MANAGING FINANCIAL RISK IN FORESTRY AND THE FOREST PRODUCTS INDUSTRY

by

BROOKS C MENDELL

(Under the direction of Michael L Clutter)

ABSTRACT

This dissertation addresses the topic of financial risk management in forestry and the forest products industry. The research introduces a framework for thinking about risk management in forestry and conducts three studies addressing the current use of and potential applications for derivative securities – specifically, options, futures, forwards, and swaps – in managing financial risk in forestry enterprises. The first study documents the use of derivatives by publicly-traded firms within the forest products industry as of the fiscal year ending in 2002. Of the nineteen largest U.S.-based, publicly traded forest products firms, seventeen specify active derivative positions, mostly used to manage interest rate and foreign currency exposures. The second study tests the potential for using options on forwards in a wood procurement setting using recently available data on actual pulpwood transactions. The results indicate potential for this contract in practice and as a benchmarking tool, but further study of price volatilities is required to improve the robustness of calculated option prices. The third study investigates the potential for cross-hedging urea – a nitrogen-based fertilizer commonly used in forest management – with natural gas futures contracts in the U.S. South. The correlation between urea cash prices and natural gas futures is statistically significant and the cross-hedge reduces the variance associated with out-of-pocket cash urea fertilizer costs. However, on average, the cross-hedge results in approximately 1% greater total out-of-pocket costs associated with the urea fertilizer purchases.

INDEX WORDS: Forestry, forest products, risk management, hedging, derivatives
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CHAPTER 1

INTRODUCTION

In November 2002, at the Paperloop Global Forest Products conference in New York, a three-member panel of forest products industry Chairmen and CEOs fielded a question regarding their use of financial derivatives – currency, interest rate, and commodity derivative securities – to manage financial risk exposures. While one firm had used currency derivatives previously, none of the three firms, at that time, used financial derivatives. Additionally, they expressed little interest and much skepticism regarding the potential role of derivative securities in their financial portfolios. This episode raises questions regarding financial risk management and derivative use within the forest products industry.

Increasingly, some view forest management as valuing and choosing between a series of real options (Zinkhan 1995; Plantinga 1998; Newman 2002). In great part, this thinking has focused on the traditional forest management problem of identifying the optimal forest rotation. This work developed in parallel with evolution in real options theory and the application of option theory to investment decisions (Dixit and Pindyck 1994). Real option theory addresses limitations in the use of net present value (NPV) analysis – which states to accept all investment projects where the present value of the of incoming cash flows (benefits) exceeds the present value of the outgoing cash flows (costs) – in that it ignores issues of flexibility, volatility, and contingency associated with potential investments. Simply, NPV analysis takes a view of decisions as fixed, while real options analysis assumes a dynamic view of future choices.

1 The three firms represented included two leading Canadian firms and the North American subsidiary of a firm based in South Africa.

2 Flexibility refers to management’s ability to defer, abandon, expand or contract an investment based on new investments or new opportunities. Volatility references changing market conditions – particularly in terms of changing prices – or the introduction of new technologies that can alter the attractiveness or relevance of potential investments or investment strategies. Contingency refers to situations where future investments are contingent upon investments made today. Presumably, these real “options” provide value to the investor and should be included in project valuation.
Theoretically, this work provides a useful way for further exploring and framing tradeoffs from and comparing forest management decisions.

However, the leap to real options thinking and research in forestry bypasses research and applications regarding the use of financial options and related derivative contracts in managing forest businesses. Efforts to apply and better understand the potential for financial derivative contracts – including option and forward-like instruments – have included projects on hedging lumber with lumber futures contracts (Deneckere et al. 1986), calculating the option value of converting timberlands to alternate uses (Zinkhan 1991), using option valuation to confirm estimates of optimal forest rotations (Plantinga 1998), and valuing forest assets using option pricing models (Hughes 2000). Additional qualitative work has further explored options and contracts that act like derivatives in landowner assistance programs, wood supply contracts, and development restrictions on timberlands (Zinkhan 1995), and the potential for financial engineering in wood supply contracts and portfolio insurance (Yin and Izlar 2001). This dissertation research extends the literature associated with forestry investments and forest business management by studying opportunities for using widely accepted financial contract structures and strategies for optimizing the financial performance of timberland and forest industry assets.

This research uses established approaches and applied tools in finance to investigate issues of risk management for timberlands management and the forest products industry. It attempts to address components of the question, “Given developments in the broader field of applied finance, how might forestry professionals and timber-dependent firms enhance their financial risk management associated with forest management and timberland investments?” I approach this question by seeking to understand the relevant literature, documenting the current use of financial derivatives within the forest products industry, and exploring additional opportunities for applying financial derivatives in forestry and forest industry settings.

As a whole, I view this dissertation as part of an ongoing research program in forest finance and risk management. The manuscripts selected for inclusion seek to introduce this theme, establish the

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3 Hughes (2000) values forest assets associated with the sale of Forestry Corporation of New Zealand in 1986.
baseline for one type of financial risk management in the forest products industry, and explore potential applications of derivative-based risk management strategies in forest management and forest operations.

Ultimately, we wish to better understand how to think about risk management – the identification, assessment, and management of a firm’s exposure to selected forms of risk through the use of insurance, financial derivatives, and operating strategies – and financial risk – those risks that a firm is not in the business of bearing – in the forest products industry. In sum, we investigate current practice and potential opportunities for managing financial risk and return in the forest products industry.

This research assumes that vigorous management of forestry enterprises – and by extension, organizations of any form – requires the deliberate identification, assessment and management of risks. These risks include, for example, those in operations (i.e., equipment breakdowns), distributions (i.e., transportation delays), and human resources (i.e., hiring and retaining personnel). In this research, I focus on financial risks, defined as those risks that a firm is not typically in the business of bearing, and one category of tools – derivatives – available to manage these risks (Figure 1.1). For a forestry firm or timberland investor, these may include, but are not limited to, the impacts of exchange rates, energy prices, and interest rates. In contrast, business risks are those “that the firm must bear in order to operate its primary business” (Culp 2001). In the forest products industry, these may include lumber prices, equipment uptime, and customer service.

According the Financial Risk Management dictionary of the American Stock Exchange, an alternate and related definition of risk management is “the application of financial analysis and diverse financial instruments to the control and, typically, the reduction of selected types of risk.”
A practical and reasonable response to the distinction between financial and business risks by a forest resource professional might assert that time and resources be focused on what the firm can control, and those factors beyond firm control should be ignored. This reaction parallels the assumptions under which financing and risk management policies are irrelevant according to corporate finance theory. These assumptions can be summarized as:

*Perfect capital markets*, which specify a world where funds and investments flow easily and unencumbered by “friction.” This world assumes no transactions costs, no taxes, no institutionally imposed frictions (such as short selling restrictions or trading delays), and no bankruptcy costs.

*Symmetric information*, which assumes that all participants – buyers, sellers, borrowers, lenders – possess and perceive identical information, and share common perceptions and ideas about how new information impacts prices.

*Given investment strategies*, which states that the investment decisions firms embark upon are taken as given and independent of financing decisions. In other words, firms do not factor issues such as whether available investment funds will come from debt or equity, or from sources internal or external to the firm.

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5 Operational – or “natural” hedges – include the diversification of firm activities to reduce a risky exposure and the matching of assets and liabilities of foreign subsidies to minimize exposure to foreign currency risk. Insurance protects typically against (firm) specific, undesirable events such as fire and theft.
Equal access, which dictates that firms and individuals can issue the same securities in the capital markets under identical terms. In this world, equality reigns with multinational corporations and individual investors able to borrow and loan funds at identical rates of interest.

While these assumptions prove useful in developing theory and research concepts, they are violated regularly in the real world. However, the violations, which include the existence of market imperfections and frictions, provide opportunities for developing and implementing financial risk management strategies.

The continued development within the financial markets of new financial instruments – derivative securities – improves the liquidity of risk. Derivative securities “derive” their value from the prices of other underlying assets, such as equity securities (stocks), fixed income securities (i.e. bonds), currencies or commodities (i.e. wheat, gold or lumber). The most common of these financial instruments are forwards, futures and options. These derivative securities theoretically serve to manage exposure to the risks associated with the underlying assets. They do this by locking in prices and volumes in advance, thereby reducing uncertainty. When used correctly, futures and options act as a form of insurance against unexpected price movements. This phenomenon, where risk associated with one asset is offset with a position in financial derivatives, is called hedging. Alternately, “speculators” trade futures and options simply to profit from price level changes.

Hedging decisions – by corporations, individual investors, and asset managers – seek to reduce risk by protecting an asset or position in the spot (cash) market with an opposite position in the financial markets, such as an option, future, or forward contract (Figure 1.2). Hedging does not eliminate risk; rather, it transforms undesirable risks into acceptable and manageable forms by increasing certainty and decreasing volatility for selected transactions. Thus, risk management and hedging programs help firms achieve their optimal risk profile by balancing the costs of hedging with the protection offered.
A lumber manufacturer can lock in prices for future lumber sales by buying lumber futures contracts traded on the Chicago Mercantile Exchange ([www.cme.com](http://www.cme.com)). If lumber prices go up, the gain in the lumber sales price is offset by the loss from the lumber futures contract. If lumber prices fall, the loss in the lumber sales price is offset by the gain from the lumber futures contract.

Chapters Two, Three, and Four of this dissertation describe three discrete research projects related to the use of derivative securities and hedging strategies to manage financial risk in forestry and the forest products industry. Chapter Two documents the use of derivative contracts to hedge financial risk by publicly traded forest products firms in the United States as of December 31, 2002. Chapter Three studies the use and pricing of options on forward contracts in a wood procurement setting. Chapter Four evaluates the potential for cross-hedging urea – a nitrogen-based fertilizer commonly used in forest management – with natural gas futures contracts in the U.S. South. Chapter Five concludes the dissertation by summarizing the key findings and outlining the next steps and on-going projects in this program of studying financial risk management in forestry and the forest products industry.

This chapter and introductory essay introduce a perspective on financial risk management with respect to the forest products industry by proposing a framework for thinking about risk management and

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Figure 1.2: Example of Hedging Commodity Risk by a Lumber Manufacturer
financial exposure for forestry firms that lays the groundwork for later chapters. The literature review summarizes the relevant theory and research in finance and forestry with respect to the general theme of financial risk management and when deliberate management of these risks may be appropriate. Additionally, the literature review introduces the literature relevant to the studies described in Chapters Two through Four. A risk management framework follows, along with a discussion of applying it to the forest products industry. This framework provides an approach for organizing the studies carried out in the dissertation. Finally, this introduction pursues the theme of financial risk management in forestry and the forest products industry as a source of ideas for additional research.

Literature Review

As noted, risk management resides integrally in the solid general management of a firm. The firm, a nexus of contracts and bundle of cash flows, involves ongoing financial relationships between investors, employees, customers, suppliers, and creditors. Risks associated with market moves, liquidity, credit, and operations affect the nature and terms of these relationships.

In most instances, managing risk may occur by default, with corporate and investment managers weighing the risks and returns of alternate financing, operating, and investment strategies. This weighting and decision making may include the assigning of probabilities to expected outcomes, and the assessment of real options associated with expected downstream opportunities. The role of a designated “risk manager” remains relatively new within corporate hierarchies, and importance placed on these roles vary (Grinblatt and Titman 2002). Some firms view the risk manager defensively, while others may incorporate risk management into its process of appraising alternative investment opportunities, as risk features both potential upsides and downsides. In other words, the traditional view of a risk manager protecting the firm from catastrophes or other downside risks ignores the risk of missing out on profitable or strategic opportunities with upside potential.

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6 Coase’s 1937 article “The Nature of the Firm” explored how firms comprise collections of formal and implicit contracts, and how firms can allocate resources differently than markets through some authoritarian control. This paper is cited frequently as the seminal work in the “nexus of contracts” theory of the firm.
The risk of missing or underinvesting in promising projects represents a risk unto itself. Risk management can play an important role in protecting and increasing the series of cash flows that make up the corporation, and the associated opportunities for future investments that require these cash flows. Rather than husbanding resources exclusively for precautionary safety nets or insurance-like reserves, risk management can include the allocation of capital among competing investment alternatives.

Derivatives, however, get used primarily to reduce cash flow volatility and unwanted exposures associated with changing prices and interest and exchange rates, allowing corporate managers a means for securing predictability (and sound sleep). As such, the use of derivatives to manage corporate risk has continued to grow. In November 2001, the Bank for International Settlements released data, which estimated the total global notional amount – the face value – of outstanding over-the-counter (OTC) derivatives contracts at $169.7 trillion as of June 2003. In comparison, these estimates stood at $127.5 trillion in June 2002 and $99.8 trillion in 2001, representing annual increases of approximately 33% and 28% respectively.\(^7\)

Bodnar, Hayt, and Marston (1998) published the third of a series of surveys on financial risk management and derivatives use by non-financial firms in the U.S. 399 firms participated in the survey and 200 (50.13%) reported using derivatives. Large firms were more likely to use derivatives than smaller firms. Foreign currency exposure was the risk most commonly managed with derivatives, followed by interest rate risk, and then commodity price risk. For firms that reported not using derivatives, the most important reasons cited were “insufficient exposure” and “exposures effectively managed by other means.”

Guay and Kothari (2003) study the magnitudes of the risk exposures hedged with derivatives by 234 non-financial firms. These firms using derivatives represented 56.7% of their sample, randomly drawn from the 1,000 largest market value firms available on COMPUSTAT. Overall, firms have become

\(^7\) Over-the-counter (OTC) refer to those derivative contracts traded directly between participants through dealers and brokers, as opposed to “exchange traded” contracts available on exchanges such as the Chicago Mercantile Exchange and Chicago Board of Trade. Of the $169 trillion, over 55% came in the form of interest rate swap agreements. Commodity contracts represented less than 1%, with the balance in other forms of interest rate contracts and foreign exchange contracts.
more familiar with derivative securities and the ways that they can be used to manage risk. However, they find that derivative holdings are small relative to firm size and risk exposures, implying that corporate derivative use may be not be an important part of corporate risk management activities or impact significantly firm value.

Why manage financial risk? Theoretical motivations for risk management include taxes, financial distress costs, and executive incentives. Understanding the motives for managing financial risk provides a basis for investigating the reasons for and methods of managing and hedging exposures and risks faced by forestry professionals and businesses.

A firm can raise money two ways: borrow it from bondholders or banks (debt) and sell shares of the company to investors (equity). Each type of money carries different implications for the firm and for the stakeholders. Bondholders require their promised interest payments, regardless the performance of the firm. Failure to make payments associated with debt can result in bankruptcy. Shareholders share in the benefits of outstanding firm performance as their shares of equity increase in value, but have little recourse if the firm falters, watching share value fall. In the case of bankruptcy, shareholders resign themselves to watching bondholders step to the front of the line to ‘pick the carcass.”

In 1958, Modigliani and Miller (M&M) rewrote the way we think about a firm’s debt-equity choice. In perfect markets, firm value remains unaffected by financing decisions (Modigliani and Miller 1958) and, by extension, hedging. M&M showed that firm value derives, when viewed from a balance sheet perspective, from its assets and not from the chosen distribution between debt (liabilities) and equity. The strict “perfect market” assumptions used to advance the work of M&M include: no transaction costs, no taxes, no bankruptcy costs, and fully-informed and diversified market participants. M&M extends to hedging with the idea that individual investors, through leveraging their own portfolios, can replicate any financing activities considered or pursued by the firm. In this world, investors prefer managing their own risk exposures through diversification or selected hedging in lieu of corporate managers diverting resources away from managing the core businesses to manage these same exposures.
However, hedging theory asserts that risk management can add value to a firm in the presence of certain market imperfections. Smith and Stulz (1985) summarize that the key opportunities for risk management to contribute to firm value occur when the results of risk management activities can reduce expected tax liabilities, reduce bankruptcy costs, or better diversify investor portfolios.\(^8\) Risk management theory has expanded to include these and other market imperfections that can result in volatility that may prove costly to corporations.

Generally, hedging adds value when the loss from receiving one dollar less in profit exceeds the gain from one dollar more in profit. In other words, when firm value suffers more by a negative economic move – such as an adverse change in foreign exchange rates – than is helped by a positive move, the firm can increase its value by hedging.

Froot, Scharfstein, and Stein (1993) argue that firms use derivatives to hedge “non-diversifiable costs associated with market frictions such as taxes, financial distress costs, and external financing costs.” In developing a general framework for evaluating corporate risk management policies, they justify risk management in situations where externally obtained funds for investment prove more expensive than internally generated funds. Since variability in the availability of internal funds for investment can lead to firms seeking outside funding, extra costs or, even worse, underinvestment can occur because of a funds crunch. Thus, reducing the variability of cash flows can add to firm value through supporting optimal investment and financing strategies by the firm. While it builds on Myers (1977), the work differs with Myers on the point that the volatility of future cash flows is only a problem if it compromises the firm’s ability to make investments because of unavailable internally generated funds. Thus, it is the risk of not being able to invest in good projects, not lack of good projects, that justifies hedging.

Stulz (1996) revisits hedging theory to reconcile the fact that corporations appear to hedge “selectively,” and argues that the primary objective of corporate risk management programs is to

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\(^8\) Smith and Stulz footnote, “if markets are perfect and complete, the value of the firm is independent of its hedging policy for other reasons, as well. For example, if a firm hedges the value of an input by purchasing forward contracts and that input price rises, the firm’s pricing and production policies should not be affected by the existence of the hedge. The opportunity cost of the input is its current price, not the (sunk) cost of the forward contract.”
“eliminate the probability of costly lower-tail outcomes” that would adversely affect firms’ investment activities. The results from Guay and Kothari (2003) documenting limited derivative positions relative to firm size and exposures provide additional support for this thesis.

Which firms hedge? Empirical evidence continues to evolve, but a number of trends have become evident in the research. Larger firms use derivatives more than smaller firms (Bodnar, Hayt and Marston 1998; Nance, Smith, and Smithson 1993; Dolde 1993; Geczy, Minton, and Schrand 1997). The evidence from these studies reduce the influence of an alternate theory: that smaller firms have greater bankruptcy exposure and, as a result, have more to gain from hedging and could be expected to have relatively larger derivative positions. However, hedging programs do have start-up costs and do appear to benefit from economies of scale, partly explaining why smaller firms are less likely to hedge.

Nance et al (1993) and Geczy et al (1997) find support for the idea that firms with greater growth opportunities are more likely to use derivatives. The studies use spending in research and development (R&D) and market valuation measure to proxy growth opportunities. Results indicate that firms with higher R&D expenditures and higher market-to-book ratios are more likely to use derivatives than companies that spend less on R&D, have lower market-to-book ratios, and therefore, probably have fewer investment opportunities. This evidence is consistent with the idea that firms hedge to ensure that they have enough cash on hand to fund their investment opportunities internally.

Several industry and firm specific research projects also test hedging theory. Tufano (1996) studies hedging in the gold mining industry and finds that the only systematic factor affecting hedging across the firms was managerial ownership and compensation structure. Petersen and Thiagarajan (2000) return to the gold industry to test risk management theory by estimating and comparing the risk exposures of two gold mining industry firms with opposite risk management strategies. Their research demonstrates how firms in the same industry may differ in the risks they choose to hedge and the strategies used to manage risk generally.
Haushalter (2000) surveys 100 oil and gas firms to study their risk management activities between 1992 and 1994. He finds that firm hedging activities vary, and, for example, are positively associated with firm leverage and with total assets. These findings are consistent with theory to hedge in order to reduce the costs of financial distress, and with empirical research indicating hedging increases with firm size partly due to economies of scale (Mian 1996; Geczy et al 1997).

Brown (2001) conducts an in-depth study of the foreign exchange risk management program of a single firm. Brown finds a sophisticated foreign currency risk management program that does not hedge for reasons commonly argued in the literature. Rather, factors such as smoothing earnings and securing competitive prices in the market drive decisions. Additionally, Brown found that accounting treatment of derivatives did impact the choices made by the firm.9

Firms may implement financial policies that act as substitutes to hedging if these policies reduce expected taxes, transactions costs, or agency costs. Policies include more convertible debt, more preferred stock, greater liquidity of firm assets, and smaller dividend payouts. Dividend policy can impact hedging needs as lower dividend payouts leave more funds available for paying bondholders, reducing potential distress costs. Liquidity, as measured by the firm holding more liquid assets, reduces the need to hedge as the firm is better prepared for responding to unknown events or price impacts that may require rapid response and ready cash.

Corporate structure and the geographic nature of operations may impact hedging decisions and the need to hedge. Firms with foreign operations or extensive import and export activities may be more likely to use foreign currency derivatives to hedge exchange rate exposures. Alternately, firms can pursue a strategy of operational hedging by, in part, matching foreign located operations and assets with debt and

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9 Specifically, the firm Brown studied preferred to use option contracts in hedging because of the associated accounting treatment and because they were priced competitively. In cases where a hedge was deemed appropriate but option contracts were unavailable, the firm chose to by-pass the hedge rather than use forward contracts. These situations occurred for “illiquid currencies.”
funding sources denominated in the same foreign currency.\textsuperscript{10} Operational hedges help mitigate the long-term exchange rate exposure faced by multinational corporations, particularly in the case of firms with broad operations across multiple currencies (Pantzalis et al 2001).

To evaluate and value uncertain negative cash flows associated with adverse events, firms can use insurance premiums to obtain certainty equivalent cash flows (Culp 2001). The payoff from insurance, net the cost of the premium, provides a base case cash flow in the event of the negative event. Understanding the certainty equivalent result supports the risk management decisions determining which risks to hedge, and which risks are best left uninsured. While these contracts hand off insurable risks to an insurer who may be better able to assess and price such risks, they come at a cost and mitigate an exposure which may or may not be acceptable or economically significant to the overall performance of the firm. In sum, firms can manage risk through alternate operating and financing strategies. In this project, we take these strategies as given.

Research and issues of risk management among timberland investors and managers can be organized into three broad categories: timberland risk as a portfolio asset, risk at the stand-level, and risk at the individual forest-level (Caulfield and Newman 1999). Asset level analysis applies portfolio theory and the Capital Asset Pricing Model (Markowitz 1959) to demonstrate the impacts of timberland assets on portfolio diversification, risk, and returns (beginning with Mills and Hoover 1982, and including Mills 1988; Thomson 1992; and Caulfield 1998b).

Stand and forest level analysis centers on determining optimal silvicultural treatments and timber rotations, and incorporating product price risk and other uncertainties into these decisions and strategies. Newman (2002) notes that the development of the optimal forest rotation literature includes exploration into issues of forestland price uncertainty (Norstrom 1975) and catastrophic uncertainty (Routledge 1980; Reed 1984; Reed and Errico 1986) before moving, in the late 1980s and 1990s into research increasingly

\textsuperscript{10} For example, a U.S. firm building a sawmill in Canada may choose to borrow required capital in Canadian dollars, and may use proceeds from selling lumber produced by this mill to pay employees located in Canada and interest expense associated with the Canadian denominated debt.

Faustmann (1849), in demonstrating how to value land dedicated for forest management, inspired the series of questions leading to the cited research. How to maximize the present value of future harvests resulted in questions of optimal rotations, profitable forest management strategies, and risk wise timberland valuating techniques. Regardless, the forestry literature lacks substantive investigations into risk management and derivative use at the firm level or in the context of contractual obligations and transaction-level risk management in forestry operations.

Chapter 2 opens this area of research by documenting the use of derivative contracts by publicly-traded U.S. forest products firms. Using notional contract values as proxies for derivative-based hedging activity, I test the magnitudes of use against the levels of use expected by non-financial firms from the hedging theory and empirical studies cited previously.

As noted, Modigliani and Miller (1958) established that, absent taxes and other market frictions, a firm’s capital structure is irrelevant. In other words, financing decisions cannot create value for a firm unless they in some way affect either the firm’s ability to operate its business or its incentive to invest in the future. Chapter 3 presents a study which explores directly the former while the project in chapter 4 explores a hedging strategy targeted at the latter.

Chapter 3 details the application of options on forwards, as derived by Thorpe (1985), to a wood procurement setting for a pulp mill in southern Mississippi. Wood procurement managers at sawmills and pulp mills in the forest products industry seek stable or predictable wood flows at low or predictable prices. In that sense, wood procurement manages wood flows with cash flows. Tools or strategies that improve the control over these wood flows at no additional cost or reduce wood costs with minimal impact on wood flows are desirable. Black-Scholes (1973) produced methods for pricing forward
contracts and options on forwards. Black (1976) extended this work to cover applications of options, forwards and futures to commodities, such as agricultural products.

By developing the model necessary to price options on forwards, Thorpe (1985), by default, accounts for logistical issues associated with implementing pure options in forestry operations. These contracts separate the expiration of the option from the maturity of the forward contract. In that way, should the holder of the long option for pulpwood choose to exercise, the seller has sufficient time (in our paper, five business days, or a week) to deliver the contracted pulpwood. Additionally, the terms of these contracts are flexible and adjustable to fit the requirements of particular counterparties. In this way, a derivative contract may be used to enhance the way a firm operates a core business function.

The project described in Chapter 4 studies the feasibility of using natural gas futures contracts to cross-hedge urea, the most common nitrogen fertilizer used in forest management. Discussions with forest managers revealed that high, short-term urea prices can lead them to forgo planned forest management investments. This decision to “underinvest” relies on short-term cost and cash flow considerations. To cross-hedge, a producer or user of a commodity hedges the price of one commodity with the futures contracts of a correlated but different commodity to lock in expected future net prices or margins.

In developing a theoretical description of hedging to better account for the actual behaviors of a broad class of hedgers, Anderson and Danthine (1981) explicitly address cross hedging. They note that in implementation, “the best cross hedge may be calculated in exactly the same way as a standard hedge.” Rahman et al (2001), adapting a model employed by Hayenga and DiPietre (1982), tested the feasibility of cross-hedging cottonseed meal with soybean meal futures. The basic linear regression model used for this study follows a similar methodology for testing the feasibility of cross-hedging urea with natural gas futures. A direct price movement relationship results from a simple linear regression of lagged urea cash prices on natural gas futures. Using estimated hedge ratios, we calculate net realized urea prices for the U.S. South cash market for nine fertilization seasons over five years.

Faustmann, through his work in Germany in 1849, established that forestry has long developed perspectives on financial risk and opportunity cost. Recent advances in applied finance and risk
management theory provide opportunities to revisit current timberland and forest operation management. While it is possible that practices common in forestry effectively replicate traditional hedging and arbitrage strategies, the forestry literature lacks documentation of the use or existence of established financial strategies from other industries for managing, measuring and assessing financial risk at the corporate and operating level in forestry businesses and the forest products industry.

Risk Management Framework

Integrated forest products firms – those owning the full array of pulp and paper mills, sawmills and timberlands – are divesting their timberlands. Most of these industrial timberlands are sold to timberland investment management organizations (TIMO’s) on behalf of institutional investors (Clutter et al 2004; Caulfield 1998a) or firms that specialize in tree growing and timberland management. Some of these firms are publicly traded on Wall Street (i.e., Plum Creek, Rayonier). Thus, timberlands are securitized when an investor can buy shares in a company primarily in the timberland business. This overcomes a historical limitation to timberland investing – liquidity – and, theoretically, allows the average investor to add “timberlands” to their investment portfolio without forcing them to buy a chunk of land, albeit at the cost of higher systematic risk relative to private equity timberland investments.

More generally, the extent to which forest products firms remain integrated through the entire manufacturing process and supply chain affects the type of risk to which the firm faces exposure. Culp (2001) describes the range of relevant risks as “an outright spot or forward-like asset exposure or…basis risk – or both,” with basis risk referring to differences between the spot (cash) price and futures (or forward) price of a commodity. A sawmill that owns no timberland for providing its own logs or controls no lumber trucks to deliver its manufactured lumber products faces, for the most part, basis risk, or the risk of rising log prices relative to lumber prices. The freight and transportation logistics firm that

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11 Basis risk may also refer to the risk of rising prices of a raw commodity product relative to the prices of the primary products produced from that commodity. For example, this could include the risk of rising raw sawlog prices relative to lumber prices. Culp (2001) uses an extended example featuring a wheat miller to highlight issues of risk exposures through a supply chain. In my discussion of this concept, I paraphrase some of his key points through the sawmill example.
picks up the pallets of lumber at the sawmill and delivers them to the wholesale distribution center or the retail lumber yard has no log or lumber price exposure. Rather, the logistics firm receives payment for a service independent of the product shipped, but may face exposure to the risk of rising fuel prices for its truck fleet.

A simple risk management model provides a framework for identifying and evaluating exposures faced by forest industry firms and forestry operations. Froot et al (1993), in developing a general framework for evaluating corporate risk management policies, justify risk management in situations where externally obtained funds for investment prove more expensive than internally generated funds. Since variability in the availability of internal funds for investment can lead to firms seeking outside funding, extra costs or, even worse, underinvestment can occur because of a funds crunch. Thus, reducing the variability of cash flows can add to firm value by supporting optimal investment and financing strategies by the firm.

Adopting the general approach of Froot et al (1993), and explicitly including the impacts on operations of variable cash flows, supports a risk management framework for identifying hedging opportunities in forestry businesses (Figure 1.3).

For example, sawmills are in the business of manufacturing and selling lumber. Prices of lumber – the primary output – and prices of logs – the primary raw material input – drive earnings. The core business of lumber manufacturing matches the price exposure associated with lumber prices; the mill is in the lumber business. The exposure associated with log prices represents a mismatch: the sawmill is not in
the business of speculating on log prices. Volatility associated with buying and managing log flows may adversely affect cash flows associated with operations and investments. Through this framework, exposure to log prices has been identified as a risk that the firm may want to hedge.

This approach relies on the idea that earnings can be driven by factors outside of a firm’s core business. A sawmill manufactures lumber. It is not in the business of speculating on energy or gold or, most importantly, log prices. Anything that can reduce a mill’s exposure to major log price moves could provide beneficial stability and predictability. In theory, forest products firms can hedge away lumber price risk through lumber futures markets. Deneckere et al (1986) demonstrated how this could be marginally effective. Similarly, mills might want to lock in favorable log prices in advance. In this way, we adopt the view that firm risk falls into the two broad classes described previously: business and financial.

As opposed to integrated forest product firms that own timberlands, TIMOs can recognize total returns, both the appreciation of their land and timber assets and the income from logs sales. Unlike lumber manufacturers who can hedge their core lumber business, TIMOs face difficulty in directly hedging the real estate exposure for their clients. Liang et al (1998) suggest that existing futures contracts fail to hedge real-estate investments, specifically investments into real estate investment trusts (REITs). Additionally, TIMOs may work with sufficiently long time horizons – with investments typically lasting 10 years – to mitigate log price exposure by adjusting harvest levels with log price levels. However, TIMOs may require short-term regular cash flows, and hedging can, in theory, reduce cash flow volatility.

The risk management framework provides a basic tool for identifying financial risk exposures faced by forest products firms. Isolating transactions and exposures that may result in variable cash flows provides a basis for evaluating risk management and hedging alternatives. In sum, this research focuses on the current use and potential application of derivative contracts for managing identified financial risks in forestry and the forest products industry.
Conclusion

Published risk management research in forestry and the forest products industry has focused on impacts of real options on optimal rotations, issues of catastrophic risk, accounting for risk through proper discount rates and portfolio theory, and exploratory efforts into options valuations. This dissertation builds on this work, and previous theoretical and empirical research in the finance literature, to assess the role of derivatives in industry risk management programs, to apply option-pricing theory to an application in wood procurement, and to test a cross-hedging application in forest management. The framework introduced in this chapter serves as a guide to identifying those financial exposures and business activities that may benefit from alternate risk management programs and hedging strategies.
CHAPTER 2

DERIVATIVES USE IN THE FOREST PRODUCTS INDUSTRY¹

Abstract

The extent to which firms in the forest products industry use financial derivatives for hedging purposes remains undocumented in the forestry and finance literatures. This study provides evidence of derivatives-based hedging activity by forest products firms from the 2002 10-K filings of 19 U.S.-based, publicly traded forest products firms. These firms represented nearly $123 billion of the U.S. forest products industry as measured by revenues in 2002. While all 19 firms claim to use derivatives, 17 specify active derivative positions as of December 31, 2002. The total notional values – the face value – of these derivative contracts stood at $9.2 billion. Interest rate hedges – mostly in the form of swaps – accounted for 62% of these derivatives, with foreign currency and commodity derivatives accounting for 35% and 3% respectively. In testing these derivative activities against aspects of hedging theory, only the correlation between firm size and derivatives use proved statistically significant.
Introduction

The extent to which firms in the forest products industry use financial derivatives for hedging purposes – especially with respect to managing exposures to changes in interest rates, foreign currencies, and commodity prices – remains undocumented in the forestry and finance literatures. A fundamental understanding of forest industry derivatives use would help assess how hedging theory, which suggests that financial risk management can add to firm value, corresponds with practice in the forest products industry. As such, this study is interested in establishing a (current) baseline for derivatives use for hedging purposes by firms in the forest products industry, and, furthermore, comparing these results with expectations derived from the existing empirical literature on corporate hedging practices.

In measuring the use, or lack thereof, of financial derivatives by publicly traded forest products firms for hedging purposes, this study seeks to accomplish two objectives. First, we want to determine the nature and level of hedging within the financial derivative portfolios of forest products firms, if these portfolios exist. Second, we seek to test the levels and nature of hedging by these forest products firms against those found in broader empirical studies of derivatives use by corporations for hedging activities. In other words, we want to measure the amount of hedging forest products firms are engaged in through the use of derivatives, and how this hedging activity aligns with the reasons and levels of derivatives related hedging we should expect as predicted by theory and cross-industry hedging studies. Ultimately, we hope this study initiates additional projects on the role of derivative instruments and financial risk management in the forest products industry to provide industry practitioners and timberland managers an improved understanding and set of strategies for enhancing the risk management of their forestry enterprises.

Like the Berkman and Bradbury (1996) study of derivative use by firms in New Zealand, this study aggregates data from audited financial statements, avoiding non-response bias inherent in industry surveys and applying a common interpretive eye across the studied set of financial statements. Also, the data collected permits for a relatively continuous measure of hedging activity as opposed to a rudimentary assessment of whether or not firms hedge with derivatives. In other words, while we are interested in
whether or not firms hedge, we are much more interested in how and how much they hedge through the use of derivatives.

This project studies a specific industry; the firms studied do not represent a random sample. Rather, we attempt a nearly comprehensive study of derivative use for one industry as of one point in time. For 19 publicly traded, U.S.-based forest products firms, we present detailed evidence of the levels – the magnitudes as measured by the notional amounts of the derivative contracts\(^2\) – and nature of derivative contracts used to hedge financial risk exposures associated with interest rates, foreign exchange, and commodities as of December 31, 2002. Three approaches are used to aggregate data and calculate summary statistics on the derivative contracts: by hedge type as defined by the Financial Accounting Standards Board (FASB), by hedge purpose (i.e., hedging interest rate, foreign currency or commodity risk), and by derivative contract type (i.e., forwards, futures, options or swaps). Once the baseline assessment and descriptive statistics associated with the derivatives use by the studied forest products firms is established, we test three hypotheses with regards to how the magnitude of derivatives use across these 19 firms correlates with firm specific variables – such as market value, leverage, and research and development (R&D) expenditures – and agrees with hedging theory. These hypotheses are as follows:

* Larger firms use derivatives for hedging more than smaller firms.* This is consistent with the idea that economies of scale exist for financial risk management activities. While smaller firms theoretically have more to gain from hedging because they generally have greater exposure to bankruptcy risks,

\(^2\) Notional value refers to the principal or face value of the respective derivative contracts. For example, an interest rate swap on $500 million has a notional value of $500 million. An option contract for 10,000 MMBtu of natural gas has a notional value of 10,000 times the price per Btu of natural gas, not the value of the option contract itself. In other words, the notional value is the size of the position itself. Hedge accounting requirements under SFAS require firms to report the fair value of their derivative contracts, not the notional values. The fair value estimates the value of the contract itself under current conditions. The fair value provides the net gain or loss on the derivatives outstanding (today). Notional principal is the face value used to price derivative contracts, but does not represent the dollar amount transferred between parties. (Hence the term “notional” principal.) The press and derivatives industry often report in terms of notional amounts to indicate an overall level of market usage.
empirical research shows this perspective lacks support in practice. Also, larger firms presumably feature more sophisticated risk management programs and are, thus, expected to use more derivatives.

**Firms with more growth opportunities hedge more with derivatives.** With growth opportunities measured by annual research and development (R&D) expenditures and market-to-book ratios, this idea supports the view that there is an increased likelihood of hedging for firms with higher distress costs. Financial distress costs include direct and indirect costs associated with potential bankruptcy. According to Grinblatt and Titman (2002 p. 562), “the threat of bankruptcy affects a firm’s relationships with its lenders and in other ways affects its ability to operate efficiently,” and high growth opportunity and R&D spend firms tend to have higher financial distress costs. Therefore, firms with more growth opportunities would be more inclined to hedge to ensure sufficient internally generated cash funds are on hand to maintain required investment levels (Froot et al 1993; Nance et al 1993) and to ensure the ability to meet their debt obligations.

**Highly levered firms are more likely to use derivatives than less levered firms.** This hypothesis is also consistent with the idea that firms hedge to avoid financial distress costs. While empirical finding feature mixed results on this hypothesis, the argument relies on the firm’s need to meet debt obligations and minimize the potential for actual and perceived financial distress among customers and suppliers. Hedging could benefit the firms by reducing risk exposures and cash flow volatility.

Generally speaking, the relevant hedging theory predicts increased derivatives use for larger firms, firms with greater investment opportunities (and increased likelihood of facing distress costs), and firms with greater tax implications. Hedging theory also predicts increased derivatives use among more geographically diverse firms, and for firms with Chief Executive Officers and other key senior executives.

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3 These studies include Bodnar et al (1998); Nance et al (1993); Berkman and Bradbury (1996); Mian (1996); and Dolde (1993). Survey data and follow-up interviews by Walt Dolde (1993) indicate support for the view that “smaller firms may have stronger motives to hedge,” smaller firms were less likely to hedge in practice. However, smaller firms that did hedge with derivatives tended to hedge greater percentages of their interest rate and foreign currency exposures than did larger firms.

whose wealth sensitivity to stock price is relatively large.\textsuperscript{5} This paper tests directly the three selected hypotheses while addressing qualitatively other aspects of hedging theory.\textsuperscript{6}

Derivative securities offer relatively inexpensive and efficient methods for corporations to isolate and restructure various aspects of risky exposures, allowing for the transference of risks from those who do not want them to others who may manage them more efficiently. Next, we review and summarize the literature to provide an overview of the theoretical and empirical hedging literature, and the relevant studies with respect to the forest products industry. Second, we provide a summary note on hedge accounting and SFAS 133, the statement released by the Financial Account Standards Board (FASB) in 1998 changing the way firms account for hedging activities in their financial statements. Third, we describe how the studied firms were identified and the methods used to analyze the firms, and we provide descriptive statistics of the firms themselves and their derivative positions. Fourth, we discuss the analytic findings with respect to the expected findings described in the literature. Finally, we summarize the findings and describe additional research projects we expect to flow from this effort.

Literature and Methodology

In perfect markets, firm value remains unaffected by financing decisions (Modigliani and Miller 1958) and, by extension, hedging. Modigliani and Miller (M&M) showed that firm value derives, when viewed from a balance sheet perspective, from its assets and not from the chosen distribution between debt (liabilities) and equity. The strict “perfect market” assumptions used to advance the work of M&M include no transaction costs, no taxes, no bankruptcy costs, and fully informed and diversified market participants. M&M extends to hedging with the idea that individual investors, through leveraging their own portfolios, can replicate any financing activities considered or pursued by the firm. In this world,

\textsuperscript{5} Management incentives to hedge can occur when executives hold large volumes of stock in their firm. Tufano (1996) found increased hedging among firms in the gold mining industry where managers held large stock positions, and where CFOs had been hired more recently. Alternately, Haushaulter (2000), in studying the oil and gas industry, found weak links between firm use of derivatives and management compensation structures.

\textsuperscript{6} Current research by M. Clutter highlights the role of taxes in driving structural changes in the forest products industry, and fully integrated double-tax entities divest timberlands to single tax REITs and TIMO-related structures.
investors prefer managing their own risk exposures through diversification or selected hedging in lieu of
corporate managers diverting resources away from managing the core businesses to manage these same
exposures.

However, hedging theory asserts that risk management can add value to a firm in the presence of
certain market imperfections. Smith and Stulz (1985) summarize that the key opportunities for risk
management to contribute to firm value occur when the results of risk management activities can reduce
expected tax liabilities, reduce potential bankruptcy costs, or better diversify investor portfolios.7 Risk
management theory has expanded to include these and other market imperfections that can result in
volatility that may prove costly to corporations. Broadly summarized, these include:

1) Costly external financing (Froot, Scharfstein, and Stein 1993)
2) Taxes (Smith and Stulz 1985; Stulz 1996; Leland 1998)
3) Costs of managerial risk aversion (Stulz 1984; Smith and Stulz 1985)
4) Financial distress costs (Myers 1977; Smith and Stulz 1985).

Myers (1977), in describing the set of potential investments for a firm as options, distinguishes
between firms that issue risky debt from those that issue risk-free debt or no debt at all. He argues that
firms with risky debt will, at times, forgo positive NPV investments due to an “underinvestment
problem.” Firms with more debt – and thus more fixed interest payments and greater potential for default
– have greater incentive to hedge to reduce firm variances, and, thus, the likelihood of underinvestment.
The potential for underinvestment results because firms must make interest payments first, prior to
allocating investment funds. Leland (1998), in evaluating investment risk with respect to capital structure,
extends this concept and documents how hedging activities facilitate increased leverage.

7 Smith and Stulz footnote, “if markets are perfect and complete, the value of the firm is independent of its hedging
policy for other reasons, as well. For example, if a firm hedges the value of an input by purchasing forward
contracts and that input price rises, the firm’s pricing and production policies should not be affected by the
existence of the hedge. The opportunity cost of the input is its current price, not the (sunk) cost of the forward
contract.”
Froot, Scharfstein, and Stein (1993) argue that firms use derivatives to hedge “non-diversifiable costs associated with market frictions such as taxes, financial distress costs, and external financing costs.” In developing a general framework for evaluating corporate risk management policies, they justify risk management in situations where externally obtained funds for investment prove more expensive than internally generated funds. Since variability in the availability of internal funds for investment can lead to firms seeking outside funding, a potential shortfall of funds can result in extra costs or, even worse, underinvestment. Thus, reducing the variability of cash flows can add to firm value by supporting optimal investment and financing strategies by the firm. While it builds on Myers (1977), this work differs with Myers on the point that the volatility of future cash flows is only a problem if it compromises the firm’s ability to make investments because of unavailable internally generated funds. It is the risk of not being able to invest in good projects, not lack of good projects, that justifies hedging.

Smith and Stulz (1985) emphasize the roles of a convex tax structure, potential financial distress costs, and managerial risk aversion in encouraging hedge implementations. They argue that firms use derivatives to hedge “non-diversifiable costs associated with market frictions such as taxes, financial distress costs, and external financing costs.” Reducing expected bankruptcy costs leads to higher expected payoffs to firm bondholders and shareholders. “By reducing the variability of the future value of the firm, hedging lowers the probability of incurring bankruptcy costs. This decrease…benefits shareholders.” Stulz (1984) also asserts that manager risk aversion drives hedging.

DeMarzo and Duffie (1995) study hedging decisions as impacted by managers motivated by career concerns, and find that these decisions are affected by the accounting information made available to shareholders. Knopf, Nam, and Thornton (2002) also study the relationship between corporate hedging and managerial incentives.

Stulz (1996) revisits hedging theory to reconcile the fact that corporations appear to hedge “selectively,” and argues that the primary objective of corporate risk management programs is to “eliminate the probability of costly lower-tail outcomes” that would adversely affect firms’ investment activities.
Empirical studies have sought to test each aspect of hedging theory with a range of methods and a range of results. Block and Gallagher (1986) “find a positive but statistically insignificant relation between the debt-equity ratio and hedging.” Block and Gallagher surveyed the 500 largest U.S. firms, as identified in the Fortune 500 rankings, to study the use of interest rate futures. 193 (38.6%) of the firms responded. 37 (19.2%) reported using interest rate futures or options. They noted that firms in traditional commodity industries (mining, meat products, oil and natural gas, agriculture) were more likely to use interest rate futures and options (25% to 18.6%).

Wall and Pringle (1989) study 250 swap users through searching 1986 annual report footnotes. This group includes four forest products industry firms (with the notional principal of their 1986 swaps): Great Northern Nekoosa Corporation ($50 million), James River ($11.8 million), Mead (unreported), and Scott Paper ($90 million).^8

Nance, Smith, and Smithson (1993) use the COMPUSTAT database and survey data from 169 firms on 1986 use of hedging instruments to test determinants of corporate hedging. 104 of the firms reported using forwards, futures, options, and/or swaps. They argue that smaller firms are more likely to hedge because of the disproportionate impacts of financial distress costs relative to firm size. However, among their findings are increased hedging among larger firms, firms with more investment growth opportunities, and firms with less debt interest coverage.

Dolde (1993) surveyed Fortune 500 firms in 1992. Of the 244 responses, 85% said they used swaps, options, forwards, and futures, with greater use among larger firms than smaller. Dolde reconciles this with the experience of risk management professionals who cite requisite personnel, training, and computer startup investments for corporate derivatives use, which may act to deter smaller firms from using derivatives.

Berkman and Bradbury (1996) study the use of derivative instruments from the audited financial statements of 116 firms in New Zealand, where firms are required to report both the notional and fair

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^8 We note, but do not comment on, the fact that these four companies no longer operate as independent firms.
values of their on- and off-balance sheet financial instruments. They find that derivative use increases with, for example, leverage, firm size, and the payout ratio; derivative use decreases with interest coverage and liquidity. They find support for the notion that derivative use relates positively to firm growth options. Of the 116 firms, 7 were in the forest products industry.

Mian (1996) aggregates hedging data from 1992 annual reports for a sample of 3,022 firms. 771 firms (25.5%) use derivatives. 13 of the firms come from Agriculture and Forestry, 5 of which are classified as hedgers. Empirical results are mixed with respect to hedging theory, though firm size, particularly with respect to economies of scale as opposed to financial distress or external financing costs, is clearly shown as a determinant of corporate hedging activities.

Geczy, Minton, and Schrand (1997) study the use of currency derivatives and find support for Froot et al (1993) that firms might use these contracts to reduce volatility of cash flows that might impair investments in positive growth opportunities. In their sample of 372 of the Fortune 500, they find support for hedging activities associated with firm size. 41% of the firms use currency derivatives in some form or combination in 1990. 27 of the firms in their sample are identified as “Forest and paper products” firms as categorized by Fortune. Of these 27 firms, 5 (18.5%) used currency derivatives and 12 (44.4%) used derivatives of some type.

Bodnar, Hayt, and Marston published in 1998 the third of a series of surveys on financial risk management and derivatives use by non-financial firms in the U.S. 399 firms participated in the survey and 200 (50%) reported using derivatives. Large firms were more likely to use derivatives than smaller firms. Foreign currency exposure was the risk most commonly managed with derivatives, followed by interest rate risk, and then commodity price risk. For firms that reported not using derivatives, the most important reasons cited were “insufficient exposure” and “exposures effectively managed by other means.”

Howton and Perfect (1998) studies currency and interest rate derivative use in a sample of 451 Fortune 500/S&P 500 firms and 461 randomly selected firms. 61% and 36% of the firms use derivatives

9 2 hedge interest rate exposures, 4 hedge currency price risk, and 4 report hedging commodity price risk.
respectively, with swaps accounting for over 90% of the interest-rate derivatives and forwards and futures accounting for over 80% of the derivatives used for hedging foreign currency exposures. The determinants of derivative use differed between the two samples. The Fortune 500/S&P sample support expected determinants such as taxes, external financing and distress costs, and currency-risk exposure. The random sample of firms exhibits no such support for hedging theories. The paper, thus, supports hedging theory with respect to larger firms, but leaves open for future research investigations to explain differences between the two samples.

Allayannis and Weston (2001) address the issue of whether or not hedging affects firm value through a sample of 720 U.S. nonfinancial firms between 1990 and 1995. Focusing on foreign currency use over time, they use Tobin’s Q as a proxy for market value and find that, on average, firms that face foreign currency exposure and hedge have 4.87% higher firm values than firms that do not hedge these exposures. These results were significant at the 5% level.

Hentschel and Kothari (2001), using data from the financial statements of 425 large U.S. corporations, find no statistically significant relation between the risk characteristics of firms and their derivative positions. These findings are consistent with the view of Stulz (1996) that firms utilize derivatives to manage risk associated with short-term – less than one year – contracts. “Since the cash flows associated with these contracts typically represent a small fraction of firm value, risk reduction for these contracts is unlikely to have material effects on overall firm volatility.” However, this view diverges from traditional corporate risk management theories.

Guay and Kothari (2003) study the magnitudes of the risk exposures hedged with derivatives by a random sample of 234 non-financial firms. Overall, they find that derivative holdings are small relative to firm size and risk exposures, implying that corporate derivative use may be not be an important part of corporate risk management activities or impact firm value significantly.

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10 Tobin’s Q is the ratio of the market value of firm assets to the replacement value of the assets. Well-managed firms are expected to have higher Q values than poorly managed firms.
Several industry and firm specific studies have also sought to test hedging theory. Tufano (1996) studies hedging in the gold mining industry and finds that the only systematic factor affecting hedging across the firms was managerial ownership and compensation structure. Specifically, Tufano found that managers with large stock positions hedge more, while managers with large stock options positions hedge less.\footnote{The hedging preference appears to correspond with the type of security held. Hedging reduces volatility and protects stock prices, while options gain value with increased or unhedged volatility.} Petersen and Thiagarajan (2000) return to the gold industry to test risk management theory by estimating and comparing the risk exposures of two gold mining industry firms with opposite approaches to hedging and managing risk.

Haushalter (2000) surveyed 100 oil and gas firms to study their risk management activities between 1992 and 1994. He finds that firm hedging activities vary, and, for example, are positively associated with firm leverage – potentially to reduce the potential for financial distress and, as a result, financial contracting costs – and with total assets. The link between hedging activities and firm size is consistent with economies of scale, as also noted in Mian (1996) and Geczy et al (1997).

Brown (2001) conducts an in-depth study of the foreign exchange risk management program of a single firm. Brown finds a sophisticated foreign currency risk management program that does not hedge for reasons commonly argued in the literature. Rather, factors such as smoothing earnings and securing competitive prices in the market drive decisions within the risk management program. Additionally, Brown found that accounting treatment of derivatives did impact the choices made by the firm.\footnote{Specifically, the firm Brown studied preferred to use option contracts in hedging because of the associated accounting treatment and because they were priced competitively. In cases where a hedge was deemed appropriate but option contracts were unavailable, the firm chose to by-pass the hedge rather than use forward contracts. These situations occurred for “illiquid currencies.”}
Key ideas and empirical results from the hedging literature can be summarized as follows:

- Larger firms are more likely to hedge than smaller firms (Dolde 1993; Nance, Smith, and Smithson 1993; Bodnar, Hayt, and Marston 1998; Geczy, Minton, and Schrand 1997).
- Derivatives use is more common among firms with more growth opportunities as measured by R&D expenditures and market-to-book ratios (Nance et al. 1993; Geczy et al. 1997).
- Derivatives use more likely among highly levered firms (Nance et al. 1993; Block and Gallagher 1986).

Alternately, several cross-sectional studies provided conflicting results that do not support the hedging theories explaining and justifying corporate hedging activities. Guay and Kothari (2003) find little support for hedging theory, aside from the correlation between firm size and derivatives use. Wall and Pringle (1989) and Geczy et al. (1997) found weak and no support for the idea that hedging increases with leverage. While Tufano (1996) and Petersen and Thiagarajan (2000) found support for the connection between management incentives and hedging activity in their analysis of the gold mining industry, Haushalter (2000), in studying the oil and gas industry, did not.

Firms may implement financial policies that act as substitutes to hedging if these policies reduce expected taxes, transactions costs, or agency costs. Policies include more convertible debt, more preferred stock, greater liquidity of firm assets, and smaller dividend payouts. In other words, firms can manage risk through alternate operating and financing strategies. In this project, we take these strategies as given.

Dividend policy impacts needs to hedge, as lower dividends leave more funds available for paying bondholders. Liquidity – firms with more liquid assets – also have less reason to hedge as they are better prepared for responding to unknowns. Corporate structure and the geographic nature of operations may impact hedging, as firms with foreign operations or extensive import and export activities may be more likely to use foreign currency derivatives to hedge exchange rate exposures.
With respect to these ideas and the literature reviewed previously, several studies assume that derivatives use at the firm level can proxy for risk management activities (e.g., Nance, Smith and Smithson 1993; Mian 1996; Geczy, Minton, and Schrand 1997; Knopf, Nam, and Thornton 2002). However, more recent research comment on the central role played by operational hedging techniques into the implementation of risk management programs (e.g., Geczy, Minton and Schrand 2000; Guay and Kothari 2003). According to Guay and Kothari, “if hedging with derivatives is only a small component of firms’ overall risk management activities, then derivatives use will be a noisy proxy for risk management activities, and the mixed results documented in the literature are understandable….”


Yin and Izlar (2001) illustrate the potential for financial engineering in the management of institutional timberland investments. They address qualitatively the potential role of option-based supply contracts and note the potential application of these tools for forest industry firms. In sum, previous research into risk management and derivatives use in the forestry literature fails to address the actual use of derivative instruments or broader risk management strategies at either the corporate or operational level.
Note on Hedge Accounting

For each forest products firm in the final study group, we collected fiscal year end (FYE) 2002 information on the types of derivative securities held, the notional principal of these derivative instruments, and the designated purpose of each derivative security as required by Statement of Financial Accounting Standards (SFAS) No. 133, “Accounting for Derivative Instruments and Hedging Activity.” Fiscal year 2002 is the latest year for which data were available at the time we began gathering data for this study. With respect to this study, we focus on hedge accounting as specified in No. 133.

SFAS 133 changed hedge accounting because it required for the first time that all derivative instruments be shown on the balance sheet as assets or liabilities at fair (market) value. The accounting for changes in fair value would depend on the purpose of the derivative. Prior to SFAS 133, derivative instruments were typically recorded off balance sheet (Gastineau et al 2001).

Under SFAS 133, the emphasis of the accounting moved towards disclosing the firm’s objectives for using a derivative instrument while moving away from accounting for the specific types of derivative instruments used. As a general example, it has become more important to know that an instrument is hedging the fair value of an asset exposed to interest rate changes, and less important to know that the instrument was an option, swap, or forward contract. Specifically, gains and losses on derivatives flow into earnings in the period in which they occur, unless the derivatives qualify for hedge accounting, in which case the gains and losses are recorded in equity as other comprehensive income (OCI) until the derivative positions are settled. After these derivatives are closed out, the recorded earnings recycle into earnings. In other words, the accounting for derivatives depends on how the derivatives are used.

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13 Generally Accepted Accounting Principles (GAAP) pertaining to disclosure about financial derivatives is contained in Financial Accounting Standard No. 133, which was released in 1998, and supersedes No. 119. No. 138 and No. 149 contain amendments to No. 133. Complete descriptions of these statements are available at www.fasb.org.

14 Fair value, according to Trombley (2003), is the “amount at which an asset or liability could be bought, sold, or settled in a voluntary transaction between unrelated parties.” In other words, it represents the value of the contract, whereas notional value represents the face value of the derivative’s underlying assets. For example, in the case of a call option for one share of Weyerhaeuser stock, the fair value is the price of the option and the notional value is the current market price of the Weyerhaeuser stock.
The motivation and thinking behind the changes in hedge accounting are summarized by paraphrasing FASB selected basic principles underlying the new rules (SFAS No 133, p.1):

- Derivatives are assets and should be reported in the financial statements.
- Fair value is the most relevant measure for financial instruments and the only relevant measure for derivatives. Adjustments to the carrying amount of hedged items should reflect changes – gains and losses – in their fair values that are attributable to the risk being hedged and that arise while the hedge is in place.
- Special accounting for items designated as being hedged should be provided only for qualifying transactions, and one aspect of qualification should be an assessment of offsetting changes in fair values or cash flows.

Derivatives that qualify for hedge accounting hedge risks associated with changes in interest rates, prices, foreign currency exchange rates, and credit. Also, the exposure to risk must have the potential of affecting earnings as reported. Firms that utilize derivatives to hedge these risks much designate the derivative as either:

- A **fair value hedge**, which hedges the exposure to changes in fair value of a recognized asset or liability, or an unrecognized firm commitment. One example of fair value risk is found in fixed interest bonds, where the fair value of the bonds falls with increases in interest rates. Thus, fair value hedges eliminate risk associated with asset fair values.

- A **cash flow hedge**, which hedges cash flow volatility associated with a recognized asset or liability or future transaction. The future cash flows hedged may also be associated with an expected transaction for which a contract does not yet exist. To contrast the example cited for the fair value hedge, variable interest rate bonds are subject to cash flow risk, as the interest cash flows are subject to change as a result of changes in interest rates. Cash flow hedges can also be used to manage cash flow variability associated with commodity purchases or sales, such as those associated with energy and agricultural commodities, and future transactions exposed to foreign currency rate changes. Thus cash flow hedges use derivatives to offset the variability of expected future cash flows.
An exposure to changes in the value of a net investment in a foreign operation refers to risk associated with changes in value of net investments in a foreign operation. For example, a U.S. firm may own 100 percent of a British company with net assets of 50 million British pounds. Any increase or decrease in value of the British pound relative to the U.S. dollar will result in a corresponding change of the value of the U.S. firm’s net investment in the British company. Thus net investment hedges refer to derivative contracts or cash instruments to hedge the foreign currency exposure of a net investment in a foreign operation.

Derivatives that fail to qualify for hedge accounting must be so identified in the financial statements as non-designated. Under SFAS 133, derivatives that do not qualify for hedge accounting are marked to market through earnings. Also, changes in the fair value of derivative and embedded derivative instruments would be included within net income.

In aggregating information on the derivatives used by forest products firms, we recorded types of hedges used, the types of financial instruments used (when specified in the 10-K), and the notional value of the derivative positions. We focus on the notional value because it provides a ready indication of the magnitude of the assets, cash flows, and transactions being hedged with derivatives. While fair value measures the market value of the financial contact itself, the notional value indicates the value of the assets underlying the derivative positions.

The reporting quality of derivative notional values in the financial statements varied by firm. Several firms specified the notional values of all derivative positions, while other firms provided partial or indirect data. To calculate notional values in situations with incomplete information, I used two approaches. For commodity contracts with specified commodity types and volumes, I used 2002 year-end prices to estimate the notional values of the contracts. For contracts that required additional information, I contacted the firms directly to seek data and clarification. In most cases, Investor Relations or Treasury groups at the respective firms were able to confirm my assumptions and/or point me to other publicly-available documents that provided the necessary insight to estimate notional values. All
assumptions and calculations made to estimate notional values not explicitly listed in published 10-Ks are included as footnotes to the raw data set.

In recording the derivatives information of the firms, we also do not explicitly record, analyze, or compare the firms’ hedging objectives. This is important, and a probably topic for additional study, because risk management objectives say something about what the firm is concerned about (cash flows, earnings, value) and how it will implement derivative-based hedges. Generally speaking, we do not concern ourselves with the question, “is the firm concerned about current market values or net profit flows (whether measured in cash or accounting terms)?”

Data and Analysis (Descriptive Statistics)

This study seeks to provide empirical evidence of derivative use in the forest products industry by those corporations that depend on wood raw materials as a primary input or output in their overall business. As such, we specify the following corporate-level criteria for inclusion within the study group:

1) Headquartered in the U.S.
2) Publicly traded on a U.S. stock exchange.
3) Market Cap exceeded $500M at some point in 2002
4) Derived 50% or more of 2002 revenues from the manufacture and sale of primary forest or wood products: timber, logs, pulpwood, lumber and conventional building materials, pulp and paper and/or depend on wood raw materials as a primary input or output of the business.

Using relevant four-digit SIC codes under the broader two-digit 24 (lumber and wood products), 26 (paper and allied products), and 08 (forestry), we filtered out an initial list of 95 publicly-traded, U.S. based forest products firms with sales exceeding $250 million. This list did not include Plum Creek Timber Company, a timber-based real estate investment trust (REIT). Of the 53 publicly-traded, U.S.

15 $250 million was used as the initial screen to develop a rough picture of the possible candidates. Screening by market capitalization may have screened out legitimate candidates, as we sought to include firms that exceeded $500 million in market cap at any point in 2002. The credentials of the screened firms were later checked by pulling max 2002 stock price from COMPSTAT and multiplying this by shares outstanding.
based REITs with revenues exceeding $250 million, Plum Creek, at the time this study began, was the only one primarily in the timber business, as confirmed from their business descriptions. This screen provided an initial list of 96 firms. Many firms, such as International Paper, have multiple SIC codes and, as such, were listed multiple times. Additionally, a couple of firms had pre and post merger listings, such as Westvaco (now MeadWestvaco). Screening out duplicates and “orphans” reduced the list to 59 firms.

Next, we screened this list against criteria 4 that requires 50% or more of firm revenues derived from or were dependent on primary forest products. The process comprised of checking the business description, raw material summary, and divisional revenues of the firms in their 2002 10-K SEC filings. Several firms, such as Armstrong Greetings Corporation and La-Z-Boy Incorporated, were eliminated based on their business descriptions as secondary users of primary wood products to produce value-added paper or manufactured goods. Other firms were eliminated because the description of their business raw material requirements specified that they purchase, rather than manufacture, primary wood products for their businesses. These firms included Schweitser-Mauduit, which purchases fluff pulp to produce specialty papers and tobacco products, and Universal Forest Products, which purchases lumber and other primary wood products for its lumber and building products manufacturing, treating, and distribution business. Other firms, such as Maxxam Incorporated, were eliminated because their forest products businesses represented a minority share of overall firm revenues. This process reduced the list to 22 firms.

Finally, we screened against criteria 3 that these companies exceeded $500 million in market capitalization at some point during 2002. While the $500 million figure is somewhat arbitrary, we felt the need to establish a minimum firm size per findings in the empirical literature. The hedging literature identifies some correlation and economies of scale associated with hedging activities, and this size requirement was consistent with prior literature using large samples (such as Guay and Kothari 2003). Screening out these smaller firms eliminated Buckeye Technologies, Crown Pacific Partners (filed for Chapter 11), and Pope & Talbot. This reduced the final list to 19 firms. The process for identifying the candidate firms is summarized in Table 2.1.
Ultimately, the objective is to capture those firms, and the industry, that generate most of their revenue from businesses which require substantive contact with and the direct use of trees, logs, and wood fiber. Table 2.2 lists the 19 firms in the final study group with their trading symbol, primary forest product businesses, and selected 2002 financial results including revenues, net income, and peak market capitalization.

Table 2.2

Data on the derivative positions as of December 2002 of these firms was collected from SEC Form 10-K filings. To calculate notional values in situations with incomplete information, 2002 year-end prices were used to estimate the notional values of the contracts. For contracts that required additional information, calls were made to Investor Relations or Treasury groups at the respective firms to confirm assumptions and/or obtain other publicly-available documents that provided the necessary insight to estimate notional values. All 19 firms state that they use derivative contracts regularly or selectively to manage risk exposures associated with interest rates, foreign exchange rates, and commodity prices. All 19 firms indicated that none of their derivatives positions are used for trading purposes as opposed to hedging purposes. Several firms acknowledged that, in certain situations, efforts to hedge risk through the use of derivatives might not qualify for hedge accounting treatment. As of December 31, 2002, 17 of the 19 firms (89%) had outstanding derivative positions.

Table 2.3 provides descriptive statistics of the final group of forest products firms. Derivatives users are those firms reporting active derivatives positions on the books as of December 31, 2002; derivatives non-users are those firms reporting no outstanding derivatives positions at the same point in
time, even if they had used derivatives previously. Most discussion and analysis in this paper focuses on the aggregate figures for all studied firms.

Table 2.3

Table 2.3 variables selected for 2002 describe firm size, firm profitability, proxies for growth potential, and leverage. In total, the firms had mean (median) 2002 revenues of $6,467 million ($2,581 million) and net incomes of -$2.1 million ($23 million). The firms had long-term debt of $7,020 million ($2,067 million) and long-term debt-to-total asset ratios of .35 (.36).\(^\text{16}\)

Tables 2.4, 2.5, and 2.6 present descriptive statistics on the notional principals of the derivatives positions by hedging type, as required in SFAS 133, by purpose, and by derivative type as reported in the firms’ Form 10-K filings at the 2002 fiscal year end. All statistics distinguish between results for the entire study group and for the sub-group of identified derivative users.

Table 2.4

Table 2.4, which segregates derivative-related hedging activity as reported under SFAS 133, shows the majority of derivative-based hedging takes place in the form of fair value and cash flow hedges. For all notional values of derivatives across the study group, fair value and cash flow designated hedges account for 34% and 38% of total notional value of derivatives use respectively. This corresponds to the fact that most interest rate hedges – whether fixed to variable or variable to fixed – and foreign currency transaction hedges fall into these two categories. Additionally, the medians and counts across all categories indicate the majority of the activity taking place with a minority of the firms.

\(^{16}\) While the descriptive statistics suggest derivative users are larger, less profitable, and more debt laden relative to derivative non-users, the limited size of the study group prohibit a statistically significant result.
Table 2.5

Table 2.5, which segregates the same notional amounts by hedging purpose, shows results consistent with previous empirical research: most derivatives are used for hedging interest rate and foreign currency exposure, with interest rate hedges dominating the mix with 62% of the activity as calculated from the aggregated notional values. In contrast, commodity hedges account for 3% of the total notional values. Also, of the applications, interest rate hedges appear more commonly used and evenly distributed across the forest products firms, with 13 firms – 76% of the derivative users and 68% of the total group – reporting active interest rate hedges as of the end of 2002.

Table 2.6

Table 2.6 summarizes the hedging activity by derivative type. Swaps, mostly associated with interest rate agreements, comprise 61% of these contracts as calculated from the aggregated notional values, while options account for but 4%. The “other” category refers to debt instruments that qualify for hedging accounting as net investments of foreign operations, but do not fall in the other categories.

As noted previous, the empirical research into corporate hedging and derivatives use includes references and limited summary statistics specific to the forest products industry. Block and Gallagher (1986), in surveying the 500 largest U.S. firms to study the use of interest rate futures, noted that firms in traditional commodity industries (mining, meat products, oil and natural gas, agriculture) were more likely to use interest rate futures and options (25% to 18.6%). Wall and Pringle (1989), in their study of 250 swap users, identified four forest products industry firms (with the notional principal of their 1986 swaps): Great Northern Nekoosa Corporation ($50 million), James River ($11.8 million), Mead (unreported), and Scott Paper ($90 million). These four firms no long operate as independent entities.

Mian (1996) aggregates hedging data from 1992 annual reports for a sample of 3,022 firms. 13 of the firms come from Agriculture and Forestry, 5 (38%) of which are classified as hedgers. Details
regarding the purpose of the hedging activities reveal that 2 firms (15%) hedge interest rate exposure, 4 firms (31%) hedge foreign currency exposure, and 4 firms (31%) hedge commodity price risk.

Geczy, Minton, and Schrand (1997) study the use of currency derivatives. Their sample includes 372 of the Fortune 500. 27 of the firms in their sample are identified as “Forest and paper products” firms as categorized by Fortune. Of these 27 firms, 5 (18.5%) used currency derivatives and 12 (44.4%) used derivatives of some type.

While the sample sizes and categories used by separate studies limit comparability, results from Mian (1996) and Geczy (1997) do indicate a growing acceptance and use of derivatives for hedging purposes among forest products industry related firms (Table 2.7). At least two issues may influence the results across the three studies in Table 2.7. First, forest industry consolidation – through merger and acquisitions activity (M&A) in the late 1990s and early 2000s – affects the number and characteristics of the firms within the industry. Second, accounting standards and requirements changed after the studies by Mian and by Geczy and prior to this study. These changes, as implemented by SFAS 133, affect, at a minimum, the nature and consistency of derivative-related reporting in firm financial statements.

Table 2.7

To test the relationship between the hedging activity and firm characteristics as predicted by hedging theory, I tested three hypotheses: large firms hedge more than small firms, highly leveraged firms hedge more than less leveraged firms, and firms with greater growth and investment opportunities hedge more than firms with lesser growth opportunities. The hypotheses and expected relationships are summarized in Table 2.8.
Each hypothesis is tested twice for significance. Testing hedge activity relative to firm size uses market capitalization and firm value as proxies for company size, with firm value computed as the market value of equity plus current liabilities plus long-term debt plus the book value of any preferred stock. To test hedging activity relative to growth opportunities, research and development (R&D) expenditures divided by sales and market value divided by book value proxy firm growth potential. Testing hedge activity relative to leverage uses long-term debt divided by total assets and EBIT (earnings before interest and taxes) divided by interest expense to proxy debt levels. In five of the six tests, a positive relationship is expected between the level of hedging activity and the firm specific variable. Hedging theory expects a negative relationship between hedging activity and EBIT over interest expense, as a healthier interest coverage indicates reduced potential for financial distress costs, translating in reduced benefits for hedging with derivatives.

Table 2.9 provides the Pearson Product-Moment Correlation Coefficients for the total notional values of the derivative positions of the firms and the variables specified in Table 2.8.\textsuperscript{17}

The results indicate statistically significant relationships result with respect to firm size – a significant positive correlation – but statistically insignificant relationships with respect to future growth opportunities and with leverage. “Growth opportunities” variables appear to offer little insight into the risk management activities – or any activities, for that matter – of these forest products firms; as a group, they feature low levels of research and development expenditures. These results fail to provide insight.

\textsuperscript{17} All 19 firms are included in the results as reported. Using the 17 firms using derivatives in 2002 results in different correlation coefficients but identical significance results.
into when firms choose to use derivatives for hedging purposes, and how derivative use fits into the overall risk management programs of forest products firms.

Conclusion

For 19 forest products firms, we aggregated detailed evidence on the levels of derivatives use for hedging activities. Of the study group, 17 reported active derivative positions as of the end of 2002. For most of these firms, the notional amounts of these derivatives securities are small relative to firm revenues and market values. Consistent with large sample surveys and empirical studies, most derivative activity is associated with hedging exposure to interest rates, followed by foreign currency exposure and, to a minor degree, commodity prices. In testing this use of derivatives against hedging theory, only the correlation between derivatives use and firm size proved statistically significant.

This study extends the literature because it: 1) documents for the first time the use – by type, by purpose, and by magnitude – of derivatives in the U.S. forest products industry; 2) uses post SFAS 133 data, which changed the manner in which firms report out their hedging activities; and 3) compares, where possible, the results of previous empirical work with risk management activities in the forest products industry. As a single-industry, small group study of reported derivatives as of one point in time, this project requires caution with regards to generalizing and analyzing the results. Additional work assessing these derivative positions over time will provide added insight into how the use of derivatives in the forest products industry has evolved, and how changing accounting requirements may impact results.

The overall size of the derivatives positions, and of the derivatives programs, of the forest products firms is economically small. As such, this may prove consistent with the ideas that forest product firms use derivatives to refine and adjust an overall risk-management program that includes other hedging activities or strategies (e.g., operational hedges). It may be that the risk for forest industry firms (e.g., operating risks, log prices) cannot be managed to any outstanding degree with standard derivatives contracts, traded or OTC, written over asset prices such as interest rates, exchange rates and commodity
prices. Or, it may be that these types of exposures are immaterial to the overall performance an integrated forest products firm.

Also, limitations imposed or perceived from SFAS 133 to qualify for hedge accounting may cause firms to restrict their use of derivatives. However, qualitative assessments of the hedging objectives stated in the financial statements, and large non-designated swaps held by International Paper in particular and others, do not indicate extraordinary concern for using derivatives for hedges that do not qualify for hedge accounting as long as the position meets business objectives.

Forest products firms make centralized decisions on using derivatives. For example, mill or division managers may (want to) use derivatives to hedge specific transactions that are important to their respective units (and their performance reviews and bonuses), but may be small relative to the exposure of the entire firm. In fact, the evidence indicates that derivatives are used primarily to manage risk associated with interest rates and foreign currency rates, and these exposures are managed at the treasury level or higher. Commodity derivatives, mostly for energy related products, may be entered into at a division or unit level, but the findings and results remain unclear on that point.

With respect to the derivative positions held by forest products firms, future research may address questions regarding the effectiveness of these hedging activities, the characteristics of derivative positions held by these firms over time, and the relative use of derivatives by firms headquartered internationally. Given the limited economic significance of the derivative positions, on average, relative to firm size and market values, additional research will provide insight as to why firms spend considerable effort and resources to hedge this relatively small component of their overall risk profile.
Table 2.1: Firm identification process

<table>
<thead>
<tr>
<th>STEP</th>
<th>CRITERIA</th>
<th>FIRMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIC search of US public, forest, wood, paper, timber REITs &gt; $250MM</td>
<td>1 &amp; 2</td>
<td>96</td>
</tr>
<tr>
<td>Screen out duplicates and firms eliminated through mergers</td>
<td>1 &amp; 2</td>
<td>59</td>
</tr>
<tr>
<td>Screen out firms with primary forest and wood revenues &lt; 50% of total</td>
<td>1, 2, &amp; 4</td>
<td>22</td>
</tr>
<tr>
<td>Screen out firms with 2002 Market Cap below $500MM</td>
<td>1, 2, 3 &amp; 4</td>
<td>19</td>
</tr>
</tbody>
</table>
Table 2.2: Firms in final study group with selected 2002 financial data

<table>
<thead>
<tr>
<th>SMBL</th>
<th>Company Name</th>
<th>Revenue</th>
<th>Net Income</th>
<th>Peak Market Cap</th>
<th>Primary Forest/Wood/Paper Businesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCC</td>
<td>BOISE CASCADE CORP</td>
<td>7,412.33</td>
<td>11.34</td>
<td>2,262.00</td>
<td>Building products, paper, packaging</td>
</tr>
<tr>
<td>BOW</td>
<td>BOWATER INC</td>
<td>2,581.10</td>
<td>-142.40</td>
<td>3,176.30</td>
<td>Timber, lumber, paper, pulp</td>
</tr>
<tr>
<td>GP</td>
<td>GEORGIA-PACIFIC CORP</td>
<td>23,271.00</td>
<td>-735.00</td>
<td>7,907.52</td>
<td>Building products, paper, pulp</td>
</tr>
<tr>
<td>GLT</td>
<td>GLATFELTER</td>
<td>543.82</td>
<td>37.60</td>
<td>844.51</td>
<td>Paper</td>
</tr>
<tr>
<td>GPK*</td>
<td>GRAPHIC PACKAGING INTL CORP</td>
<td>1,057.84</td>
<td>-178.65</td>
<td>1,835.69</td>
<td>Packaging</td>
</tr>
<tr>
<td>IP</td>
<td>INTL PAPER CO</td>
<td>24,976.00</td>
<td>-880.00</td>
<td>22,134.42</td>
<td>Paper, packaging, forest products</td>
</tr>
<tr>
<td>KMB</td>
<td>KIMBERLY-CLARK CORP</td>
<td>13,566.30</td>
<td>1,674.60</td>
<td>34,116.33</td>
<td>Paper products</td>
</tr>
<tr>
<td>LFB</td>
<td>LONGVIEW FIBRE CO</td>
<td>769.28</td>
<td>5.13</td>
<td>628.25</td>
<td>Timber, pulp, paper, packaging</td>
</tr>
<tr>
<td>LPX</td>
<td>LOUISIANA-PACIFIC CORP</td>
<td>1,942.70</td>
<td>-62.00</td>
<td>1,312.53</td>
<td>Building products</td>
</tr>
<tr>
<td>MWV</td>
<td>MEADWESTVACO CORP</td>
<td>7,242.00</td>
<td>-389.00</td>
<td>7,301.42</td>
<td>Packaging, paper products</td>
</tr>
<tr>
<td>PKG</td>
<td>PACKAGING CORP OF AMERICA</td>
<td>1,735.66</td>
<td>48.18</td>
<td>2,204.76</td>
<td>Packaging</td>
</tr>
<tr>
<td>PCL</td>
<td>PLUM CREEK TIMBER CO INC</td>
<td>1,137.00</td>
<td>233.00</td>
<td>5,911.89</td>
<td>Timber, building products</td>
</tr>
<tr>
<td>PCH</td>
<td>POTLATCH CORP</td>
<td>1,286.22</td>
<td>-234.38</td>
<td>1,041.70</td>
<td>Timber, wood products, pulp</td>
</tr>
<tr>
<td>RYN</td>
<td>RAYONIER INC</td>
<td>1,117.43</td>
<td>54.17</td>
<td>1,626.27</td>
<td>Timber, wood products, fiber products</td>
</tr>
<tr>
<td>SSCC</td>
<td>SMURFIT-STONE CONTAINER CORP</td>
<td>7,483.00</td>
<td>85.00</td>
<td>4,478.22</td>
<td>Packaging</td>
</tr>
<tr>
<td>SON</td>
<td>SONOCO PRODUCTS CO</td>
<td>2,812.15</td>
<td>135.32</td>
<td>2,870.21</td>
<td>Packaging</td>
</tr>
<tr>
<td>TIN</td>
<td>TEMPLE-INLAND INC</td>
<td>4,518.00</td>
<td>53.00</td>
<td>3,227.82</td>
<td>Packaging, building products</td>
</tr>
<tr>
<td>WMO</td>
<td>WAUSAU-MOSINEE PAPER CORP</td>
<td>948.70</td>
<td>23.07</td>
<td>721.52</td>
<td>Paper</td>
</tr>
<tr>
<td>WY</td>
<td>WEYERHAEUSER CO</td>
<td>16,474.00</td>
<td>241.00</td>
<td>15,065.12</td>
<td>Timber, wood products, pulp, paper, packaging</td>
</tr>
</tbody>
</table>

Notes: All figures in millions and for 2002 fiscal year ending December 31, 2002.
Data sources and calculations: Revenues = COMPUSTAT DATA 12; Net Income = COMPUSTAT DATA 172; Peak market cap = COMPUSTAT DATA 22 (peak stock price) * COMPUSTAT DATA 25 (common shares outstanding).
*Graphic Packaging’s 2002 Market Cap is based on peak 2002 stock price and shares outstanding as reported in GPK proxy/prospectus dated July 17, 2003.
Table 2.3: 2002 descriptive statistics

<table>
<thead>
<tr>
<th>Descriptive Statistic</th>
<th>All Firms (19)</th>
<th>Derivative Users (17)</th>
<th>Derivative Non-users (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Median</td>
<td>Mean Median</td>
<td>Mean Median</td>
</tr>
<tr>
<td>Revenues</td>
<td>6,467.09 2,581.10</td>
<td>7,105.24 2,812.15</td>
<td>1,042.85 1,042.85</td>
</tr>
<tr>
<td>Net Income</td>
<td>-2.11 23.07</td>
<td>-17.42 11.34</td>
<td>128.03 128.03</td>
</tr>
<tr>
<td>R&amp;D Expenditures</td>
<td>49.76 8.60</td>
<td>60.58 13.80</td>
<td>1.07 1.07</td>
</tr>
<tr>
<td>MV Equity</td>
<td>4,463.95 2,215.96</td>
<td>4,698.48 2,215.96</td>
<td>2,470.49 2,470.49</td>
</tr>
<tr>
<td>Assets</td>
<td>9,333.99 4,289.00</td>
<td>10,128.42 4,947.40</td>
<td>2,581.38 2,581.38</td>
</tr>
<tr>
<td>Total Debt</td>
<td>7,020.31 2,067.00</td>
<td>7,694.18 3,547.87</td>
<td>1,292.40 1,292.40</td>
</tr>
<tr>
<td>Long-Term Debt</td>
<td>3,442.17 1,611.35</td>
<td>3,729.38 1,611.35</td>
<td>1,000.88 1,000.88</td>
</tr>
<tr>
<td>LT Debt/ Tot Assts</td>
<td>0.35 0.36</td>
<td>0.35 0.36</td>
<td>0.31 0.31</td>
</tr>
</tbody>
</table>

Note: All figures in millions except LT Debt/Total Assets.
Data sources and calculations: Revenues = COMPUSTAT DATA 12; Net Income = COMPUSTAT DATA 172; Market Value Equity = COMPUSTAT DATA 24 (year close stock price) * COMPUSTAT DATA 25 (common shares outstanding); (Total) Assets = COMPUSTAT DATA 6; Total Debt = COMPUSTAT DATA 181; Long-Term Debt = COMPUSTAT DATA 9.
Table 2.4: Notional hedging positions by type

<table>
<thead>
<tr>
<th></th>
<th>Total Notional</th>
<th>HEDGE TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fair Value Cash Flow Net Invest of For Op Non Desig</td>
</tr>
<tr>
<td><strong>All (19)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>485.54</td>
<td>166.05 183.54 51.74</td>
</tr>
<tr>
<td>Median</td>
<td>140.00</td>
<td>0.00 64.50 0.00</td>
</tr>
<tr>
<td>Stand Dev</td>
<td>795.16</td>
<td>390.19 305.64 145.68</td>
</tr>
<tr>
<td><strong>Derivative Users (17)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>542.66</td>
<td>185.59 205.13 57.82</td>
</tr>
<tr>
<td>Median</td>
<td>165.00</td>
<td>0.00 70.00 0.00</td>
</tr>
<tr>
<td>Stand Dev</td>
<td>823.64</td>
<td>409.18 316.84 153.30</td>
</tr>
<tr>
<td>Count</td>
<td>17</td>
<td>8 15 3</td>
</tr>
<tr>
<td>Maximum</td>
<td>3,272.00</td>
<td>1,600.00 1,000.00 570.00</td>
</tr>
<tr>
<td>Minimum</td>
<td>8.00</td>
<td>0.00 0.00 0.00</td>
</tr>
</tbody>
</table>

Note: All figures in millions.
Table 2.5: Notional hedging positions by purpose

<table>
<thead>
<tr>
<th>HEDGE PURPOSE</th>
<th>Total Notional</th>
<th>FX</th>
<th>IR</th>
<th>Commodity</th>
</tr>
</thead>
<tbody>
<tr>
<td>All (19)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>485.54</td>
<td>170.76</td>
<td>301.25</td>
<td>13.52</td>
</tr>
<tr>
<td>Median</td>
<td>140.00</td>
<td>8.30</td>
<td>140.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Stand Dev</td>
<td>795.16</td>
<td>320.80</td>
<td>593.41</td>
<td>25.57</td>
</tr>
<tr>
<td>Derivative Users (17)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>542.66</td>
<td>190.85</td>
<td>336.69</td>
<td>15.11</td>
</tr>
<tr>
<td>Median</td>
<td>165.00</td>
<td>25.00</td>
<td>165.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Stand Dev</td>
<td>823.64</td>
<td>334.22</td>
<td>619.25</td>
<td>26.64</td>
</tr>
<tr>
<td>Count</td>
<td>17</td>
<td>10</td>
<td>13</td>
<td>8</td>
</tr>
<tr>
<td>Maximum</td>
<td>3,272.00</td>
<td>1,000.00</td>
<td>2,600.00</td>
<td>102.00</td>
</tr>
<tr>
<td>Minimum</td>
<td>8.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Note: All figures in millions
### Table 2.6: Notional hedging positions by derivative type

<table>
<thead>
<tr>
<th>DERIVATIVE TYPE</th>
<th>Total Notional</th>
<th>For/Fut</th>
<th>Swaps</th>
<th>Options</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All (19)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>485.54</td>
<td>126.00</td>
<td>295.92</td>
<td>17.15</td>
<td>46.47</td>
</tr>
<tr>
<td>Median</td>
<td>140.00</td>
<td>0.00</td>
<td>70.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Stand Dev</td>
<td>795.16</td>
<td>317.30</td>
<td>607.18</td>
<td>31.48</td>
<td>145.65</td>
</tr>
<tr>
<td><strong>Derivative Users (17)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>542.66</td>
<td>140.82</td>
<td>330.73</td>
<td>19.16</td>
<td>51.94</td>
</tr>
<tr>
<td>Median</td>
<td>165.00</td>
<td>8.30</td>
<td>140.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Stand Dev</td>
<td>823.64</td>
<td>333.24</td>
<td>634.44</td>
<td>32.76</td>
<td>153.50</td>
</tr>
<tr>
<td>Count</td>
<td>17</td>
<td>9</td>
<td>13</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Maximum</td>
<td>3,272.00</td>
<td>1,197.10</td>
<td>2,651.00</td>
<td>100.00</td>
<td>570.00</td>
</tr>
<tr>
<td>Minimum</td>
<td>8.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Note: All figures in millions
Table 2.7: Comparison of forest industry specific findings in empirical hedging studies

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Forestry-related sample size</td>
<td>13</td>
<td>27</td>
<td>19</td>
</tr>
<tr>
<td>% Hedging w/ derivatives</td>
<td>38%</td>
<td>44%</td>
<td>89%</td>
</tr>
<tr>
<td>% Hedging IR</td>
<td>15%</td>
<td>n/a</td>
<td>68%</td>
</tr>
<tr>
<td>% Hedging FX</td>
<td>31%</td>
<td>19%</td>
<td>53%</td>
</tr>
<tr>
<td>% Hedging commodities</td>
<td>31%</td>
<td>n/a</td>
<td>42%</td>
</tr>
</tbody>
</table>
Table 2.8: Tested hypothesis and expected relationship

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Notional values correlated with:</th>
<th>Expected relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large firms hedge more than small firms</td>
<td>Firm Value</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td>Market Capitalization</td>
<td>Positive</td>
</tr>
<tr>
<td>Firms with more growth opportunities hedge more</td>
<td>R&amp;D Expense/Sales</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td>Market Value/Book Value</td>
<td>Positive</td>
</tr>
<tr>
<td>Firms with greater leverage hedge more</td>
<td>Long-Term Debt/Total Assets</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td>EBIT/Interest Expense</td>
<td>Negative</td>
</tr>
</tbody>
</table>
Table 2.9: Correlation coefficients for notional values of derivatives and key variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Correlation</th>
<th>Significant at p(0.10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firm Value</td>
<td>0.78</td>
<td>Yes</td>
</tr>
<tr>
<td>Market Value</td>
<td>0.70</td>
<td>Yes</td>
</tr>
<tr>
<td>R&amp;D/Sales</td>
<td>0.32</td>
<td>No</td>
</tr>
<tr>
<td>MV/BV</td>
<td>0.08</td>
<td>No</td>
</tr>
<tr>
<td>LT Debt/Total Assets</td>
<td>0.15</td>
<td>No</td>
</tr>
<tr>
<td>Interest Coverage</td>
<td>0.15</td>
<td>No</td>
</tr>
</tbody>
</table>
CHAPTER 3

PRICING FINANCIAL DERIVATIVES ON FOREST PRODUCTS

Abstract

Wood procurement managers at sawmills and pulp mills in the forest products industry seek stable or predictable wood flows at low or predictable prices. Tools or strategies that improve the control over these wood flows at no additional cost or reduce wood costs with minimal impact on wood flows are desirable. Work in financial economics derived from Black-Scholes (1973) produced methods for pricing forward contracts and options on forwards. These financial tools may present procurement managers and wood suppliers with alternatives for managing volume and price risk, especially during periods of expected uncertainty, such as winter or rainy seasons. We explain the potential application of options on forward contracts to forestry operations, derive the relevant pricing equations, use these equations to price a series of options on forwards using actual pulpwood price data, and discuss the implications of these instruments on forestry markets. We find that while current volatility estimates make these contracts prohibitively expensive, alternate volatility assumptions could affirm the potential use of these derivative contracts in forest products operations as a risk management tool and cost benchmarking application.

Key Word List: Derivatives, forest products, option pricing, forwards
Introduction

Raw material procurement managers at wood using facilities juggle, at a minimum, stumpage contracts, fee harvests, and gatewood to manage their wood supplies and inventories. With clear skies, a flexible group of foresters and loggers, and a well-running mill, these managers may enjoy periods of relative calm as wood flows and mill raw material needs match perfectly. However, during periods of stormy weather, when loggers and log trucks stay out of the woods and uncommitted timber owners hold out for higher prices, procurement managers spend their days at the mill counting truck loads and watching the wood pile shrink. Many a mill manager has purportedly said to the procurement team, “you’re the best group of foresters I’ve ever had…till we run out of wood.” And many a procurement manager has paid dearly for those final loads of wood that let the mill complete its last shift.

Outside of harvesting timber from fee (company owned) forestlands, procurement managers at wood-using manufacturing facilities tend to purchase forest-sourced raw materials in one of three ways. One, they buy stands of trees, or the right to harvest these trees, directly from landowners. In this situation, the mill hires and manages the logging activity, works directly with the landowner, fronts the capital, and, most importantly, decides when to harvest the tract, weather permitting.

Two, they provide loggers or wood dealers guaranteed prices for given tracts of timber or volumes of logs. These are exploding prices, meaning they expire after pre-determined time periods, typically one to six months. While the mill and the supplier may have an understanding about when and how much wood will be delivered, neither is contractually obligated. The mill may not need the wood, or decide the guaranteed price is too high, and limit deliveries through quotas. Alternately, the logger or wood supplier may find a better market for their wood, and choose to divert flows elsewhere.

Finally, managers may procure gatewood by buying, at a fixed price, all wood delivered “through the gate” at the mill that meets the mill’s specifications. While this method requires the least oversight, it
also provides the least amount of direct control over desired wood flows. Frequently, sawmills and pulp mills use some combination of the three described methods to meet their raw material needs.²

At times, the above methods fail to ensure the requisite volumes of wood arrive to the mill. Severe weather may impede forest-related activities, restricting the total volumes of wood delivered to mills in a given region. Hurricanes, ice storms, and unseasonably wet weather remain common concerns for mill managers.³ From the perspective of the wood suppliers, Greene et al (2002) note that weather and planning impacts were the second and third most likely reasons logging crews lost productive time in the woods, behind market causes such as quotas and mill closures. Regardless the relationships or planning behind a wood procurement system, mills can find themselves short on wood, faced with choosing between shutting down the mill or meeting raw material needs on the spot market at extreme prices or through extraordinary efforts.

Procurement and mill managers face additional situations where known uncertainties must be accounted for in planning future wood supply needs and receipts. Pulp mills schedule regular maintenance shutdowns that may last indeterminate lengths of time.⁴ End product markets may change due to forecasted price increases. Procurement managers may have to adjust for permanent or temporary impacts on the wood procurement team personnel due to retirements, new hires, sabbaticals, or maternity leaves. Mill managers may be concerned about the impacts from bringing new equipment on-line within the mill, or the impact on regional wood supplies and prices on the opening of new, competing mills

² Greene et al 2002, in collecting data from 152 mills and 83 logging crews from 12 states (AL, AR, FL, GA, LA, ME, MS, SC, NC, OK, TX, VA) to study the capacity of wood supply systems, identified three primary methods for procuring wood by mills: dealer systems (43%), direct wood purchase systems (33%), and preferred supplier systems (20%). Wood sources included fee lands (24%), stumpage purchases (13%), market purchases (58%), and other sources (5%).
³ The 4th Quarter 2002 Timber Mart-South Newsletter, in detailing mill downtimes, noted that “the loss of residue chips from sawmill curtailment hurt pulp mill chip supplies when wet weather reduced logging,” particularly in Alabama and Mississippi. Hurricanes Isabelle and Lily affected the entire Southeast in October 2002, and ice and snow impacted the Appalachian and Atlantic regions in early December. The 1st Quarter 2003 Timber Mart-South Newsletter detailed additional impacts from winter storms, particularly in Georgia.
⁴ For example, a mill may be down for two to three weeks, with the possibility of coming back on line early. In such a situation, the procurement manager would need to have a certain volume of raw material in inventory or scheduled for delivery on a contingency basis.
within a shared and common wood basket. Each of these situations may result in additional efforts and costs by procurement foresters and wood suppliers in maintaining expected or adjusted wood flows.

These situations provide a basis for investigating options on forward contracts as a potential cost control and inventory management tool in the forest products industry. Forward contracts do not require organized exchanges, such as the Chicago Mercantile Exchange or the Chicago Board of Trade, and are negotiated directly between buyer and seller. Additionally, the structure and use of forward-like contracts are familiar to the forest products industry. Option contracts allow sellers to generate additional cash flow while buyers could secure the right to additional volumes of wood without committing large amounts of capital while mitigating some exposure to the spot markets during periods of expected price volatility or volume uncertainty. While less common in forestry, options have some basis in the forestry literature and have long been part of forestry discussions associated with stumpage and land purchases.\(^5\)

This study investigates the potential for options on forwards, a hybrid contract that, once we get past the name and the theory, will feel familiar in its contract structure to forest industry professionals. Also, improved tracking of wood raw material transactions the last few years provide the data required to test and evaluate pricing models required for facilitating options on forwards transactions between buyers and sellers of primary forest products.

Acceptance of options on forwards as a legitimate tool for wood raw material procurement managers depends, first and foremost, on the ability of these contracts to generate value for users of wood raw materials. Wood procurement managers seek stable or predictable wood flows at low or predictable prices. Tools or strategies that improve the control over these wood flows at no additional cost or reduce the cost of the wood flows with no negative impact on wood flows are desirable. Thus, analyzing the application of these contracts, we hypothesize that options on forwards reduce peak wet weather wood costs for wood using firms. To test this hypothesis, we price 4 week, 8 week, and 12 week options on pulpwood forward contracts for southern Mississippi in 2002.

\(^5\) Mills and forestry professionals occasionally include options on the right to harvest timber or to purchase blocks of land in contracts.
This paper first reviews the relevant literature to derive the forward and option pricing formulas, and how they would be used to price these contracts in forestry operations. Next, we use these equations to price a series of options on forwards using actual pulpwood price data, checking the results through sensitivity analysis to assess the impacts of changing volatility and discount rate assumptions. Finally, we discuss the advantages and logistical implications for using these contracts in practice, and the implications for these contracts on forestry markets.

**Literature review**

Derivative securities are financial instruments whose values and payoffs are ‘derived’ from the prices and payoffs of other underlying assets. Of the major derivative security contract structures – forwards, futures, options, options on futures, and options on forwards - forwards and options on forwards appear the most viable for application in forest businesses for three primary reasons. First, forwards, unlike futures contracts, do not require organized exchanges like the Chicago Mercantile Exchange. Futures contracts exist for high volume, easily standardized commodities such as corn and gold, whereas forward contracts can be created for specified products on a regional basis, which is often the case with forestry products. Second, recently available forestry transaction data provides opportunities to potentially calculate robust option prices. Finally, forwards and options on forwards possess characteristics familiar to those currently negotiating and structuring forestry contracts.

Specifically, forwards are contracts where the seller agrees to deliver to the buyer a specific underlying asset on a specific delivery date in the future for a predetermined price. Payment occurs at the time of delivery. European options are contracts which give the buyer the right, but not the obligation, to buy or sell an underlying asset for a specific price on a specific expiration date in the future. Options on forwards combine these contract structures to give buyers the right, but not the obligation, to buy or sell a forward contract.

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6 For example, the value of a call option – the right but not the obligation to buy – on 100 shares of International Paper (IP) stock is derived from the price and performance of the IP stock itself. The option is the derivative security while the IP stock is the underlying asset.
Black and Scholes (1973) solved the options pricing riddle by deriving a formula that cleanly calculates what a financial option is worth. This breakthrough in the field of financial economics values a European call option – the right to buy stock on a specific date in the future – on a non-dividend-paying stock using five variables, four of which are immediately observable: the underlying stock price, the risk-free rate of interest, the time to expiration, and the exercise price. The fifth variable, the volatility of the underlying stock price, can be determined from historical data or by determining an implied volatility based on prices of currently traded options. Their formula for valuing European call options on non-dividend paying stocks is as follows:

$$C = SN(d_1) - Xe^{-rt}N(d_2)$$  \[1\]

Where:

- $C$ = the value (price) of the call option,
- $S$ = the current stock price,
- $d_1 = (\log(S/X) + rt + \sigma^2 t/2) \sigma \sqrt{t}$,
- $d_2 = (\log(S/X) + rt - \sigma^2 t/2) \sigma \sqrt{t}$,
- $N(d)$ = cumulative normal probability density function,
- $X$ = exercise price of the option,
- $t$ = time to expiration (expiry) of the option,
- $\sigma^2$ = annualized variance of the continuously compounded returns on the stock,
- $r$ = continuously compounded return on a riskless investment with a maturity $t$.

Empirical research in the finance literature documents both the power and limitations of the Black-Scholes model in pricing options. MacBeth and Merville (1979) studied options on six actively traded stocks and found that the implied volatilities of these options were inversely related to the strike prices of the options.\(^7\) The result indicated that Black-Scholes option prices tended to be too low for deep in-the-money calls and too low for deep out-of-the-money calls. Rubinstein (1985) found that Black-

---

\(7\) The implied volatility is the volatility implied by the price of an option using the pricing model, in this case Black-Scholes. In other words, the implied volatility answers the question, “If the option costs X, what is the volatility implied by this price?” It is another way of calculating the market’s consensus on the volatility of a given underlying asset, because we can take market-traded options and back into volatility implied by the option price.
Scholes underestimates the values of call options close to expiry relative to call options with more distant expiration dates. While the results were statistically significant, Rubinstein concluded they were not significant in practical or economic terms, as the biases in the model represented a 2 percent deviation from Black-Scholes market pricing. In sum, Black-Scholes provides reasonably consistent and accurate estimates of actual market-traded option prices.

Black (1976) later worked through the valuation formulas for and implications from futures and forward and options contracts on commodities. Producers and users of commodities can draw insight from and shift risk through exchange-traded futures contracts. Information comes through the fact that futures contracts are continuously traded, revealing market sentiment through changing prices. Forward contracts, whose prices remain fixed for the contract life, are priced with the following formula:

\[ f = (x^* - c) \exp[r(t - t^*)] \]  

[2]^{9}

Where:

- \( f \) = the current value of a forward contract at price \( c \),
- \( x^* \) = the price at time \( t \) for a forward contract for delivery at \( t^* \),
- \( c \) = the contract price,
- \( r \) = riskless rate of return,
- \( t \) = some time less than \( t^* \),
- \( t^* \) = the delivery date.

The assumptions behind this formula are (1) no transaction costs, (2) all riskless investments earn the riskless rate, (3) forward contracts may be traded freely at any time \( t \) less than \( t^* \), and they exist for all choices of \( c \) and \( t^* \). Paraphrasing Thorp (1985), the proof of this formula based on these assumptions is:

---

8 According to Grinblatt and Titman (2002), “many traders refer to what is known as the smile effect. If one plots the implied volatility of an option against its strike price, the graph of implied volatility looks like a ‘smile.’ This…suggests that the Black-Scholes model underprices both deep in-the-money and deep out-of-the-money options relative to near-at-the-money options.”

9 A more generalized and currently used result has \( f = (x^* - c) \exp(rT) \), where \( T \) is simply the remaining time to maturity of the contract (Hull 2000).
1) Enter into a forward contract to sell described by $x^*$ and $t^*$ (assumption 3).

2) Contract price $x^*$ is set at $t$ to clear the market, negating the need for additional payments.

3) At $t^*$, you buy at $c$ under the original contract and sell the same thing at $x^*$ under the second contract, earning or losing $x^* - c$ (assumption 1).

4) Therefore, “$f$ is worth $x^* - c$ at $t^*$.” By assumption 2, $f$ is worth $(x^* - c)e^{r(t - t^*)}$ at $t$.

Thorp (1985) builds on this work by Black (1976) to derive the valuation formula for both European call and put options on forward contracts, noting that the boundary condition for a European call on a forward contract is equal to the boundary condition of a European call on a futures contract. This condition, in words, is that the maximum value of the forward contract, as described by $x^*$ and $t^*$, will be determined by $x^* - c$ or 0, whichever is greater. Therefore, the solution for a European call on a forward contract equates to that of a European call for a futures contract. Putting the formula in terms of forward contracts, we get:

$$w(x, t) = e^{r(t - t_m)}[x^*N(d_1) - cN(d_2)]$$  \[3\]

Where:

- $w(x, t)$ = current value of a European call on a forward contract,
- $d_{1,2} = (\ln(x/c) +/- \sigma^2(t^* - t)/2)/(\sigma(t^* - t)^{1/2})$,
- $N(d)$ = cumulative normal probability density function,
- $t_m$ = date the forward contract matures

The significance of $t_m$ is worth noting further. The options expire at $t^*$, while the forward contract matures at $t_m$, where $t_m > t^*$. Operationally, this makes sense: it is unrealistic to expect delivery of the commodity from the forward contract to occur on the same day that the holder of the option exercises the right to demand delivery. Even if, in the best case with regards to logs or pulpwood, the trees had been harvested or were sitting in a wood yard inventory, forestry professionals require time to load the wood and route
the trucks. Thus, some time, from \( t^* \) to \( t_m \), exists that, from a theoretical standpoint, can be hedged risklessly by selling a forward at \( t^* \) at price \( x(t^*) \) (Thorp 1985).\(^{10}\)

Also, we should note that the actual application of these contracts assumes that the forward contracts have values of zero at time zero, and that the options have value requiring cash payment at time zero for the option. In other words, the parties involved agree that the price for the commodity to be delivered in the future (wood) is equitable, while the option to lock in this price has a value which deserves the payment of a premium today.

Forwards and options are not unheard of in forestry. Guaranteed prices, as described in the introductory comments, are forms of forward contracts, though they lack the requirement for buyers to accept the wood and the seller to deliver the wood. Gatewood systems provide wood suppliers with open-ended options, giving them the right, but not the obligation, to deliver wood that meets particular specifications to a specific place for a pre-determined per unit price.\(^{11}\) Since timber markets are regional and tend to include the same players over time, forward contracts are de facto enforced by the desire to maintain good working relationships over time between buyers and sellers. Unscrupulous dealers can be frozen out of wood markets.

In terms of applying options theory to forestry, Zinkhan (1991) investigated the option value of converting timberlands to alternative land uses to help explain why investors might purchase forestlands with per-acre prices higher than calculated based on the net present value of timber production from that land. Forest management and timber supply contracts may also include options for long-term cutting rights, buyout options in landowner assistance programs, purchase options on tracts of timber, and options to develop or restrict development on timberlands (Zinkhan 1995). Research has also explored the use of

\(^{10}\) In practice in forestry, this time between exercising the option and taking delivery of the wood, approximately one week, will likely remain, strictly speaking, exposed and unhedged for the participating parties.

\(^{11}\) The “price” or premium of this option would be the difference between the gatewood price and the price paid to the wood supplier by a preferred market. Thus, the supplier receives less – the price of the option – for the right and convenience of delivering wood at anytime. This works when gatewood prices fall below market or mean market prices. Alternately, a mill can raise its gatewood price above market to attract wood, thereby “purchasing” call options, the cost being the extra premium paid per unit of wood above alternate markets available to the wood supplier.
options and how option values may impact optimal timber rotations (Plantinga, 1998; Newman, 2002), the treatment of afforestation as a real option and the subsequent policy implications (Thorsen, 1999), the application of option pricing models to forest asset valuations (Hughes, 2000). Hughes, in valuing forest assets associated with the sale of Forestry Corporation of New Zealand in 1986, notes and explores that, relative to traditional discounted cash flow valuation approaches that depend on projections of future prices, option valuation requires only estimates of future log price volatility.

Yin and Izlar (2001) illustrate the potential for financial engineering in the management of institutional timberland investments. They address directly and qualitatively the potential role of more sophisticated financial supply contracts and portfolio insurance for timberland managers and note the potential application of these tools for forest industry firms.

Method and Data

Using formula [3] derived by Thorp (1985) for pricing options on forwards, we value a series of pulpwood contracts for a wood procurement region located in southern Mississippi. This region was selected for four reasons:

1. Several pulpwood users are located in this region, including a pulpmill with annual consumption of 2.5 million tons.
2. The region includes a variety of wood suppliers, including a major wood dealer.
3. The pulpmill and the wood dealer have, in the past, considered a variety of contract structures, including option-like agreements.
4. Available transaction data for the region continues to improve, enabling the testing of these pricing models. Forest2Market provided the transaction data for this project.

In applying this formula with a specific dataset with a specific region and set of participants in mind, we aim to determine whether or not these contracts can be applied realistically in an actual operational setting.
We use pine pulpwood as the underlying asset because it is the most easily standardized of the primary forest products for which we have transaction data. The ability to have a standardized, fungible product simplifies the logistics, pricing, and related contract negotiations. By relying on standardized product specifications, participating parties can remove quality and specifications from the discussion. Futures contracts traded on the Chicago and New York exchanges rely on standardized contract specifications, making price the only changing variable.

Analogous to the pricing of plain vanilla options, the only input to the formula for options on forwards that is not directly observable is the volatility, which provides a measure of the uncertainty of the price changes – the returns – of the commodity forward contract over time. The volatility of the forward contract can be defined as the annualized standard deviation of the pulpwood price with respect to the forward contract. In this study, the forward contract volatility calculation results from the annualized standard deviation of transacted pay-as-cut pine pulpwood prices within the evaluated procurement region in southern Mississippi.

To estimate the volatility of pulpwood forward contract prices, we use historical data of actual pulpwood transactions. We use the natural logarithm of the pulpwood price returns. In calculating historical volatilities, two questions must be addressed: How many daily observations must be included and should the annual volatility be based on 365 calendar days or 252 trading days? Per convention noted in Hull (2000), we placed more emphasis on recent history, focusing on the prices for the last six months of 2002. More specifically, it is common to match the historical data with the duration of the option. For example, a one-year option would use one year’s worth of historical data to determine the volatility. Due to limitations of the data set – we lack prices for each trading day and the observations are unevenly distributed – and because our options are for relatively short durations, we use the six and twelve month samples for calculating historical volatilities. In this way, we attempt to maximize the utility of the

---

12 Pulpwood price returns are the difference between a transacted pulpwood price and the transacted price immediately previous to it.
available observations. Finally, Hull notes that “trading days should be used” for volatility calculations and we adopt this convention as stated.

The data set from Forest2Market includes 227 pulpwood transactions on and between January 2 and December 5, 2002 from four transaction types: lump sum negotiated, lump sum sealed bid, pay-as-cut negotiated, and pay-as-cut sealed bid.\textsuperscript{13} The transactions included 288,447 total tons of pulpwood valued at over $2.1 million. The weighted average price of these tons was $7.45. Table 1 contains these descriptive statistics.

Arguments can be made which support the purging of lump sum transactions from the data set for volatility calculations. For example, the per-unit pine pulpwood prices within a lump sum bid are often adjusted to make the overall bid meet particular objectives.\textsuperscript{14} This weakens the usefulness of the pulpwood prices from lump sum bids as these prices may not reflect exclusively the value of the pulpwood to the buyer. In other cases, small volumes of pulpwood may be assigned insignificant prices as the bidder considers the pulpwood more trouble than valuable. As such, we believe pay-as-cut prices better reflect the agreement between a buyer and a seller on a fair price for that specific product and screened the data set to focus on these pay-as-cut transactions.\textsuperscript{15}

The Forest2Market 2002 data set for this southern Mississippi region included 88 pay-as-cut transactions. The transactions included 175,667 tons of pine pulpwood valued at $1,378,071 with a weighted average per ton price of $7.84. These descriptive statistics are also included in Table 3.1.

\textsuperscript{13} In lump sum transactions, the buyer provides one price for the entire timber tract. In pay-as-cut transactions, the buyer provides the seller with a per-unit price for each tree species and product (sawlogs, chip-n-saw, pulpwood, and topwood). Negotiated sales result from direct one-on-one negotiations between the buyer and the seller, while sealed bid sales are an auction process.

\textsuperscript{14} Examples of this might include reaching a certain total bid price (i.e., “if we add $1 per ton on the pulpwood, we can push the total bid to $100,000…”), or subsidizing the price paid for other products.

\textsuperscript{15} Pay-as-cut transactions are not without concerns. These prices may be structured to also subsidize prices for other, more valuable or voluminous products on the same tract. Additionally, a buyer may actually back into per-unit prices by taking a local gatewood price, subtracting out the estimated logging and hauling costs, and calling the balance the pulpwood stumpage price.
Table 3.1

Table 3.2 summarizes the six and 12-month daily and annualized volatility calculations for both the full data set and the pay-as-cut subset. The six-month volatility calculations for July through December of 2002 include 95 observations for the full data set and 32 observations for the pay-as-cut subset. While the pay-as-cut subsets are characterized by lower volatilities, all of the volatility calculations far exceed volatilities commonly observed for equity options.\textsuperscript{16}

Table 3.2

The volatility calculations support the idea that multiple, identifiable factors likely exist which affect the volatilities calculated from the data set. In this paper, we account for one of those factors by segregating the pay-as-cut transactions from the full data set to account for understanding that pay-as-cut and lump sum sales generated prices in two fundamentally different ways. Other factors to explore in a related transaction evidence analysis research effort include seasonality, transaction size, distance from the mill, and loggability. Data plots (Figure 3.1 and Figure 3.2) suggest and reinforce the potential for these and other significant factors. This study remains focused on the theory and application of the option on forward contracts in a wood procurement setting given basic volatility calculations for a specified procurement region.

Figure 3.1

Figure 3.2

\textsuperscript{16} Historically, blue chip stocks feature annualized volatilities around 20%, while high tech stocks may exceed 40%.
The options on forwards considered would not be exchange-traded; rather, they would be negotiated and contracted between two specific parties in the over-the-counter (OTC) markets. The structure of these negotiations leaves open the possibility and practicality of alternate approaches, or including other factors, when estimating volatilities for the option value calculations. As long as both parties to the negotiation agree to the included factors, all other aspects of pricing the options on forwards can remain standardized and straightforward, as demonstrated in the following sections.

However, option contracts traded in OTC markets have inherent limitations relative to their exchange-traded brethren. Options holders in OTC markets lack the opportunity to sell the option to someone else prior to expiration, thus limiting – or eliminating - liquidity. In other words, the inherent value of the specific pulpwood option contract that a mill holds may, for all practical purposes, reside only with that mill. The mill, in most cases, would not be able to sell this option contract to someone else for their use. Second, both parties must be comfortable with the credit worthiness of the counter party. If the writer – the wood supplier – goes bankrupt or cannot deliver the contracted pulpwood, the option holder suffers. This is an inherently manageable and common issue in OTC markets, as margin accounts (akin to collateral), letters of credit, and enforceable financial penalties are used to mitigate exposure. Additionally, initial transaction costs may prove excessive, due to previously noted issues, and to the potential requisite use of lawyers, bankers, or other finance professionals. This final issue requires further investigation, as contract standardization, accepted pricing models, and counterparty familiarity may reduce transaction-related expenses.

**Options on Forwards Calculations**

The model for pricing options on forwards requires six inputs: the per unit price of pulpwood today, the per unit strike price of pulpwood in the agreed upon forward contract, the assumed risk free rate of interest, the time to expiration of the option, the time between exercising the option and taking delivery of the pulpwood, and the pulpwood price volatility. As noted above, we assume 252 annual trading days for model calculations.
To approximate the actual 2002 transaction data received from Forest2Market, we assume a trading stumpage price of $7.50 per ton (close to the weighted average) and use an equivalent at-the-money strike price to satisfy the requirement that the forward contract have no value at time = 0. We assume a risk-free rate of 5% and assume that pulpwood deliveries from exercised options would occur approximately 5 business (trading) days following expiration. These assumptions used to calculate the option prices are summarized in Table 3.3.

Table 3.3

Table 3.4 summarizes the calculated prices for options on forward contracts for pine pulpwood in southern Mississippi in 2002. The 20, 40, and 60 day prices approximate options lasting four, eight, and twelve weeks, as the pricing model relies on trading (business) days. As a point of comparison, the final column provides option on forward prices for the case where volatility is 100% while holding all other assumptions constant.

Table 3.4

The calculated prices feature both expected and noteworthy results. Prices increase with time and volatility, the exception being the 60-day prices for the two highest volatilities, whose prices fall below their 40-day and, in one case, 20-day counterparts. This result is consistent with the empirical Black-Scholes studies cited previously which indicate that Black-Scholes derived prices tend to under price deep in the money calls. While theoretically interesting, this result is unimportant from both practical and economic standpoints. Neither procurement managers nor investors would likely pay $7.40 for right to pay $7.50 at a later date. Also, the difference between the 60-day price of $7.40 and 40-day price of $7.43 comes to $0.03 or less than one-half of one percent.
The extreme volatilities produce option prices approaching the maximum boundary condition of the $7.50 strike price. The test case comparison using a volatility of 100%, still high relative to publicly-traded equities, generates prices that could prove economically feasible given reported ranges of delivered pine pulpwood prices in the south of $22 to $24 per ton.

Hughes (2000) addresses the pivotal role of volatility calculations in generating robust prices from the Black-Scholes model. The same issue applies here as the option on forwards pricing model relies on directly related mathematical derivations and assumptions. However, in the case of Hughes, the relative sensitivity of log prices and forest valuation to changing log price volatility assumptions were relatively small as compared to those observed in this project with respect to pulpwood prices. The suggested strategy above, for pricing the option based on the stumpage component of a delivered price, represents one approach for mitigating this issue on the logistical side in seeking to improve the applicability of these contracts in practice.

Application and Discussion

For forestry operations, options on forwards may be preferable to forward contracts alone. Consider the following cases:

1) A mill wants wood, but the supplier has a better market elsewhere.
2) A supplier wants to deliver wood, but the mill can’t use or does not need the wood.
3) A mill wants wood and the supplier wants to deliver.
4) A mill does not want wood, and a supplier has alternate markets.

In 1, the mill needs an imperative, something to force delivery (if it does not own the wood outright) while the supplier must receive value for forgoing their preferred alternative. The mill exercises the option getting the wood they need, and the supplier received the option premium in advance to use as they
see fit. In 2, the mill does not want the wood, and does not have to take it, letting the option expire. The supplier wants to deliver because the forward price is preferable to their alternatives, but they already pocketed the premium. Both gain. In 3, the option gets exercised and the wood gets delivered. Both parties are satisfied. In 4, the option expires and the wood goes elsewhere. Both parties are satisfied. In sum, it is not difficult to imagine situations where the flexibility and enforceability of options on forwards could attract users in the forest industry.

In practice, how would options on forwards contracts for pine pulpwood work? Assume the following situation: A pulpmill that uses 2.5 million tons of pulpwood per year, approximately 50,000 tons per week, frequently experiences rising raw material costs in the winter due to poor weather and the challenge of moving sufficient volumes to maintain mill inventories. Historically, problems occur in mid to late December, as the holidays approach and all mills in the region supplement normal inventory levels.

This October, the raw material manager wants to secure 10,000 tons of total insurance at below peak cost for the final two weeks of December. Negotiating with a major wood supplier in the area, the raw material manager and wood supplier agree to negotiate a forward contract for 10,000 tons to be delivered during the final two weeks of December. This wood has a delivered cost of $25 per ton. Then, the wood supplier agrees to sell the raw material manager a 40 business-day option on this contract, priced at $2 per ton. This option gives the raw material manager the right, but not the obligation, to call the wood supplier on the date the option expires, December 15, and implement the forward contract. This obligates the wood supplier to deliver 10,000 tons within the two-week time frame, for which the raw material manager will pay $25 ton.

The associated cash flows can be summarized as follows. In October, the pulp mill pays the wood supplier $20,000 [$2*10,000] for a 40-day option on a forward contract for 10,000 tons of pine pulpwood. The option expires and can be exercised on December 15. On December 15, if the mill finds it does not need the volume, or it can obtain cheaper pulpwood elsewhere, it lets the option expire and the supplier keeps the $20,000.

These assumptions approximate the characteristics of a major pulp mill located in New Augusta, Mississippi.
If the mill exercises the option, the wood supplier is obligated to deliver 10,000 tons of pine pulpwood to the pulp mill over the next two weeks. The mill pays the supplier the agreed $25 per ton of delivered wood for a cost of $250,000 \[25\times 10,000\]. The total cost incurred by mill is $270,000 \[250,000 + 20,000\], or $27 per ton.

For this option to make economic sense, the forward price should be equal to or less than the spot price at time of expiry. The option cost is sunk and irrelevant at that point. The supplier gets the advance cash from selling the call option, and should then be in a position to ensure sufficient volumes of wood will be available should the procurement manager exercise the option contract. The supplier gives up the additional gain from excessive, short-term pulpwood prices. It is possible the supplier may be forced to shift operations or crews from other (more profitable) operations to meet the commitments associated with the option.

The volatility calculations cover the stumpage component of the delivered price. From an exposure, consistency, and pricing standpoint, this aspect of pricing the option contract is logical. While the pulp mill, in this situation, is concerned with the delivered price of pine pulpwood, their actual exposure is to fluctuations in the stumpage component of the wood, as we assume fairly constant logging and hauling costs. The supplier faces the same exposure, with the possible exception of volatility associated with fuel costs. Thus, it is the volatility of the stumpage that drives the option value.

While the option on the forward offers potential value in and of itself as part of a wood supply manager’s “portfolio” of wood supply contracts, the price of the contract has implications as a benchmark against which to measure other wood supply activities. The prices calculated above essentially provide a per unit variable cost of locking in raw material price and volume, akin to the use of tracking portfolios in investment management. In this way, the price of a financial instrument – the option on forward contract – is used to track costs associated with managing a real timber and wood raw material assets. Forest product manufacturing facilities engage in other activities to manage wood flows and wood inventories are or can be measured in this way: on-site inventory and scaling activities, off-site wood yards, wet...
storage facilities, and traditional procurement activities. A robust option on forward value may provide insight into the relative costs of current or potential wood procurement activities.

Conclusion

Current wood procurement practices include few instances where wood users or wood sellers are legally or contractually obligated to accept or deliver wood flows. This creates added exposures and opportunities for strategies or contract structures that provide wood using facilities and wood supplies with the tools and incentives to enhance the associated management of wood flows and costs. This paper investigates the potential application of options on forwards in addressing limitations of conventional wood supply contracts.

Of the basic derivative contracts, options on forwards have basic features that could make them attractive and workable to forestry professionals. They can be negotiated and traded directly between participants, the terms of these contracts are flexible and adjustable, and the pricing calculations are relatively straightforward. Additionally, the contract’s components – options and forwards – are familiar in structure and function to forestry professionals.

Regardless, this paper isolates several unresolved issues. The initial volatility calculations required to value options on forwards contracts make this tool currently untenable. We recognize the fundamental roles played by data quality, comfort with the data, and familiarity with these contract structures. The pulpwood price data set includes a range of stumpage prices from both bid sales and per unit deals, with associated information regarding volumes, accessibility, and quality. Additional study of these data can help us isolate the key factors and, potentially, estimate workable volatilities for the option pricing model.

Situations arise – adverse weather conditions, personnel changes, operational and market uncertainties – that can make the use of an option for future raw material deliveries attractive and cost effective. This project studied and evaluated the premise and pricing issues, clearly identifying
opportunities for additional research in understanding factors affecting pine pulpwood volatilities and managing logistics associated with implementing new financial contract structures.
Table 3.1: 2002 Pulpwood Transactions, Southern Mississippi Procurement Region

<table>
<thead>
<tr>
<th></th>
<th>All Transactions</th>
<th>Pay-as-Cut Transactions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of transactions</td>
<td>227</td>
<td>88</td>
</tr>
<tr>
<td>Total Tons</td>
<td>288,447</td>
<td>175,667</td>
</tr>
<tr>
<td>Tons/Transaction</td>
<td>1,270.69</td>
<td>1,996.22</td>
</tr>
<tr>
<td>Total Sales Value</td>
<td>$2,149,700</td>
<td>$1,378,071</td>
</tr>
<tr>
<td>$$/Transaction</td>
<td>$9,470.04</td>
<td>$15,659.90</td>
</tr>
<tr>
<td>Weighted Average $$/Ton</td>
<td>$7.45</td>
<td>$7.84</td>
</tr>
<tr>
<td>Variance</td>
<td>3.83</td>
<td>2.76</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>1.96</td>
<td>1.66</td>
</tr>
</tbody>
</table>

Data source: Forest2Markets
Table 3.2: 2002 Pulpwood Price Volatility Estimations

<table>
<thead>
<tr>
<th></th>
<th>All Transactions</th>
<th>Pay-as-cut transactions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data range</strong></td>
<td>12 month</td>
<td>6 month</td>
</tr>
<tr>
<td><strong>Daily Stand Dev</strong></td>
<td>0.460219</td>
<td>0.436629</td>
</tr>
<tr>
<td><strong>Trading Days</strong></td>
<td>252</td>
<td>252</td>
</tr>
<tr>
<td><strong>Annual Volatility</strong></td>
<td>730.6%</td>
<td>693.1%</td>
</tr>
</tbody>
</table>
Figure 3.1: 2002 Southern Mississippi Pine Pulpwood Transactions
Data source: Forest2Markets
Figure 3.2: 2002 Southern Mississippi Pay-as-cut Pine Pulpwood Transactions
Data source: Forest2Markets
Table 3.3: Assumptions Used in Option on Forwards Pricing Model

<table>
<thead>
<tr>
<th></th>
<th>All Transactions</th>
<th>Pay-as-cut transactions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data range</strong></td>
<td>12 month</td>
<td>6 month</td>
</tr>
<tr>
<td><strong>Stumpage Price</strong></td>
<td>$7.50</td>
<td>$7.50</td>
</tr>
<tr>
<td><strong>Strike Price</strong></td>
<td>$7.50</td>
<td>$7.50</td>
</tr>
<tr>
<td><strong>Risk free rate</strong></td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td><strong>Delivery</strong></td>
<td>5 days later</td>
<td>5 days later</td>
</tr>
<tr>
<td><strong>Volatility</strong></td>
<td>730.6%</td>
<td>693.1%</td>
</tr>
</tbody>
</table>
Table 3.4: Calculated Prices for Options on Pulpwood Forward Contracts, 2002

<table>
<thead>
<tr>
<th></th>
<th>All Transactions</th>
<th>Pay-as-cut transactions</th>
<th>Test Case</th>
</tr>
</thead>
<tbody>
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<td><strong>Data range</strong></td>
<td>12 month</td>
<td>6 month</td>
<td>12 month</td>
</tr>
<tr>
<td></td>
<td>6 month</td>
<td></td>
<td>6 month</td>
</tr>
<tr>
<td><strong>Volatility</strong></td>
<td>730.6%</td>
<td>693.1%</td>
<td>454.9%</td>
</tr>
<tr>
<td><strong>20 Day Price</strong></td>
<td>$7.42</td>
<td>$7.39</td>
<td>$6.18</td>
</tr>
<tr>
<td><strong>40 Day Price</strong></td>
<td>$7.43</td>
<td>$7.43</td>
<td>$7.04</td>
</tr>
<tr>
<td><strong>60 Day Price</strong></td>
<td>$7.40</td>
<td>$7.40</td>
<td>$7.27</td>
</tr>
</tbody>
</table>
Figure 3.3: Southern Pine Pulpwood Delivered Prices, 2000-2003
Data Source: Forest2Markets
CHAPTER 4

CROSS-HEDGING UREA FOR FORESTRY APPLICATIONS\textsuperscript{1}

\textsuperscript{1} Mendell, B. C. and M. L. Clutter. Submitted to the *Journal of Forest Economics* in February 2004.
Abstract

This paper studies the feasibility of using natural gas futures contracts to cross-hedge urea, the most common nitrogen fertilizer used in forest management. A direct price movement relationship results from a simple linear regression of lagged urea cash prices on natural gas futures. Using estimated hedge ratios, we calculate net realized urea prices for the U.S. South cash market for nine fertilization seasons over five years. Net realized costs for urea were lower than cash prices in 3 out of 9 seasons, or 33% of the time. Overall, the cross-hedge cost averaged an additional $2.70 per ton over the cash cost to implement. The results suggest that natural gas futures are currently marginally effective in hedging price risk associated with urea cash purchases.

**Key Word List:** Hedging, cross-hedging, forestry, fertilization, risk management
Introduction

In 2001, the area of southern pine stands fertilized comprised 1.3 million acres (NCSFNC 2002), using approximately 103,000 tons of urea in the process.² Recent research continues to demonstrate how the application of nitrogen fertilizers, such as urea, can increase the growth rate and yields from loblolly pine (*Pinus taeda*) plantations across the southeastern United States (Bekele and Hudnall 2003; Will et al. 2002; Amateis et al. 2000).³ Regardless, the clear productivity gains from nitrogen fertilizer applications and their general acceptance among forestry companies, forest managers may opt out of preplanned fertilization due to rising or high urea prices, thereby reducing expected yields and, possibly, the total returns from the forest investment. In other words, situations exist when forest managers forego fertilizer applications due to short-term financial considerations.

Hedging risk with futures contracts, a strategy common in agriculture, provides one method for minimizing exposure to volatility in commodity prices. For example, a farmer can lock in attractive selling prices through the use of futures contracts on the Chicago Board of Trade for products such as corn, soybeans, and wheat. Ranchers can lock in buying prices of feeder cattle and selling prices for live cattle with feeder cattle and live cattle futures contracts on the Chicago Mercantile Exchange. However, many commodities do not have active futures markets, affecting opportunities for those looking to hedge price risk. In these situations, cross-hedging may prove useful.

To cross-hedge, a producer or user of a commodity hedges the price of one commodity with the futures contracts of a correlated but different commodity. For example, producers of cottonseed oil cross-hedge their price exposure with soybean oil futures contracts (Dahlgran 2000) and buyers of diesel fuel can cross-hedge with fuel oil futures contracts (Conley 1994). Another common example is the use of fuel oil and heating oil futures by airlines to cross-hedge their jet fuel purchases, since no jet fuel futures

² Dr. H. Lee Allen, Director of the North Carolina State Forest Nutrition Cooperative (NCSFNC).
³ Fertilization also helps production of non-wood products. For example, according to forestry extension work by Professor David Moorhead at the University of Georgia, pines straw production (needle yield) can be increased 40 to 50% two years following fertilization. [www.bugwood.org/fertilization](http://www.bugwood.org/fertilization)
market exists. In sum, a simple cross-hedge offsets a cash position in one commodity with a futures position of a different commodity.

When researching the risk reduction potential of cross hedging, several issues must be considered. First, which futures contract will best cross hedge the commodity in question? Second, what is the appropriate size of the futures position for the cross hedge? Finally, how effective and risky is the cross hedge relationship?

We selected natural gas because of its strong price and production relationship with urea. Natural gas accounts for ninety percent of the total cash cost associated with the production of ammonia, the foundation for producing all nitrogen fertilizers, such as urea (The Fertilizer Institute 2003). Since urea production and costs are closely related to natural gas prices, and since severe swings in natural gas prices sometimes result in forest managers changing silvicultural plans, possibly to the long-term detriment of a forest’s health or productivity, we explored the potential effectiveness of cross-hedging as a strategy for reducing the risk and exposure associated with urea price volatility.

The practical pricing issue for cross-hedging becomes evaluating the basis risk in using natural gas futures contracts as a price (risk) management tool for procuring and pricing urea. Strictly, the basis risk equals the spot (cash) price of the asset to be hedged (urea) minus the futures price of the contract used (natural gas). To provide a direct price movement relationship, urea cash prices are regressed on natural gas futures prices. Using estimated hedge ratios, we calculate net realized urea prices for nine fertilization opportunities over five growing seasons, 1998 through 2002, in the U.S. South.

This study hypothesizes that net realized prices from cross-hedging urea with natural gas will be lower than cash prices. Unlike urea, natural gas has established and active futures markets. To evaluate the potential cross-hedge, we must establish a robust relationship between urea prices and natural gas futures prices. Finally, this ability to cross-hedge prices should be demonstrated in overall lower average

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4 This relationship first came to our attention anecdotally, as practicing foresters and timberland investment managers changed forest management plans because of short-term volatility associated with urea prices, providing the observations from which to develop our hypothesis.

5 Fertilizer use accounts for only about 4% of natural gas demand. The major use is home heating.
urea costs to the timberland managers. In sum, this hypothesis tests a method by which industrial and private timberland managers could reduce price-risk associated with fertilization activities.

The remainder of this study and analysis comprises four sections. First, we review the relevant literature to develop a theoretical and methodological framework for this study. Second, we estimate regressions to establish the price relationship between urea cash prices and natural gas futures prices. Third, we apply the regression results to a urea cross-hedging strategy to evaluate the potential effectiveness of the cross-hedge. Finally, we discuss the implications of the results for actual application and for further study.

Literature and Methodology

In developing a theoretical description of hedging to better account for the actual behaviors of a broad class of hedgers, Anderson and Danthine (1981) explicitly address cross hedging. They note that in implementation, “the best cross hedge may be calculated in exactly the same way as a standard hedge.” They derive optimal hedging strategies using a mean-variance framework for hedging in a single futures market. In other words, Anderson and Danthine assume that hedgers focus on the mean and the variance of profits to optimize the risk-return performance of their positions in making hedging decisions.

Several applied studies provide valuable and useful considerations in developing the methodology. In cross-hedging wholesale pork products using live hog futures, Hayenga and DiPietre (1982) used the following basic model:

\[ \text{CP}_{ij} = a_{ij} + b_{ij} \text{FP}_{ij} + u_{ij}, \]

Where \( \text{CP}_{ij} \) is the average cash price of the jth wholesale pork product during the contract period i each year, \( \text{FP}_{ij} \) is the average closing price of the nearby live hog futures contract during contract period i each year, and \( u_{ij} \) is the error term.
Graff et al (1997), in outlining cross hedging strategies and techniques for a series of agricultural commodities,\(^6\) summarize the process for determining appropriate hedge ratios. Hedge ratios dictate the appropriate size of the futures position to take relative to the given exposure in the spot markets. In defining the hedge ratio, they reference the basic model structure:

\[
\begin{align*}
\text{(2)} & \quad \text{Expected Cash Price} = \beta_0 + \beta_1 (\text{Futures Price}) \nonumber \\
\end{align*}
\]

Where \(\beta_0\) is the intercept – or the expected basis – and \(\beta_1\) is the hedge ratio, which is the futures contract quantity position divided by the spot market quantity being hedged.

Rahman et al (2001) adapted the Hayenga and DiPietre (1982) model for testing the feasibility of cross-hedging cottonseed meal with soybean meal futures. The basic linear regression model used for this study follows a similar methodology for testing the feasibility of cross-hedging urea with natural gas futures.

Average weekly urea prices from the Southcentral U.S. region for the five years 1998 through 2002 from Green Markets and average weekly natural gas futures closing prices from the New York Mercantile Exchange (NYMEX) were used to estimate the following basic model:

\[
\begin{align*}
\text{(3)} & \quad \text{UCP}_w = \beta_0 + \beta_1 \text{NGFP}_w + u_w \nonumber \\
\end{align*}
\]

Where \(\text{UCP}_w\) is the average of the high and low per ton price of urea in the cash markets for the week, \(\text{NGFP}_w\) is the average per million British Thermal units (BTU)\(^7\) daily closing price of the natural gas contracts on the New York Mercantile Exchange (NYMEX) for the week, \(\beta_0\) is the intercept term or

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\(^6\) Graff et al (1997) present techniques and examples for cross hedging milo (grain sorghum), sunflowers, feeder cattle, cull cows, alfalfa, and millfeed.

\(^7\) Each NYMEX natural gas futures contract represents 10,000 million BTUs. A typical price quote for this contract might be $2.00 per mm BTU. Thus, the nominal contract value would be $2 \times 10,000 = $20,000.
expected basis, and \( u_w \) is the stochastic disturbance. We also estimate regressions by lagging the weekly natural gas data:

\[
(4) \quad UCP_w = \beta_0 + \beta_1 NGFP_{w-i} + u_w, 
\]

Where \( i \) refers to the number of weeks lagged in the regression. For example, \( i=1 \) indicates that the natural gas futures prices come one week prior to the predicted cash urea prices. We estimated a series of lagged regressions because, unlike traditional agricultural cross hedges where the commodities involved may be direct substitutes and change prices in parallel, natural gas is an input of urea production which may result in a delay as changes in natural gas prices would be reflected in spot urea market prices.

In searching for the proper lag length, we also tested a finite distributed lag model – what Greene (2003) refers to as a dynamic model – which includes the current and lagged values of the explanatory variables as regressors. However, this model does not serve the direct function required of the model in the cross-hedge, which is, simply, to determine when changes in one market – natural gas futures – best correlate with changes in another market – urea spot prices. As such, we estimated a series of regression parameters with one increasingly lagged independent variable.

Regression equation (3) describes the relationship between average weekly urea cash prices and average weekly natural gas closing futures prices. \( NGFP_w \), the initial futures market price and independent variable, is predetermined and known when hedging; the corresponding cash urea price, the dependent variable, must be estimated. \( \beta_0 \), the intercept term, represents the mean difference between the average weekly natural gas futures prices and the weekly urea cash prices. The intercept term also captures the expected basis. \( \beta_1 \), the slope coefficient and hedge ratio, estimates the typical relative cash price change with respect to a one-dollar change in the futures contract. For example, a \( \beta_1 \) of 1.0 indicates that a $1 change in the futures price corresponds with a $1 change in the cash price in the same direction. A \( \beta_1 \) of 10.0 indicates that each $1 change in the futures price, the cash price of the commodity being hedged changes by $10 in the same direction. A negative \( \beta_1 \) would indicate an inverse price relationship.
and, in the case of procuring urea, would require a selling hedge. Also, it establishes the hedge ratio for
determining the size of the futures position to be taken for a given amount of cash position held.

(5) \[ \text{Cash quantity hedged} = \frac{\text{Futures contract quantity}}{\beta_i} \]

In sum, the cash quantity hedged is the amount of the commodity being hedged per futures contract.

Data and Analysis

The data set used in the analysis was constructed using data from two primary sources. Average
weekly FOB cash urea prices were obtained from Green Markets, a weekly newsletter covering fertilizer
markets. Daily natural gas futures price data were provided by the New York Mercantile Exchange
(NYMEX). We calculated weekly average natural gas futures closing prices by summing the daily
closing prices for the given week and dividing by the number of trading days for that week. Figure 4.1
shows the plotted weekly data.

![FIGURE 4.1](image)

Each natural gas futures contract ends trading three days before the first of the next month. In
constructing the data set from the raw data provided by NYMEX, we accounted for this by picking up the
next month’s contract for the final two trading days of each month. In this way, the data series always
includes prices for the contracts that are both most recent and active.

Six weeks of data over the five-year time period were excluded from the data set because urea
price data were unavailable. These were the weeks of 12/28/98, 12/27/99, 12/25/00, 12/24/01, 12/31/01,
and 12/30/02.
TABLE 4.1

Using weekly data, eight separate regressions of cash urea prices were estimated on natural gas futures prices using the model defined previously (Table 4.1). Slope coefficients ranged from 0.471 to 0.586, with maximum results appearing with a five week lag between the natural gas futures prices and the cash urea prices. Calculated F-values are greater than corresponding critical values in all cases. These results indicate that changes in lagged average weekly natural gas futures prices can partly explain changes in the weekly cash urea prices. The maximum $R^2$ of 0.586 indicates that about 59% of the variation in urea cash prices about its mean is explained by the 5 week lagged natural gas futures price. Typically, effective cross hedging strategies have an $R^2$ in excess of 0.80, though 0.70 may also prove useful (Graff et al 1997). These results indicate that currently natural gas futures may prove marginally useful, at best, in hedging urea cash prices. To further test these results, we apply these results to simulated hedges for each of the five years 1998 through 2002.

Cross-Hedging Strategies

In forest management, urea fertilizer applications take place in the late fall or early spring. For fall applications around October, budget and operational decisions are being finalized in late spring; for fertilizations in the spring, budget and operational decisions may be finalized around September of October. While the actual timelines of urea applications and the adjoining price and contract negotiations may vary, we assume that forest managers would seek to cross-hedge urea price exposure in parallel with

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8 All equations exhibited t-values significantly different from zero.
9 Inspection of the plotted data indicated that coefficients of correlation would continue to weaken with each additional lagged regression beyond the tested time frame.
10 According to Dr. Barry Shiver at the Warnell School of Forest Resources at the University of Georgia, forestry managers avoid summer and winter applications for efficacy and logistical reasons. Summer and winter rains can leach urea from forest soils, while dry soil conditions and high temperatures in summers can volatize urea. Logistically, services that apply fertilizers, such as crop dusters, work agricultural jobs in the summer and retrofit their equipment to be available for forest management jobs in the spring or fall.
the finalization of their seasonal management plans. Thus, we use the four to six month time frames for locking in tested cross-hedges.

We test the urea cross-hedge for nine potential applications over five years: fall 1998, and spring and fall 1999 through 2002. In these tests, we make the following assumptions:

- For fall applications in October, managers cross-hedge in mid to late May.
- For spring applications in March, managers cross-hedge in mid to late October.
- Cross-hedges offset 1,000 tons of urea.
- Cross-hedges assume a four to six week lag between changes in natural gas prices and the associated changes in urea prices.

To detail the steps required for placing a cross hedge on urea using natural gas futures, we work through two examples, as summarized in Table 4.2 and Table 4.3.

In May 1998, a Southern forest manager commits to fertilizing thousands of acres of pine plantations in October 1998. On May 18, urea costs $152.50 per ton. The manager is concerned that prices will rise with natural gas going into the winter months. To reduce exposure to fluctuating urea prices, the manager decides to cross-hedge 1,000 tons of urea. The manager understands that changes in urea prices lag changes in natural gas futures by four to six weeks, so the decision is made to hedge with September natural gas futures contracts. On May 18, September natural gas futures are trading at $2.27 per mm btu (NYMEX; 1 contract = 10,000 mm BTUs). To place the cross-hedge, the manager must determine the number of natural gas futures contracts necessary to offset the purchase of 1,000 tons of urea. Using the 5-week lag hedge ratio of 15.35, the manager decides to purchase 1 natural gas futures contract (equation (5): 10,000/15.35 = 651.46 tons of urea hedged per contract; 1000/651.46 = 1.54 contracts to hedge the entire 1000 tons).

11 In practice, forest managers commonly negotiate turn-key fertilizer applications with contractors on a per-acre basis. The contractor, not the forest manager, would then purchase urea directly from a supplier before adding costs for fuel and application services in negotiating rates with the forest manager. This study tests the effectiveness of cross-hedging independent of how total pricing is negotiated. Therefore, if the hedge is deemed effective, the next step would be to translate the results into actual per-acre application prices.
August 27, 1998 is the last trading day for the September 1998 natural gas futures contract, ending at $1.63 per mm btu. The forest manager closes the cross-hedge by selling the natural gas futures contract, taking a loss of $0.64 per mm btu ($2.27 - $1.63) for a total loss of $6,400 on the contract ($0.64 * 10,000).

On October 5, 1998, urea costs $132.50 per ton. The forest manager pays this price for the 1,000 tons of urea. The loss on the futures contract equals an extra $6.40 per ton of urea ($6,400/1000 = $6.40). The total cost per ton of urea is $138.90 per ton.

<table>
<thead>
<tr>
<th>TABLE 4.2</th>
</tr>
</thead>
</table>

The second example begins in October 2000, when the forest manager commits to fertilizing Southern pine plantations in March 2001. On October 16, 2000, urea costs $167.00 per ton. Once again, the manager seeks to account for the four to six week lag between natural gas futures and urea prices by using the February natural gas futures contract for the cross hedge. On October 16, natural gas futures are trading at $5.23 per mm btu. The manager purchases 1 February natural gas futures contract to establish the cross hedge.

January 29, 2001 is last trading day for the February 2001 natural gas futures contract, ending the day at $6.32 per mm btu. The forest manager closes the cross-hedge by selling the natural gas futures contract, making a profit of $1.09 per mm btu ($6.32 - $5.23) for a total gain of $10,900 on the contract ($1.09 * 10,000).

On March 5, 2001, urea costs $222.50 per ton. The forest manager pays this price for the 1,000 tons of urea. The gain on the futures contract reduces the net per ton urea cost by $10.90 per ton ($10,900/1000 = $10.90). The total cost per ton of urea is $211.60 per ton.
TABLE 4.3

Using the same procedures as described in the above examples, cash costs and net realized costs from cross-hedging are summarized by season in Table 4.4. In 3 out of 9 cross hedges over five years, the futures transactions saved the forest manager money. On average, the cross-hedge cost the manager an additional $2,700 per season, or $2.70 per ton of urea. The standard deviation of the unhedged urea cost per ton is $35.82. The hedged urea cost per ton is $31.02. While these results show how the hedge, as intended, can reduce the variance of the actual cash urea costs, the cross-hedge was not profitable 67% of the time (6 out of 9).

TABLE 4.4

Discussion and Conclusion

In exploring a cross-hedging application in forestry, we hypothesized that net realized prices from cross-hedging urea with natural gas will be lower than cash prices. While the cash-futures relationship between urea cash prices and natural gas futures prices was found to be statistically significant, the direct price movement relationship is marginally robust enough to implement cross-hedging as an effective strategy. Net realized costs from cross-hedging were generally higher than the unhedged cash costs. Thus, the key findings do not support the hypothesis that cross-hedging can effectively lower forestry fertilization costs associated with purchasing urea.

What situations exist when this cross-hedge might make sense? We would expect substantial increases in natural gas prices to increase the lagged correlation with urea cash (spot) prices. In fact, within the five year data set, summer 2001 shows rapidly increasing natural gas futures prices. The correlation coefficient for 2001 reaches 0.623, indicating there may be periods of expected uncertainty when cross-hedging urea may meet a specific business need.
Traditional reasons why cross-hedging with futures may work imperfectly in practice include a mismatch hedged asset and asset underlying the futures contract, inexact dates for purchasing the hedged asset or closing the futures contract, and poorly matched contract sizes. In this case, the lagged correlation presents an additional problem, as the need to close out the futures contract four to six weeks prior to fertilization leaves the forest manager unhedged and exposed for that interim time period. Additionally, the large size of the natural gas futures contract (10,000 mm BTU) limits its potential use and flexibility for small or even mid-size forestry operations. This mismatch between the size of the futures contract and urea spot purchases forces the manager to choose between over-hedging – buying more futures contracts than needed for the given transaction – and under-hedging – leaving a portion of the urea purchase unhedged, as in the above cross hedging example. Finally, this approach to cross-hedging urea costs can only roughly approximate the actual urea application costs incurred by forest managers, who often pay a contractor a per acre cost for applied urea. This per acre fee moves with urea and fuel costs, indicating a potential hedging opportunities for the contractors themselves.

A major question not addressed in this study is whether or not hedging adds value to the overall forestry investment. While plans may change, and while the actual financial and productivity impacts on forestlands from last minute fertilizations may vary, this paper focused strictly on reducing the price exposure associated with incorporating urea as part of a comprehensive forest management plan. Additional research investigates the financial sensitivity of and effects on timberland returns of forgoing planned silvicultural treatments.

In closing, forest managers may benefit from alternative pricing methods, such as forward contracts, deferred pricing, or storing. The benefits from hedging strategies accrue when they begin to offer a more cost-effective method for mitigating price and volume exposures associated with commodity transactions. As yet, cross hedging urea costs with natural gas futures appears to provide an incomplete and marginally useful pricing strategy.
Figure 4.1: Weekly Average Natural Gas Futures and Urea Cash Prices, 1998-2002
Table 4.1: Estimated Parameters for Cross Hedging Urea with Natural Gas Futures

<table>
<thead>
<tr>
<th>Variable</th>
<th>Lag 0</th>
<th>Lag 1</th>
<th>Lag 2</th>
<th>Lag 3</th>
<th>Lag 4</th>
<th>Lag 5</th>
<th>Lag 6</th>
<th>Lag 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta_0$</td>
<td>95.36</td>
<td>93.90</td>
<td>92.26</td>
<td>91.21</td>
<td>90.43</td>
<td>90.35</td>
<td>90.46</td>
<td>90.75</td>
</tr>
<tr>
<td></td>
<td>(3.18)</td>
<td>(3.09)</td>
<td>(2.99)</td>
<td>(2.92)</td>
<td>(2.86)</td>
<td>(2.85)</td>
<td>(2.86)</td>
<td>(2.89)</td>
</tr>
<tr>
<td>$\beta_1$</td>
<td>13.61</td>
<td>14.10</td>
<td>14.65</td>
<td>15.02</td>
<td>15.29</td>
<td>15.35</td>
<td>15.35</td>
<td>15.28</td>
</tr>
<tr>
<td></td>
<td>(0.91)</td>
<td>(0.88)</td>
<td>(0.86)</td>
<td>(0.84)</td>
<td>(0.82)</td>
<td>(0.82)</td>
<td>(0.82)</td>
<td>(0.83)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.471</td>
<td>0.503</td>
<td>0.539</td>
<td>0.563</td>
<td>0.583</td>
<td>0.586</td>
<td>0.585</td>
<td>0.579</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.469</td>
<td>0.501</td>
<td>0.537</td>
<td>0.562</td>
<td>0.581</td>
<td>0.585</td>
<td>0.583</td>
<td>0.578</td>
</tr>
<tr>
<td>F-Value</td>
<td>225.75</td>
<td>254.96</td>
<td>293.07</td>
<td>322.68</td>
<td>348.05</td>
<td>351.27</td>
<td>347.89</td>
<td>338.97</td>
</tr>
<tr>
<td>n</td>
<td>255</td>
<td>254</td>
<td>253</td>
<td>252</td>
<td>251</td>
<td>250</td>
<td>249</td>
<td>248</td>
</tr>
</tbody>
</table>
Table 4.2: Example of Cross-Hedging Urea with Natural Gas (Fall 1998)

<table>
<thead>
<tr>
<th>Date</th>
<th>Cash</th>
<th>Futures</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 18, 1998</td>
<td>$152.50 per ton</td>
<td>Long 1 Sept. natural gas futures contract @ $2.27/btu</td>
</tr>
<tr>
<td>August 27, 1998</td>
<td></td>
<td>Short 1 Sept. natural gas futures contract @ $1.63/btu</td>
</tr>
<tr>
<td>October 5, 1998</td>
<td>Buy 1,000 tons of urea @ $132.50/ton</td>
<td>Loss = $0.64/btu</td>
</tr>
</tbody>
</table>

Cost of purchasing 1,000 tons of urea = ($132.50) x 1,000 = ($132,500)
Profits from futures transactions = ($0.64) x 10,000 x 1 = ($6,400)
Total cost = ($132,500) + ($6,400) = ($138,900)
Net realized cost = ($138,900)/1,000 = ($138.90)/unit
### Table 4.3: Example of Cross-Hedging Urea with Natural Gas (Spring 2001)

<table>
<thead>
<tr>
<th>Date</th>
<th>Cash</th>
<th>Futures</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 16, 2000</td>
<td>$167.00 per ton</td>
<td>Long 1 Feb. natural gas futures contract @ $5.23/btu</td>
</tr>
<tr>
<td>January 29, 2001</td>
<td></td>
<td>Short 1 Feb. natural gas futures contract @ $6.32/btu</td>
</tr>
<tr>
<td>March 5, 2001</td>
<td>Buy 1,000 tons of urea @ $222.50/ton</td>
<td>Gain = $1.09/btu</td>
</tr>
</tbody>
</table>

Cost of purchasing 1,000 tons of urea = ($222.50) x 1,000 = ($222,500)
Profits from futures transactions = $1.09 x 10,000 x 1 = $10,900
Total cost = ($222,500) - $10,900 = ($211,600)
Net realized cost = ($211,600)/1,000 = (211.60)/ton
Table 4.4: Comparison of Cash Costs (CC) and Net Realized Costs (NRC), 1998-2002 ($/ton)

<table>
<thead>
<tr>
<th>Season</th>
<th>Cash Costs (CC)</th>
<th>Net Realized Costs (NRC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall 1998</td>
<td>$132.50</td>
<td>$138.90</td>
</tr>
<tr>
<td>Spring 1999</td>
<td>$115.00</td>
<td>$121.00</td>
</tr>
<tr>
<td>Fall 1999</td>
<td>$105.00</td>
<td>$100.00</td>
</tr>
<tr>
<td>Spring 2000</td>
<td>$157.50</td>
<td>$161.30</td>
</tr>
<tr>
<td>Fall 2000</td>
<td>$167.00</td>
<td>$155.20</td>
</tr>
<tr>
<td>Spring 2001</td>
<td>$222.50</td>
<td>$211.60</td>
</tr>
<tr>
<td>Fall 2001</td>
<td>$125.00</td>
<td>$147.20</td>
</tr>
<tr>
<td>Spring 2002</td>
<td>$121.00</td>
<td>$129.20</td>
</tr>
<tr>
<td>Fall 2002</td>
<td>$139.50</td>
<td>$144.90</td>
</tr>
</tbody>
</table>
At a certain level, forestry managers and timberland investors manage risk instinctively. This occurs through the normal calculus of assessing the risks and rewards associated with silvicultural treatments, capital allocation, and timber sales. We expect—though we have not studied or documented—that forest resource and industry professionals have approaches for identifying, assessing, and managing the fundamental sources of risk and uncertainty encountered by their operational activities and enterprises. Alternately, these same practitioners participate in a business environment subject to financial risks emanating from outside of the forestry sector, such as those coming from changes in interest rates, foreign currency exchange rates, and commodity prices.

This dissertation, as a first step, reviewed the relevant finance literature to better understand how financial theory and firms in general view the reasons to and methods for managing these financial risk exposures. Next, this effort studied the extent to which the forest industry makes use of derivatives to manage financial risk, and how their use aligns with expected use as described in the empirical literature. We found that most U.S. publicly-traded forest products firms—17 of the 19 studied (89%)—used derivatives for risk management purposes as of fiscal year end 2002. However, of the three hypotheses tested, only one—that hedging activity increases with firm size—was significant.

Additionally, we investigated and tested two specific applications of derivative contracts for managing financial risk in forest industry settings. The logistics and pricing models for options on forwards indicate potential useful and flexible applications for these financial contracts in a procurement setting. Options on forward contracts, when viewed as one tool in a portfolio of wood procurement approaches, could help wood procurement managers and wood suppliers price and shift wood supply risk. Also, the calculated values of these contracts provide a useful benchmark for other wood procurement and
inventory activities. Currently, this application is limited most severely by data constraints, but possible solutions exist, which include the use of private data sets for negotiating business-to-business options on forwards that meet specific objectives.

The second application studied – cross-hedging urea with traded natural gas futures contracts – demonstrated how cross-hedging can be used to mitigate cash price volatility in silvicultural operations. The benefits from hedging strategies accrue when they begin to offer a more cost-effective method for mitigating price and volume exposures associated with commodity transactions than available from alternate pricing methods, such as forward contracts and storing. However, this specific application proved currently unworkable as the correlation between urea cash prices and natural gas futures, while statistically significant, lacks the strength for a robust hedging strategy.

Risk management theory argues that firms will benefit from hedging if they find it costly to delay or alter investment plans and have limited access to external funding sources. A major question not addressed in the cross hedging study is whether or not hedging strategies add value to the overall forestry investment. Additional research will investigate the financial sensitivity of and effects on timberland returns of forgoing planned silvicultural treatments.

However, our approach in this project to studying financial risk may give a false impression or advance a misleading implication: that risk management concerns only the reduction and minimization of risk, that risk management is inherently defensive and negative and reductive. To the contrary, risk management includes consideration of, one, synergistic and efficiency opportunities within the business and, two, new investment and business development opportunities. As a whole, risk management, as we have studied it here and as we currently view it, aims to help professional managers and investors dedicate their time to working on what they can control and what they are good at, and it helps ensure that the identification and assessment of alternate extensive business opportunities and enhancements retain prominence in any overall risk management plan.
This dissertation considered a single aspect of risk management: the use of derivative securities to mitigate exposure to financial risks. Hedging – by corporations, individual investors, and asset managers – does not eliminate risk; rather, it transforms undesirable risks into acceptable and manageable forms by increasing certainty and decreasing volatility for selected transactions and positions. Risk management and hedging programs help firms achieve their optimal risk profile by balancing the costs of hedging with the protection offered.

In practice, forest products firms face a series of risks, including operational risk associated with equipment and logistic failures; market risk associated with unexpected movements in prices and interest rates; and political risk associated with changing regulatory conditions. In this research effort, we focused on financial risks that a firm is not typically in the business of bearing, and one category of tools – derivatives – available to manage these risks. However, the full range of tools and strategies available to forest industry professionals include the use of insurance, product and financial diversification, and operational hedging. Strategic decisions associated with corporate risk management should require the identification and implementation of natural hedges, of taking advantages of resources and approaches currently and easily available to the firm, in parallel or prior to implementing involved derivative based programs.

In continuing with this research program into the identification, assessment, and management of financial risk in forestry and the forest products industry, several potential projects emerged from this dissertation.

Risk management programs in the forest products industry. The study of derivative use among forest products firms provided a singular snapshot of one aspect of financial risk management within this industry. We noted during the course of this research that firms clearly changed their approach to managing financial risk – and the role that derivatives played in these approaches – over time. Why and how these approaches changed is open to speculation and added study, but several factors were clearly noted in the financial statements: changes in accounting rules, impacts and inheritances from mergers and
acquisitions, and changing macroeconomic conditions affected derivative-related policy and practice. Additionally, we are interested in the role that turnover and relative experience at the senior management levels may have affected the willingness to use derivatives. The relevant financial literature notes, with mixed results, the impacts of management tenure and compensation plans on risk management programs. Closer study of these topics, particularly as they may reflect on firm profitability across the industry, will provide investors, researchers, and firm compensation committees with added insight for decision making.

A larger and more complete study of overall risk management programs appears necessary. We studied a snapshot and could further pursue an understanding of how the use of derivatives has changed with time within the industry. And while the use of derivatives may be seen as a proxy for the existence of a more complete risk management program, the research and empirical evidence to make this claim currently has not been completed. We did not assess the effectiveness of the derivatives put in place by these firms. In practice, derivatives use complements a larger program that accounts for exposures through, for example, the strategic location of assets and liabilities, through diversification, and through the selective use of insurance. All of these areas remain open for further study in forestry and the forest products industry.

Transaction-level use of derivative contracts. In parallel with the study into the potential application of options on forwards in wood procurement, we developed a case study which works through the pricing and operational issues considered by a major pulp mill in southern Mississippi in the late 1990s. This mill, in conjunction with a major regional wood supplier and a now-defunct energy firm, investigated the potential use of options and option-like contracts for long-term wood supply agreements and an asset transfer. Additionally, the 2002 forest products industry financial statements studied for Chapter Two reference occasional specially-constructed, single-purpose derivative contracts for specific investment and operational situations. These actions and events indicate a willingness to use, or at least consider, the use of financial derivatives for transactions to shield particular operations or components of the forest products supply chain from specific types of financial risk. Further study of these tailor-made
derivative contracts, the situations under which they have appealed to integrated forest products firms, and their success in achieving stated objectives would provide insight into helping understand the risk management cultures and programs of industry participants.

*Alternative strategies to managing financial risk.* Financial risk management strategies do not require the use of derivatives. And, in fact, these firms have been making decisions all along regarding their respective exposures to financial risk. Approaches include inventory management, long-term purchase agreements, and logistic flexibility. However, a knowledgeable quantitative and qualitative understanding of these strategies remains unstudied. This research would have particular value to smaller firms, who may not have the resources and scale to fully implement a diversified hedging program, and international markets, where firms headquartered and primarily located in foreign countries may not have access to the deep financial and derivative markets available in the United States. For example, timberland and agricultural investors in Uruguay, where we are witnessing the growth of forestry as an industry, seek better understanding of hedging and risk management strategies applicable to a small country wedged between two major economies, Brazil and Argentina.

*Equity and commodity market responses and relationships to hedging activities.* Short and long-term event studies in the finance literature help assess the equity market response to individual firm decisions, activities, and events. Exploring a potential relationship between the performance of forest industry equities relative to derivative positions and hedging programs address questions of firm sensitivity to interest rates and foreign currency exchange rates. Additionally, time series studies of the relative performance of forest industry stocks, publicly-traded real estate investment trusts (REITS), and traded commodities may provide insight into the effectiveness and potential of risk management programs.

A primary concept of risk management is to get rid of what you are not good at to focus on what you are (or want to be) good at. We practice this daily through buying insurance, specializing at work, and improving our educational and skill levels. This process of allocating time and resources requires
prioritizing, decision making, and specialization. Research that explores and tests opportunities for the forest products industry to benefit from the insights and successful strategies of other fields, or that identify unique exposures or strategies within the forestry and timberland sectors, can provide forest managers, timberland investors, government agencies, and timber-owning conservation organizations with an improved set of tools and strategies for meeting their operational and strategic objectives.
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