraction option. This result is obtained because contracting now yields 90 percent of $1,000M + $50M, or $950M, which is less than staying in business and not

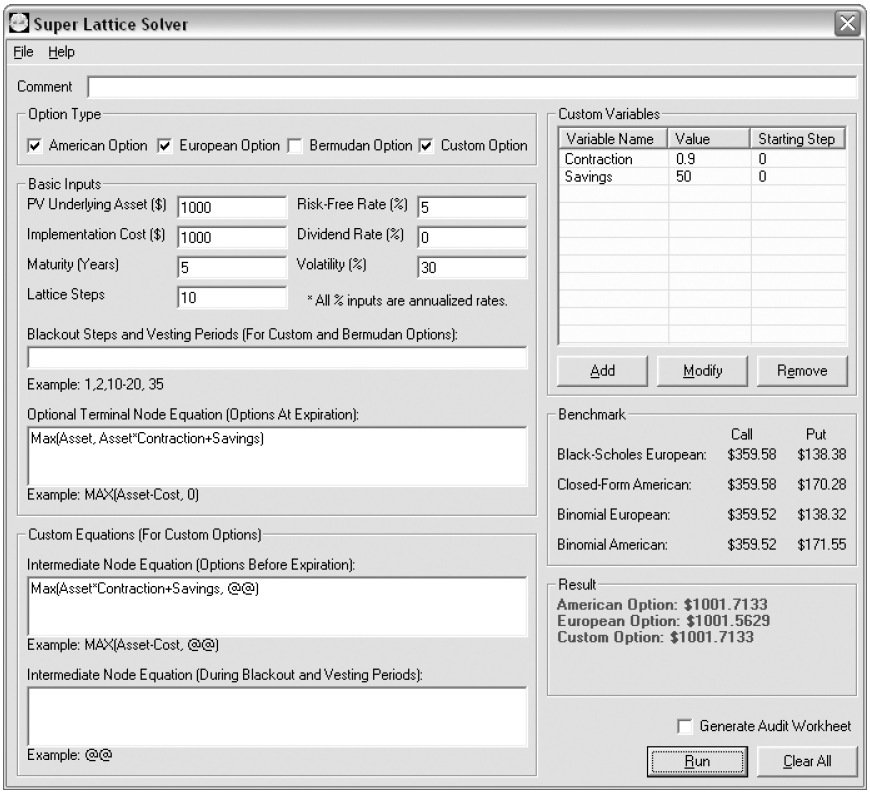

FIGURE 10.7 Simple American and European Options to Contract with a 10-Step Lattice

contracting and obtaining $1,000M. Therefore, the optimal decision is to not contract immediately but keep the ability to do so open for the future. Hence, in comparing this optimal decision of $1,000M to $1,001.71M of being able to contract, the option to contract is worth $1.71M. This should be the maximum amount the firm is willing to spend to obtain this option (contractual fees and payments to the vendor counterparty).

In contrast, if *Savings* were $200M instead, then the strategic project value becomes $1,100M, which means that starting at $1,000M and contracting 10 percent to $900M and keeping the $200 in savings, yields $1,100M in total value. Hence, the additional option value is $0M which means that it is optimal to execute the contraction option immediately as there is no option value and no value to wait to contract. So, the value of executing now is $1,100M as compared to the strategic project value of $1,100M; there is no additional option value, and the contraction should be

executed immediately. That is, instead of asking the vendor to wait, the firm is better off executing the contraction option now and capturing the savings.

Other applications include shelving an R&D project by spending a little to keep it going but reserving the right to come back to it should conditions improve; the value of synergy in a merger and acquisition where some management personnel are let go to create the additional savings; reducing the scope and size of a production facility; reducing production rates; a joint venture or alliance, and so forth.

To illustrate, following are some additional quick examples of the contraction option (as before, providing some additional sample exercises).

■ A large oil and gas company is embarking on a deep-sea drilling platform that will cost the company billions to implement. A DCF analysis is run and the NPV is found to be $500M over the next 10 years of economic life of the offshore rig. The 10-year risk-free rate is 5 percent, and the volatility of the project is found to be at an annualized 45 percent using historical oil prices as a proxy. If the expedition is highly successful (oil prices are high and production rates are soaring), then the company will continue its operations. However, if things are not looking too good (oil prices are low or moderate and production is only decent), it is very difficult for the company to abandon operations (why lose everything when net income is still positive although not as high as anticipated, not to mention the environmental and legal ramifications of simply abandoning an oil rig in the middle of the ocean). Hence, the oil company decides to hedge its downside risk through an American Contraction Option. The oil company was able to find a smaller oil and gas company (a former partner on other explorations) interested in a joint venture. The joint venture is structured such that the oil company pays this smaller counterparty a lump sum right now for a 10-year contract whereby at any time and at the oil company's request, the smaller counterparty will have to take over all operations of the offshore oil rig (i.e., taking over all operations and hence all relevant expenses) and keep 30 percent of the net revenues generated. The counterparty is in agreement because it does not have to partake in the billions of dollars required to implement the rig in the first place, and it actually obtains some cash up front for this contract to assume the downside risk. The oil company is also in agreement because it reduces its own risks if oil prices are low and production is not up to par, and it ends up saving over $75M in present value of total overhead expenses, which can then be reallocated and invested somewhere else. *In this example, the contraction option using a 100-step lattice is valued to be $14.24M using SLS. This means that the maximum amount that the counterparty should be paid should not exceed this amount. Of course, the option analysis can be further complicated by analyzing the actual savings on a present value basis. For instance, if the option is exercised within the first five years, the savings is $75M but*

if exercising during the last five years then the savings is only $50M. The revised option value is now $10.57M.

■ A manufacturing firm is interested in outsourcing its manufacturing of children's toys to a small province in China. By doing so, it will produce overhead savings of over $20M in present value over the economic life of the toys. However, outsourcing this internationally will mean lower quality control, problems in delayed shipping, added importing costs, and assuming the added risks of unfamiliarity with the local business practices. In addition, the firm will consider outsourcing only if the quality of the workmanship in this Chinese firm is up to the stringent quality standards it requires. The NPV of this particular line of toys is $100M with a 25 percent volatility. The firm's executives decide to purchase a contraction option by locating a small manufacturing firm in China, spending some resources to try out a *small-scale proof of concept* (thereby reducing the uncertainties of quality, knowledge, import-export issues, and so forth). If successful, the firm will agree to give this small Chinese manufacturer 20 percent of its net income as remuneration for its services, plus some start-up fees. The question is, how much is this option to contract worth, that is, how much should the firm be willing to pay, on average, to cover the initial start-up fees plus the costs of this proof of concept stage? *A contraction option valuation result using SLS shows that the option is worth $1.59M, assuming a 5 percent risk-free rate for the one-year test period. So, as long as the total costs for a pilot test are less than $1.59M, it is optimal to obtain this option, especially if it means potentially being able to save more than $20M.*

Figure 10.7 illustrates a simple 10-step contraction option while Figure 10.8 shows the same option using 100 lattice steps (example file used is *Contraction American and European Option*). Figure 10.9 illustrates a five-year Bermudan Contraction Option with a four-year vesting period (blackout steps of 0 to 80 out of a 5-year, 100-step lattice) where for the first four years, the option holder can only keep the option open and not execute the option (example file used is *Contraction Bermudan Option*). Figure 10.10 shows a customized option where there is a blackout period and the savings from contracting change over time (example file used is *Contraction Customized Option*). These results are for the aeronautical manufacturing firm example.

Exercise: Option to Contract

You work for a large automobile spare parts manufacturing firm that is unsure of the technological efficacy and market demand of its products. The firm decides to hedge itself through the use of strategic options, specifically an option to contract 50 percent of its manufacturing facilities at any time within the next five years.

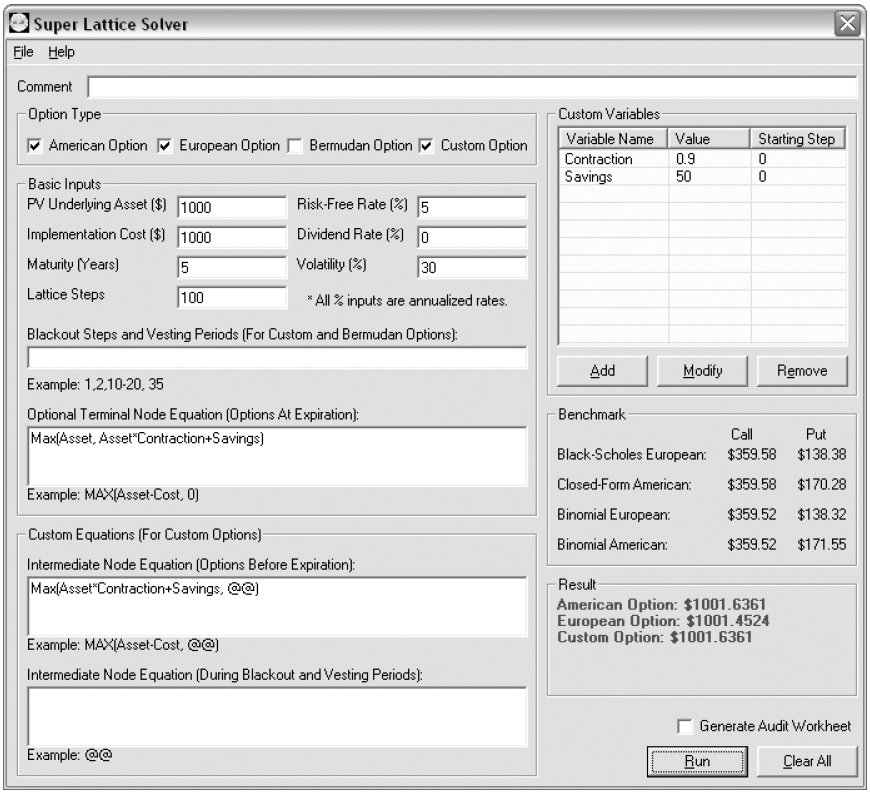

FIGURE 10.8 American and European Options to Contract with a 100-Step Lattice

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 expected future cash flows discounted at an appropriate market risk-adjusted discount rate) is found to be $1 billion. Using Monte Carlo simulation, you calculate the implied volatility of the logarithmic returns on the projected future cash flows to be 50 percent. The risk-free rate on a risk-less asset for the next five years is found to be yielding 5 percent. Suppose the firm has the option to contract 50 percent of its current operations at any time over the next five years, thereby creating an additional $400 million in savings after this contraction. This is done through a legal contractual agreement with one of its vendors, who had agreed to take up the excess ca-

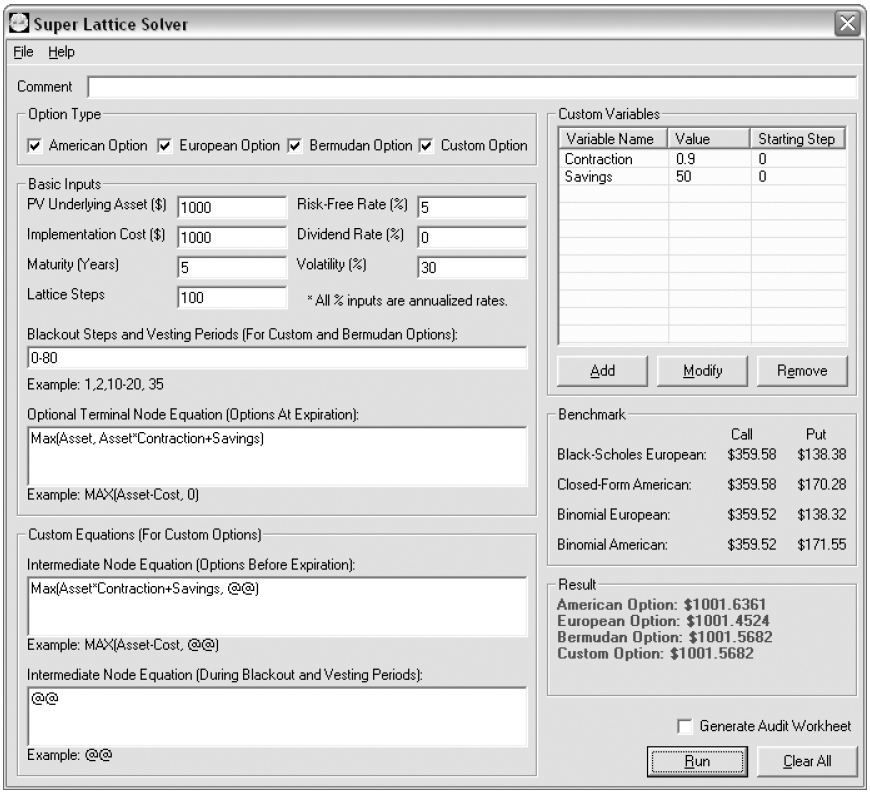

FIGURE 10.9 A Bermudan Option to Contract with Blackout Vesting Periods

pacity and space of the firm. Then the firm can scale back its existing workforce to obtain this level of savings.

A *Closed-Form American Approximation Model* can be used, because the option to contract the firm's operations can be exercised at any time up to the expiration date and can be confirmed with a binomial lattice calculation. Do the following exercises, answering the questions that are posed:

1. Solve the contraction option problem manually using a 10-step lattice and confirm the results by generating an audit sheet using the software.
2. Modify the continuous dividend payout rate until the option breaks even. What observations can you make at this break-even point?

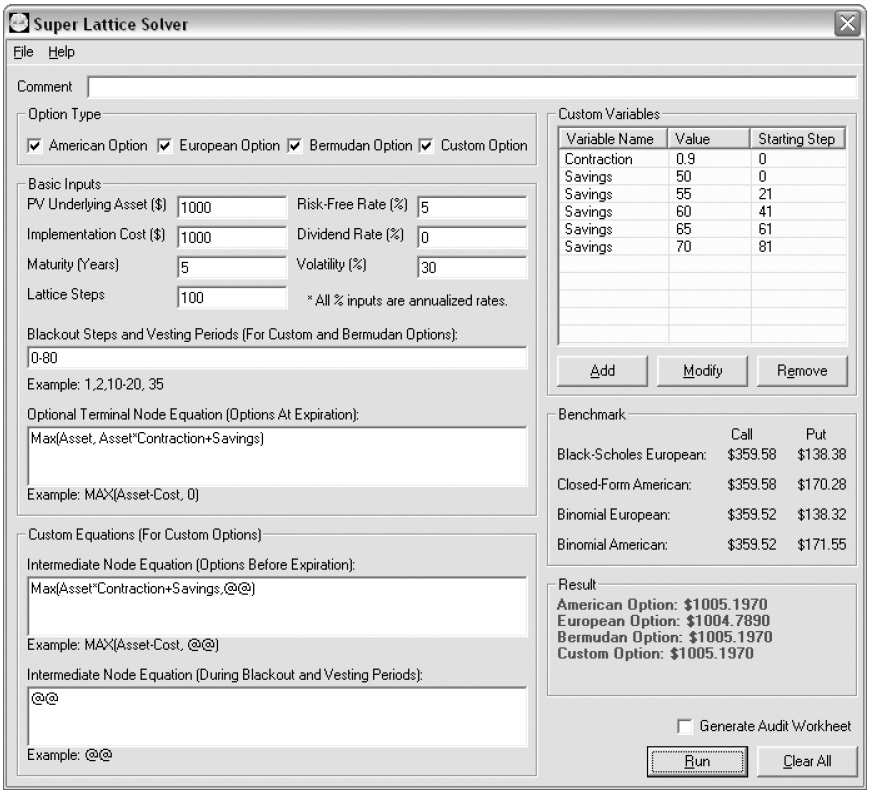

FIGURE 10.10 A Customized Option to Contract with Changing Savings

3. Use the *Closed-Form American Approximation Model* in the benchmark area of the software by using the corresponding put option. In order to do this appropriately, you will need to rerun the model with modified input parameters. What are these required input parameters?
4. How can you use the *American Abandonment Option* as a benchmark to estimate the contraction option? If it is used, are the resulting option values comparable?
5. Change the contraction factor to 0.7, and answer Question 4. Why are the answers different? Suppose the initial estimate of $400 million in savings is applicable only if the contraction option is executed immediately. However, due to opportunity costs and time value of money, assume that the $400 million goes down by $10 million each year. What happens to the value of this option and how much is it worth now?