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It May Be Cheaper to Manufacture at Home

by Suzanne de Treville and Lenos Trigeorgis

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Summary. Conventional financial tools can lead to supply chain mistakes. Most managers use the discounted cash flow (DCF) model to help them make decisions such as where to locate a new manufacturing plant or whether to use a foreign or domestic supplier. But DCF typically undervalues flexibility—and as a result, companies may end up with supply chains that are low cost as long as everything proceeds according to plan but extremely expensive if problems arise.

De Treville, of the University of Lausanne, and Trigeorgis, of the University of Cyprus, argue that you can avoid this pitfall by complementing a DCF analysis with a real options valuation. This technique lets you put a dollar figure on flexibility in the supply chain and helps you assess the value of having direct control.

The authors explain how a real options approach helped the Swiss company Flexcell decide whether to locate a new plant at home or abroad. The CEO was able to show his board that the flexibility afforded by a factory near company headquarters would more than make up for the 15% per unit cost savings that would have been realized at a factory elsewhere. He also demonstrated that the costs resulting from a disruption to a Swiss plant would be much lower than those resulting from a disruption to a foreign plant. The decision to manufacture at home has paid off handsomely, especially in view of the uncertainties created by the current economic crisis. **close**

Artwork: Michael Johansson, **Toys'R'Us**, 2006, dinghy, boat equipment, welded metal frame, spray paint, 2 x 2.6 m

When making supply chain decisions, such as where in the world to locate a new plant or whether to use a foreign or domestic supplier, most managers rely on the discounted cash flow (DCF) model to help them value the alternatives. The trouble with this approach is that DCF typically undervalues flexibility. As a result, companies may end up with supply chains that are lean and low cost as long as everything goes according to plan—but horribly expensive if the unexpected occurs.

You can avoid this trap by complementing a DCF analysis with a real options valuation, which allows you to put a dollar figure on flexibility in the supply chain. This was the tack taken by Flexcell, an innovative Swiss company offering lightweight solar panels for a wide variety of applications.

A small start-up founded in 2000, Flexcell was looking to expand operations after a German investor signed on as its major shareholder in 2006. Like many companies, it faced a difficult choice: Where should it locate its new factory? It considered three options: China, eastern Germany (the location favored by the new investor), and a site next to its own headquarters. The Chinese option was quickly discarded; it would have limited Flexcell's ability to customize its products, and the challenges of getting a distant plant up to speed on a production process involving new technologies were deemed too great.

Deciding between the German and Swiss sites was more difficult. A plant in eastern Germany would have been near enough to permit a reasonable amount of customization, and it would have

lowered per unit manufacturing costs by 15%. But the Flexcell management team believed it was more important to have the plant right at home.

Flexcell's CEO, Alexandre Closset, made a successful case for the Swiss location by claiming two key advantages of domestic manufacturing: flexibility in timing production commitments and the ability to directly manage problems. To do so, he had to look beyond the traditional DCF model.

> **One CEO showed that the flexibility afforded by a factory at home more than made up for the 15% per unit savings at a factory abroad.**

Closset decided to treat flexible timing as a postponement option: If the plant were in Switzerland, he could delay production commitments and investments for several months, during which he could gather critical information about demand. This decision allowed him to use the real options valuation framework, which in turn let him put a dollar figure on flexibility. The real options framework also let him put a dollar figure on the ability to manage production problems directly rather than from afar.

Let's look at how real options valuation can help you make sound supply chain decisions.

Calculating the Value of Flexibility

Using the DCF model, you forecast demand (typically by averaging high and low expected sales scenarios), multiply the result by your unit price, subtract production costs, adjust this earnings figure to get an estimate of future cash flows, and

discount those flows to allow for risk, using the classic capital asset pricing model. All other things being equal, your decision about where to manufacture will be determined primarily by cost.

But what if all other things are not equal? Suppose that global manufacturing requires you to place a firm production order far ahead of time, whereas domestic manufacturing allows you to wait until you know the actual demand.

Consider first the effect on global manufacturing. When you place a production order ahead of time for less than the maximum potential demand, you are effectively capping your sales and cutting off the possibility of benefiting if demand proves higher than you'd forecast. This reduces your expected level of sales and your expected revenue. The loss of flexibility thus lowers the net present value obtainable from your global manufacturing option.

How does flexibility affect the value obtainable from your domestic manufacturing option? Postponing your production order until you have a better estimate of demand reduces the risk of either stocking out or producing excess. Using the DCF model properly to assess the value thus gained requires adjusting the discount rate to reflect the fact that most of the risk you were facing has now been eliminated. And choosing an appropriate discount rate can be an exercise in guesswork.

This is where real options theory helps. In a real options valuation model, the relevant discount rate becomes the risk-free rate via a simple adjustment to the demand outcome probability. And coming up with values for this variable does not require a series of separate estimates; the values arise naturally in the real options calculation. (For a sample calculation, see the sidebar "Valuing Postponement in Supply Chain Operations.")

Valuing Postponement in Supply Chain Operations

Conventional supply chain valuations are based on the traditional discounted cash flow (DCF) model. You forecast demand (typically by averaging high and low expected sales scenarios), multiply the result by your unit price, subtract production costs, adjust this earnings figure to get an estimate of future cash flows, and discount those flows to allow for risk, using the classic capital asset pricing model. All other things being equal, your decision about where to manufacture will be determined primarily by cost.

Let's assume your product sells for $100 a unit and costs $60 to produce abroad and $70 to produce domestically. You estimate that next year you have a 50% chance of selling 180,000 units and a 50% chance of selling 60,000 units. Your expected sales are the average of the two: 120,000 units, generating $12 million in revenue. Applying a risk-adjusted discount rate of, say, 20% gives you a present value of $10 million. Producing globally saves you $10 per unit, or $1.2 million in all; when discounted at 20%, your expected savings are $1 million in present value terms. All other things being equal, global production is the cheaper strategy.

But what if all other things are not equal? Suppose that global manufacturing requires you to place a firm production order far ahead of time, whereas domestic manufacturing lets you wait until you know the actual demand. Clearly, the difference in timing reduces the value of the global production facility and increases the value of the domestic one. But by how much?

In your global manufacturing calculations, you must reduce your expected revenue due to the lack of flexibility. Your expected sales, as we saw above, are 120,000 units, so that's the amount most managers, forced to place an order ahead of time, would opt for. That production commitment changes your expected revenue, which is now the average of 120,000—your new cap—and 60,000. Selling 90,000 units at $100 per unit and applying a risk-adjusted discount of 20% yields a present value of $7.5 million for your expected next year's revenue. Because your production costs are $60 per unit, or $7.2 million, the expected net present value of your global supply chain becomes just $0.3 million.

What about the domestic manufacturing option? Remember that the present value of an expected demand of 120,000 units was $12 million a year, or $10 million after the 20% discount. If you had $10 million in hand today and invested it in risk-free assets at, say, 8%, it would be worth $10.8 million in a year's time. What must your demand outcome probabilities be in order to produce an expected value of $10.8 million? Instead of assuming a 50% probability of selling 180,000 units and a 50% probability of selling 60,000, you need to change your probability estimates to 40% and 60% respectively. (180,000 units × 40% = 72,000 units; 60,000 units × 60% = 36,000 units. With these adjustments, expected sales are 108,000 units, for $10.8 million in expected revenue.)

Now back to DCF. If demand is high, you will produce—and sell—180,000 units, for an expected revenue of $18 million. The production costs will be $12.6 million (180,000 × $70); thus, the expected value will be $5.4 million ($18 million − $12.6 million). If demand is low, you will produce and sell 60,000 units, for an expected revenue of $6 million. Subtracting the production costs, $4.2 million, yields an expected value of $1.8 million.

Applying your adjusted probabilities of 40% for the high-demand scenario and 60% for the low-demand one gives you an expected profit of $3.24 million, which, discounted by the risk-free rate of 8%, is worth $3 million. Thus, the expected value of your domestic supply chain is much greater than the expected value of your global one, even when you take the difference in production costs into account.

At Flexcell, Closset was able to show the board that the value of the postponement option afforded by the Swiss location more than made up for the 15% per unit cost savings that could be realized in eastern Germany. And the decision to locate in Switzerland is paying off handsomely in the current economic crisis, which has caused considerable variability in demand and increased the value of flexibility. Because it can rapidly adjust production levels, Flexcell has neither built up unwanted inventory nor faced stock outs.

The Value of Direct Control

Let's return to the second factor Closset cited in favor of domestic production: the advantage of direct physical control. Investors in commodity markets understand this advantage well. Direct physical control lowers your exposure to risk. For example, bad weather and other unforeseen events can make commodities such as oil and wheat unavailable regardless of contractual supply agreements. Investors therefore pay a premium for physical control. The advantage thus gained, called the "convenience yield," is analogous to the dividend paid in financial markets to investors who own stock rather than merely holding an option to buy it. You can determine a commodity's convenience yield by comparing prices in the derivative and spot markets; it is simply the difference between the value of owning the commodity and the value of having an option to buy it.

The value of direct control over manufacturing-site alternatives is harder to ascertain. Still, you can approximate it by comparing the costs of unexpected disruptions to global and domestic supply chains. The difference is the convenience yield of the domestic facility, which you can factor into your project valuation calculations using the real options framework.

Flexcell's Closset did just that, showing the board that the costs resulting from a disruption to a Swiss plant would be much lower than those resulting from a disruption to one in eastern Germany. For example, if a problem with a new product configuration were to arise in a local factory, engineers could start working on it within minutes, whereas having to get them to eastern Germany could halt production for a couple of days. Including the convenience yield of the Swiss factory in his calculations helped to demonstrate the greater value of the Swiss location.

The decision to manufacture in Switzerland is paying off in this regard as well. Although Flexcell encountered some difficulties while scaling up production, it was able to meet its delivery commitments for the thousands of units presold through 2008 and 2009 because the design engineers and production people were all on site. In addition, the proximity of product development to manufacturing has helped Flexcell take full advantage of its innovative capabilities, allowing it to tailor offerings ever more exactly to customer needs. This enhanced responsiveness and customization provide a powerful competitive advantage.

Having Your Cake, Too

Will applying real options valuation to supply chain projects explode the feasibility of global supply chains? Not at all. You don't necessarily need flexibility throughout your entire supply chain, as the Italian clothing manufacturer Benetton demonstrated in the 1960s.

Benetton realized that many clothes were differentiated by color, not shape or design. So it employed women in northern Italian villages to weave garments in neutral colors and shipped the garments to its headquarters, dyeing them there at the last minute in order to choose colors on the basis of the latest consumer trends. By postponing just the dyeing, Benetton dramatically reduced its overall production risks. The rest of the process could still be fixed far in advance.

One simple intuition was enough to give Benetton a significant competitive advantage. When the choices are more nuanced, however, real options valuation can help supply chain strategists make much better informed decisions about which parts of the supply chain to locate where.

We've focused on putting a dollar figure on the flexibility gained by keeping production close to home. But there are other ways to increase flexibility, of course—for example, by investing in excess capacity or inventory. Taking a real options valuation approach to these decisions as well can help companies appreciate just where in a fashionably lean, globally dispersed supply chain hidden costs may lurk.

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