Industry characteristics and investment decisions: An alternative approach to pulp and paper production

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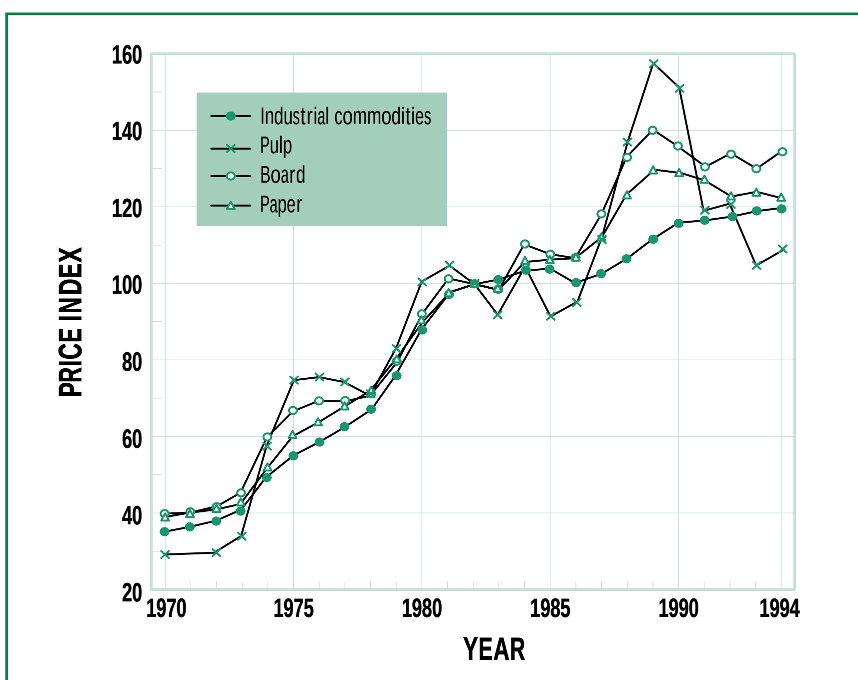
The net present value rule may not always be appropriate in this industry. An alternative, called the options approach, may be required.

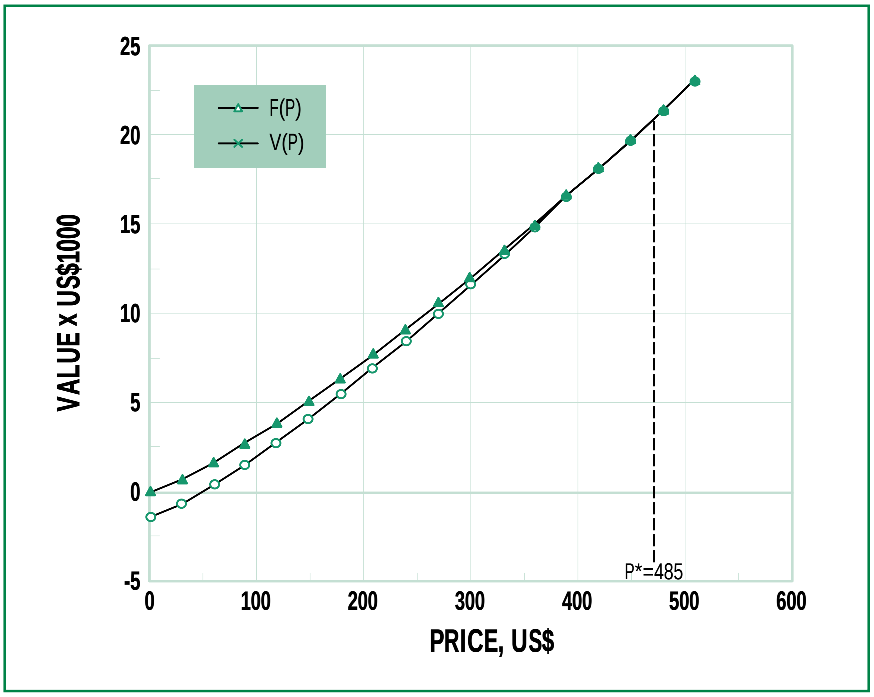
It is widely known that the pulp and paper industry features heavy capital investment, a high degree of asset specificity, and unusual market cyclicality (1). However, it remains poorly understood how these characteristics affect investment decisions and business performance in pulp and paper production. A major problem with the current investment assessment is its inability to give these factors an adequate consideration.

Conventionally, the net present value (NPV) rule is used in investment decision-making. According to this rule, an investment should be made as long as its NPV is greater than zero. To be sure, sensitivity or benchmark analyses with regard to risk and uncertainty, initial capital expenditures, cost and price inflation, discount rate, tax rate, and other parameters are usually performed when determining the NPV. Analysts can run into many complications in dealing with these issues. Nevertheless, comparative statics is still divorced from dynamics, and separate scenarios may not present a complete picture.

The usefulness of the NPV rule is substantially limited by its faulty assumptions. It assumes that an investment is generally reversible, i.e, that its capital expenditures can be recovered should market conditions turn out to be worse than expected. As in other industries, however, investments in the pulp and paper industry are largely irreversible. Once a pulp and paper mill is set up with a large sum of capital outlays, it generally stays in production, even facing unfavorable market conditions. The mill can be shut down if the output price is too low or the



1. Price indices (1982 = 100)



*2. V(P), F(P), and P**

Item	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
					YEAR					
Average price	320	274	295	361	403	405	380	336	344	311
Total costs	299	292	278	283	193	306	319	323	329	334
Pretax profit	21	–18	17	78	111	99	61	13	15	–23

I. Total cost and profitability for an average southern linerboard mill, nominal US$/short ton **(I)**

input price is too high. But in doing so, substantial fixed costs and mothballing expenses are incurred. Studies have demonstrated that it is the irreversibility of investing in a specific asset that makes the impact of uncertainty more pronounced *(2, 3)*.

A growing body of literature shows that the ability to evaluate options associated with an irreversible investment in an uncertain world can profoundly affect the decision to invest *(4, 5)*. For example, when a company decides to exercise its option by entering into a business, it forgoes the possibility of waiting for new information that might alter investment timing. As a result, the company cannot disinvest should market conditions change adversely. Thus, the lost option is valuable, and this option value is an opportunity cost that must be included as part of the cost of the investment. Unfortunately, the option value is plainly ignored by the NPV rule.

Furthermore, it has been found that the option value is sensitive to market volatility, the scale of expenditure, the degree of asset specificity, and other parameters *(5, 6)*. This suggests that investment analysis should assess not only the project value but also the associated option value. And an investment decision should be made only if the expected cash flow from a project exceeds the cost of the project by an amount equal to the value of keeping the investment option alive. Because of the significance of an option in this new approach, it has been called "the options approach to capital investment *(7)*".

The purpose of this paper is to illustrate how the options approach can be used in assessing pulp and paper investment projects and to determine what insights we may gain from adopting it.

CHARACTERIZING THE PULP AND PAPER INDUSTRY

The pulp and paper industry shares three important features concerning investment: substantial capital requirements, a high degree of asset specificity, and an unusual market cyclicality.

Substantial capital requirements

The technology in the pulp and paper industry is characterized by economies of scale. Mills in the wood pulp and in the paper and paperboard sectors with annual production greater than 300,000 tons account for 75% and 58.5% of industry capacity, respectively *(8)*. To achieve economies of scale, however, a substantial initial investment is required to get a modern mill on-line. The current cost estimate for building a model paper or paperboard mill is about US$ 500 million. In the linerboard sector, a kraft mill with a capacity of 1300 tons/day requires an initial investment of (a) US$ 520 million for furnish consisting of 25% recycled fiber and 75% unbleached kraft or (b) US$ 585 million for furnish consisting of 100% virgin fiber *(9)*. Assuming a 17-year mill life and a straight-line schedule for depreciation, the annual capital cost of such a mill is US$ 30.6–34.4 million.

High degree of asset specificity

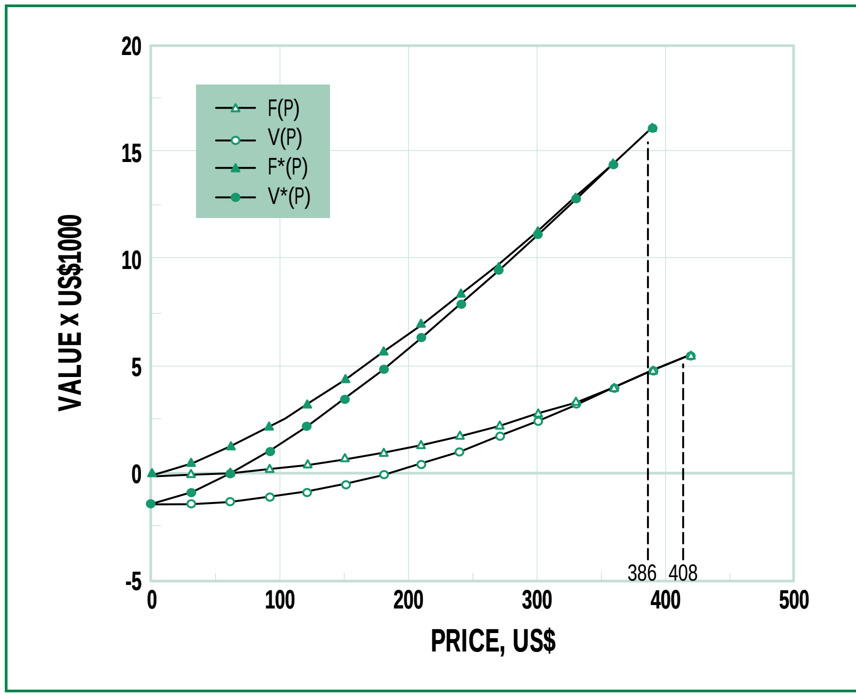
The degree of specificity of an asset is defined as the fraction of its value that would be lost if it were excluded from its major use *(10)*. Pulp and paper mills are obviously established for pulp and paper production. Outside of their specific uses of manufacturing pulp and paper, plant and equipment lose much of their value. Therefore, once set up, they will continue to be used for their designed purposes. Of course, if markets for their inputs and outputs were always favorable, investing in these specific assets might even be preferred because specialization can enhance productivity and profitability. However, since pulp and paper markets are highly cyclical, their designed manufacturing operations must be sustained even when output prices are severely depressed or input prices are significantly inflated, because the likelihood of switching to other uses is very small. Furthermore, temporary mothballing implies substantial fixed costs, as well as suspension and maintenance expenses. As a result, mills continue their operations as long as the potential losses are less than the sum of fixed costs and other expenses associated with a temporary shutdown.

High capital requirements and asset specificity underscore the lack of reversibility and flexibility in operating pulp and paper mills. This, in turn, makes the industry vulnerable and sensitive to stochastic market conditions.

Unusual market cyclicality

In general, pulp, paper, and paperboard prices are highly cyclical. As shown in **Fig. 1,** these prices, though rising at a faster pace from the late 1980s, present more volatility than does the price index for all industrial commodities. Driven by business cycles, pulp and paper prices tend to decline in economic recessions and rise during recoveries. Strong competition and the irregular patterns of capacity expansion and inventories often exacerbate price fluctuations, resulting in wide market swings *(1)*. While there are few financial concerns during boom periods (other than reaping the maximum profit), prices can be so low during slack periods as to cause either a substantial profit margin squeeze or an inability to cover production costs.

Table I suggests that in the linerboard sector, while market upturns can lead to pretax profit margins greater than 25% of sales prices, downturns can cause prices to drop close to the cost of manufacturing and delivery for an average southern mill. Therefore, maximization of profits during boom periods and minimization of losses during recessions are two equally important concerns for management to address in the long run.



3. Changes in V(P), F(P), and P*—increased price drift

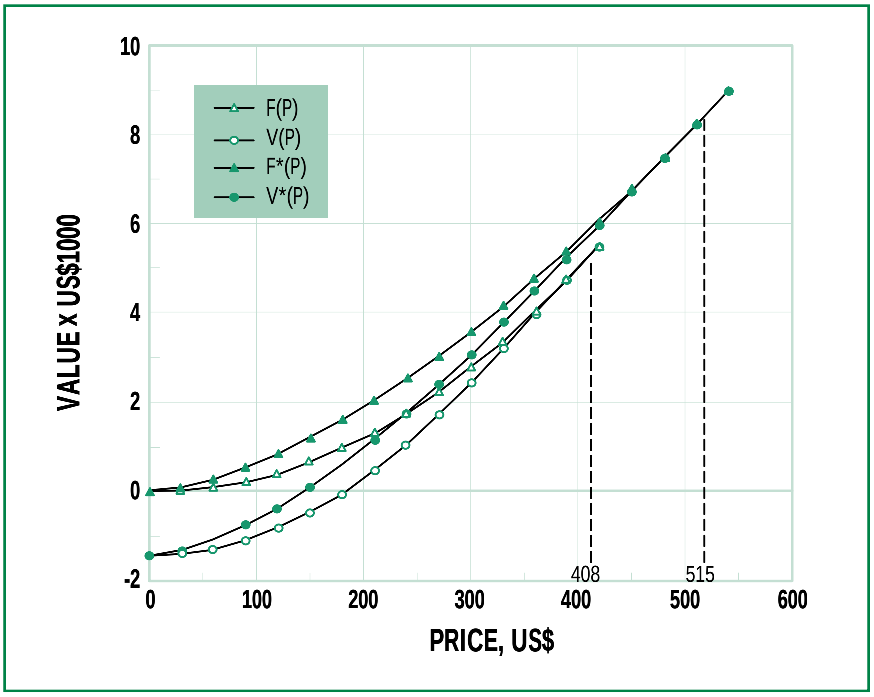
Item	Quantity
Capacity, tons/day	1300
Total investment, US$ million	585
Furnish: wood, MFT*/ton	1.77
Fiber cost, US$/MFT	55
Operating costs, US$/ton	200
Other costs, US$/ton	
Fiber	97
Chemicals	13
Energy	20
Labor	34
Materials	34
Landfill	1
Outbound freight	13
Property tax, insurance	30
Sales, general, administration	15
Depreciation	74
TOTAL	331

*MFT = moisture-free ton(s)

***II. Estimated total manufacturing costs in the linerboard sector* (IX)**

AN ILLUSTRATION OF THE OPTIONS APPROACH

The essential steps involved in the options approach to investment are (a) to formulate the functions for both the project value and the option value by treating the output prices and/or input costs as stochastic processes and (b) to solve for the critical price level at which the investment should be made by using the "value-match" and "smooth-pasting" conditions *(6, 11)*. The value-match condition requires that the project value match the option value when the market price is as high as the



4. Changes in V(P), F(P), and P—increased price volatility*

Parameter	Base case	ALTERNATIVE SCENARIOS I	II	III	IV	V	VI
α	0.042	0.022	0.042	0.022	0.022	0.022	0.022
σ	0.242	0.121	0.121	0.242	0.121	0.121	0.121
r	0.06	0.06	0.06	0.06	0.07	0.06	0.06
C_v	258.0	258.0	258.0	258.0	258.0	229.0	258
C_f	74.0	74.0	74.0	74.0	74.0	74.0	59.3
P^*	485.3	408.1	385.7	515.5	421.5	373.8	387.2

III. Estimated optimal entry thresholds for a linerboard mill

entry threshold, whereas the smooth-pasting condition further demands that the two value curves meet tangentially at the entry threshold.

Setting up a project involves an initial investment. Then, a stream of fixed costs, C_f, which are the depreciated annual values of this initial investment, must be incurred, regardless of the operation of the project. Suspending the operation entails shutdown and maintenance costs, *M*. (Note that, in this case, maintenance cost takes on a different meaning from that related to normal operation. In the latter case, the expenses are included in material cost.) For linerboard production, these costs—the fixed costs, shutdown costs, and maintenance costs—are substantial. So, an appropriate expression for the unit-output profit from such a mill in operation is as follows:

$$\pi = P - C_v - C_f \qquad (1)$$

where

π = profit
P = sales price
C_v = variable cost
C_f = fixed cost.

The unit-output profit obtained from a mill that is suspended is as follows:

$$\pi = -C_f - M \qquad (2)$$

The operation will not be shut down as long as $P - C_v - C_f > -C_f - M$, or $P > C_v - M$.

Since the capacity for such a mill is relatively fixed once it is set up, it is reasonable to normalize the mill's output to one unit per year so that we can take linerboard prices over time as a stochastic variable following a geometric Brownian motion, as follows:

$$dP = \alpha P dt + \sigma P dz \qquad (3)$$

where α and σ are the constant drift and standard deviation of the prices, respectively, and dz is a Wiener process. Applying Ito lemma and manipulating, the net value of the mill $V(P)$ can be expressed as follows:

$$V(P) = \begin{cases} K_1 P^{\beta_1} - (C_f + M)/r & \text{if } P < C_v - M \\ D_2 P^{\beta_2} + P/\delta - (C_v + C_f)/r & \text{if } P > C_v - M \end{cases} \qquad (4)$$

where

r = discount rate
d = $r - a$
K_1, D_2 = constants to be determined.

β_1 and β_2 are defined as follows:

$$\beta_1 = 0.5 - \alpha/\sigma_2 + \sqrt{[\alpha/\sigma^2 - 0.5]^2 + 2r/\sigma^2} > 1 \qquad (5)$$

$$\beta_1 = 0.5 - \alpha/\sigma_2 + \sqrt{[\alpha/\sigma^2 - 0.5]^2 + 2r/\sigma^2} < 0 \qquad (6)$$

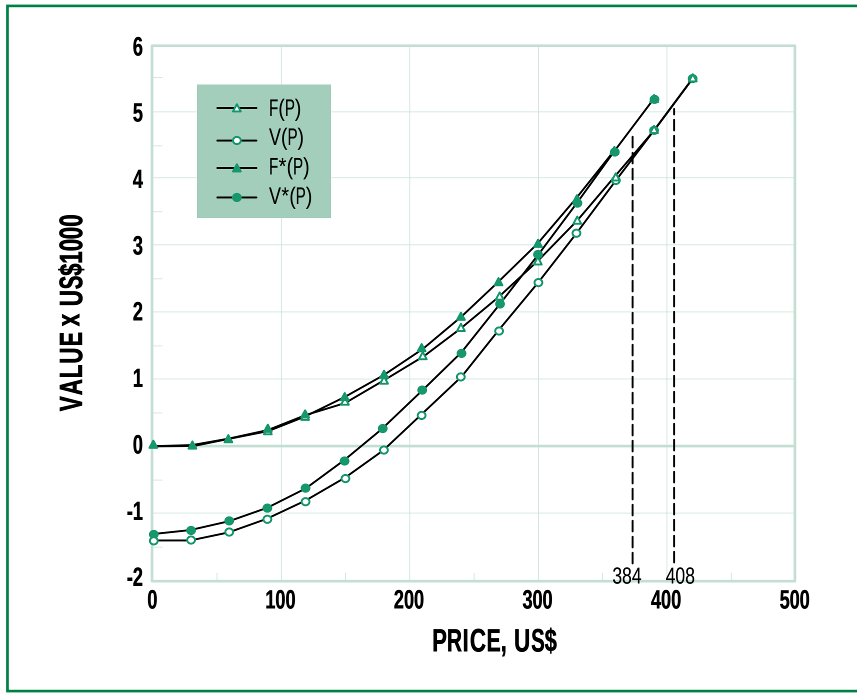
The constants K_1 and D_2 can be determined by using the condition $P = C_v - M$ where the two regions meet.

We can similarly find the value of the option to invest in the mill, *F(P)*, as follows:

$$F(P) = A_1 P^{\beta_1} \qquad (7)$$

where A_1 is a constant to be determined.

At the optimal point, *P**, where the investor exercises the investment option, we have the "value-matching" and "smooth-pasting" conditions. The former suggests that, at *P**, the investor is indifferent between making the investment to receive a net payoff *V(P*)* or holding the option worth of *F(P*)*. According to this condition, when the market price is lower than *P**, even if the project value is greater than zero, it is too early to make the investment. The latter implies that the curvatures of the two value curves at *P** should be the same as well.



5. Changes in V(P), F(P), and P—reduced fiber cost*

Since these conditions only can be satisfied in the operating region where $P > C$, we get the following:

$$A_1[P^*]^{\beta_1} = D_2[P^*]^{\beta_2} + P^*/\delta - (C_v + C_f)/r \qquad (8)$$

$$\beta_1 A_1[P^*]^{\beta_1 - 1} = \beta_2 D_2[P^*]^{\beta_2 - 1} + 1/\delta \qquad (9)$$

Substituting D_2 and eliminating A_1 from Eqs. 8 and 9 gives us the following optimal investment rule:

$$(\beta_1 - \beta_2)\, D_2[P^*]^{\beta_2} + (\beta_1 - 1)P^*/\delta - \beta_1(C_v + C_f)/r = 0 \qquad (10)$$

Because Eq. 10 is a nonlinear function in *P**, we need to solve it numerically.

The cost information for a model linerboard mill was adopted from Null *(10)*. For the case with 100% kraft furnish, the initial investment is US$ 585 million. So, the fixed cost, C_f, is US$ 74/ton, which is the depreciation of the initial investment applying the 17-year, straight-line procedure. The sum of all other costs is the variable cost, C_v, which includes costs for fiber, chemicals, energy, labor, materials, landfill, outbound freight, property tax and insurance, and overhead for sales, general, and administration. The resultant variable cost is US$ 258/ton, so the total cost, $(C_v + C_f)$, is US$ 332/ton (see **Table II**). If the mill is shut down, the cost of mothballing and maintenance is set at US$ 10/ton based on industry experience *(8)*. We then estimated the annual price drift and volatility using quarterly prices for standard kraft linerboard (42-lb) from 1979 to 1994 *(1)*. Price drift (α) and volatility (σ) are 4.2% and 24.4%, respectively. Obviously, although the nominal price growth rate is relatively high, the linerboard market is very cyclical.

The results for *P** are presented in **Table III.** Our base case indicates that with a stochastic market and irreversible investment, the entry threshold into the linerboard sector for an investor is US$ 485.3/ton (**Fig. 2**). This price level is much higher than not only that of the break-even price in a static world—US$ 332/ton (the sum of variable and fixed costs)—but also most of the recent market prices. This helps to explain why the industry tends to favor "capacity creeping" and "mini-mills" with a certain percentage of recycled fiber over large mills with 100% virgin fiber in recent capital spending plans *(12)*. The reason is that the former gives rise to a generally lowered fixed cost as well as a possibly lowered variable cost.

By changing various parameters, we can examine alternative scenarios to gauge the impact of these parameters on *V(P)*, *F(P)*, and *P**. Because the critical entry value associated with our original price drift and volatility parameters is too high to serve as a benchmark for our comparative study, we lowered them in Case I, which indicates that if $\alpha = 0.022$ and $\sigma = 0.121$, then the entry price declines to US$ 408/ton. Compared to this, Case II suggests that when the expected price growth rate increases, a rational investor will lower his/her entry threshold. As depicted in **Fig. 3,** an increased rate of price change leads to an increased project value, *V(P),* which grows faster than the opportunity cost of waiting, *F(P).* Therefore, the optimal entry price drops.

However, as market volatility increases (Case III), investors demand a higher entry price (US$ 515/ton) to execute the investment decision. **Figure 4** shows that although an increase in σ raises the value of the project *V(P)* due to a greater likelihood of price upturns, it results in the value of the investment option *F(P)* shifting up as well for any *P.* As a result, *V(P)* and *F(P)* meet at a higher *P**, both postponing and reducing investment. Similarly, increasing the interest rate also raises the critical price *P** at which investment occurs. This is because, even though a higher *r* implies, other things being equal, a higher opportunity cost of waiting to invest, its damping effect on the expected rate of price increase is more pronounced, shifting *V(P)* downward. As a result, the two curves meet at a higher price.

Case V shows that when the cash fiber cost can reduce from US$ 97/ton to US$ 68/ton, then the entry threshold declines to US$ 374/ton. This occurs because *V(P)* is impacted to a greater degree than is *F(P),* resulting in a lowered *P** (see **Fig. 5**). Finally, Case VI suggests that if the capital intensity can be lowered US$ 74/ton to US$ 59.3/ton, then the entry threshold declines to US$ 387.2/ton. Note that while reduced capital intensity means lower fixed costs, reduced cash fiber outlay means lower variable costs. Changes in capital intensity and fiber cost cause the investment threshold to be reduced in different ways. This is because fixed costs are sunk and thus must be incurred regardless of operation, but variable costs only occur when the mill is operating.

DISCUSSION AND CONCLUSION

Our analysis leads to some interesting implications. We found that the characteristics of the pulp and paper industry cause increases in entry thresholds and decreases in project values. Furthermore, these characteristics make it difficult to maintain stable cash flows and sound business performance. Therefore, investors must take these factors seriously when they decide whether, when, where, and how to enter the industry. Similarly, managers must be sophisticated in the ways that they assess risky operations when deciding how to run a project. Otherwise, as the history of the industry tells, poorly calculated decisions can result in nothing but severe financial consequences *(8).*

What should be emphasized here is that learning how to apply the NPV rule is not sufficient, and an adequate understanding of the various options is fundamental. Pulp and paper industry characteristics and market dynamics in recent years have made this a relevant pursuit. This important idea has motivated us to introduce the options approach into pulp and paper investment analysis. To make intelligent investment choices, we believe that analysts and managers need to make a reasonable choice first in the ways that they conduct their business. TJ

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