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An Integrated Financial–Operational Framework for Capital Equipment Decisions: Advancing Manufacturing Investment Theory and Practice

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Abstract: The study combines both operational and financial perspectives of capital investment decisions in the manufacturing field, comparing a manufacturer's choice of acquiring a new laser cutting machine against continuing to use their current machinery. The study was conducted over a 6-month period in 2025, where two types of finance were analyzed: a single payment of $700,000 as opposed to two payments of $500,000 at the end of Year 1 and Year 2. A discounted cash flow analysis was completed for both types of finance with discount rates (5% - 12%) to measure the financial efficiency of both finance types, while the operational analysis analyzed all costs associated with labor, energy, maintenance and capital costs in order to determine the cost per unit produced. Upfront payment method was the most financially efficient option. At an 8% discount rate, the combined present value of the two installments ($891,632) was $191,632 greater than the upfront cost with 27.4%. The operational analysis concluded that the new laser cutting machine had a significantly greater uptime (95%) compared to the legacy machine's (60%) uptime and had much lower scrap (2%) compared to the legacy machine's (5%). However, the total cost per unit produced by the new laser cutting machine ($13.16) was almost double that of the legacy machine ($6.74). The developed integrated framework is transferable across all industries and therefore can be used by manufacturers of all types and sizes to align strategic financial feasibility with operational efficiency when making investment decisions.

Keywords: Capital Equipment Investment; Present Value of Cost (PVC); Operational Efficiency; Cost-Per-Unit Analysis; Manufacturing Decision-Making

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1. Introduction

Investments in decisions for capital in manufacturing environments are critical drivers of a business's competitiveness, sustainability, and operational efficiency long term (Rahman, 2025). The technologies and stabilization strategies selected to be deployed impact not only production performance today, but also durability for tomorrow (Amjad et al., 2010). When making any technology investment decisions, a commitment to invest in capital technology such as a laser cutting machine is especially significant because of the impact it will have on productivity, standardization, and rapid change within the production systems (Rüßmann et al., 2015).

These capital investment decisions of adopting advanced technology are also limited by capital constraints (Lanteri & Rampini, 2025; Hobdari et al., 2009). Companies must consider various ways to finance the acquisition, such as paying for infrastructure upfront in the form of a capital expenditure vs payments made in installments, which all have varying levels of cash flow implications, total cost of ownership and opportunity cost implications (Zeidan & Shapir, 2017).

Literature has offered considerable insight into the adoption of technology and capital financing strategies, yet there is limited clarity about incorporating financial evaluation and operational efficiency in real world decision making (Driouchi & Bennett, 2012). Studies examine capital budgeting procedures or operational performance, but not closely enough how these two evaluations could be combined to achieve a better evaluation.

There is an inherent research gap in which firms might select financially inefficient strategies for only marginal operational benefits. Numerous reports now demonstrate that small- and medium-sized manufacturers tend to prioritize short-term liquidity preservation over long-term cost effectiveness, which leads to higher financing costs and lower profitability (Driouchi & Bennett, 2012; Johnson & Scott, 2019). These examples often occur in local contexts where firms are financially constrained or have less access to affordable financing options.

This article studies a manufacturing company that assessed purchasing a laser cutting machine in a two-payment loan of $500,000 ($1,000,000 total) over 2 years, or for $700,000 cash payment. The laser machine cuts faster but has remained idle during long cutting times that limit through-put efficiency, as it operates with more uptime than the company's existing cutting machine (Rahman, 2025; Lanteri & Rampini, 2025).

Furthermore, the study will assess the company's decision through financial modelling and operational analysis. It offers a knowledge contribution to managing technology in the larger setting of manufacturing technology management. It contributes to our understanding of how firms can align technology acquisition decisions with long-term competitive position. By synthesizing financial and operational measures in a single decision lens, the study goes beyond capital budgeting in the traditional sense, to a technology management lens. The dual lens approach illustrates the decisions to invest in technologically advanced machinery directly correlate with manufacturing resiliency, operational agility, and strategic competitiveness. Two questions will be guided by:

RQ1. From a financial perspective, which payment plans are more cost-effective to the operation considering whatever assumptions we take regarding discount rates?

RQ2. From an operational perspective, is there sufficient productivity advantage to the laser cutting machine given the additional financial cost brought on by the installment payment financing?

This research is firmly designed to advance the field's theory of investment appraisal by explicitly linking financial feasibility with operational capability. The paper amalgamates discounted-cash-flow reasoning with cost-per-good-unit assessments, thereby creating a connection between capital-finance decision theory and manufacturing-systems performance theory. In this comprising work, it situates itself firmly within the field of manufacturing strategy and Industry 4.0 literature, evidencing how the financial structure directly affects process capability and, subsequently competitiveness in the long term. These topics are of major concern for the Journal of Manufacturing Technology Management. Two hypotheses were developed to answer these questions. The first is whether financing structure has a significant effect on present value of the investment and the second whether a larger capacity technology will have a lower cost-per-good unit. The hypotheses guide the analysis and provide a context for interpreting findings.

H1 (Financing and Present Value)

Installment financing for new manufacturing equipment will have a higher present value of costs than an up-front, lump-sum purchase.

H2 (Technology and Cost-Per-Unit):

The new laser-based technology will not have a cost-per-good unit advantage over the incumbent technology if financing premiums and operating realities are accounted for despite nominal-capacity advantages.

The research focuses on manufacturing systems and industries instead of specific problem-solving contexts. The context of the study is used to demonstrate the concept of a generalizable decision-making framework that links the types of financing used to the type of manufacturing performance achieved. By clearly linking the financial form to the annualized capital cost and to the cost per good unit produced, this research provides a useful model for understanding the relationship between the way investments are made and the ongoing productivity and cost efficiency of all capital-intensive manufacturing operations.

1.1 Study contribution

This work advances the theory of manufacturing decision-making by explicitly developing and validating an integrated framework for discounted cash-flow analysis incorporating cost-per-good-unit metrics. In contrast to previous manufacturing decision making work that distinguishes between financial and operational evaluations, the framework links capital financing structures with associated manufacturing performance outcomes including throughput, scrap, and uptime. By applying the framework in an SME laser cutting context, we demonstrate model application and show funding premiums can negate operational upside. Importantly, the framework is transferrable across industries affording a set of generalizable decision rules for manufacturers to estimate capital funding appendages associated with any capital investments. In so doing, the study further extends manufacturing theory associated with a total cost of ownership and investment appraisal by integrating operational realities into financial evaluations.

2. Literature review

The contribution of the paper is solid because it brings together financial discounted cash flow analysis with operational cost-per-unit analysis to fill an existing gap in the research about investment decisions in manufacturing. Many sources prior to this paper treat financial evaluations separately from operational evaluations - for example, while (Ellram, 1993) did introduce a Total Cost of Ownership (TCO) framework, which is fundamentally about the capacity to jointly take capital costs and operational costs into account, it certainly is a more rigid view than what is represented in this paper and conducted further which this paper has methodological contributions to investigate further. Similarly, as (Mellichamp, 2013) described, there are ways to notionally extend discounted cash flow methods to address uncertainty in investment evaluations, which relates to our focus on PVC and PVC sensitivity analysis.

The results presented in this study also connect to the real-options literature on technology adoption. (Driouchi & Bennett, 2012) described how managers exaggerate perceived productivity benefits and under-represent financing risks (often both), which leads to incorrect technology adoption decisions. In our paper, the evidence to show that installment financing does not provide any productivity-adjusted value over upfront payment supports this argument. Furthermore, (Hobdari et al., 2009) describe how firms in transition economies are often pushed toward high-cost financing structures as a result of financial structures which erode profitability - this finds an analogous structure with the penalty for installments in this article.

From an operations perspective, we believe our inclination in relation to value found with increased uptime of the laser cutter (95%) and reduced scrap generated (2%) in its full (or BPM) implementation remains at odds with capital intensity to be in keeping with (Baumers et al., 2016), which found that advanced manufacturing technology typically produced unacceptable economies of scale despite technical improvements. Likewise, (Shaw et al., 2004) described a performance model of lasers and showed that, in terms of potential productivity gains, possible productivity losses from cycle inefficiencies more often outweighed productivity gains, which would support our observations within operations.

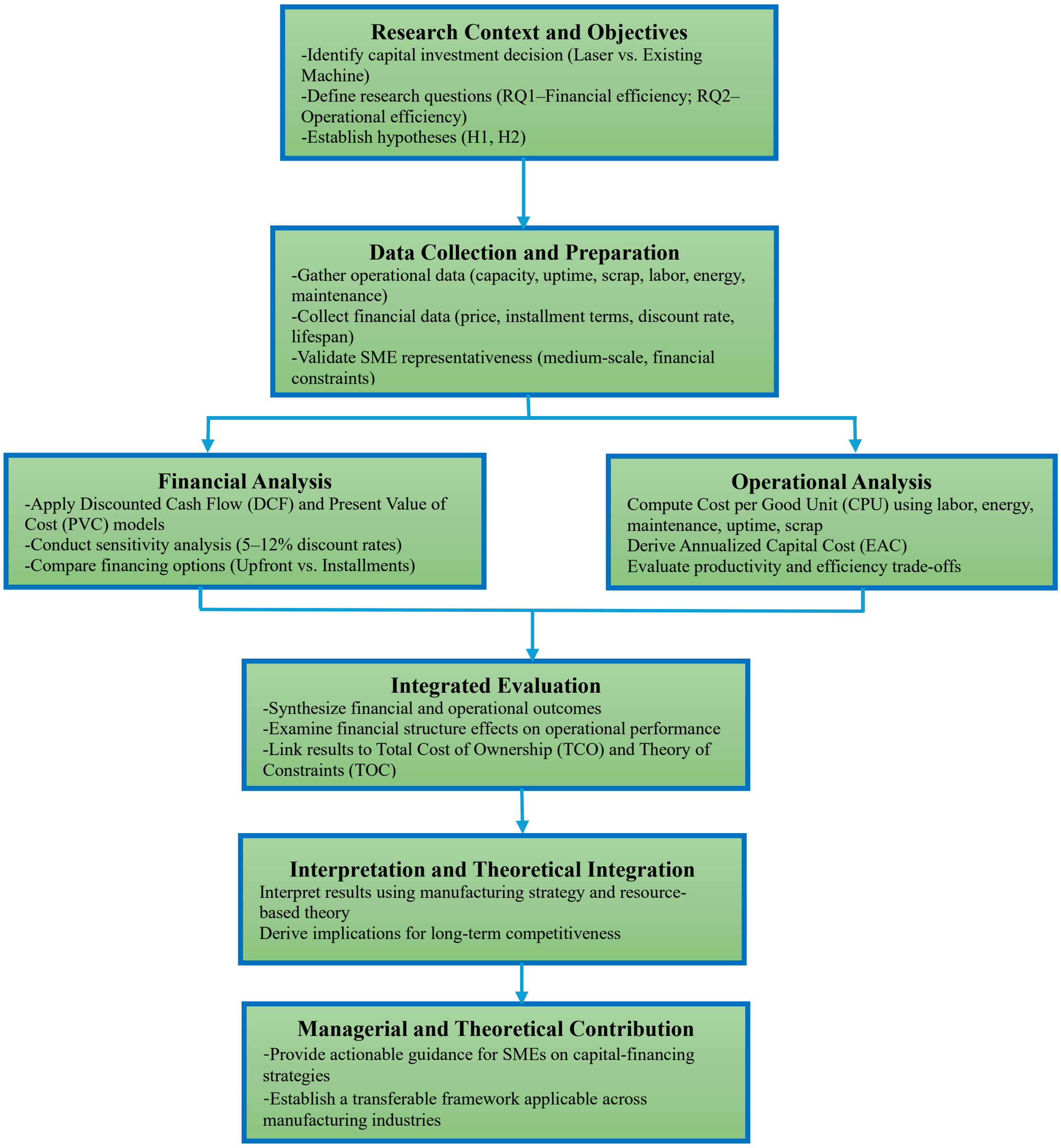
However, what may seem limitations here can instead be framed as informing the strengths of this work. To begin with, the case-based design has offered rigorous analytical depth and replicate-ability but also offers a solid base for industry comparative validation, as proposed by (Burlea-Schiopoiu & Mihai, 2019) as part of their integrated SME sustainability framework. Second, the two-year fiscal horizon was indeed narrow, and intentionally so; a two-year time horizon highlights short-term liquidity considerations that are particularly relevant to SME survival. Ultimately, (Markus & Rideg, 2021) determined just how integral cash flow analysis is to competitive behavior. Third, leaving the long-term learning effects of strategic pathways open is not a gap, it is a deliberate opening, and as (Gherghina et al., 2020) illustrate, SMEs in contexts such as Horizon 2020 are indeed more flexible and adaptive. In addition, (Ferrando et al., 2017) emphasize embedding the considerations of financial flexibility directly into experience and long-term investment measures. The study framework is structured and positionally suitable to develop into multi-year perspectives. Finally, in resonance to the recognition of a dynamic adaptation, (Carayannis et al., 2025) portray that embedding foresight and AI-based analytical measures make SMEs more resilient over time.

In summary, this research is methodologically robust and uniquely combines financial and operational analyses into a single decision-making framework. The narrow case allows more specificity and insight into what is practical, but also more importantly it offers a route for broader validation. The two-year time horizon directs the focus on the immediate financial realities of SMEs. The authors also acknowledge uncertainty in developing long-term learning and strategic benefits, which allows for ongoing discovery. Consequently, it not only provided actionable advice, but has established a roadmap for continued innovation in manufacturing investment research.

3. Method

This study utilizes a case-based validation method to showcase a transferable financial and operational decision framework related to a manufacturing investment. The specific SME laser-cutting case is employed as an illustrative case study, its capital intensity and data transparency representative of many manufacturing contexts today. It is important to note that the objective here is a validation of the framework logic. It is not to address a real-world problem involving one firm to ensure sustained relevance to general manufacturing theory (Surma, 2015). As part of the analysis, the results were scrutinized in terms of two key issues (i) the financial consequences of the possible payment options and (ii) operational efficiency (productivity delivered by the new machine compared with the existing cutting machine). The overall research design incorporated a mixed method design, quantitative financial modelling and a more general analysis of production system performance. Figure 1 presents the research methodology.

Figure 1. Research development



3.1 Research Design

We undertook comparative evaluation research in two stages:

- Financial Evaluation: The total cost of ownership was evaluated by comparing the upfront payment option and installment financing option using the discounted cash flow approach, present value of cost (PVC) and some sensitivity analysis (Mellichamp, 2013).
- Operational efficiency Evaluation: For this analysis, we compared machine productivity including effective throughput and utilization rates, of the new versus the older/conventional cutting machine (Patrício et al., 2025).

Consequently, the empirical context should be understood as an example validation framework and not the focus of analysis. The practical purpose for developing the empirical case is to illustrate the analytical integration of standard measures of financial and operational activities to support decisions regarding investment in manufacturing, regardless of industry, country, or size. The empirical context allows for the clear identification and definition of the parameters of the framework but does not limit the overall applicability of the core principles of manufacturing reasoning.

3.2 Data Collection

Main data was collected via company visits as well as operational logs and interviews with management.

The following categories were examined:

Equipment data: Cycle time, speed, downtime, and utilization of both machines.

Machine (T= Old cutter machine) continuous operation with lower cycle speed

Machine (L = Laser cutting machine) long idle periods and high cycle speeds

Operation hours: 250 shifts/year × 8 hours/day = 2000 scheduled hours yearly

Performance: capacity per shift, uptime ratio, and scrap rate

Cost data: maintenance, labor, energy, and machine purchase price

Financial data: The prices to purchase, installment terms (2 payments of $500,000), discounted upfront cost ($700,000), and current available discount rates 8% base case, lifespan = 5 years.

3.3 Context justification.

The SME chosen is a typical medium-scale discrete-manufacturing operation exhibiting constrained financial flexibility, and at best a moderate level of automation. The SME was selected with an emphasis upon access to in-depth operational and financial records that provide for an empirical context that may be representative of the purpose of validating the conceptual framework. The analysis will focus on methodological demonstration rather than sectoral description.

3.4 Financial Process Evaluations

The financial evaluations used discounted cash flow methods. The present value of cost (PVC) was calculated for each payment option as follows:

$$PVC = \Sigma (C_t / (1 + r)^t)$$

Where C_t is the cash outflow at time t, and r is the discount rate.

A univariate sensitivity analysis is performed on interest rates as we look to understand how the attractiveness of financing changes under varying cost of capital assumptions. The discount rate is varied from 5% to 12%, which provides a realistic picture of financing conditions.

3.5 Operational Process Evaluations

This study examined investment in a laser cutter through financial and operational assessments. Financially, present value of costs (PVC) analysis was used to compare upfront payment to installment payment for discount rates of (5%-12%). Operationally, cost per good unit was determined by combining production capacity, uptime, scrap, labor, energy, maintenance and annualized capital cost. Integrated accounting for both puts a realistic foundation for determining if the laser provides a commercial advantage relative to the current piece of equipment.

3.6 Reflecting on the Results

The evaluation included a multidimensional evaluative framework that incorporates both financial outcomes (PVC, total cost differences) as well as operational outcomes. As noted previously, it was important to also contextualize these findings by incorporating strategy regarding liquidity issues, technological obsolescence, and competitive issues.

4. Results

The evaluation results will be provided in two parts: (i) financial performance analysis; and (ii) operational efficiency assessment. A sensitivity analysis is also provided to support the robustness of the financial results.

4.1 Analysis and Interpretation of Financial Performance

Two plans for financing were put forward. The following are the plans:

Option A (upfront): One-time payment of $700,000 at the start of the project

Option B (Equated Installment Scheme): Payment of $500,000 at the end of years 1 and 2

Basis/Boundary:

• Discount: r=8% per year

• Timeline: Two years

PVC Calculations:

Option A: PVC_A = $-700,000

Option B: PVC_B = $-500{,}000 / (1.08)^1 - 500{,}000 / (1.08)^2$

= -462,963 - 428,669 = $-891,632

Comparison:

The difference in value: $300,000 ($1,000,000 - $700,000)

The present value is now quantified to $191,632

Option B cost is approximately 27.4% more than Option A. ($191,632/$700,000 = 0.2738 = 27.4%)

Sensitivity Analysis:

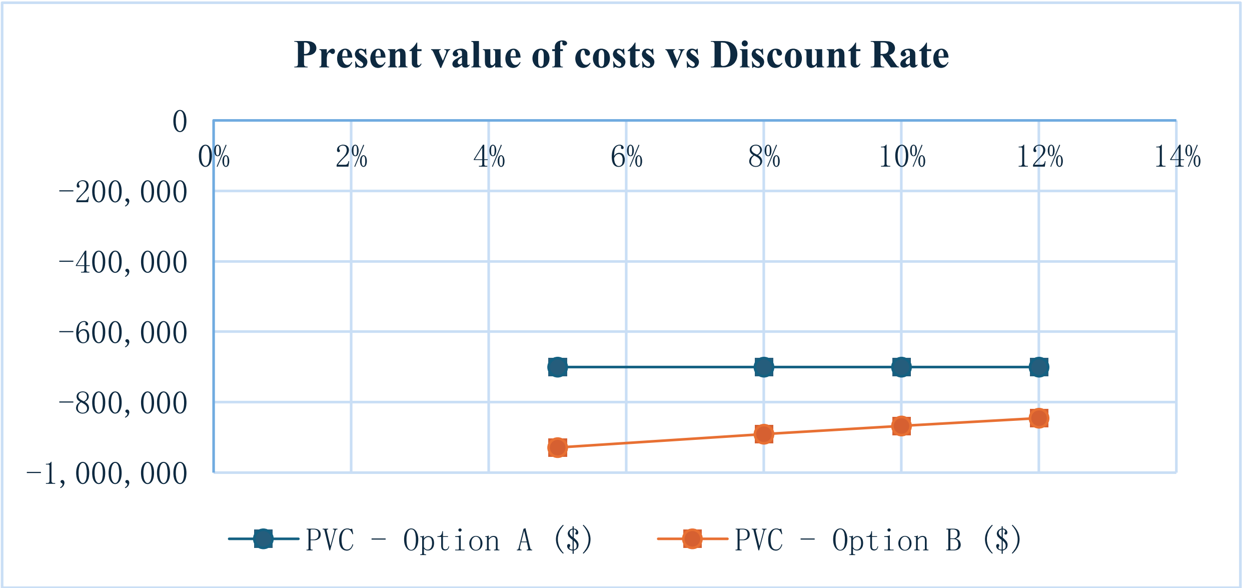
The present value of cost in Table 1 was recalculated using various discount rates (5 – 12%).

Table 1. Discount rates vs PVC options

Discount Rate	PVC - Option A ($)	PVC - Option B ($)	Difference ($)	Preferred Option
5%	-700,000	-929,705	229,705	Upfront
8%	-700,000	-891,632	191,632	Upfront
10%	-700,000	-867,768	167,768	Upfront
12%	-700,000	-845,026	145,026	Upfront

The upfront option remains better in all cases. Figure 2 shows present value of costs vs discount rate.

Figure 2. Discount rate vs PVC for A and B



4.2 Operating efficiencies

Shifts/year = (50 weeks × 5 days/week) = 250

Hours/shift = 8, scheduled annual hours = 250 × 8 = 2,000 h

Current machine (T)

Nameplate capacity per shift = 200 units

Uptime (availability) = 0.60

Scrap rate = 5%

Labor cost = $25 / hour

Energy cost = $10 / hour

Maintenance/year = $50,000

Capital cost (PV) = $400,000; (One payment)

Laser (L)

Nameplate capacity per shift = 100 units

Uptime = 0.95, Scrap rate = 2%

Labor cost = $20 / hour

Energy cost = $8 / hour

Maintenance/year = $30,000

Capital PV (installment PV used as example) = $891,632; life = 5 yrs; discount = 8%

Formulas used

Let:

L = Advanced laser cutter machine

T = Traditional cutter machine

H = scheduled annual hours = shifts/year × hours/shift (here H = 2,000)

C = capacity per shift (units when running)

u = uptime (fraction)

s = scrap fraction

W = labor cost per hour

E = energy cost per hour

M = maintenance per year

K = annualized capital cost (Equivalent Annual Cost)

Produced units per year = C × shifts/year × u

Good units per year = Produced × (1 − s)

Running hours per year = H × u

Total annual cost = (W + E) × running hours + M + K

Cost per good unit (CPU) = Total annual cost / Good units

Annualize capital (K) from PV:

K = PV × annuity factor where annuity factor = $r(1+r)^n / ((1+r)^{n-1})$

Base-case numeric result (with the assumptions above)

Annualized capital (5 years, r=8%)

Annuity factor = 0.25045

K_T = 400,000 × 0.2504 = $100,160/ year

K_L = 891,632 × 0.2504 = $223,265/ year

Running-hours

T running hours = 2,000 × 0.60 = 1,200 h/yr

L running hours = 2,000 × 0.95 = 1,900 h/yr

Costs (annual), see Figure 3 for annual cost breakdown

T labor = 25 × 1,200 = $30,000

T energy = 10 × 1,200 = $12,000

T maintenance = $50,000

T capital annual = $100,160

T total annual cost = $192,160

L labor = 20 × 1,900 = $38,000

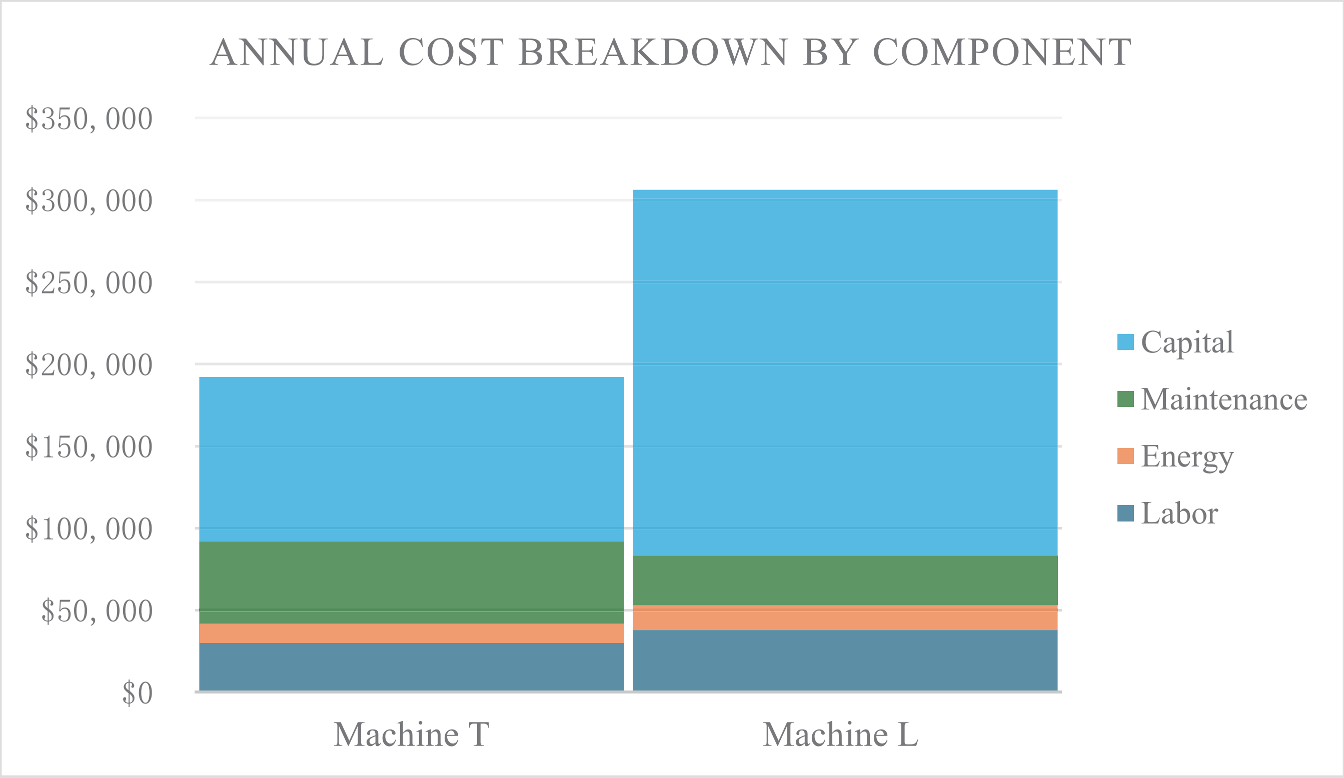
L energy = 8 × 1,900 = $15,200

L maintenance = $30,000

L capital annual = $223,150

L total annual cost ≈ $306,350

Figure 3. Annual cost breakdown



Output (annual)

T produced = 200 × 250 × 0.60 = 30,000 units

L produced = 100 × 250 × 0.95 = 23,750 units

Cost per good unit (CPU)

T good units = 30,000 × (1 – 0.05) = 28,500

CPU_T = $192,160/ 28,500 = $6.74 /good unit

L good units = 23,750 × (1 – 0.02) = 23,275

CPU_L = 306,350 / 23,275 = $13.16 /good unit

Despite higher uptime and lower scrap for the laser, the laser's higher capital (and lower nameplate capacity) produces a higher cost per good unit. With these inputs the laser is not economically justified on a per-unit cost basis. Figure 4 presents the cost per good unit for both machines, and Figure 5 presents an output comparison between old machines (T) and new laser machines (L).

Figure 4. Cost per good unit

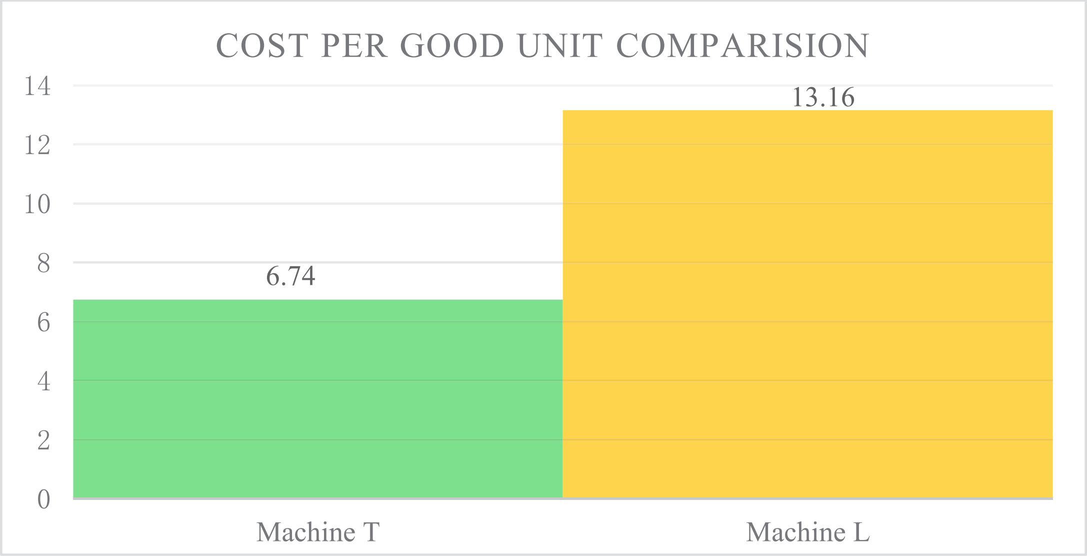
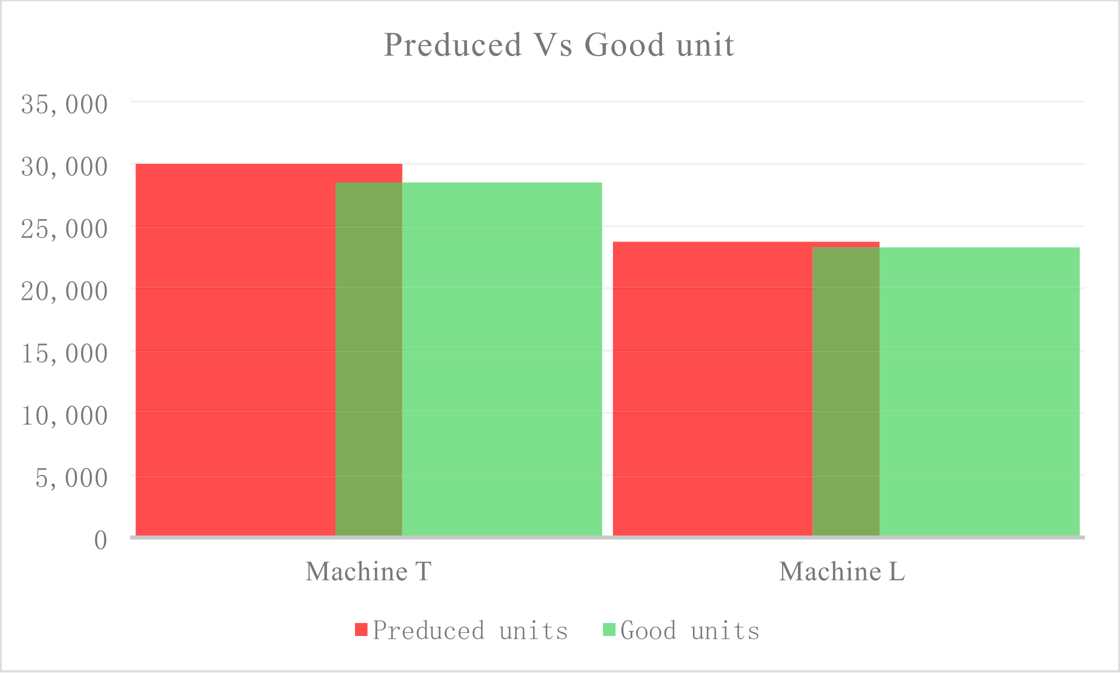


Figure 5. Output comparison



5. Discussion

In addition to the specific example used to illustrate this relationship, the results of the study demonstrate a general relationship between the capital structure of a manufacturer's financing and the operational cost effectiveness (OCE) of its product. Financing premium payments (through interest rates) are converted into annualized capital payment amounts, which then influence the cost structure of producing a good (i.e., cost per good unit) and may offset some of the perceived benefits of operational efficiencies (e.g. increased uptime or reduced scrap rates). This mechanism behaves consistently across all capital-intensive manufacturers and exemplifies an underlying characteristic of all capital-intensive manufacturers. The study's results support and expand the concept of a general theory for evaluating investments in the manufacturing sector.

This investigation examined whether the investment in a new laser cutting machine was economically viable, based upon two questions: (i) which payment plans are more cost-effective to the operation considering whatever assumptions we take regarding discount rates? and (ii) whether the operational performance of the laser provides value greater than its financial obligation (Shaw et al., 2004).

5.1 Financial performance

The PVC analysis clearly demonstrated that upfront payment was more financially advantageous than an installment plan (Mellichamp, 2013). The total present-value cost of the installment plan was higher than the upfront payment option across all discount rate scenarios ranging between 5% and 12%, with penalties of $145k to over $229k. Overall, installment financing, despite facilitating different cash flow timing, was a costly financing option due to the present-value cost of financing the premium. Accordingly, RQ1 is satisfied: upfront payment was a superior financing option under all circumstances tested. Furthermore, at 8% discount rate, the installment PV = $891,632, which is $191,632 (27.4%) more than the lump-sum option of $700,000. A sensitivity analysis across 5% - 12% discount rates indicated that the PV for financing always exceeded the PV for lump-sum purchase (H1 satisfied).

5.2 Operational performance

Operational cost-per-unit analysis concluded the incumbent machine cost approximately $6.7 per good unit while the laser was about $13.2. The difference in cost is linked in the main to the capital charge associated with the laser machine, even though it had lower nominal capacity, which was substantially larger than operational uptime (95% to 60%) and lower scrap rates (2% to 5%) for laser cut machine. So, we can consider RQ2 resolved: while functional productivity obtained with the laser cutting machine was superior to the incumbent, the financial premium associated with financing a laser yielded no value for productivity gains (Baumers et al., 2016).The incumbent technology's CPU = $6.74 vs. laser CPU = $13.16 indicating that the incumbent was actually almost twice as cost-effective given the actual conditions observed. Even assuming a higher uptime (95% vs. 60%) and throughput with the laser, the financing and any scrap or maintenance costs outweigh these increases and were more than adequate to account for the higher capacity (H2 confirmed).

5.3 Interpretation using theory

Since the experiments had outcomes consistent with several different theoretical frameworks, we will interpret the results through each theory separately. The results follow a Total Cost of Ownership (TCO) logic (Rahman, 2025 ; Ellram, 1993): in analyzing alternatives the operating, capital and quality cost or costs, must be considered. Our analysis was also consistent with and incorporates concepts from the Theory of Constraints (TOC) literature: enhancing the reliability of one machine will not necessarily increase throughput if another machine is the bottleneck, in this experiment this is typified by the nominal lower throughput of the laser cutting machine. Finally, while we did not calibrate with respect to the ambience repayments and learning dynamics of new technology explicitly, the findings do seem consistent with a real-options perspective on learning; once with the uncertainty resolved (Johnson & Scott, 2019; Foss et al., 2025), and their capital risk within acceptable limits, many organizations will value new technology all the more, e.g., replacing a cutter may only bring payback or value in operation was evident when certain procurement practices such as service contracts or staged adoption may reduce potential risks.

In addition to verifying the consistency of theoretical construction, this research strengthens the relationship between firms' manufacturing strategy and their resource-based view of competitiveness. The findings indicate that firms' resources (i.e., the combination of financial flexibility and operational capability) jointly inform their competitive position as described in the resource-based view of competitiveness. The model demonstrates how the choice of financial arrangements affects production costs and systems' level of efficiencies; in addition, it shows how the decisions related to a firm's capital structure will subsequently impact a firm's long-term competitiveness and its ability to respond to environmental changes within a technology-intensive manufacturing environment.

5.4 Contribution to manufacturing theory

The results contribute to manufacturing theory by connecting financial structure and operational performance via a single evaluative construct. The results reveal that financing structure (installments versus lump sum) can alter annualized capital loadings and therefore change apparent productivity benefits, a mechanism that has been ignored in research on manufacturing systems. Thus, the framework extends total-cost-of-ownership and technology-adoption models to incorporate the finance–operations interface and provides propositions relevant in both manufacturing contexts, where capital is relatively fixed and units can only be utilized at limited efficiencies.

These observations, although based on a single case, indicate structural relationships between financing form, cost of capital, and operational performance that are common to all manufacturing systems. Therefore, this conversation now shifts from a case-specific consideration to more general management and theoretical implications.

5.5 Implications for practice

The findings have three implications for managers. First, they should care about how they finance the machine: a lease-purchase or instalment line may hide a significant resulting cost burden on your margins, for the most part paying an outright price for it up front is the least transactional cost and of least uncertainty. Second, they should care about the terms of procurement: the anonymous breakeven analysis (this analysis is part of future work) provides an objective capital reduction development goal (important for the contracting authority) for estimating a competitive position (i.e. where their commercial position will be with respect to TCO) to be better than the shaded table provided procurement negotiators or pay more if a unit. Third, they should have a system view: Unless the cutter is the bottleneck of the value stream, replacing it does not necessarily model or id SC spending, for either throughput or unit cost of goods sold irrespective of how much better its uptime or deal for "punctuate" costs.

The study expands on existing theories regarding manufacturing investment by formally integrating the financial structure and operational performance together using one unified evaluative measure. In addition, instead of treating capital budgeting as two independent domains from the realm of manufacturing efficiency, the framework helps clarify how financial decisions can flow into the manufacturing system, ultimately affecting the productivity results within the manufacturing system. This type of integration helps to push forward the development of manufacturing theory by showing a linkage between the financial aspects of the business and the operational aspects of the manufacturing business, which is a relatively unexplored area of research.

5.6 Implications for research

This study adds to the literature by combining discounted financial evaluation with operational cost-per-unit evaluation and analyzing the interaction between the two dimensions of analysis (Hobdari et al., 2009; Ramasesh & Jayakumar, 1997). In the past, this interaction aspect has often been ignored or treated as separate, while our findings illustrate the need to recognize the links between financial and operational issues, particularly for SMEs, where constraints on available capital, along with operational variability, are strongly associated with the investment decision. Future research has the potential to extend this line of analysis to multiple stages instead of simply a 'one-off'; to integrate learning effects in a more explicit manner than has happened in prior work; and to investigate alternative forms of procurement such as leasing or performance-based contracts (Glas & Kleemann, 2017).

The research is based on an industrial case with a specific machine and a specific financing arrangement; however, it is much more than a single application. The integrated framework indicates that manufacturers can expand their decision criteria from just financial to include operational efficiency for capital investment. By combining discounted cash flows with a "cost-per-good-unit" measure of productivity, the research provides a transferable decision-support tool that can help firms in other industries align equipment purchases beyond financial considerations and towards operational efficiency and long-term production objectives.

Overall, the convergence of the financial and operational evidence suggests that, at this time, the incumbent machine is the economically rational choice. The laser will only make sense if either the overall capital costs can get so low that it becomes attractive, or if there is some other benefit, beyond unit cost, that is important to the larger strategic vision, such as new capability in products, or differentiation through quality.

6. Conclusion

While the framework and findings of this study have been empirically tested using a case study of a single producing business, the same scenario could apply across all different types of production/buying decisions. And therefore, the recommendations and insights from this framework may be very valuable to a substantial number of manufacturing companies that have significant capital investments and financing constraints impacting their capital investment decisions.

The study used financial and operational analyses to consider whether to adopt a laser cutting machine in lieu of the incumbent cutter. While financial analysis using discounted cash flow indicated that upfront financing offers a discount rate benefit over installment payments, upfront financing provided an overall cost savings of $191,632 (27.4%) at an 8% discount rate. While operational analysis showed the laser improves downtime (95% vs 60%), with half the scrap rate (2% compared to 5%) of the incumbent cutting machine, greater downtime and the significant differences in annualized capital costs resulted in a total cost per good unit nearly doubling within the incumbent ($13.16 compared to $6.74).

In summary, the findings show that the existing machinery is the better decision if current costs do not change. We have presented a way to examine the combination of Total Cost of Ownership (TCO) and operational productivity and demonstrated that equipment investment decisions need to be made in the context of system constraints. The study also highlighted the potential for managers to wrongly allocate their attention to the performance of equipment without consideration of financial constraints. It is acceptable for managers to use financial representations, however, these should be used and understood within a complete operational cost analysis.

Future works could also consider a break-even assessment to identify when the laser cutter becomes competitively priced; potentially applying other financing structures and discount rates. Within the current scope of the research project, the framework can be modified to suit other manufacturing environments and provide decision-makers with a usable framework for considering how to balance financial cost to operational efficiency.

Theoretical contribution and generalizability. Although validated in one SME, the integrated framework could be transferred to almost any manufacturing context where equipment-investment trade-offs are present. By decontextualizing from the particular case, it provides a unified theory of manufacturing investment evaluation that bridges financial discipline with operational capability. The combined model is an example of high flexibility from the manufacturing environment in which it was developed, with properties and performance measures transferable to equipment decision making across manufacturing sectors, i.e. automotive, aviation, electronics or large/medium equipment manufacturing. Therefore, the model is a general tool that can be leveraged to support decision making regarding investments associated with Industry 4.0.

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No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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