STOCKHOLM SCHOOL OF ECONOMICS
Department of Accounting
BE351 Degree Project in Accounting and Financial Management
Spring 2025

Vertical Vertigo - The (Lack of) Benefits from Vertical Integration in the Forest Products Industry

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Abstract

In this paper we examine the effects of vertical integration on financial performance in the global forest products industry, focusing on two key outcomes: profitability and earnings volatility. Using panel data from 42 forestry, pulp, and paper firms spanning the period 2020–2024, we measure vertical integration as a continuous variable—the proportion of wood fiber sourced internally—to capture both partial and full integration structures. To measure its effects, we use OLS regression models, with additional robustness checks applied to the profitability model to ensure reliable inference. First, we find that higher levels of vertical integration are significantly associated with increased profitability. Second, we find no evidence that vertical integration reduces earnings volatility. Rather, while statistically insignificant, our findings suggest that vertical integration may even amplify earnings volatility under certain conditions. Our study contributes to the limited empirical literature on the financial impacts of vertical integration in the forestry sector and underscores the importance of strategic fit in implementing this strategy.

Supervisor: Henrik Andersson

Keywords: vertical integration, forest products, forestry, process industry, profitability, earnings volatility, transaction cost theory, best ownership, resource-based view

Acknowledgements: We would like to thank our supervisor Henrik for his guidance and valuable feedback during the thesis writing process.

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1. Introduction

The forest products industry, situated at the intersection of cyclical and capital-intensive industries, faces a unique mix of pressures: fluctuating market demand, volatile input prices, long investment horizons, and increasingly stringent environmental regulations. For firms operating in this space, strategic choices around structure and control are pivotal for long-term viability. One such choice is vertical integration, where companies expand their control over multiple stages of the supply chain. Given the pressures these firms face, securing control over inputs, whether through owning forest lands or establishing long-term sourcing contracts, offers great upsides as it helps ensure a stable flow of raw materials for their operations. However, this strategy, while potentially stabilizing and value-creating, also risks introducing rigidity, complexity, and significant capital commitments (D'Aveni & Ravenscraft, 1994).

Recent developments in the Nordic forestry sector illustrate this strategic conundrum. In 2023, Sweden’s largest forest owners' association Södra announced its divestment of over 150,000 hectares of Baltic forestland, citing a renewed focus on core domestic operations. Around the same time, Skogsfond Baltikum exited the region entirely, while other actors like SCA moved in the opposite direction, acquiring tens of thousands of hectares across the Baltics to bolster their supply security. These divergent strategies reflect an unresolved question: does control through vertical integration offer financial advantages, or is flexibility more effective in facing today’s pressures?

While vertical integration is a common strategic choice in this sector, its financial impacts remain insufficiently explored. Prior research in sectors such as oil and gas, agrifood, and manufacturing has yielded mixed results, with some studies suggesting that integration stabilizes performance by insulating firms from market shocks, while others caution against potential rigidity and bureaucratic costs. To contribute to this ongoing debate, we apply two OLS regressions to test whether profitability and earnings volatility have a significant relationship with vertical integration, while controlling for key firm-level characteristics including capital expenditure, age, leverage, and size. Our study sample comprises 42 forestry firms from North America, Scandinavia, South America, and Europe over the period 2020–2024.

Our contribution lies in offering a deeper view of the impacts of vertical integration by measuring it as a continuous variable—capturing both full and partial integration in line with Perry's (1989) idea of partial integration—an approach which, to our knowledge, has not yet been applied in this context. This should allow us to granularly assess if varying degrees of internalizing raw material sourcing systematically impact our variables of interest. This question is especially relevant in today's forestry sector, which faces heightened environmental, social, and governmental (ESG) expectations and new trade policies such as the EU Deforestation Regulation (EUDR) that may incentivize firms to pursue vertical integration. Ultimately, our findings aim to inform both academic literature and strategic decision-making for managers, investors, and policymakers navigating this sector.

The paper proceeds as follows: we start by reviewing relevant literature, including theoretical motives behind vertical integration such as transaction cost theory, the resource-based view, and agency theory, as well as empirical studies on the effects of this strategy on financial performance in forestry and other industries. We will then outline our methodology before presenting our hypotheses and initial regression model specifications. This section also details the data collection and cleaning processes, as well as the measurement of our variables. In the findings and analysis section, we first present a descriptive overview of our dataset, followed by the results of the preliminary diagnostic tests and the corresponding adjustments made to develop our finalized models. We then test our hypotheses and summarize the key results, which are subsequently interpreted and discussed in light of existing theory and industry context.

2. Literature Review

2.1 Introduction to Vertical Integration in the Forest Industry

Vertical integration refers to the process of eliminating contractual or market exchanges by substitution of internal exchanges within the boundaries of the firm. Firms can implement this in two directions: backward (upstream) or forward (downstream). A firm can be described as vertically integrated if it has two distinct stages of production in which either (1) the entire output of the upstream process is used fully or partially as an intermediate input in the downstream process; and (2) the entire required input for the downstream process comes fully or partially from the output of the upstream process (Perry, 1989). In the forestry sector, an example would be a firm that manages forest lands (upstream) to supply its sawmills or paper mills (downstream) with timber.

By extension, vertical integration can be either full or partial. In full vertical integration, all of the output from the upstream process is used internally, and downstream processes source exclusively from this internal supply. Partial vertical integration describes firms that operate with different degrees of internalization: (1) some of the upstream output is used internally, while the rest may be sold to external buyers; and (2) some of the downstream input is sourced externally rather than being fully supplied by the firm's upstream operations.

2.1.1 Historical Development of Vertical Integration in the Forestry Sector

Before exploring how vertical integration may impact the modern forestry firm, it is essential to examine its historical evolution. The relationship between human societies and forests has deep historical roots, with evidence of organized forestry dating back to the Middle Ages. These early forms of management highlight the long-standing economic and ecological significance of forest resources (James N. Hogg, Hans A. Jöbstl, 2008).

About three hundred years ago, trees in Europe were diminishing rapidly as populations grew and industrialization kicked off (Holmes, 1975; Morgenstern, 2007). And with this realization, a precursory idea for vertical integration emerged with the concept of sustainable forest management. In 1713, Hans Carl von Carlowitz, a Saxon mining administrator, published *Sylvicultura Oeconomica*, where he introduced the concept of sustainably managed timber production to support industries like mining. This birthed the broader idea of aligning forestry management with industrial demand by treating timber production as being part of a longer and intertwined supply chain instead of being shortsightedly over-exploited.

The industrial revolution was pivotal in transforming the forestry sector by revolutionizing means of distribution and production as a result of the era’s technological advancements such as iron ships, steam engines, and railways; technology that significantly expanded the timber market and opened doors for firms to innovate (Holmes, 1975). This era naturally saw the rise of early adopters of vertical integration such as the Weyerhaeuser Company which was founded in 1900. Initially, the firm's operations encapsulated only timber production and transportation, later expanding in 1902 with the purchase of their own sawmill (Warren, 1999; Weyerhaeuser, n.d). Weyerhaeuser’s choice of forward integration interestingly resonates with broader trends in American manufacturers at the time, as identified by Livesay and Porter (1969). They attributed this trend to, among others, a desire to streamline sales and distribution processes and reduce reliance on third parties rather than purely a desire to internalize profits generated by distributors.

Zooming out, we can also find evidence of vertical integration trends outside of North America. In Europe, the formation of Svenska Cellulosa Aktiebolaget (SCA) in 1929 created Europe's largest forestry enterprise at the time, combining extensive forestlands, sawmills, and paper mills under one umbrella, as stated by Company-histories.com (n.d). The rationale to form the vertically integrated venture was to create a streamlined operation and enhance competitiveness, particularly when considering the U.S.S.R.'s strong foothold in the European timber market at the time.

This trend of vertical integration continued well into the mid-20th century, though it manifested differently depending on the region. In Eastern Europe, particularly in the Soviet Union and its satellite states, industrial and agrarian nationalization took place following World War II. While the push for communism certainly played a role, the immediate effect was a rapid increase in state-owned firms that controlled entire supply chains which allowed those governments to better control costs and stabilize production in order to revive their economies (Herman, 1951). In contrast, the trend of vertical integration in North America's forestry sector progressed more organically. This continued into the post-war housing boom which saw forestry companies expand their operations. And by the late 1950s, major players like Weyerhaeuser and Georgia-Pacific were fully integrated operations, employing "armies" of loggers and truck drivers and operating hundreds of mills (State of Oregon, n.d)

However, by the end of the 20th century, North America saw this trend begin to reverse from a combination of taxation and market-driven factors. Straka (2013) notes that this period saw up to 66% of forest land owned by vertically integrated forestry companies divested and shifted ownership to real estate investment trusts[1] (REITs) and timber investment management organizations (TIMOs). The author explains that some reasons for this were that new tax advantages made TIMOs and REITs a better land ownership structure, and the realization that an internal timber supply was less critical than previously believed as the

[1] Timber REITs are publicly traded firms that own and manage forestland but usually do not operate processing facilities.

modern market itself could be a sufficient and sometimes cheaper source of timber. In contrast, some major players in the Nordics such as Stora Kopparberg and Enso Oyj chose to maintain substantial upstream integration. Their merger in 1998 established the new Stora Enso as one of the world's largest forestry companies at the time with 2.1 million hectares of forest land and extensive pulp and paper operations, reflecting their long-term commitment to stay vertically integrated at the time (Stora Enso, 1998).

2.1.2 State of Vertical Integration in the Forestry Sector Today

Today, significant advancements in technology and research have reshaped the forestry sector, enabling firms to adopt highly integrated business models and everything in-between. On one hand, some companies are vertically disintegrating, such as Stora Enso who is preparing to sell approximately 12% of its total forest assets (Stora Enso, 2024). While on the other hand, firms like Finland's UPM-Kymmene Oyj have gone beyond traditional local vertical integration, instead opting for a global-scale integration model as exemplified by their $3+ billion investment in Uruguay, creating the largest single-line pulp mill in the world. Currently, UPM's operations encompass everything from tree genetics, nurseries, harvesting, processing, and shipping, leveraging 900,000+ hectares of forest land to annually supply 26.0 million cubic meters of timber to its mills. (UPM Paso de los Toros, 2023; UPM, 2024; UPM Forests, n.d)

However, the decision to vertically integrate today is not as straightforward as before. Modern forestry firms must also, beyond competitiveness, consider the impact of various contemporary variables before making such decisions, such as ESG factors and sustainability regulations. For example, the EUDR prohibits the sale of wood products that contribute to deforestation and forest degradation within the European Union. This is expected to significantly alter global forestry supply chain configurations, potentially further incentivizing firms to vertically integrate to ensure supply chain control and continued access to vital markets (WWF, 2023; S&P Global, 2023). All in all, the degree of vertical integration in today's forestry firms reflects a balance between the traditional desire for operational efficiencies and competitiveness, all while grappling with evolving sustainability requirements and pressures.

2.2 Theoretical Foundations of Vertical Integration

Building on the historical evolution and current landscape of vertical integration in the forestry sector, it is essential we examine the economic and strategic drivers that underlie the decision to vertically integrate. To understand the rationale behind this decision, we will discuss three key theoretical perspectives from which we can view the implementation of this strategy.

2.2.1 Transaction Cost Theory

Transaction cost theory (TCT) argues that firms establish their boundaries by comparing the costs of internal coordination i.e. vertical integration (e.g., administration costs) with market transaction costs. Transaction costs may arise at different stages of transactions, including: (1) contacting costs, i.e. costs of researching suppliers and comparing offers; (2) contracting costs, i.e. costs of negotiating and drafting a contract; and (3) controlling costs, i.e. costs of monitoring suppliers and ensuring compliance (Williamson, 1993).

According to Williamson (1993), transaction costs exist for two main reasons: bounded rationality (the idea that people's ability to make rational decisions is limited by incomplete information and cognitive limitations) and opportunism. And as firms seek to protect themselves from exploitation, they invest time and money on things like monitoring partners and meticulously drafting contracts.

In TCT, firms may decide whether an internal or external transaction is most efficient by considering three intertwining dimensions of the transaction:

(1) Asset specificity refers to how much a firm's investment is tailored to a particular transaction (e.g., a forestry firm's sawmill that can only process one type of wood). High specificity leads to a bilateral dependency, increasing the risk of supplier opportunism.

(2) Uncertainty refers to the unforeseeable factors that can impact the transaction. High uncertainty makes it both difficult to draft contractual agreements that anticipate all contingencies that the firm desires and increases the likelihood of additional costs such as renegotiation costs.

(3) Frequency refers to how often the transaction occurs. If the transaction occurs frequently, firms may want to internalize the transaction to prevent incurring repeated transaction costs.

Ultimately, if transaction costs are comparably high, firms may favor vertically integration to reduce dependence on suppliers and transaction costs. On the other hand, if the costs of internal coordination are comparably too high, firms may find it more attractive to source on the open market instead.

2.2.2 The Resource-based View

The Resource-based View (RBV) views firms as unique bundles of resources and competencies, emphasizing the impact of these unique internal aspects on firm performance and sustained competitive advantages. It offers an alternative perspective to vertical integration as it can be seen as a firm's natural attempt to acquire and better develop, maintain, protect, and leverage resources crucial for competitiveness according to Wernerfelt (1984).

This was later refined by Barney (1991) who defined the criteria for resources to form the foundation of sustainable competitive advantage as: valuable, rare, imperfectly imitable, and non-substitutable (VRIN). He further expanded this in Barney (1995) by introducing the VRIO framework, replacing the previous non-substitutable criterion with "Organization" to emphasize that firms need to be adequately positioned and structured to fully leverage its strategic resources.

The Wernerfelt (1984) seminal RBV paper introduces the idea of resource position barriers—advantages derived from a firm's unique capabilities and resources that are difficult for others to imitate—which firms develop by accumulating distinct resources such as novel silvicultural practices, etc. Vertical integration thus serves as a way for firms to build on and create new competitive advantages by learning new competencies and reducing dependencies on external parties.

Additionally, Wernerfelt (1984) draws on Salter and Weinhold (1980) to outline two resource-based acquisition strategies that provide a useful lens through which we can view vertical integration in RBV terms:

(1) Related complementary integration refers to acquiring resources to create synergies with the firm's existing capabilities, allowing it to internalize critical resource dependencies.

(2) Related supplementary integration refers to acquiring more of the same resources the firm already possesses, reinforcing its resource position barriers by, for example, increasing the cost of imitation.

Lastly, if a firm's resources shape its competitive domain as suggested by RBV, then vertical integration efforts by firms in the forestry sector should also be guided by their internal resource base. This perspective is supported by Richardson (1972), who highlights that firms tend to expand into areas in which they have pre-existing resources and capabilities, implying a natural boundary of vertical integration efforts to areas where firms can exploit their resource position barriers and are organized to deploy and coordinate their strategic resources effectively.

2.2.3 Agency Theory

Agency Theory (AT) posits that firms often operate on a principal-agent basis: the former assigning work for the latter to perform. This decoupling of ownership and control may cause information asymmetries which allows agents to act on misaligned incentives, giving rise to agency costs. Agency theory suggests that firms employ governance strategies such as vertical integration to minimize these challenges between principals (owners/managers) and agents (suppliers) (Eisenhardt, 1989)

Eisenhardt (1989) highlights the idea that agents are utility-maximizing entities who act in their own self-interest, not necessarily aligned with the firm's objectives. This becomes problematic when firms collaborate with suppliers where information asymmetries make it difficult to ensure aligned interests. The resulting agency problems can be categorized as follows:

(1) Moral hazard refers to the agent shirking their responsibilities (e.g., suppliers skipping quality controls). It occurs when principals have difficulties in monitoring the agent's actions.

(2) Adverse selection refers to the agent misrepresenting one's abilities or intentions. It occurs when principals are unable to screen these aspects either at the time of hiring or while the agent is working.

To address these issues, AT suggests that a firm's choice to use vertical integration as a governance mechanism reflects a balance between the costs and effectiveness of implementing internal control and screening mechanisms, and the net benefits of vertical integration. Although implementing internal measures may help monitor agents without altering firm boundaries, they can be costly and flawed. And although vertical integration reduces agency costs, bureaucratic inefficiencies and higher fixed costs may arise from it (Eisenhardt, 1989).

2.3 An Analysis of Vertical Integration and Financial Performance

The relationship between vertical integration and financial performance is a well studied topic with several authors investigating this relationship across various industries (e.g., Misund, 2016 – oil and gas; Simhauser et al., 2015 – electricity; Grau & Reig, 2015 – agrifood; Kaiser & Obermaier, 2020 – manufacturing; Charrey, October 2023 – forestry). However, findings remain mixed with some highlighting gains in financial stability and efficiency, while others point to increased administrative costs and diminishing returns.

2.3.1 Earnings Volatility

Vertically integrated firms in the energy sector show evidence of less volatile earnings compared to their non-integrated counterparts. The authors attribute this stability to the inherently more diversified asset bases that can generate both downstream and upstream revenue, helping absorb price shocks.

In the electricity industry, for example, vertically integrated firms could stabilize earnings by offsetting losses in generation with gains in retail when prices fall, and vice versa when prices rise. Similarly, Misund (2016) states that integrated oil and gas firms benefit from the more stable downstream revenues, which help mitigate the impact of commodity price fluctuations.

In the forestry sector, Charrey (October, 2023) highlights similar findings, noting that integrated firms enjoy stabilized earnings, as timber holdings naturally act as a hedge against fluctuating timber prices, with price shocks being partially absorbed by downstream operations. Similarly, the Brazilian pulp firm Suzano’s vertically integrated model enables it to manage input price swings and maintain stable earnings according to Moody’s Investors Service (2022), attributing this stability to their control over timber, energy, and logistics which mitigates their exposure to external market turbulence.

However, while these authors found vertical integration to stabilize earnings, this effect should not be interpreted as universal. As Stuckey & White (1993) note, returns from interlinked supply chain stages are often correlated. This suggests that vertical integration may not always provide diversification benefits, meaning its ability to stabilize earnings likely depends on industry and firm specific factors. D'Aveni & Ravenscraft (1994) support this notion, arguing that vertical integration in industries with highly uncertain demand can amplify earnings volatility rather than reduce it, as it may introduce strategic rigidity and more administrative costs.

Moreover, the work by Charrey (July, 2023) raises the question of how impactful vertical integration truly is in this aspect. The author notes that upstream-focused forestry firms such as timber REITs, while more exposed to swings in pure wood demand and prices, are also able to adjust harvest rates accordingly to market conditions—for instance, reducing harvests and accumulate stock during low prices and increasing harvests during high prices—providing them with a degree of earnings flexibility which can smoothen out earnings over time.

2.3.2 Profitability

Beyond stabilizing earnings, vertical integration can also impact overall firm profitability. In the Spanish agrifood industry, Grau and Reig (2015) found that vertically integrated firms were better at sustaining profitability levels in the context of the 2008 economic crisis, experiencing less decline in return on assets (ROA) compared to non-integrated firms. Similarly, Kaiser and Obermaier (2020) also found a positive correlation between vertical integration and financial performance in the German manufacturing industry.

Grau and Reig (2015) underscore reduced transaction costs and supplier dependence, which lowered firms' exposure to input price swings and supplier opportunism, as key reasons for this resilience. Furthermore, the authors suggest that integrated firms, due to improved control over raw materials, are better positioned to uphold product quality and brand reputation during crises, which might contribute to their resilience.

Similarly, Kaiser and Obermaier (2020) attribute this correlation to cost savings and reduced supplier dependence, alongside increased market power and the ability to create internal competences that provide competitive advantages, echoing a main tenet of RBV. Interestingly, they also highlight that vertical integration may not always be positive, as their findings suggest an inverted U-shaped relationship with the best financial performance corresponding with moderate levels of vertical integration. Buzzel (1983) supports this idea, noting that the extent of profitable vertical integration is not fixed but rather a product of the market and competitive conditions in which firms find themselves in.

In the forestry sector, Charrey (October, 2023) suggests similar impacts, with integrated firms mostly maintaining stable return on capital employed (ROCE) and EBIT margins even during the economic downturn of 2007 to 2009. This becomes especially impressive considering the significant impact the crisis had on U.S. firms concentrated in the primary wood segment[2]. They experienced a 31% decline in industry output value, with almost every major mill undergoing curtailments and more than 30 large mills closing permanently (Keegan et al., 2012).

On the other hand, the ROCEs of upstream-focused REITs can generally be assumed to be comparatively low considering the vast majority of their assets biologically appreciate in value and do not generate income until harvested; this accumulation of assets combined with average harvest rates of 2-4%, as found by Charrey (July, 2023), suggest modest income relative to their asset base.

2.3.3 Contextual Fit and the Theory of Best Ownership

Beyond transaction cost and resource-based explanations, the relationship between vertical integration and financial performance may also depend on firm-specific characteristics and the strategic context in which integration occurs. Kaiser and Obermaier (2020) find that integration is positively associated with financial health but suggest that the relationship is nonlinear and that the best performance occurred at moderate levels of integration, implying that beyond a certain point, the complexity and loss of flexibility may outweigh the benefits. This reinforces the idea that vertical integration is not inherently beneficial in all cases, but rather depends on factors such as firm capabilities, asset specificity, and industry context.

This view closely aligns with the theory of optimal or best ownership, developed by Grossman and Hart (1986) and Hart and Moore (1990), which holds that ownership should lie with the party best able to derive value from controlling an asset. In the forestry sector, this implies that firms with the necessary scale, operational competence, or investment capacity

[2] The primary wood segment refers to the upstream stages of forestry operations, including logging and the initial processing of timber into basic products such as planks.

are best positioned to successfully internalize upstream assets. Firms lacking these characteristics may find long-term contracts to be a more efficient sourcing strategy. This theoretical framework offers a valuable lens for interpreting our empirical findings, particularly why vertical integration appears to enhance profitability for some firms but not others.

2.3.4 ESG and Financial Performance in Modern Forestry Firms

To get a deeper understanding of how vertical integration may impact financial performance in the forestry industry, it is crucial to also acknowledge the effects of another variable at play with this strategy: ESG. In addition to the historical advantages of leveraging vertical integration—such as improved cost efficiency and supply chain stability—modern forestry firms also reap benefits from sustainable supply chains.

In recent times, ESG factors have become increasingly material for firms across industries, including forestry. Research on companies worldwide suggest that strong ESG practices can positively influence firm performance, potentially constituting a competitive advantage in its own right by boosting investor appeal and financial resilience (Taliento et al., 2019; Friede et al., 2015). In the forestry sector, the same relationship seems to hold according to Zeng & Jiang (2023). However, they find that the strength of this relationship may vary from market to market. In highly developed markets with higher ESG standards, this influence on performance was weaker and vice versa for less developed markets. Thus, forestry firms may best benefit from the ESG effect in regions where it differentiates them, rather than where it is vastly required by all firms.

Vertical integration serves as an effective way to strengthen ESG practises by providing firms with firm control over the implementation of sustainable practices within their supply chains—see, for example, the SCA's Östrand mill construction in Sweden. The €150 million investment allowed SCA to leverage renewable energy sources and reforestation efforts to make this mill's carbon footprint "smaller than that of any comparable mill in the world". This investment not only helped SCA to boost production capacity, it also helped them capitalize on the growing demand for sustainable wood products while creating over 1,500 jobs in the process, illustrating how the pursuit of ESG may both directly and indirectly impact financial performance (European Investment Bank, 2022)

2.4 Risks and Trade-offs of Vertical Integration

Although the previous texts have mostly discussed the potential perks of vertical integration—such as diversified income streams, market volatility protection, enhanced ESG performance—it is important to recognize that the benefits and the associated costs extend beyond what has been discussed. Next, we thus aim to paint a more holistic picture of this strategy by outlining some less discussed benefits and potential downsides that may apply to the sector.

One such underexplored benefit is vertical integration's potential to lower a firm's cost of equity capital (Yu et al., 2025). The authors find that, in addition to the effects of reduced supply chain risks, integration also minimizes information asymmetry for investors as firms improve visibility into operations, enabling more accurate, consistent, and transparent disclosures, thereby lowering the risk premium associated with investor uncertainty. Fu (2023) draws this parallel into forestry by describing how, in addition to acting as a hedge against price volatility, combining low volatility timber assets with downstream activities may lower the risk beta of the combined entity as a whole. The author also notes how backward integration can improve capital access, as forest assets can serve as loan collateral, and create tax efficiencies by (1) offsetting divisional gains and losses against each other; and (2) enabling timber revenue to be taxed as capital gains rather than as income in some jurisdictions, including the United States.

On the other hand, vertical integration inherently involves increasing operational layers and complexity, which can lead to coordination challenges, underutilized capacity, and increased costs (D'Aveni & Ravenscraft, 1994). Additionally, Buzzel (1983) argues that internalizing production risks making facilities in one stage of the process obsolete in changing market conditions, not only reducing strategic flexibility but also possibly introducing inertia as exit barriers are created. D'Aveni & Ilinitch (1992) discuss these risks in the forest product industry in their study on complexity, measured as a net score of the number of links between production stages and Gort's (1962) vertical diversification measure, in vertically integrated forest firms and how it correlates with firms' beta and bankruptcy likelihood. They concluded a positive correlation in turbulent market environments, attributing this elevated risk to a combination of firm inertia, coordination difficulties, and underutilized processes that limit efficiency and strategic flexibility.

2.5 Contribution and Hypothesis

Although vertical integration has been explored across multiple industries, there remains a significant lack of empirical evidence within the forestry sector. In particular, little is known about the impact of vertical integration as a continuous variable on financial performance measures such as profitability and earnings volatility in the forest products industry.

Previous studies have examined the relationship between vertical integration and financial performance (e.g., Simhauser et al., 2015; Kaiser & Obermaier, 2020), financial risk in the forestry sector (D'Aveni & Ilinitch, 1992), and the determinants of backward integration through forest ownership (see Korhonen et al., 2014). But to our knowledge, none have explored how varying degrees of vertical integration—consistent with Perry's (1989) idea of partial integration—affect our variables of interest within the forest products industry. This is something we believe warrants examining in more detail, especially when considering the global importance of the forestry sector and the mixed findings in the broader literature regarding how vertical integration impacts financial outcomes.

We address this gap by creating a unique dataset of major forest products firms across the world, including North America, Scandinavia, South America, and Europe. Our sample contains firms with varying levels of integration, which should enable a more granular analysis of how the extent of internal sourcing may affect these financial metrics. To test this relationship, we measure vertical integration as the percentage of raw materials sourced internally, earnings volatility as the standard deviation of EBITDA, and profitability as the operating margin. Based on this research design, we test the following hypothesis:

$H0_1$: There is no significant relationship between the level of vertical integration and the volatility in earnings in the forest products industry.
$H0_2$: There is no significant relationship between the level of vertical integration and the level of profitability in the forest products industry.

The overarching aim of our study is to provide relevant insights reflective of the various states of vertical integration of firms in this industry. Given our focus on both profitability and earnings volatility, we expect our findings to not only contribute to the academic literature, but also to professionals—such as investors and policy makers—who evaluate and oversee this industry, by offering a deeper understanding of the financial impacts of this classic strategy on the global forestry sector.

3. Methodology

3.1 Research Design

This thesis employs a quantitative research design using panel data to examine the relationship between vertical integration and two dimensions of financial performance in the forestry sector: profitability and earnings volatility. The study covers 42 international firms operating in forest products over a five-year period (2020–2024), allowing us to test whether more vertically integrated firms demonstrate systematically different financial outcomes compared to their less integrated peers.

Our analysis uses Ordinary Least Squares (OLS) regression models, with robust standard errors and bootstrapping measures to correct for potential heteroscedasticity and normality concerns. To further ensure the accuracy of coefficient estimates, we also assess the models' adherence to multicollinearity and linearity assumptions by assessing their Variance Inflation Factors (VIF) and Harvey-Collier statistics. The regressions control for key firm-level characteristics, including capital expenditure, age, leverage, and size. Furthermore, a semi-structured interview with a senior equity analyst from Danske Bank's Stockholm office was conducted to enrich the discussion and interpretation of our quantitative analysis.

3.2 Preliminary Model Specifications

3.2.1 Model 1: Earnings Volatility (Hypothesis 1)

To test Hypothesis 1, we begin with a preliminary specification to examine the effect of vertical integration on earnings volatility. The initial model is formulated as follows:

$$Earnings\ Volatility_i = \alpha + \beta_1 Vertical\ Integration_i + \beta_2 CapEx_i + \beta_3 Age_i + \beta_4 Leverage_i + \beta_5 LogSize_i + \varepsilon_i$$

Where:

$EarningsVolatility_i$: The range (min/max) of EBITDA margin (2020–2024)

$Vertical\ Integration_i$: Share of wood fiber sourced internally

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$CapEx_i$: Capital expenditures divided by total revenue (CapEx/Sales)

Age_i : Number of years since the firm's founding

$Leverage_i$: Defined as Debt/Equity[3]

$LogSize_i$: Natural logarithm of total revenue

3.2.2 Model 2: Profitability (Hypothesis 2)

To test Hypothesis 2, we also begin with a preliminary specification to examine the effect of vertical integration on profitability. In line with the previous model, we include the same set of firm-level controls to maintain consistency in the estimation framework.

$$Profitability_i = \alpha + \beta_1 Vertical\ Integration_i + \beta_2 CapEx_i + \beta_3 Age_i + \beta_4 Leverage_i + \beta_5 LogSize_i + \varepsilon_i$$

Where:

$Profitability_i$: The average EBITDA margin (2020–2024)[4]

3.3 Data Collection and Sample Selection

To test the proposed hypotheses, we constructed a panel dataset comprising 42 forestry, pulp and paper companies[5] operating across a range of countries and market contexts. These firms were selected based on their comparability in terms of operational scope and the availability of consistent financial data.

[3] We acknowledge that high leverage is not reflected in EBITDA margins, but we include it since it is a commonly used control variable and that highly leveraged firms likely exhibit corresponding behaviours such as cost control that impact EBITDA margins.

[4] EBITDA margin is used as the profitability measure due to its comparability across firms with different capital structures, tax jurisdictions, and depreciation schedules. It isolates operating performance more effectively than net income-based metrics.

[5] These companies operate in the production of different types of forest-based products, including timber, pulp, paper, and wood-derived materials, and display varying degrees of upstream vertical integration, particularly with respect to forest ownership.

Table 1

Forestry Firms Included in the Study

Country	Company
Sweden	Ahlström-Munksjö, Billerud AB[6], Essity AB, Holmen AB, Nordic Paper Holding AB, Rottneros AB, SCA AB, Södra Skogsägarna ekonomisk förening, Stora Enso Oyj[7]
Finland	Mätsä Board Corporation, UPM-Kymmene Corporation
Ireland	Smurfit Kappa Group plc[8]
Portugal	Altri SGPS, S.A., Semapa SGPS, S.A., The Navigator Company, S.A.[9]
Spain	ENCE Energía y Celulosa, S.A.
Norway	Norske Skog ASA
UK	Mondi plc
Poland	Arctic Paper S.A.
Canada	Canfor Corporation, Canfor Pulp Products Inc., Mercer International Inc., Resolute Forest Products Inc.[10], West Fraser Timber Co. Ltd., Western Forest Products Inc.
USA	Domtar Corporation[11], International Paper Company, Kimberly-Clark Corporation, PotlatchDeltic Corporation, Rayonier Inc., Sylvamo Corporation[12], Weyerhaeuser Company
Japan	Oji Holdings Corporation
China	C&S Paper Co., Ltd., Hengan International Group Company Limited, Lee & Man Paper Manufacturing Ltd., Nine Dragons Paper (Holdings) Limited

[6] In 2022, BillerudKorsnäs AB rebranded to Billerud AB, reflecting a simplified corporate identity following the full integration of Korsnäs acquired in 2012.
[7] While headquartered in Finland, Stora Enso has significant operations in Sweden. It is often included in both countries' forestry sector analyses depending on context.
[8] In 2023–2024, Smurfit Kappa merged with US-based WestRock to form a new entity, Smurfit WestRock
[9] Formerly Portucel Soporcel
[10] Resolute Forest Products was acquired by Paper Excellence in 2023, joining its sister company Domtar under the same ownership structure.
[11] Domtar was acquired by the Canadian group Paper Excellence in 2021, becoming part of a vertically integrated global pulp and paper conglomerate.
[12] Sylvamo was spun off from International Paper in 2021 to focus on global uncoated paper markets. It now operates independently, with a strategic footprint primarily outside North America.

Mexico	Kimberly-Clark de México, S.A.B. de C.V.[13]
Chile	Celulosa Arauco y Constitución S.A. (Arauco), Compañía Manufacturera de Papeles y Cartones S.A. (CMPC)
Brazil	Klabin S.A., Suzano S.A.
Total	42

The primary financial data—including EBITDA, EBIT, revenue, capital expenditure, debt, and total assets—were collected from company annual reports, complemented by standardized financial databases (e.g., Capital IQ and Orbis). All financial figures were converted to USD to ensure comparability across firms and regions, using average annual exchange rates for each year.

The data spans the period 2020–2024, a five-year window chosen because it reasonably captures a full economic cycle, in order to capture cyclic fluctuations. This balance makes it possible to observe how structural characteristics such as vertical integration affect firm performance across varying macroeconomic conditions.

To ensure consistency and accuracy, the dataset underwent a systematic filtering and cleaning process. Firms with incomplete or missing financial data for any year within the 2020–2024 window were excluded. Additionally, firms with irregular reporting structures, significant M&A activity that compromised year-to-year comparability, or outlier figures that could not be verified were also removed.

Where available, discrepancies between database values and annual report figures were resolved manually, with preference given to primary-source company disclosures. All ratio variables (e.g., EBITDA margin, capex/sales) were recalculated to maintain consistency in definitions across firms. Firm-level variables such as capital expenditure, age, leverage, and size were standardized across the panel to facilitate valid regression comparisons.

3.3.1 Vertical Integration Data

The data on vertical integration, measured as the percentage of wood fiber sourced internally, were obtained through analyst estimates provided by a senior equity analyst contact at Danske

[13] Kimberly-Clark de México operates independently from its U.S. parent, Kimberly-Clark Corporation, and is publicly listed on the Mexican Stock Exchange.

Bank's Stockholm office. These estimates are considered reliable within the investment community and reflect both publicly available disclosures and industry-specific knowledge.

Vertical integration is operationalized as a firm's total wood fiber self-sufficiency, which is further broken down into two categories:
(1) Owned forest resources: The share of wood fiber sourced from forests the company owns and manages.
(2) Long-term contract sourcing: Wood fiber sourced from contracted forest owners under long-term agreements.

The aggregate of these two components constitutes each company's vertical integration level as a percentage of its total wood fiber input.

4. Findings and Analysis

4.1 Description of Data

In table 2, a descriptive statistical summary of the dependent, independent, and control variables is presented. The table displays the mean, standard deviation, minimum, and maximum values for each variable for an effective overview of our sample's distribution and variability.

Table 2

Descriptive Statistical Summary of the Variables

Variables	Mean	Std. Dev	Min	1st Qu.	Median	3rd Qu.	Max
Earnings Volatility	13.482	8.113	1.651	6.622	11.843	15.513	35.939
Profitability	20.537	11.966	3.219	13.331	16.938	24.797	67.641
Vertical Integration	0.295	0.304	0.000	0.050	0.200	0.500	0.950
CapEx	0.010	0.081	0.030	0.056	0.074	0.098	0.393
Age	77.450	29.506	8.000	59.250	97.500	100.000	105.000
Leverage	1.191	1.864	0.006	0.291	0.681	0.896	9.678
LogSize	7.874	1.097	5.444	7.003	7.980	8.802	9.807

Note. For descriptive statistics of the raw Size variable, see appendix Table A1.

From table 2, we observe that the variation across all variables in our data is generally high. In earnings volatility, the maximum of 35.939 in relation to the quartile values over the five year period suggests significant variation in firms' ability to maintain financial stability, which is further evidenced by the standard deviation of 8.113 relative to the 13.482 mean. The average profitability is estimated at 20.537% with a standard deviation of 11.966 percentage points, indicating a wide spread in the firms' profit-making ability. Shifting our focus to vertical integration, the average of 29.5%, also shows extreme variability when considering the standard deviation 30.4%, which suggests that firms in our sample employ vastly varying supply chain strategies within this sector, ranging from non-existent to nearly full vertical integration suggested by the min and max values. Taking a closer look at its quartile values, they indicate that a majority of firms in our sample rely significantly on external sources for their wood fiber needs. The median indicates that half of the firms possess relatively low levels of vertical integration not exceeding 20%, while the third quartile value of 0.500 reveals that 75% of the firms do not exceed a 50% level of vertical integration.

4.1.1 Preliminary Model Diagnostics and Adjustments

After constructing our initial models, we conducted a series of tests to examine their adherence to the assumptions of Ordinary Least Squares (OLS) methodology; a critical step to improve the accuracy and reliability of our interpretations and conclusions. We will start with presenting the results of the initial diagnostic tests, which will be followed by a discussion of the corresponding adjustments made to refine the models.

Our initial diagnostic tests examined the fundamental assumptions of normality, linearity, homoscedasticity, and multicollinearity. The results of the first three tests are summarized in Table 3 and Table 4. For detailed results of our multicollinearity test, see appendix A2.

Table 3

Initial Earnings Volatility Model: Diagnostics Summary

Test	Statistic	Degrees of Freedom	P-value	Interpretation
Breusch-Pagan	3.1663	5	0.6744	Homoscedasticity
Harvey-Collier	0.38346	35	0.7037	Linearity
Shapiro-Wilk	0.90217	NA	0.00167	Non-normality of Residuals

Table 4

Initial Profitability Model: Diagnostics Summary

Test	Statistic	Degrees of Freedom	P-value	Interpretation
Breusch-Pagan	24.643	5	1.63e-04	Heteroscedasticity
Harvey-Collier	4.4473	35	8.41e-05	Non-linearity
Shapiro-Wilk	0.9354	NA	0.0198	Non-normality of Residuals

From these summaries, we can see that our initial earnings volatility model demonstrated satisfactory homoscedasticity and linearity results, with the Breusch-Pagan and Harvey-Collier tests yielding p-values greater than 0.05 (0.6744 and 0.7037 respectively), we thus fail to reject the null hypotheses of homoscedasticity and linearity between our variables. However, the Shapiro-Wilk test was indicative of non-normally distributed residuals in our model, as it returned a p-value less than 0.05 (1.63e-04). On the other hand, the initial profitability model faced many challenges, failing both the homoscedasticity and linearity checks, as evidenced by Breusch-Pagan and Harvey-Collier tests with p-values of 1.63e-04 and 8.41e-05 respectively. Additionally, the Shapiro-Wilk test indicated that the assumption of normally distributed errors does not hold, with a p-value of 0.0198. On a positive note, neither model demonstrated multicollinearity issues as seen in the low VIFs—the highest being capex's 1.499.

In light of these results, we began by log-transforming our dependant variables to normalize the data while also reducing the influence of outliers, which can be exemplified in Table 2 as values exceeding 1.5 times the interquartile range from the third quartile—for example, maximum values of 35.939 for earnings volatility and 67.641 for profitability. To address the linearity issues in our initial profitability model, we added a centered quadratic term, clogsize^2, a common procedure used to capture non-linear relationships (see Karakoc, 2025). Informed by our Component + Residual Plots, this diagnostic revealed a convex U-shaped deviation from the line of best fit for LogSize—indicative of a quadratic relationship between the variables that a squared term would be better at capturing. For a detailed summary of the plot, see Figure A3 in the appendix. This finding also resonates with studies such as Karakoc (2025) that find the relationship between firm size and profitability to often follow a nonlinear pattern rather than a strictly linear one[14]. To operationalize clogsize², we centred logsize before squaring it to reduce the inherent multicollinearity between logsize and the squared term for more reliable coefficient estimates. Finally, we chose to apply robust standard errors and a bootstrap procedure with 1,000 resamples to ensure reliable inference given the concerns of heteroscedasticity and non-normality in the initial profitability model.

4.2 Hypothesis Testing

Building on the model diagnostics and adjustments discussed above, including log-transformations, a centered squared term for firm size, and robust standard errors, we proceeded to test our two hypotheses using the following finalized models:

H0$_1$: There is no significant relationship between the level of vertical integration and the volatility in earnings in the forest products industry.

$$LogEarnings\ Volatility_i = \alpha + \beta_1 Vertical\ Integration_i + \beta_2 CapEx_i + \beta_3 Age_i + \beta_4 Leverage_i + \beta_5 LogSize_i + \varepsilon_i$$

H0$_2$: There is no significant relationship between the level of vertical integration and the level of profitability in the forest products industry.

$$LogProfitability_i = \alpha + \beta_1 Vertical\ Integration_i + \beta_2 CapEx_i + \beta_3 Age_i + \beta_4 Leverage_i + \beta_5 cLogSize_i + \beta_6 cLogSize^2_i + \varepsilon_i$$

4.3 Summary of Results

4.3.1 Regression Results - Hypothesis 1

We will now present the results of our finalized earnings volatility regression model to empirically evaluate the relationship between vertical integration and earnings volatility. The regression results are displayed in Table 5 below. For the regression results of the preliminary models, see in the appendix Table A4 and Table A5.

[14] The author explains that initially, firm growth may increase profitability as firms benefit from, among others, economies of scale and improved access to financing. However, after a certain point, the net negative impacts of additional growth as diseconomies of scale, organizational inertia, and coordination costs might begin to outpaces these incremental benefits.

Table 5

Finalized Earnings Volatility Model: Regression Output

Variable	Coef.	SE	t-value	Pr(>|t|)	Sig.
Intercept	3.949	0.643	6.143	4.47e-07	***
Vertical Integration	0.501	0.319	1.572	0.125	
Capex	-0.253	1.212	-0.209	0.836	
Age	-0.002	0.003	-0.799	0.430	
Leverage	-0.075	0.045	-1.675	0.103	
LogSize	-0.162	0.075	-2.162	0.037	*
Residual SE	0.512	df	36	F-statistic	2.945
Multiple R^2	0.291	Adj. R^2	0.192	p-value	0.025

Note. ****p* < 0.001, ***p* < 0.01, **p* < 0.05, .*p* < 0.1. *Blank cells indicate* *p* ≥ 0.1.

From the table, we can see that approximately 29% of the variation in earnings volatility (multiple $R^2 = 0.291$) is explained by the model, with an adjusted R^2 of 0.192. Although these numbers are indicative of a relatively modest explanatory power, our model's F-statistic ($F = 16.02$, $p < 0.05$) indicates that it is statistically significant.

Vertical integration surprisingly has a positive coefficient ($\beta = 0.501$), suggesting that more integrated firms experience higher earnings volatility. However, this effect is not statistically significant ($p = 0.125$), which leads us to accept the null hypothesis that no significant relationship exists between vertical integration and earnings volatility.

Logsize is found to have a statistically significant negative effect on earnings volatility ($\beta = -0.162$, $p = 0.037$), with a 1 unit increase in the log of the firm size decreasing earnings volatility by 0.162 units. On the other hand, our other control variables—capex, age, and leverage—are shown to have no statistically significant effect on earnings volatility. However, leverage ($\beta = -0.075$, $p = 0.103$) is borderline significant at the 10% level, indicating the potential existence of a negative relationship between debt and earnings stability for firms in this industry.

Lastly, the intercept is highly significant ($p < 0.001$) and of considerable magnitude ($\beta = 3.959$), evidencing a strong baseline level of earnings volatility when all independent variables are set to zero, evidence of notable inherent volatilities for firms in this industry.

4.3.2 Regression Results - Hypothesis 2

Table 6

Finalized Profitability Model: Regression Output

Variable	Coef.	SE	t-value	Pr(>|t|)	Sig.
Intercept	2.559	0.147	17.367	< 2e-16	***
Vertical Integration	1.428	0.186	7.684	5.12e-09	***
Capex	-0.074	0.696	-0.106	0.916	
Age	-0.003	0.002	-1.561	0.128	
Leverage	0.078	0.025	3.143	0.003	**
cLogSize	0.054	0.042	1.261	0.216	
cLogSize²	0.070	0.034	2.088	0.044	*
Residual SE	0.280	df	35	F-statistic	16.02
Multiple R²	0.733	Adj. R²	0.687	p-value	9.259e-09

The results from the model examining the effect of vertical integration on firm profitability are presented in Table 6. The model explains a substantial portion of the variation in profitability, with an adjusted R^2 of 0.687. The F-statistic ($F = 16.02$, $p < 0.001$) confirms that the model is statistically significant overall.

Vertical integration exhibits a strong and statistically significant positive relationship with profitability ($\beta = 1.428$, $p < 0.001$); this finding leads us to reject our null hypothesis since higher levels of internal sourcing of wood fiber are associated with increased firm profitability. In practical terms, a one-unit increase in the vertical integration index (e.g., moving from 0% to 100% internal wood fiber sourcing), is associated with a 1.428 increase in profitability, corresponding to a notable increase in EBITDA margin. This result is consistent with prior literature emphasizing the strategic and cost advantages of vertical integration, particularly in industries characterized by high input volatility and supplier dependence (Grau & Reig, 2015; Charrey, October 2023).

The coefficient for logsize is positive but not statistically significant (β = 0.054, p = 0.216), while its squared term is also positive and statistically significant (β = 0.070, p = 0.044). Together, these coefficients indicate a nonlinear, accelerating relationship between firm size and profitability. That is, while small increases in size have limited impact, profitability tends to rise more steeply as firms become larger.

Leverage has a positive and statistically significant relationship with profitability (β = 0.078, $p < 0.01$), indicating that firms with higher debt-to-equity ratios in the sample tend to report higher EBITDA margins, holding other variables constant. Age does not show a statistically significant association with profitability (β = –0.003, p = 0.128). Similarly, capital expenditure intensity is also not significantly related to profitability (β = –0.074, p = 0.9159).

Table 7

Finalized Profitability Model: Robust Standard Errors and Bootstrap Estimates

Variable	SE	t-value	Pr(>|t|)	Bootstrap SE	Bootstrap 95% CI
Intercept	0.134	19.149	< 2e-16	0.156	2.267, 2.879
Vertical Integration	0.157	9.113	9.087e-11	0.165	1.108, 1.791
Capex	0.479	-0.155	0.878	0.695	-1.6202, 1.2256
Age	0.001	-2.235	0.032	0.001	-0.0054, -0.0003
Leverage	0.024	3.311	0.002	0.033	0.002, 0.143
cLogSize	0.047	1.140	0.262	0.054	-0.0215, 0.1923
$cLogSize^2$	0.028	2.479	0.018	0.043	-0.0496, 0.1253

Taken together with Table 6, the results presented in Table 7 confirm the robustness of our main finding: the positive effect of vertical integration on firm profitability as the coefficient for vertical integration. Originally estimated at β = 1.428 in Table 6, the effect remains highly significant under both robust and bootstrap methods. In Table 7, we can see its robust standard error of 0.157 with a bootstrap standard error of 0.165, both of similar magnitude and below the original OLS standard error of 0.186, suggesting that the coefficient estimate is stable and not overly sensitive to the measure used. The resulting robust t-value of 9.113 and the bootstrap 95% confidence interval of ([1.108, 1.791]), which excludes zero, further support the effect's statistical significance.

In contrast, under the bootstrap, the squared term for firm size (cLogSize²) is no longer significant as its confidence interval includes zero. However, leverage remains significant, with a confidence interval ([0.002, 0.143]) that narrowly excludes zero, suggesting a positive but potentially more modest and less certain effect than what was previously indicated by our original OLS regression.

4.4 Diagnostics of Final Models

Following the adjustments to our models, we conducted a second round of diagnostic tests to reassess the finalized models' adherence to the same key OLS assumptions (see Table 8 and Table 9 below). We will additionally examine the strength and direction of linear relationships among the independent variables in our models using a correlation matrix.

Table 8

Finalized Earnings Volatility Model: Diagnostics Summary

Test	Statistic	Degrees of Freedom	P-value	Interpretation
Breusch-Pagan	2.6353	5	0.756	Homoscedasticity
Harvey-Collier	0.5634	35	0.5767	Linearity
Shapiro-Wilk	0.9862	NA	0.8857	Normality of Residuals

Table 9

Finalized Profitability Model: Diagnostics Summary

Test	Statistic	Degrees of Freedom	P-value	Interpretation
Breusch-Pagan	3.846	6	0.6975	Homoscedasticity
Harvey-Collier	4.7468	34	3.65e-05	Non-linearity
Shapiro-Wilk	0.8759	NA	2.95e-04	Non-normality of Residuals

Beginning with the earnings volatility model, it continued to satisfy the homoscedasticity and linearity assumptions, as evidenced by the Breusch-Pagan and Harvey-Collier tests with p-values of 0.756 and 0.5767 respectively. Most notably, the Shapiro-Wilk test revealed an improvement in the distribution of residuals with a p-value of 0.8857. Shifting our focus to the finalized profitability model, our adjustments lead to great improvements in homoscedasticity with the Breusch-Pagan test p-value increasing from 0.0001633 to 0.6975.

However, challenges with non-linearity and non-normally distributed residuals persist as seen in the Harvey-Collier and Shapiro-Wilk tests' p-values (3.65e-05 and 2.95e-04 respectively). Multicollinearity continued to not be a concern, as all VIFs remained well below 2—the highest being for vertical integration (1.673). For more details, see appendix Table A6.

Table 10

Correlation Matrix of Variables

Variable	1	2	3	4	5	6	7	8
LogP	1							
LogEV	0.05	1						
VI	0.78	0.27	1					
CapEx	0.47	0.14	0.48	1				
FirmAge	0.06	-0.15	0.16	-0.19	1			
Leverage	0.24	-0.33	-0.02	0.07	0.19	1		
LogSize	-0.01	-0.39	-0.13	-0.12	0.09	0.16	1	
$cLogSize^2$	-0.01	-0.17	-0.16	0.13	0.04	-0.13	-0.25	1

Note. LogP = LogProfitability; LogEV = LogEarningsVolatility; VI = Vertical Integration. Centered LogSize (cLogSize) was excluded since its correlational structure was identical to LogSize.

Similarly, the correlation matrix estimates generally raise no concerns of multicollinearity, nor does it suggest any alarming risks of confounding effects in our model. As expected, vertical integration showcases a strong positive correlation with profitability (LogP) ($r = 0.78$), while it's only weakly associated with earnings volatility (LogEV) ($r = 0.27$). On a bivariate level, this resonates with our findings that vertical integration appears to be more correlated with profitability than with earnings volatility in general. We can also see that, when examining for potential confounding effects of firm size, it is only modestly correlated with vertical integration (LogSize: $r = –0.13$), suggesting that firm size is unlikely to have biased the observed relationship between vertical integration and our dependent variables. Taking these results together with the earnings volatility model's output, vertical integration and earnings volatility still exhibits a positive relationship (r = 0.27), and as for logsize, it also maintains a negative correlation with earnings volatility (r = –0.39). This implies that larger firms tend to exhibit greater earnings stability, independent of their degree of vertical integration. These findings also echo our regression result, where logsize emerged as a statistically significant predictor of reduced earnings volatility ($\beta = -0.162$, $p = 0.037$), while vertical integration was insignificantly positive.

All in all, the vast majority of variables in the matrix are only minimally or moderately correlated with each other, which is positive as it reduces concerns of multicollinearity and biased coefficient estimates. Vertical integration (with profitability) and capex (with profitability and vertical integration) stand out as the only relationships exhibiting noteworthy high correlations ($r > \pm 0.40$). However, these are expected as the correlation between capex and vertical integration is reflective of the capital-intensive nature of vertical integration, while the strong associations of both variables with profitability are consistent with the previously discussed literature on the effects of investments into supply chain control on firm performance. It is also important to acknowledge that capex, despite showing a strong correlation with profitability, did not emerge as a statistically significant predictor in the regression analysis.

5. Discussion

This part describes the empirical findings in the light of the theoretical models and industry context. Rather than revisiting results, we focus on understanding their implications for strategic decision-making, the trade-offs inherent in vertical integration, and how these insights align with, or challenge, existing literature. The discussion also considers limitations in our methodology and measurement, and suggests directions for future research.

5.1 Interpretation of the Profitability Findings

The positive and statistically significant relationship observed between vertical integration and profitability supports our second hypothesis and aligns with both theoretical expectations and prior studies. The coefficient estimate ($\beta = 1.428$, $p < 0.001$) indicates that firms with higher internal wood fiber sourcing achieve substantially higher EBITDA margins (while accounting for size, leverage, capital intensity, and age).

This result can be understood through several strategic management theories. In light of transaction cost theory (TCT), upstream integration reduces exposure to market-based transaction costs—such as input price volatility, supplier opportunism, and contract renegotiation (Williamson, 1993). In the forestry sector, where input prices fluctuate with macroeconomic cycles, securing raw materials internally enables more predictable and efficient operations, and as a result, directly improves margins.

Another aspect is the structural resilience of integrated firms. By controlling core inputs, they are less susceptible to supply disruption and can provide constant output irrespective of economic fluctuation. This aligns with previous research in agrifood and manufacturing sectors; where integrated firms outperform their counterparts during economic downturns (Grau & Reig, 2015; Kaiser & Obermaier, 2020).

However, improved profitability does not necessarily equate to better capital efficiency or financial flexibility (discussed further in Section 5.3). The capital intensity of vertical integration—particularly in forestry, where assets are long-term and illiquid—may constrain returns on capital despite stronger margins. This underscores a broader trade-off: although vertical integration improves profitability, it may also impede adaptive capital allocation and liquidity.

5.1.1 Supply Assurance and Investment Incentives

Another explanation for the observed profitability differences is that firms with greater control over their raw material supply may be more inclined to make long-term investments in capital-intensive industrial operations. In industries—such as pulp and paper—where facilities require significant upfront capital and long asset life cycles, supply security can reduce perceived risk and increase the willingness to invest in capital-intensive infrastructure. Vertically integrated firms, particularly those with forest ownership or long-term contracts, may therefore achieve higher profitability by operating at greater scale and with improved efficiency.

In contrast, firms that lack control over key inputs may be more hesitant to invest in industrial capacity. This hesitation can deter from expanding production, thus reducing operational efficiency, and ultimately lowering profitability. According to an equity analyst at Danske Bank (interview, April 20, 2025), this dynamic is likely to be more pronounced in pulp production, where firms are heavily dependent on a consistent and proximate supply of pulpwood. Pulpwood is relatively costly to transport and less easily traded across long distances, making unintegrated pulp producers more geographically constrained. In contrast, paper producers—typically closer to the downstream end of the value chain—benefit from greater sourcing flexibility, as pulp is a globally traded commodity. It may therefore be the case that those firms with the highest degree of forest ownership or control are pulp producers, whose operations lie further upstream and are more capital intensive. These characteristics strengthen their strategic incentive to secure input availability through upstream integration, particularly through forest ownership or long-term contracts.

It is also worth noting that the profitability impact of capital-intensive investments might not be immediate. While CapEx exhibits a strong correlation with profitability (as seen in Table 10), it remains statistically insignificant in the regression analysis, which might suggest an effect where benefits are reaped in subsequent periods. Future research in the forest products industry could explore this further by employing models that account for time-lagged effects.

5.1.2 Best Ownership and Selection Effects

One possible explanation for the profitability advantage of vertically integrated firms is the theory of best ownership (Grossman & Hart, 1986; Hart & Moore, 1990). This theory suggests that the party best able to create value from controlling an asset should own it, particularly when contracts are incomplete and long-term investments are needed.

It may be the case that vertically integrated firms are not randomly selected; rather, they may self-select based on their comparative advantages in managing upstream operations. To some degree, the causal relationship between vertical integration and profitability reflected in the data may reflect a selection effect wherein only firms with the necessary scale, capabilities, or investment horizons chose to internalize upstream operations. This would align with Kaiser and Obermaier’s (2020) view that the financial impact of integration heavily depends on firm-specific context, and the resource-based view which suggests that firms pursue vertical integration when it positions them to leverage their unique internal resources for competitive advantage.

Thus, rather than suggesting that vertical integration is inherently more profitable, our results indicate that it might be a successful strategy when adopted by firms that are, in effect, the best owners of upstream assets.

5.2 Interpretation of the Earnings Volatility Findings

Despite our expectations and prior literature generally suggesting that vertical integration should help reduce earnings volatility, our findings do not find any support for this stabilizing effect. Instead, our results indicate the contrary: a positive relationship between vertical integration and higher earnings volatility ($\beta = 0.501$, $p = 0.125$). While the lack of statistical significance advises against drawing any definitive conclusions, it still warrants deeper exploration to better understand its unexpected direction.

One possible explanation for this finding is in how vertical integration is measured in our study: it focuses on firms' self-sufficiency in wood fiber which places the focus on timber holdings. In contrast to Charrey (October 2023), who suggests that vertical integration should stabilize earnings as such holdings can serve as natural hedges against input price volatility, our results indicate that it may increase earnings volatility by adding uncertainty to a firm's asset base. This is consistent with Misund (2016), who notes that assets with uncertain future economic benefits—such as oil reserves—can heighten earnings volatility. A similar dynamic may be at play in the forest products industry, where the valuation and cash flow potential of forestland and long-term supply contracts are likely sensitive to commodity price fluctuations, investor sentiments, and regulatory shifts such as the EUDR.

From another perspective, these timber assets can be viewed as real options given the inherent managerial flexibility to delay or adjust harvests. While this is potentially advantageous as noted by Charrey (July 2023), it is difficult to fully capture its benefits within standard accounting frameworks due to its intangible nature. This aligns with Srivastava (2014), as cited in Misund (2016), who argues that firms with high intangible asset intensity are more prone to earnings volatility due to the uncertainties of their growth opportunities and the challenges associated with recognizing these assets. As such, our vertical integration measure may inadvertently highlight the uncertainties associated with holding timber which potentially explains its observed relationship with earnings volatility.

5.2.1 Impact of Sourcing Strategy on Earnings Volatility

An important distinction as captured by our vertical integration variable that warrants closer examination is the difference between forest ownership and long-term sourcing contracts. While both constitute a firm's wood fiber self-sufficiency, they likely have different implications for earnings volatility.

Ownership of forest assets implies a high degree of control but also introduces fixed costs and limited flexibility. These characteristics may amplify earnings volatility, especially during periods of weak market demand, if firms are locked into harvesting plans or burdened by asset maintenance costs. In contrast, long-term contracts may offer greater adaptability and cost-sharing arrangements, particularly when contracts include renegotiation clauses or indexed pricing mechanisms.

Since our vertical integration measure is an aggregate of both forms of sourcing, there is a possibility that the stabilizing effects of long-term contracts are masked by the rigidity associated with forest ownership. This measurement mixing may partially explain the failure to find a statistically significant volatility-dampening effect in our results. Breaking these sourcing strategies apart in future studies may be helpful in testing whether contract-based integration is more strongly related to earnings stability than asset-based integration.

As noted earlier (Section 5.1.1), it may be the case that firms with the highest degree of vertical integration are disproportionately pulp producers rather than paper producers. This distinction is relevant, as highlighted by the Danske Bank equity analyst (interview, April 20, 2025): pulp production tends to occur earlier in the value chain and is more capital intensive, involving substantial fixed costs. In contrast, paper manufacturing typically entails lower capital commitment and allows for greater flexibility in sourcing pulp (a globally traded commodity). Compared to paper producers, pulp producers' higher share of fixed costs makes them more vulnerable to input cost fluctuations and market volatility. As a result, these firms—those most structurally exposed to volatility—may also have the strongest incentive to secure supply through upstream integration, particularly via forest ownership or long-term contracts. In this way, high volatility and high integration may coexist, not because integration fails to stabilize earnings, but because the firms most in need of stability are also the most likely to integrate. This suggests that industry segment could act as a confounding variable in the observed relationship between vertical integration and earnings volatility, which future research could control for in order to better isolate the effect of integration itself.

5.3 Trade-offs, Capital Efficiency, and ROCE

While vertical integration appears to have a positive effect on profitability, it may be the case that these higher margins may come at the cost of capital efficiency and financial flexibility. Forest ownership—a central aspect of our vertical integration measure—requires firms to maintain large and often illiquid asset bases. While these long-term investments help control margins and stabilize the supply chain, they also bind capital that may not yield immediate or high returns. As such, firms with extensive forest ownership may generate strong operating margins, yet struggle to achieve high ROCE, which underscores the significance of assessing profitability in conjunction with capital productivity rather than relying solely on income statement measures.

This trade-off becomes increasingly relevant in light of our findings on earnings volatility. While prior literature has emphasized the stabilizing role of upstream ownership—especially in commodity-based industries (e.g., Misund, 2016; Moody's, 2022; Charrey, October 2023)—our results refute the notion that vertical integration buffers earnings fluctuations. In fact, we find no statistically significant relationship between integration and earnings volatility. A conceivable explanation lies in the same capital-intensive structure outlined above. The rigidity of forest ownership may hinder a company's flexibility in responding to short-term market shocks and its ability to smooth earnings in an uncertain market environment.

Furthermore, the integration of upstream and downstream activities in vertically integrated firms can weaken the potential of diversification benefits. As Stuckey and White (1993) point out, returns from different supply chain stages often exhibit co-movement, especially during industry-wide downturns. This co-movement may amplify rather than mitigate earnings volatility. In contrast, less integrated firms (such as timber REITs or pure-play pulp producers[15]) retain operational flexibility, allowing them to adjust harvest volumes or sourcing strategies in response to current market conditions. This adaptability may, in certain scenarios,

[15] Pure-play pulp producers specialize solely in pulp manufacturing, and source wood fiber externally, displaying no upstream integration.

enable non-integrated firms to better manage earnings volatility, even without internal control of the value chain.

To better understand these dynamics, future research could further examine the relationship between vertical integration and ROCE. As a metric, ROCE (defined as EBIT divided by capital employed) offers insight into returns from invested capital, and is thus, in a sense a better measure of profitability than operating margins. Preliminary analysis in our dataset suggests a negative relationship between vertical integration and ROCE, reinforcing the idea that the profitability benefits of integration may not extend to capital productivity.

Overall, our results point to a more nuanced financial profile of vertical integration in the forest products industry. While integrated firms may enjoy higher operating margins, they potentially do so at the expense of capital efficiency, operational flexibility, as well as responsiveness to market shocks. These findings underscore the need for a more comprehensive evaluation of integration strategies, and in capital-intensive sectors like forestry in particular, where strategic control must be balanced against the realities of fixed asset intensity and long-term adaptability.

5.4 Contribution and Implications

This thesis contributes to the ongoing academic and industry dialogue on vertical integration by providing an empirical examination of its financial impact within the underexplored forest products industry. By employing a continuous variable for vertical integration based on wood fiber self-sufficiency, this study offers new insight into how varying degrees of vertical integration affects profitability and earnings volatility and advances the literature in several ways:

First, our findings reinforce RBV and elements of TCT by demonstrating a clear and statistically significant relationship between vertical integration and profitability. This supports the idea that internalizing key inputs not only reduces exposure to external market risks, but also helps firms develop and protect strategically valuable resources—such as forest assets, proprietary management practices, and ESG-aligned supply chains—that can enhance competitive positioning and margin control.

Second, our study complicates the commonly held assumption, supported by previous work in the energy sector, that vertical integration inherently reduces earnings volatility. The absence of a statistically significant relationship in our results suggests that the stabilizing benefits of integration may not generalize across all sectors, or may be contingent on the type of integration (upstream vs. downstream) being measured. This opens space for future research into how different integration profiles affect financial resilience in cyclical industries like forestry.

Third, we highlight a potential financial trade-off between profitability and capital efficiency. Our findings suggest that while vertical integration may boost operating margins, it may also limit ROCE, particularly due to the long-term, illiquid nature of forest ownership. This nuance is particularly relevant for investors, who must consider not just earnings performance but also capital productivity when evaluating forestry firms. Similarly, corporate managers must weigh the strategic value of control and ESG differentiation against the financial rigidity that may come with deeper integration.

Finally, in the context of evolving regulatory pressures and sustainability expectations, our results offer timely insights as policies such as the EUDR are incentivizing firms to increase transparency and control over their supply chains. While vertical integration may support compliance and reputational benefits in this area, our findings suggest that such strategies must be assessed not only for their ESG alignment but also for their broader financial consequences.

In conclusion, this thesis underscores the complexity of vertical integration as a strategic choice. It contributes new evidence from an under-examined industry, challenges certain generalizations found in prior literature, and provides actionable insights for decision-makers seeking to balance control, profitability, and financial flexibility in the forestry sector.

5.5 Limitations and Further Considerations

While this study offers some novel insights into the relationship between vertical integration and financial performance in the forest products industry, it is important to also acknowledge limitations that may affect the interpretation of our results. However, these do not diminish the relevance of our findings but rather highlight the complexities of studying the linkage between strategy and performance in asset-heavy sectors such as forestry. They also point to valuable avenues for future research to expand or refine upon.

Some primary limitations of our analysis relate to the sample data. Firstly, our models rely on a relatively small sample of 42 firms which, despite its international scope, risks reflecting specific trends of the sample rather than industry-wide patterns, lowering the models' statistical power and the generalizability of our findings. Specifically, large vertically integrated firms in North America and Scandinavia are possibly overrepresented relative to smaller or emerging-market players due to a lack of data availability. Increasing the number and diversity of firms in future datasets would strengthen the robustness of the results and broaden their applicability. Secondly, the sample period 2020–2024, although sufficient to capture a full economic cycle, overlaps with several extraordinary global events—including the COVID-19 pandemic and rising geopolitical tensions—that likely affected firm behavior and performance in ways that are difficult to fully control for in our models.

Additionally, the data on vertical integration levels was sourced from analyst estimates. While these estimates are considered reliable within the investment community, they are not drawn from standardized public disclosures and may contain inherent subjectivity. The absence of consistent company-level reporting on integration levels poses a challenge for future empirical work, underscoring the need for greater transparency and standardized ESG-related disclosures in the forestry sector.

Lastly, although we discuss capital efficiency using ROCE, this variable was not formally included in our hypotheses testing. This represents a possible limitation to our study, as our profitability measure—EBITDA margin—focuses on operational performance, not on how efficiently capital is used. As vertical integration often involves substantial long-term asset commitments, not incorporating ROCE or a similar metric means our analysis may not fully capture the trade-offs between improved operating performance and reduced capital flexibility. A focused analysis of the relationship between vertical integration and ROCE or other asset efficiency measures could therefore be a valuable direction for future research in this industry.

6. Conclusion

This thesis has explored the relationship between vertical integration and financial performance in the global forestry products industry, specifically examining earnings volatility and profitability. On the basis of a panel dataset of 42 pulp, paper, and forestry companies from 2020 to 2024, we used wood fiber self-sufficiency as a proxy of vertical integration and estimated its effect using panel data regression models.

Our findings decisively point to a positive relationship between vertical integration and profitability. Firms with higher levels of internal wood fiber procurement exhibit significantly higher operating margins. Such a finding is in line with transaction cost theory that emphasizes the cost-saving and supply-assurance benefits of internalizing upstream activities. It is also aligned with the resource-based view, which frames integration as a means of potentially boosting profitability by defending and developing strategic resources. Notably, it also coincides with the best ownership theory that argues that ownership structures vary with firm-specific capabilities. However, it is important to note that our results are potentially the product of a selection effect where the firms best positioned to benefit from vertical integration choose to internalize upstream assets and therefore benefit from higher profitability. On the other hand, we cannot find evidence in favor of the hypothesis that vertical integration reduces earnings volatility. Rather, we find a weakly positive, but statistically insignificant, relationship, underscoring the potential risks of this strategy in cyclical industries.

Taken overall, our findings suggest that vertical integration in the forest products industry can be an effective strategy but one with costs. Integration appears optimal when balanced against firm-specific capabilities and strategic goals over the long-term. The lack of a volatility reduction effect cautions against viewing integration as a panacea stabilizer, instead affirming the requirement for context-specific analysis.

This thesis contributes to the literature by offering one of the few empirical studies to explore integration as a continuous variable and its financial impacts in forestry. It also integrates less-examined theoretical explanations, including best ownership, into the interpretation of vertical integration findings. Future work could extend these results through further exploration of downstream integration effects, the influence of more extended ESG considerations, and the effects of regulatory reforms like the EUDR.

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8. Appendix

8.1 Data Statistics & Model Diagnostics

Table A1

Descriptive Statistical Summary of Raw Size Variable

Variables	Mean	Std. Dev	Min	1st Qu.	Median	3rd Qu.	Max
Size	4351.800	4297.540	231.400	1100.200	2922.100	6650.900	18165.400

Note. The presence of strong positive skew and upper outliers in the raw Size distribution motivated the log-transformation of this variable.

8.2 Model Diagnostics and Outputs

Table A2

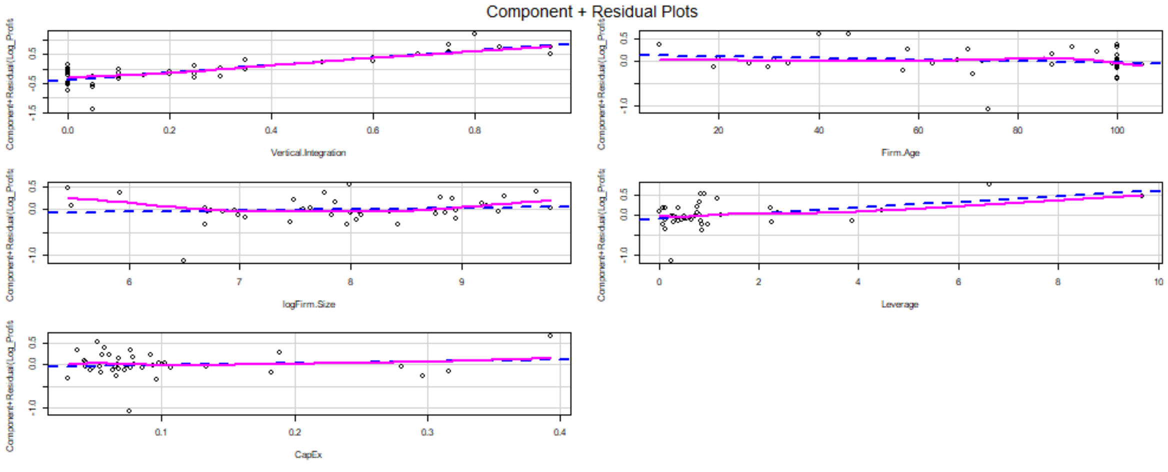
Initial Multicollinearity Diagnostics

Variable	VIF
Vertical Integration	1.469
CapEx	1.499
Age	1.214
Leverage	1.097
LogSize	1.055

Note. All Variance Inflation Factor (VIF) values are well below the common threshold of 5, indicating that multicollinearity is not a concern in the model.

Figure A3

Initial Profitability Model: Component + Residual Plots



Note. logFirm.Size and Firm.age refer to our variables "LogSize" and "Age" respectively in the main text.

Table A4

Initial Earnings Volatility Model: Regression Output

Variable	Coef.	SE	t-value	Pr(>|t|)	Sig.
Intercept	27.140	9.722	2.792	0.008	**
Vertical Integration	6.628	4.820	1.375	0.178	
Capex	-6.670	18.332	-0.364	0.718	
Age	-0.017	0.045	-0.371	0.713	
Leverage	-1.129	0.679	-1.662	0.105	
LogSize	-1.563	1.133	-1.380	0.176	
Residual SE	7.742	df	36	F-statistic	1.804
Multiple R^2	0.200	Adj. R^2	0.089	p-value	0.137

Note. ****p* < 0.001, ***p* < 0.01, **p* < 0.05, *.p* < 0.1. *Blank cells indicate p ≥ 0.1. As seen, prior to model refinement, the model's performance is very weak given the high residual standard error and low explanatory power (Adj. R^2 = 0.089) which suggests great room for improvement.*

Table A5

Initial Profitability Model: Regression Output

Variable	Coef.	SE	t-value	Pr(>|t|)	Sig.
Intercept	13.809	7.628	1.810	0.07862	.
Vertical Integration	26.387	3.782	6.977	3.52e-08	***
Capex	41.805	14.385	2.906	0.006	**
Age	-0.019	0.035	-0.543	0.59044	
Leverage	1.416	0.533	2.656	0.011	*
LogSize	-0.689	0.889	-0.776	0.443	
Residual SE	6.075	df	36	F-statistic	24.61
Multiple R^2	0.774	Adj. R^2	0.742	p-value	1.073e-10

Note. This table presents the regression output from the initial profitability model prior to any model refinements. While it demonstrates a high explanatory power and several significant predictors, later diagnostic tests (see Table 4 in the main text) revealed signs of non-linearity and non-normality of residuals, warranting adjustments as discussed in the main text.

Table A6

Finalized Profitability Model: Multicollinearity Diagnostics

Variable	VIF
Vertical Integration	1.673
CapEx	1.657
Age	1.276
Leverage	1.131
cLogSize	1.136
cLogSize²	1.258

Note. Centering LogSize prior to squaring it reduced the VIFs for both the size terms from almost 172 to approximately 1.2

8.3 AI-disclosure

Students are permitted to use generative AI tools in writing their bachelor thesis provided that they disclose their usage accordingly with the Stockholm School of Economics Disciplinary Regulations. ChatGPT was primarily used to assist the authors with RStudio coding and troubleshooting. It was also used as a grammatical aid, providing feedback and help with vocabulary and structuring. All feedback received by AI was carefully evaluated by the authors. All analytical decisions, interpretations of results, theoretical framing, and conclusions are entirely the work of the authors.