A Case Analysis of Supply Chain Investments

Louis A. Le Blanc and Gisung Moon
Campbell School of Business
Berry College
Mount Berry, GA 301449

Introduction

Strategic logistics decisions normally consider infrastructure investment, including supply chain capacity levels and design configuration (Novack et al., 1992). Logistics and supply chain managers should identify and estimate the costs, revenues and risks associated with related investments. These elements remain difficult to quantify with any degree of certainty. The competition for an organization's funds demands that the "value added" by investment projects to the enterprise be carefully measured (Speh and Novack, 1995).

Some organizations evaluate all projects against a entity-wide target rate of return. However, many capital projects in the supply chain are relatively less risky, as they involve costs savings that are measurable and rather certain, but may generate less than spectacular rates of return. An adjustment to the target return based on the riskiness of the project might prove indispensable. Investments in logistics assets with the same risk command the same required rate of return (Pringle and Harris, 1987). Consequently, lower target rates of return should be reasonable for less risky supply chain projects.

The paper describes a simulation model of an intermodal transfer and bulk commodity blending facility and the financial analysis of potential changes to the actual plant capacity and design configuration. The model estimated cash flows (measured as annual cost savings due to an increase in capacity). They are adjusted for the same volume and scheduling performance from several possible capital investment projects in logistics infrastructure. The risk-adjusted required rate of return was computed based on the risk profile of proxy firms that undertake these same kinds of investments in supply chain assets. Benefit-cost ratios were then calculated to determine which projects exceeded the required rate of return for the risk levels of these investments.

An Appropriate Discount Rate for Supply Chain Projects

It appears that risky projects are less desirable than safe ones, other things being equal. Consequently, financial managers require a higher rate of return on risky investments. Modern finance theories in capital budgeting suggest that a project should be undertaken if its net present value (NPV) is positive. To calculate the NPV of a project, financial managers must understand the risk characteristics of the project itself, as the discount rate appropriate for the project risk should be employed, rather than a company-wide hurdle rate. In estimating the required rate of return on a project, companies often use the rate of return required by security holders. While the positive relation between risk and return seems intuitive, there is still no consensus on what types of project risk is relevant and/or how to measure it.

While debatable, the capital asset pricing model (CAPM) has gained popularity among practitioners. For example, Graham and Harvey (2001) found in a survey of financial practice that 74 percent of firms always, or almost always, used the CAPM to estimate the cost of capital. This analysis utilizes the CAPM to estimate the cost of capital for a supply chain investment project.

The CAPM is widely used to estimate the return that equity investors require. The model stipulates the positive relation between the expected return and risk in an equation commonly known as the security market line (SML).

$$R_i = R_f + \beta_i \, (R_m - R_f)$$

The expected return on equity of firm i (R_i) is equal to the risk-free rate (R_m) plus a risk premium, which is proportional to its beta (β_i) and the market risk premium (R_m – R_f). Beta measures the firm's market risk that can not be diversified away, and therefore must be borne by a firm's investors, who in turn demand to be compensated accordingly for assuming risk. This model can often be extended to capital budgeting to estimate the cost of capital for a project.

Implementing the model, however, brings a few challenges. First, the parameters in the SML equation must be estimated. There are no true risk-free assets, but Treasury securities are essentially free of default risk. As common equity is a long-term claim, Brigham and Ehrhardt (2005) suggest that the yield on a Treasury bond be used to estimate the risk-free rate. A 30-year Treasury bond as of 30 September 2005 yields 4.42 percent, according to Yahoo Finance. On the basis of historical data, the long-term Treasury bonds have yielded 5.02 percent (geometric average) over the period 1928 to 2004.

The market risk premium (or the market expected return – risk-free rate) can be estimated either on a historical or forward-looking basis. Using the S&P 500 index as a proxy for the U.S. stock market, the geometric average return over the 1928-2004 time frame is 9.86 percent. With the risk-free rate of 5.02 percent on Treasury bonds, the risk-premium is then 4.84 percent on the basis of historical data.

As an alternative to historical risk-premium, a forward-looking risk-premium can be inferred by applying dividend discount model to current level of the index.

$$\text{Expected rate of return} = R_m = \frac{D_1}{P_0} + g = \frac{D_0(1+g)}{P_0} + g$$

where:

D_1	is the expected dividend on the Standard & Poors (S&P) 500 index;
P_0	is the current level of the index; and,
g	is the expected growth rate of dividend.

With the growth rate estimated with historical data for the period from 1960 to 2004, the expected return on S&P 500 is computed;

$$R_m = \frac{19.407(1+0.0532)}{1211.92} + 0.0532 = 0.0701 = 7.01\%$$

Given the current long-term Treasury bond yield of 4.42 percent, the forward looking risk-premium is only 2.59 percent, which seems low.

Finally, the analysis estimates the beta of the port facility project. Since we cannot directly observe the market prices or returns on the port facilities, we rely on surrogate firms who make similar investments in port facilities. Using Value Line and S&P's Net Advantage stock surveys, we identified 12 companies for Table 1 in the marine transportation and storage industry that appear to possess similar types of assets as port transfer facilities (excluding one company that went public in 2002). These firms include Sunoco Logistics Partners (pipelines, terminals and storage), Alexander & Baldwin (shipping and terminals) Kinder Morgan EN (pipelines and bulk terminals), Martin Midstream (marine transportation terminals), SEACOR Holdings (inland bulk barge and logistics support) and Valero L.P. (pipelines, terminals and storage).

The analysis then determines the weighted average beta of these firms, weighted by their market capitalization. As shown in Table 1, the weighted average of beta is 0.588 (while a simple arithmetic average of betas is 0.540). As a benchmark, we also use the beta of the maritime industry. According to Value Line, there are 28 firms in the broader maritime industry with an average beta of 0.67.

	Firms	Equity β	Un-Leveraged β
Proxy Firms	12	0.59	0.39
Maritime Industry	28	0.67	0.44

Table 1: Equity Beta and Un-Leveraged Beta

These betas are equity betas that represent not only business risk, but also financial risk that arises when a firm takes on debt. As a firm increases its leverage by borrowing more, the leverage causes extra risk for equity investors, reflected in higher equity beta. In fact, Hamada (1969) proposed the following equation to show the effect of leverage on equity beta.

$$\beta = \beta_u [1 + (1 - T) (D/S)]$$

where:

- T is the marginal tax rate;
- β_u is un-leveraged beta measuring only the business risk of a firm;
- D is the market value of debt; and,
- S is the market value of equity.

Therefore, an increase in financial leverage (D/S) results in additional risk to the firm business risk. By rearranging the equation, we can un-leverage the equity beta to remove any effects from financial leverage on the beta.

$$\beta_u = \beta / [1 + (1 - T) (D/S)]$$

In evaluating the port facility investment project (as part of the supply chain infrastructure), it seems sensible to focus on the business risk because it is likely a local government, or quasi governmental agency, will invest in this example project. Obviously a local or state government is not subject to Federal income taxes. Moreover, its debt financing would not have the same effect on the equity beta as described in the Hamada equation above. For these reasons, we will use un-leveraged beta to estimate the risk-adjusted discount rate. To employ the Hamada equation, we used 62 percent debt-to-equity ratio that the firms in this industry have on average.

The discount rate is lowest at 5.42 percent when forward-looking market risk-premium and Treasury bond rate are used with the un-leveraged proxy beta of 0.39. One might argue that the forward-looking market risk-premium of 2.59 percent is too low to apply to a long-term project. While we agree that the historical risk-premium of 4.84 percent is more conservative and it is possibly a better estimate for the port facility project, the lower discount rate also is used to illustrate an optimistic view.

Simulation Model of an Intermodal Transfer Facility

Simulation experiments were conducted using a model of a blending facility along the Texas seacoast at Galveston. The facility is owned and operated by a government agency that is part of the Galveston County jurisdiction (i.e., a port authority enabled by the State of Texas). This intermodal system receives and unloads bulk commodities (i.e., wheat, corn and other grains) by rail, temporarily holds the merchandise in storage, mixes product to grade, and then ships the product by ocean-going carriers. Twelve combinations of transfer plant capacity (i.e., loading, unloading and storage) were analyzed. The criterion variable was the average cost per ton to transfer and store bulk commodities.

During the simulated operation of the transfer and blending plant, several uncontrollable factors affected the cost. These factors were the following: 1) the volume at which the system operates; 2) the coordination between different modes of transportation; 3) the scheduling of successive ships arriving at the port, which determines queue time; and, 4) the lot sizes designated for each vessel.

Any of the aforementioned variables can significantly affect the cost of plant operation, regardless of capacity. In order to carefully examine the effect on cost resulting from changes in plant capacity, evaluation of such modifications should be conducted at the same level of volume and scheduling performance (i.e., queue times).

Simulation Logic and Output

The computer simulation model of the transfer and blending facility consists of several sub models. The most important of these are the loading and unloading sub models.

The simulation program was written to evaluate the ability of the transfer and blending plant to handle the forecasted volume of 550,000 tons per month. The parameter values of ship inter-arrival times and cargo sizes were formulated so as to schedule the forecasted level of bulk commodity for the blending plant system during the simulation experiments. The statistical distributions describing vessel inter-arrival times, cargo sizes, and ship types (exponential, normal, and discrete probability, respectively) in the simulation model were selected on the basis of goodness of fit testing against observed operating data. These data included the actual times between ship arrivals, load sizes in tons, as well as the distribution of ship types (i.e., bulk carriers versus tankers) arriving at the blending plant.

Ship waiting times are a function of the scheduling performance between successive ship arrivals achieved by terminal operators (i.e., better scheduling results in less carrier waiting and less inventory). A good schedule would have an incoming ship arriving at the blending facility just when the preceding vessel had finished loading in just-in-time fashion.

Other pertinent statistics provided about the one month simulations include plant volume and average inventory. Work-in-process for each simulation is influenced by the coordination of ship and rail carriers, as well as the scheduling of successive ocean-going carriers. Monthly plant volume is affected by a particular simulation's sample of randomly generated ship inter-arrival times, its sample of lot sizes, and its sample of carrier types (i.e., bulk carriers versus tankers) that affect loading rates and queue times.

Tactical Planning

Simulations of the selected length (each simulation with a different sample of vessel arrivals, lot sizes, and ship types) are repeated for a particular combination of plant capacity. One month plant simulations were selected as the appropriate length of computer execution, as they were the least costly and had the same sample variance as the longer simulations of two months and three months. The pilot results indicated that a one month simulation of the blending facility approached steady state or equilibrium conditions. The simulation were started with queues empty and facilities idles, but with one million bushels of inventory. This mitigated the initial bias or transient condition and allowed for a rather rapid achievement of steady state operation.

Experimental Design for Plant Capacity Evaluation

The average costs resulting from the simulation model of the blending plant can be employed as completely random sample observations in an experimental design framework. A factorial type design was selected to evaluate the response to a change in the capacity factors of the transfer/blending plant operation.

Randomized Factorial Framework

Rail car unloading capacity was evaluated at three levels, whereas the other factors were analyzed at two levels. A completely randomized factorial style design was employed to measure the effect of capacity factors on the cost criterion. The cost (in dollars per ton) in each cell represents the treatment mean for 15 simulation runs for each of the 12 combinations of capacity.

In the completely randomized design, each of the 180 computer simulations was conducted at a different level of operating volume and scheduling performance. Further, the values for volume and queue times are not known until after each simulation is completed.

The criterion variable in this capacity analysis is a linear function of the selected covariates, namely operating volume and queue time. An increase in volume would be associated with lower plant costs, whereas an increase in vessel queue times would be correlated with higher costs. The cost for each month-long simulation is adjusted for the same volume and schedule performance by estimated covariate values (Johnson, 1998; Lattin et al., 2003)

Applying the Risk-Adjusted Discount Rate to Supply Chain Investments

Through simulation of the intermodal transfer facility, the model estimated the cash flows that would result from the possible changes to that facility's capacity design. The average total cost per ton for the various combinations of plant capacity is the performance measure. Each cell represents the mean response for 15 simulations, adjusted for the same volume and scheduling. Each simulation represents a one-month operation of the port transfer and blending system.

The average total cost per ton of bulk commodity moved through the supply chain facility is $0.808 for the initial or current equipment combination. Although 18 different combinations of plant equipment were evaluated by the model, only those combinations with less than $0.808 average total cost per ton (i.e., less cost than Cell #1 or initial facility) were considered in the financial analysis. The present or initial facility had the low ship-loading rate, three million bushels of storage as well as three rail unloaders.

Costs and returns were calculated for the combinations of infrastructure with lower average total cost than the initial facility. The net annual cash flows were calculated by determining the difference in average total costs between combinations of capacity and then multiplying these net savings by the expected annual tonnage, approximately six million tons.

The NPV and benefit/cost (B/C) ratios from the cost savings are calculated by discounting the differential cash flows from each equipment (capacity) alternative simulated by the computer model. The analysis used the more conservative historical and therefore higher discount rates of 6.89 and 7.14 percent, using the un-leveraged proxy and industry betas, respectively.

It is assumed that annual savings would grow at 2.5 percent annually, the average inflation rate over the most recent ten year period based on the Consumer Price Index. If the internal rate of return (IRR) of a project is greater than the project discount rate, the project should be accepted. The NPV and B/C ratios are reported for a discount rate based on proxy beta (6.89 percent) and for a discount rate with industry beta (7.14).

The financial analysis indicates that a 12 percent increase in ship loading rate coupled with a 33 percent addition to rail un-loading would yield the highest benefit-cost ratio (i.e., 1.248). This represents a $1.25 return on each $1.00 invested. Increasing the ship loading rate by 12 percent provided the second best (and only other acceptable investment) with a B/C ratio of 1.107.

Summary and Conclusions

The incorporation of risk in capital expenditures is essential to evaluate alternatives and capacity strategies under conditions of uncertainty in supply chains. Rather than relying on subjective probability distributions of estimated cash flows expected to result from a project, The CAPM provides a mechanism to measure directly the systematic risk of a project, which then leads to an appropriate discount rate for the project.

This analysis estimated the cash flows produced by various potential combinations of improvements to supply chain infrastructure and discounted these cash flows on a risk-adjusted basis. Based on risk-adjusted benefit-cost ratios and other capital budgeting techniques, projects can be accepted (or rejected), as well as rank ordered if capital is scarce. The financial manager can select discount rates that are more conservative to match the organization’s tolerance for risk.

To demonstrate a CAPM model capable of evaluating expenditures on supply chain facility in this example, the value for beta should reflect the systematic risk associated with firms in the bulk commodity handling industries. Firm can be identified that normally undertake similar infrastructure investments. These enterprises would have systematic risk characteristics similar to transfer and blending facilities, and the average beta for those firms can be used as a surrogate for deriving a particular organization’s required rate of return for a logistics capital project.

References

Brealey, R. A. and S. C. Myers (2000), *Principles of Corporate Finance*. McGraw-Hill/Irwin, New York, NY.

Brigham, E. F. and M C. Ehrhardt (2005). *Financial Management: Theory and Practice*, Thomson South-Western, Boston, MA.

Fama, E. F. and K. R. French (2002), “The Equity Premium”, *Journal of Finance*, Volume 27, Number 2, pp.637-659.

Graham, J. and C. Harvey (2001), “The Theory and Practice of Corporate Finance: Evidence from the Field,” *Journal of Financial Economics*, Volume 60, Number 2-3, pp. 187-244.

Hamada, R. S. (1969), “Portfolio Analysis, Market Equilibrium, and Corporate Finance,” *Journal of Finance*, Volume 24, Number 1, pp. 13-31.

Johnson, D. E. (1998), *Applied Multivariate Methods for Data Analysts*, Duxbury Press, Pacific Grove, CA.

Lattin, J.J., D. Carroll and P. E. Green (2003), *Analyzing Multivariate Data*, Thomson – Brooks/Cole, Pacific Grove, CA.

Pringle, J. J. and R. S. Harris (1987), *Essentials of Managerial Finance*, Scott Foresman. Glenview, IL.

Siegal, J. J. (1985), “The Application of DCF Methodology for Determining the Cost of Equity Capital,” *Financial Management*, Volume 14, Number 1, pp. 46-53.

Speh, T. W. and R. A. Novack (1995), “The Management of Financial Resources in Logistics,” *Journal of Business Logistics*, Volume 16, Number 2, pp. 23-42.

Novack, R. A., L. M. Rinehart and M. V. Wells (1992), “Rethinking Concept Foundations in Logistics Management,” *Journal of Business Logistics*, Volume 13, Number 2, pp. 233-268.