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Title:

«MODELING AND BEHAVIORAL ANALYSIS IN THE SAP ERP BUSINESS SIMULATION GAME USING COMPUTATIONAL TOOLS»

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(University of Piraeus, 2026)

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ΔΗΛΩΣΗ

Η εργασία αυτή είναι πρωτότυπη και εκπονήθηκε αποκλειστικά και μόνο για την απόκτηση του συγκεκριμένου μεταπτυχιακού τίτλου.

Τα πνευματικά δικαιώματα χρησιμοποίησης του μη πρωτότυπου υλικού της ΜΔΕ ανήκουν στον/στη μεταπτυχιακό/ή φοιτητή/τρια και στο επιβλέπον μέλος ΔΕΠ εις ολόκληρο, δηλαδή εκάτερος μπορεί να κάνει χρήση αυτών χωρίς τη συναίνεση άλλου. Τα πνευματικά δικαιώματα χρησιμοποίησης του πρωτότυπου μέρους της ΜΔΕ ανήκουν στον/στη μεταπτυχιακό/ή φοιτητή/τρια και στον/στην επιβλέποντα/ουσα από κοινού, δηλαδή δεν μπορεί ο ένας από τους δύο να κάνει χρήση αυτού χωρίς τη συναίνεση του άλλου. Κατ' εξαίρεση, επιτρέπεται η δημοσίευση του πρωτότυπου μέρους της διπλωματικής εργασίας σε επιστημονικό περιοδικό ή πρακτικά συνεδρίου από τον ένα εκ των δύο, με την προϋπόθεση ότι αναφέρονται τα ονόματα και των δύο (ή των τριών σε περίπτωση συνεπιβλέποντα/ουσας) ως συν-συγγραφέων. Στην περίπτωση αυτή προηγείται γραπτή ενημέρωση του/της μη συμμετέχοντα/ουσας στη συγγραφή του επιστημονικού άρθρου. Δεν επιτρέπεται η κατά οποιοδήποτε τρόπο δημοσιοποίηση υλικού το οποίο έχει δηλωθεί εγγράφως ως απόρρητο.

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The student	The supervisor
Kyriakopoulos Petros	Dimitrios Emiris

ABSTRACT

The objective of this dissertation is to model the SAP ERPSim Business Simulation Game and apply decision-making tools to support strategic choices in areas such as loan repayment, production improvement, and liquidity management. Business simulation games serve as innovative e-learning methods, transforming the complexity of real business environments into interactive experiences that foster decision-making under uncertainty. Their integration into business schools and training programs highlights their importance as educational and strategic tools.

Methodologically, this study combines the SAP ERP Simulation Game with modeling in Excel and Analytica (using a real-world dataset extracted from the international competition that took place in May of 2024). In Excel, the Solver and Goal Seek tools were applied to optimize decision variables, including repayment strategies and production planning. Analytica was employed to develop influence diagrams and perform scenario analysis (base, optimistic, pessimistic), providing a structured framework for understanding dependencies between inputs and financial outcomes. This dual approach ensured both practical optimization of business decisions and strategic scenario exploration.

The results demonstrate that well-designed strategies in loan repayment, marketing investment, and production planning significantly affect profitability, liquidity, and overall enterprise value. Even with the limitations of the free version of Analytica, which restricted probabilistic analysis and Monte Carlo simulations, combining scenario-based modeling with Excel optimization produced valuable and actionable insights.

The findings highlight the importance of integrating simulation-based learning with decision-support tools. This combination enhances managerial decision-making, develops analytical and teamwork skills, and provides competencies directly transferable to real business contexts. The study positions business simulations as a powerful tool not only for education but also for strategic planning in dynamic environments. Future research could enhance these models with probabilistic methods, dynamic linkages, and advanced visualization dashboards to strengthen realism and usability.

Keywords: *Business Simulation Games, SAP ERP, Excel Solver, Strategic Decisions, Decision Tools, Analytica*

Περίληψη

Σκοπός της παρούσας διπλωματικής εργασίας είναι η μοντελοποίηση του Επιχειρηματικού Παιχνιδιού Προσομοίωσης SAP ERP και η εφαρμογή εργαλείων λήψης αποφάσεων για την υποστήριξη στρατηγικών επιλογών όπως η αποπληρωμή δανείων, η βελτίωση παραγωγής και ο προγραμματισμός ρευστότητας. Τα επιχειρηματικά παιχνίδια αποτελούν καινοτόμες μεθόδους e-learning, μετατρέποντας την πολυπλοκότητα των πραγματικών επιχειρηματικών περιβαλλόντων σε διαδραστικές εμπειρίες που ενισχύουν τη λήψη αποφάσεων υπό αβεβαιότητα. Η ευρεία εφαρμογή τους σε πανεπιστήμια και προγράμματα εκπαίδευσης αναδεικνύει τη σημασία τους ως εκπαιδευτικά και στρατηγικά εργαλεία.

Μεθοδολογικά, η εργασία συνδυάζει το παιχνίδι SAP ERP με μοντελοποίηση σε Excel και Analytica. Στο Excel χρησιμοποιήθηκαν τα εργαλεία Solver και Goal Seek για τη βελτιστοποίηση στρατηγικών μεταβλητών, συμπεριλαμβανομένων της αποπληρωμής δανείων και του σχεδιασμού παραγωγής. Στο Analytica αναπτύχθηκαν διαγράμματα επιρροής και πραγματοποιήθηκε ανάλυση σεναρίων (ουδέτερο, αισιόδοξο, απαισιόδοξο), παρέχοντας ένα δομημένο πλαίσιο κατανόησης των σχέσεων μεταξύ εισροών και οικονομικών αποτελεσμάτων. Ο συνδυασμός αυτός εξασφάλισε πρακτική βελτιστοποίηση στη λήψη αποφάσεων αλλά και στρατηγική διερεύνηση σεναρίων.

Τα αποτελέσματα δείχνουν ότι στρατηγικές αποφάσεις σε τομείς όπως η αποπληρωμή δανείων, οι επενδύσεις μάρκετινγκ και ο προγραμματισμός παραγωγής επηρεάζουν καθοριστικά την κερδοφορία, τη ρευστότητα και τη συνολική αξία της επιχείρησης. Παρά τους περιορισμούς της δωρεάν έκδοσης του Analytica, που δεν υποστηρίζει πιθανοθεωρητικές (ή στοχαστικές) μεθόδους και Monte Carlo προσομοιώσεις, η ανάλυση σεναρίων σε συνδυασμό με τις βελτιστοποιήσεις στο Excel παρείχαν χρήσιμα και εφαρμόσιμα συμπεράσματα.

Τα ευρήματα υπογραμμίζουν τη σημασία του συνδυασμού προσομοιώσεων με εργαλεία λήψης αποφάσεων. Η προσέγγιση αυτή ενισχύει τη διοικητική ικανότητα, καλλιεργεί αναλυτικές και συνεργατικές δεξιότητες και προσφέρει πρακτικές γνώσεις με άμεση εφαρμογή στον επιχειρηματικό κόσμο. Η μελέτη τοποθετεί τα επιχειρηματικά παιχνίδια ως ισχυρό εργαλείο όχι μόνο για την εκπαίδευση αλλά και για τον στρατηγικό σχεδιασμό σε δυναμικά περιβάλλοντα. Μελλοντικές έρευνες μπορούν να εμπλουτίσουν τα μοντέλα με πιθανοτικές μεθόδους, δυναμικές σχέσεις και εξελιγμένα dashboards για μεγαλύτερο ρεαλισμό.

Λέξεις-κλειδιά: *Επιχειρηματικά Παίγνια, SAP ERP, Excel Solver, Στρατηγικές Αποφάσεις, Εργαλεία Απόφασης, Analytica*

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List of Abbreviations, Symbols & Glossary

List of Abbreviations

COGS	Cost of Goods Sold
ERP	Enterprise Resource Planning
GL	General Ledger
GRG	Generalized Reduced Gradient
IRR	Internal Rate of Return
KPI	Key Performance Indicator
LP	Linear Programming
MIT	Massachusetts Institute of Technology
MRP	Material Requirements Planning
NPV	Net Present Value
ROI	Return on Investment
SAP	Systems, Applications and Products in Data Processing
BSG	Business Simulation Game
SGA	Selling, General and Administrative Expenses

Glossary

Enterprise Resource Planning: Σχεδιασμός Επιχειρησιακών Πόρων

Simulation Game: Παιχνίδι Προσομοίωσης

Decision Making: Λήψη Αποφάσεων

Key Performance Indicator: Δείκτης Απόδοσης

Material Requirements Planning: Προγραμματισμός Απαιτήσεων Υλικών

Net Present Value: Καθαρή Παρούσα Αξία

Return on Investment: Απόδοση Επένδυσης

Supply Chain Management: Διαχείριση Εφοδιαστικής Αλυσίδας

Warehouse Management System: Σύστημα Διαχείρισης Αποθήκης

1. Introduction

1.1 Purpose and Objectives

The purpose of this dissertation is to model the SAP ERP Business Simulation Game using decision-support tools in order to evaluate and improve strategic business decisions. The study focuses on critical managerial issues such as **loan repayment strategies, production improvement, and liquidity management**, which directly affect the sustainability and growth of a company. The objectives are twofold: (a) to demonstrate how structured modeling can enhance simulation-based learning, and (b) to provide actionable insights that are transferable to real-world managerial practice.

1.2 Research Problem

Business environments today are characterized by rapid change, uncertainty, and increasing complexity in decision-making. Managers must evaluate alternatives, balance limited resources, and make strategic choices under conditions of risk. While business simulation games such as the SAP ERP Simulation Game provide valuable experiential learning, they often lack systematic modeling that can quantify and optimize decisions – (should be taken in very strict timeframe - sometimes without addressing the issue directly / ad-hoc). The research problem addressed in this thesis is therefore how decision-support tools can be integrated with simulation games to strengthen learning outcomes and provide measurable improvements in decision-making.

1.3 Justification of the Study

Business simulation games have been widely adopted in business schools and professional training programs, demonstrating their importance as educational and strategic tools. However, their potential is often underutilized if the outcomes remain limited to gameplay observations. By incorporating Excel (Solver and Goal Seek) and Analytica (influence diagrams and scenario analysis), this study adds an analytical layer to the simulation, allowing for optimization of key strategic decisions and exploration of alternative scenarios. This justifies the contribution of the thesis, as it not only validates the educational value of business simulations but also highlights their practical application in managerial decision-making.

1.4 Structure of the Thesis

The structure of this thesis is organized as follows:

- **Chapter 1** introduces the purpose, objectives, and significance of the study, as well as the research problem under investigation.
- **Chapter 2** reviews the relevant literature, including the history and development of business games and their role in education and managerial training.
- **Chapter 3** describes the SAP ERP Simulation Game (3 scenaria) in detail, outlining its mechanics, rules, and learning objectives it serves; further, it explains the methodological approach, including the development of models in Excel and Analytica, the use of Solver and Goal Seek, and the design of scenario analyses
- **Chapter 4**. presents and discusses the results, focusing on how strategic decisions in areas such as loan repayment, production, and liquidity affect financial performance and company value
- **Chapter 5** concludes the study, summarizing the main findings, discussing their significance, and offering recommendations for future research and practice.
- **Chapter 6** includes bibliography with all the academic sources, textbooks, research papers, and online materials referenced. These sources support the theoretical background, methodological decisions.
- **Chapter 7** provides supplementary material that supports the analysis and methodology presented in the main chapters of the thesis.

1.5 Purpose and Relevance of the Study

This study develops an integrated decision-support model designed to help participants of the SAP ERPSim competition make faster and more informed strategic decisions. Because success in ERPSim is determined by company valuation, teams must quickly evaluate choices related to liquidity, production, and loan repayment under time pressure. The models created in Analytica and Excel use the structure and logic of the ERPSim Participants Guide while allowing users to enter their own data. This enables participants to explore different strategic options, understand how key decisions affect valuation, and prepare more effectively for the simulation. Since ERPSim does not include optimization or sensitivity-analysis tools, the thesis introduces a complementary analytical framework using Solver, Goal Seek, influence diagrams, and scenario-based modeling. With Monte Carlo simulation unavailable in the free version of Analytica, scenarios (base, optimistic, pessimistic) were used to illustrate how outcomes shift under varying conditions. Overall, the study offers a practical tool that helps teams test strategies in advance, understand cause-and-effect relationships, and improve their decision-making approach during the competition.

2. Bibliographic Review

2.1 Business Games and Their Importance

2.1.1 Introduction to Business Games

Business games are an important learning approach designed to reduce the complexity of real-world company problems into manageable, interactive models. Their use has grown steadily in universities, business schools, and professional training programs worldwide. Historical roots of business games can be traced to early versions of chess in China, India, and Persia, while their formal integration into education began in the 1950s. Since then, they have become a cornerstone of business education, supporting experiential learning and decision-making (Faria, Hutchinson, Wellington, & Gold, 2009).

2.1.2 Types and Formats of Business Games

Business games can be delivered in several formats: computer networks, classroom-based sessions, or hybrid approaches. Regardless of format, their primary educational aim is to develop decision-making, problem-solving skills, and strategic awareness. By applying theoretical knowledge to practical scenarios, participants gain the confidence to transfer classroom learning into real-world business practice (Faria et al., 2009).

2.1.3 Engagement and Learning Experience

A major advantage of business games is their interactive and engaging nature. Participants receive immediate feedback on their decisions, which allows them to understand consequences and adapt strategies accordingly. This continuous cycle of action and reflection increases motivation and deepens learning outcomes.

2.1.4 Teamwork and Collaboration

Business games often require participants to collaborate in teams, assigning different roles to simulate a business environment. This collaborative setting fosters communication, negotiation, and leadership skills while exposing participants to multiple perspectives. Such dynamics prepare learners for real managerial environments where teamwork is essential.

2.2 The SAP ERP Simulation Game

2.2.1 Case Study: ERPSim

A notable example of a business simulation is the SAP ERP Simulation Game (ERPSim). Learners interact with a real SAP S/4HANA environment, processing transactions and evaluating decisions that mimic workplace scenarios. ERPSim accelerates time, simulates supplier and customer interactions, and automates administrative processes, thereby allowing participants to concentrate on analytics and decision-making.

The game progresses in structured rounds: in the first, teams work with fixed inventories to maximize profits; in subsequent rounds, they manage procurement, manufacturing, and logistics to serve multiple markets. This layered design exposes participants to complex challenges such as raw material planning, distribution, and customer demand fulfillment. The game has received international recognition, including the Best Use of Technology Award (Pierre-Majorique Léger, 2006).

2.2.2 Categories of Business Simulation Games

Levant, Coulmont, and Sandu (2016) classify business simulation games into three categories:

- **Introductory BSGs** – Simple simulations with limited variables (e.g., Hot Shot Business, CD-rack game).
- **In-depth BSGs** – Domain-specific games that target skills such as sustainable development (e.g., GoVenture).
- **Immersion BSGs** – Complex, multi-session simulations focusing on real-world phenomena such as production planning, cost control, and sustainability.
- ERPSim clearly belongs to the immersion category, given its complexity and integration with ERP processes (Levant et al., 2016).

2.2.3 Learning Outcomes and Educational Frameworks

The educational outcomes of ERPSim align with Bloom's Taxonomy, which emphasizes structured progression in learning. ERPSim fosters skills from knowledge acquisition (understanding ERP processes) to higher-level cognitive abilities (evaluating strategies, creating new solutions). By identifying key performance indicators (KPIs), participants gain tools they can apply throughout their professional careers.

2.2.4 Manufacturing and Supply Chain Simulations

Many business simulations also emphasize supply chain dynamics. The classic Beer Game, developed at MIT, illustrates issues such as inventory oscillation and misaligned decision-making. ERPSim builds on this tradition, simulating upstream and downstream supply chains, logistics coordination, and the trade-offs inherent in resource allocation.

2.3 ERP Systems and SAP ERP

2.3.1 Introduction to ERP Systems

Enterprise Resource Planning (ERP) systems integrate finance, human resources, supply chain, manufacturing, and customer relations into a single, centralized platform. They enhance coordination across functions, improve data consistency, and enable real-time access to information (Naidenova & Smirnov, 2025).

2.3.2 Evolution of ERP Systems

ERP systems evolved from the 1970s Material Requirements Planning (MRP) systems to MRP II, which expanded coverage to manufacturing. From the 1990s, ERP became the dominant system, integrating nearly all business functions. Modern ERP now includes cloud-based systems, artificial intelligence, analytics, and IoT for real-time asset connectivity (Naidenova & Smirnov, 2025).

2.3.3 Benefits of ERP Systems

The advantages of ERP systems include:

- Automation of processes,
- Improved productivity and efficiency,
- Cost reductions (inventory, operations, overhead),
- Enhanced forecasting and customer service,
- Integration with partners, suppliers, and customers.

Naidenova and Smirnov (2025) emphasize ERP’s role in operational efficiency, while Jha, Sharma, and Tiwari (2016) highlight challenges such as high cost, customization difficulties, and change management.

2.3.4 Adoption Across Organizations

While ERP systems offer significant benefits, successful implementation can be complex and resource intensive. Successful ERP implementation requires strong leadership, effective change management, user training, and ongoing support. Modern ERP systems, including cloud-based solutions, offer greater flexibility and scalability, allowing businesses to adapt to changing needs and technologies Cloud computing is becoming a popular solution to reduce costs and enhance the flexibility of ERP systems. ERP systems are increasingly integrating with technologies like artificial intelligence, analytics, and the Internet of Things to provide advanced insights and capabilities (Jha et al., 2016).

2.3.5 SAP ERP as Market Leader

SAP ERP is recognized as the leading ERP system globally, used by more than 320,000 businesses across over 180 countries and supported by a global ecosystem of 300+ million cloud users and 100+ development locations. This extensive footprint demonstrates SAP’s dominant market share and its adoption across virtually every major industry sector. Estimates from industry reports indicate that over 425,000 companies worldwide use SAP products, further reinforcing their position as the most widely implemented enterprise system WMSSPL (2024). This extensive use is partly due to SAP's long history and continuous innovation in ERP solutions. While other ERP systems like Oracle, Microsoft Dynamics, and open-source options are also popular, they do not match SAP's market penetration and comprehensive industry solutions. SAP ERP is a comprehensive enterprise resource planning system that integrates various business processes and functions into a single unified system. It integrates all departments and functions across a company, combining business and information technology concepts. This integration allows for real-time access to accurate, one-source information, enhancing decision-making and operational efficiency. SAP ERP offers business intelligence features that support data analysis and the development of new insights, aiding in fast and informed business decisions. To streamline ERP deployment, SAP introduced the SAP Activate Methodology—an agile and flexible implementation framework based on best practices. This methodology enables faster adoption and adaptability to changing business environments. (SAP, n.d.)

2.4 Decision-Support Tools for Strategic Analysis

2.4.1 Spreadsheets in Decision-Making

Strategic decision-making is a complex process that involves various tools and methodologies to aid decision-makers in making informed choices. Spreadsheets, particularly Microsoft Excel, have become just as essential as calculators in the realm of business analysis and strategic decision-making. They are widely used because they allow professionals to model problems in a clear, organized format. Modeling becomes especially valuable when the issue has significant financial or organizational consequences. Moreover, decision-makers are increasingly interested in understanding how assumptions impact results—this calls for a formal, structured approach to decision-making, and spreadsheet models are a tool that enables such scrutiny (Guerrero, n.d.).

2.4.2 Why Organizations Use Modeling

Organizations use modeling because important decisions often carry financial, strategic, and operational consequences that require more than intuition or informal judgement. As Guerrero (2010) explains, managers face situations where assumptions must be tested, uncertainties examined, and outcomes compared systematically, making formal models essential for rigorous analysis. Modeling allows analysts to explore “what-if” scenarios, understand how changes in the environment affect results, and provide decision makers with evidence-based insights rather than subjective guesses. Additionally, organizations increasingly expect analytical justification for proposals, and models offer a structured way to evaluate alternatives and support transparency. Ultimately, modeling strengthens decision quality, improves communication, and enhances organizational confidence in the chosen course of action. Models can be physical, analog, or symbolic. Symbolic models—built with formulas and logic—are especially valuable for testing scenarios and structuring intuition (Guerrero, n.d.).

2.4.3 Influence Diagrams

Howard and Matheson (2005) introduced influence diagrams as tools for structuring decision problems. They map decisions, uncertainties, and outcomes, helping analysts identify key relationships. Software like Analytica builds upon influence diagrams to model scenarios and evaluate strategies systematically. In more detail, they use circles for uncertain variables, squares for decisions, and arrows to show how different factors

influence each other. A major advantage of influence diagrams is that they show which variables are independent, helping reduce unnecessary probability assessments. They also clearly specify what information is available at each decision point, which is essential for realistic modelling. Influence diagrams can be transformed into decision trees when a more detailed step-by-step evaluation is needed. Overall, they provide a simple yet powerful method for organizing uncertainty, analyzing choices, and supporting rational decision-making in many fields

2.4.4 Sensitivity Analysis

Sensitivity analysis is the process of examining how changes in input values affect the optimal solution of an optimization model. After obtaining an optimal result, analysts vary key parameters—such as costs, resource limits, or demand forecasts—to see whether the decision recommendations remain stable. According to Albright and Winston (2019), sensitivity analysis is essential because real-world data rarely remains fixed and small variations can influence optimal decisions. It helps identify which constraints are "binding," which resources create bottlenecks, and how much an objective value changes when inputs shift. Sensitivity tools such as shadow prices, allowable increases and decreases, and Solver's built-in reports reveal how robust the optimal solution is. This insight enables decision makers to test what-if scenarios, assess risk, and prioritize which inputs require more accurate estimation. Overall, sensitivity analysis ensures that optimization results are interpretable, reliable, and practically useful.

2.5 Summary

The reviewed literature demonstrates that business games and ERP systems are well-established educational and managerial tools. However, most studies emphasize qualitative learning benefits rather than quantitative, model-based decision improvements. This gap underscores the importance of the present thesis, which integrates ERPSim with Excel optimization and Analytica scenario analysis to provide structured, data-driven insights for strategic decision-making.

3. Methodology

3.1 Description of ERP Simulation Game (SAP ERPSim)

The SAP ERP Simulation Game (ERPSim), developed at HEC Montréal, is at the core of the methodology applied in this thesis. It provides a dynamic, experiential environment where participants assume the role of managers at **Muesli AG**, a company dedicated to producing and selling pre-packaged breakfast cereals. By replicating real ERP transactions in the **SAP S/4HANA** system, ERPSim enables players to experience the complexity of business decision-making while interacting with integrated business processes.

This thesis focuses on a scenario for Muesli AG which operates within a competitive business simulation game designed for university-level education, and functions as a make-to-stock manufacturer, requiring participants to forecast demand and plan production ahead of time. The company is capable of producing up to twelve different products, including six flavors in two sizes, each defined by specific recipes. A single production line limits flexibility, as only one product can be manufactured at a time, forcing teams to balance longer production runs for efficiency with the need to remain responsive to changing consumer preferences. Raw materials such as grains, nuts, and dried fruits are sourced from suppliers whose prices fluctuate, reflecting market conditions and seasonal variations. Teams must plan procurement carefully to control costs and ensure consistent supply, particularly for perishable ingredients.

Sales and marketing constitute another central aspect of the simulation. Teams must position products across different distribution channels, including grocery chains, independent grocers, and hypermarkets, each with distinct purchasing behaviors and expectations. Marketing budgets can be allocated by product and region, but overspending on items with limited availability risks inefficiency and wasted resources. Participants must therefore develop tailored pricing and promotional strategies that balance short-term sales objectives with long-term profitability.

The simulation is structured into progressive scenarios of increasing complexity. In the **Introduction scenario**, teams begin with some initial inventory and resources, enabling them to focus primarily on sales and marketing decisions. The challenge is to price and sell available products while allocating marketing efforts wisely and preparing

for the transition to production in subsequent rounds. In the **Manufacturing Extended scenario**, complexity rises as teams manage a broader customer base, expand production capacity, and make use of credit lines to finance operations. Decisions now include equipment investment, optimization of production runs, and handling of fluctuating raw material costs. By the **Manufacturing Advanced scenario**, participants must navigate additional layers of strategic planning, including the management of regional distribution centers, transportation logistics, and differentiated consumer demand across markets. This phase introduces optimization problems, requiring trade-offs between transportation frequency, warehousing costs, and the risk of stockouts, while also incorporating regional consumer preferences into product mix and distribution strategies.

Financial management underpins all stages of ERPSim. Teams must monitor cash flow, manage loans through their credit line at Weizen Bank, and make timely interest payments to maintain a strong credit rating. The company's final valuation depends not only on profitability but also on financial stability, making liquidity management and loan repayment critical elements of success.

Collaboration is another fundamental dimension of the simulation. Effective teamwork and communication are required to coordinate marketing, sales, production, procurement, and finance, ensuring that decisions across these functions are aligned. This mirrors real-world business practice, where cross-functional collaboration is essential to sustaining competitiveness.

For the purposes of this thesis, ERPSim serves not only as an educational exercise but also as a **research platform**. It provides a structured yet dynamic dataset that enables the development and testing of decision-support models. By applying tools such as **Excel Solver, Goal Seek, and Analytica**, the simulation is transformed into a laboratory for strategic decision-making, where optimization, scenario analysis, and uncertainty handling can be systematically studied. In this way, ERPSim functions both as the subject of analysis and as a practical environment for the methodological framework developed in the present work.

3.2 Models Development

The methodological framework of this thesis is based on the design and implementation of a series of decision-support models that complement the ERPSim environment. While ERPSim provides a dynamic and realistic simulation of business operations, it does not in itself offer the optimization and scenario-testing capabilities required for strategic decision-making. To address this gap, a set of models were developed, each targeting a specific area of business management: liquidity planning, loan repayment, production improvement, and profitability analysis.

The models were developed using two complementary tools: Microsoft Excel and Analytica. Excel, through its built-in functions, Solver, and Goal Seek, enables precise optimization and validation of business decisions under defined constraints. **Analytica**, by contrast, provides a flexible environment for building symbolic models, influence diagrams, and scenario analyses, making it particularly suitable for handling uncertainty, identifying interrelations between decision variables and outcomes and exploring alternative outcomes. By combining these two tools, the models achieve both numerical precision and conceptual transparency.

The development process of each model followed a structured approach. First, the objective and scope of the model were defined, clarifying the specific managerial question it aimed at addressing. Next, a conceptual framework was designed, identifying the relevant variables, assumptions, and relationships. This framework was then implemented into a formal model structure, expressed through formulas and influence diagrams. Each model also included a validation stage, where outputs were compared against expected or simulated values to ensure consistency and reliability. The models were further refined to incorporate scenarios and uncertainty handling, allowing for the evaluation of alternative strategies under varying market or financial conditions. Finally, the outputs were visualized through tables, charts, or diagrams, enabling clear interpretation of the results and practical insights for decision-making.

A key element of the modeling process was the systematic documentation of variables, formulas, and parameters, presented in structured tables for clarity and reproducibility. This ensured that the models could be adapted and extended in future work. Limitations were also explicitly identified, along with opportunities for refinement,

such as the integration of additional data, advanced optimization techniques, or probabilistic simulation methods.

In this way, the development of models bridges the gap between the qualitative learning experience of ERPSim and the quantitative rigor required for business decision-making. Each of the following subsections presents a model in detail, following the structure of objective, framework, structure, variables, validation, outputs, and limitations.

3.2.1 Classes of Variables and Model Objects

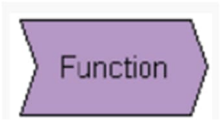
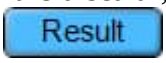
In Analytica, models are constructed using a set of clearly defined object types, each serving a distinct role in the representation of the decision system. The most fundamental distinction is between variables that represent **inputs**, **intermediate relationships**, and **outputs**. These are visually differentiated within the influence diagram, making the flow of information transparent.

- **Decision Variables** represent controllable parameters, such as batch size, loan repayment timing, or pricing choices. These are the strategic levels considered during scenario analysis.
- **Chance Variables** capture uncertainty, such as demand variation or fluctuating raw material prices. Although probabilistic simulation was not performed due to licensing limitations, these variables were treated deterministically through scenario comparisons.
- **Objective Variables** represent performance outcomes against which decisions are evaluated, such as profit, cash balance, or stock levels.
- **Constants and Inputs** include fixed parameters or externally provided data (e.g., initial cash position, production capacity).
- **Modules** are used to organize model components into logical sections, improving readability and scalability of the model.

Influence arrows connecting these objects show how each variable depends on others. This classification supports a clear conceptual model structure, allowing relationships, dependencies, and assumptions to be easily communicated and evaluated.

Table 1

	A rectangle depicts a decision variable — a quantity that the decision maker can control directly. For example, whether or not you take an umbrella to work is your decision. If you are bidding on a contract, it is your decision how much to bid.
	An oval depicts a ***chance variable*** — that is an uncertain quantity whose definition contains a probability distribution. For example, whether or not it will rain tomorrow is a chance variable (unless you are a rain god). And whether or not your bid is the winning bid is a chance variable in your model, although it is a decision variable for the person or organization requesting the bid.
	A hexagon depicts an ***objective variable*** — a quantity that evaluates the relative value, desirability, or utility of possible outcomes. In a decision model, you are trying to find the decision(s) that maximize (or minimize) the value of this node. Usually, a model contains only one objective.
	A rounded shape (with thin outline) depicts a ***general variable*** — a quantity that is not one of the above classes. It can be uncertain because it depends on one or more chance variables. Use this class initially if you're not sure what kind of variable you want. You can change the class later when it becomes clearer.
	A rounded node (with thick outline) depicts a ***module*** — that is, a collection of nodes organized as a diagram. Modules can themselves contain modules, creating a nested hierarchy.
	A parallelogram depicts an ***index variable***. An index is used to define a dimension of an array. For example, *Year* is an index for an array containing the U.S. GNP for the past 20 years. Or *Nation name* is an index for an array of GNPs for a collection of nations. Indexes identify the row and column headers of a table, and the axes and key of a graph
	A trapezoid depicts a ***constant*** — that is, a variable whose value is fixed. A constant is not dependent on other variables, so it has no inputs. Examples of numerical constants are the atomic weight of oxygen (16) or the number of feet in a kilometer. It is clearer to define a constant for each such value you need in a model, so you can refer to them by name in each definition that uses it, rather than retyping the number each time.

	A shape like an arrow tail depicts a ***function***. You can use existing functions from libraries, and define new functions to augment the functions provided in Analytica
	This node is a ***button*** — when you click a button (in browse mode), it executes its OnClick expression to perform some useful action.
	A **Text node** has no computed value, it is simply used to display text. Text nodes are often used, sometimes without any text at all, to create visible groupings behind other nodes.
	A user input node provides a place where the user of a model can enter an input value or input values. It is a type of alias, called a FormNode, of a variable in your model, and shows/sets the definition of that variable. The node contains a label and a control. The type of control depends on how the variable is defined. It may be a text box, a button that opens a table, a button that opens a list, a choice or multi-choice pulldown, a checkbox, or even (when the node is made to be tall and the embed bit is set) an entire embedded edit table
	A user output node displays a calculated result, or a button that opens a result window. It is a type of alias, called a *FormNode*, of a variable in your model. When the value is not yet computed, a  appears. When the result is a scalar, the value is shown. When the result is an array, a  appears that opens a result window. If the node is tall enough, in ACP the result table of graph appears directly in the node. User output nodes are created by selecting **Make user output** on the Object menu.

3.2.2 Liquidity Planning Model

Objective and Scope

The Liquidity Planning Model has as its main objective to ensure that the company maintains sufficient cash flow to cover its operating expenses, financial obligations, and investment needs. Liquidity is critical for the survival and competitiveness of the business, since insufficient liquidity can lead to disruptions even when the company remains profitable in the long term. The scope of this model includes revenues from sales,

procurement costs, loan repayments, and other cash outflows that directly affect the company's ability to remain solvent.

Conceptual Framework

The conceptual framework for the liquidity planning model is built around tracking and forecasting weekly cash flows over a 4-month horizon. The core purpose is to monitor liquidity by estimating the cash position at the end of each week, based on projected inflows and outflows from various operational and financial activities. The model is structured to reflect the typical cash flow cycle of an organization, including the timing of receivables, payment obligations, and recurring costs. It enables short-term financial planning by highlighting when and where cash shortfalls or surpluses may occur. Key elements of the framework include:

- Time Dimension: The model operates on a weekly basis, with 16 periods representing the 4-month forecast.
- Causal Relationships: Each week's closing balance depends on the previous week's closing balance (carried forward as the opening balance), adjusted by the week's net cash flow.
- Main Cash Flow Drivers:
    - Receivables: Incoming cash from customer payments based on predefined schedules.
    - Payables: Outgoing cash to suppliers or service providers.
    - Marketing Expenses: Planned weekly promotional and advertising spending.
    - Overhead Expenses: Fixed or semi-variable costs such as rent, salaries, and utilities.
    - Interest Expenses: Regular debt servicing payments.
- Liquidity Metric: The primary output is the closing cash balance for each week, which serves as a real-time indicator of the company's ability to meet its financial obligations.

Model Structure in Analytica

The model structure was implemented in **Analytica**, making use of influence diagrams that clearly represent the main variables and their interactions. The major variables included in the model are:

- **Receivables**: Expected incoming payments based on projected sales and average collection periods.
- **Payables**: Outgoing payments for purchases, services, and other liabilities.
- **Marketing Expenses**: Planned weekly marketing spending.
- **Overhead Expenses**: Regular administrative and operational costs (e.g., rent, salaries, utilities).
- **Interest Expenses**: Payments related to existing debt, scheduled on a weekly basis.
- **Closing Balance**: The calculated end-of-week cash balance after accounting for all inflows and outflows

  Formula(simplified):
  ClosingBalance [week 0] := Receivables[week 0] - Payables[week 0] - MktgExpenses[week 0] - Overhead[week 0] - Interest[week 0]

  ClosingBalance [next weeks] := OpeningBalance[previous weeks] + Receivables[current week] - Payables[current week] - MktgExpenses[current week] - Overhead[current week] - Interest[current week]

Each week's **opening balance** is automatically linked to the **closing balance** of the previous week, creating a time-dependent chain of cash flow projections spreading along the entire time horizon of the game.

Key Variables, Formulas and Variable‘s Description Table

This section outlines the key variables included in the liquidity planning model, along with the core formulas used to calculate the weekly cash position.

- Rounds : Representing 4 rounds
- Weeks: Representing 4 weeks
- Receivables: Manual Input
- Payables: Manual Input
- Marketing `: Cumulative Cash Balance

Table 2

Variable	Type	Description
Receivables[week]	Inflow	Expected customer payments collected each week.
Payables[week]	Outflow	Supplier payments and other obligations.
Marketing Expenses[week]	Outflow	Weekly planned marketing expenditure.
Overhead Expenses[week]	Outflow	Salaries, rent, utilities, and other operational costs.
Interest Expenses[week]	Outflow	Weekly interest payments on outstanding debt.
Total Cash Outflows[week]	Input/Output	Cash payments made during a week, including operating expenses and capital expenditures
Net Cash Flow[week]	Input/Output	Difference between total cash inflows and outflows, indicating the overall cash position
Closing Balance[week]	Output	Final cash position at the end of each week.

Moreover, additional Variables were created in order to make the model more user friendly.

- Model Node Variable that includes the whole model
- Text Node Variable that Split the variables to inputs-calculation-Outputs
- User input Nodes in order the user to be able to key in data
- User Output Nodes in order the user to be able to click on the result

Scenarios and Uncertainty Handling

Due to the limitations of the Free Edition of Analytica, which does not support probabilistic distributions or Monte Carlo simulations, uncertainty in this model is addressed using simple, predefined input variations. This approach involves creating multiple versions of key input parameters to reflect alternative business conditions and to assess their impact on weekly liquidity.

Three basic scenarios are introduced to support decision-making during the simulation:

- Base Case: Neutral scenario using default input values.
- Optimistic Case: Assumes increased revenue or reduced expenses.
- Pessimistic Case: Includes lower income and higher operational costs

These scenarios are manually implemented by adjusting the respective values for sales, marketing, overhead, or interest. Participants can immediately observe how their decisions influence the cash balance on a weekly basis, supporting experiential learning and financial planning skills

Model Validation

Model validation was performed through both internal consistency checks and external comparison with results generated in Excel. Specifically, Excel's Solver was used to optimize repayment schedules under constraints of liquidity and interest minimization, while Goal Seek was applied for break-even calculations, determining required sales or margins for maintaining a positive cash balance. These methods ensured that the outputs of the Analytica model were consistent with optimization results obtained from Excel. This combination of tools enhanced the reliability of the model by providing both structural transparency (Analytica) and numerical precision (Excel)

Limitations and Refinement Opportunities

The Liquidity Planning Model, while useful, is subject to certain limitations. These are:

1. **Edition Constraint – Variable Limit:** The model is built in the **free edition of Analytica**, which limits the number of user-defined variables and objects to **101**. This restricts model complexity and scalability, forcing simplifications and preventing the addition of desirable dynamic links (e.g., between net debt and interest expenses).
2. **No Dynamic Link between Loan and Interest Expenses:** Due to object limitations, the **interest expense** is not dynamically linked to outstanding **loans or net debt**. Instead, it is a fixed input, which limits realism in financial forecasting.
3. **No Use of Probability Distributions:** The free edition of Analytica does **not support uncertainty modeling or probability distributions**. As a result, all variables are treated as deterministic, preventing Monte Carlo simulations or sensitivity analysis.
4. **Static Time Dimensions:** The model uses a **fixed time structure** (4 rounds × 4 weeks) which might not generalize well to different planning periods or irregular cycles without structural adjustment.
5. **Simplified Cash Flow Drivers:** Key variables like **receivables, payables, marketing expenses** are manually input per week and round without linkage to operational performance (e.g., sales volume, pricing), which reduces the model's behavioral realism.
6. **No Delay or Payment Terms Modeling:** The model assumes **instantaneous cash flows** — no payment delays or receivable aging. While this is acceptable for a game context, it limits realism in replicating real-world financial flows.

The Refinement Opportunities are:

1. **Upgrade to Full Analytica Edition:** Using a licensed version would remove the variable cap, allowing you to:
    - Link interest expenses to loan balance dynamically
    - Add more drivers (e.g., revenue, production, variable costs)
    - Introduce conditional logic for delays, thresholds
2. **Incorporate Loan and Financing Logic:** Introduce variables for:
    - Loan balance by week
    - Repayment schedule
    - Dynamic interest rates; this would allow for a more robust cash flow and financing structure.
3. **Implement Uncertainty Modeling:** Use probability distributions to capture uncertain inputs like:
    - Future sales
    - Delayed receivables
    - Variable marketing spend; this would enable risk analysis and scenario planning.
4. **Enhance Cost and Revenue Modeling:** Rather than fixed expense inputs, link costs to:
    - Units sold or marketed
    - Operational activity; this would improve scalability and realism.
5. **Create Dashboards for Users:** For a simulation game, it would be helpful to:
    - Provide user-friendly input interfaces
    - Include visual outputs (charts, cash flow over time)
    - Add alerts when cash balance goes negative
6. **Model Additional Financial Metrics:** Possible enhancements:
    - Net present value (NPV) or internal rate of return (IRR)
    - Working capital calculations
    - KPI tracking across rounds

3.2.3 Loan Repayment & Company Valuation Model

Objective and Scope

This model is designed to evaluate the **impact of loan repayment strategies on company valuation**, by reducing interest expenses and increasing net income. It simulates the financial effects of repaying part or all of a loan across several planning

rounds, measuring how that decision affects long-term profitability and valuation. The scope includes:

- Four simulation rounds
- Loan repayment at the start of each round
- Calculation of interest savings and resulting profitability
- Annualization of profit for company valuation purposes.

Conceptual Framework

The model is built on the financial relationship between **loan repayment → reduced interest expense → higher net income → increased company value**. Each round begins with a user-defined repayment amount. This repayment reduces the outstanding loan, which then lowers daily interest expenses. Interest savings flow into cumulative net income, which is annualized and used to compute company valuation.

Model Structure in Analytica

The model is implemented in Analytica using the following main components:

1. **<u>Loan Repayment</u>**
   - **Payment Amount**: The amount of loan principal repaid at the beginning of the round. Manual input per round
   - **Starting Loan**: Loan balance before the round's repayment is applied (Round 1 = initial loan; later rounds = prior round ending balance unless fully repaid)
   - **Daily Loan Interest**: Baseline daily interest cost calculated on the *pre-payment* loan balance (used as an input when a dynamic interest calculation isn't modeled)
   - **New Loan**: Remaining principal after repayment
   - **Daily Interest Expense**: Interest cost per day on the **new** (post-payment) loan balance
   - **Round Interest**: Total interest accrued over the round after repayment
   - **Total Interest Paid:** Sum of Round Interest across all completed rounds. Indicates cumulative financing cost
   - **Additional Net Income**: Interest savings relative to a no-repayment (or reference) case.
   - **Annualized Net income:** Scales the cumulative net income

- **Net Debt:** Current financial leverage measure after repayments
- **Applicable Interest Rate:** Discount or capitalization rate used to translate annualized income into value
- **Company Valuation:** Estimated firm value based on the model's earnings improvement

2. **<u>Company Valuation</u>**
   - **Income Statement:** Core profitability components for each round, including Revenue and Cost of Goods Sold (COGS), which form the basis of gross profit
   - **Fixed Costs:** Recurring operational expenses not tied to sales volume (Building Depreciation, Machinery Depreciation, Direct Labor Costs, Factory Overhead, SG&A (Selling, General & Administrative)
   - **Net Debt:** The company's financial leverage measure
   - **Cumulative Net Income:** Total net income accumulated across all rounds.
   - **Annual Profit:** Extrapolated profitability
   - **Rounds Completed (Company Valuation):** Manual input that indicates the rounds that have been completed
   - **Company Valuation:** The estimated enterprise value derived from profitability.

Key Variables, Formulas and Variables Description Table

This section summarizes the key input, intermediate, and output variables used in the Loan Repayment and Company Valuation Model. It also outlines the core formulas used for calculating interest expenses, additional net income, and firm valuation. The model's logic flows from loan repayment decisions to their impact on interest costs, income, and overall enterprise value.

- **Rounds:** Representing 4 rounds (Loan Repayment)
- **Days/Round:** Representing 20 days per round (Loan Repayment)
- **Daily Initial Interest:** Fixed Value from transaction code zck11-Fixed Costs (Loan Repayment)
- **Starting Loan:** Fixed Value based on 2nd scenario of the simulation game (Loan Repayment)
- **Payment Amount:** Manual Input (Loan Repayment)

- **Avg Price/Unit:** Manual Input (Company Valuation)
- **Actual Sales Qty:** Manual Input (Company Valuation)
- **Avg Unit Cost:** Manual Input (Company Valuation)
- **Rounds (Company Valuation):** Manual Input, Used for Company Valuation Model and affects the Annual Profit (Company Valuation)
- **Total Days:** Days/Round * Rounds (Loan Repayment)
- **Total Initial Interest:** Daily Loan Interest * Total Days (Loan Repayment)
- **Initial Interest Rate:** Daily Initial Interest/Starting Loan (Loan Repayment)
- **New Loan Balance:** Starting Loan-Payment Amount (Loan Repayment)
- **Daily Interest Expense:** New Loan Balance * Initial Interest Rate (Loan Repayment)
- **Round Interest:** Daily Interest Expense * Days/Round (Loan Repayment)
- **Total Interest Paid:** Sum of Round Interests (Loan Repayment)
- **Net Debt:** (Accounts Payable (Manual Input) + New Loan Balance) – (Cash (Manual Input) + Accounts Receivable (Manual Input)). (Loan Repayment) + (Company Valuation)
- **Applicable Interest Rate:** It takes into consideration the Net Debt, Interest Premium, and Risk Premium to derive the Interest Rate, which is then used to determine the Discount Rate based on the Credit Ratings Table provided by the simulation game. (Loan Repayment) + (Company Valuation)
- **Revenue:** Avg Price/Unit * Actual Sales Qty (Company Valuation)
- **Cogs:** Avg Unit Cost * Actual Sales Qty (Company Valuation)
- **Additional Net Income (Loan Repayment):** Total Initial Interest - Total Interest Paid
- **Annualized Net Income (Loan Repayment):** Additional Net Income * 3 (fixed value that represents 4 rounds)
- **Company Valuation (Loan Repayment):** Annualized Net Income / Applicable Interest Rate
- **Income Statement:** Revenue – Cogs (Company Valuation)

- **Fixed Costs:** Buildings Depreciation (Manual Input) + Machinery Depreciation (Manual Input) + Direct Labor Cost (Manul Input) + Factory Overhead (Manual Input) + SGA (Manual Input) (Company Valuation)
- **Cumulative Net Income:** Income Statement – Fixed Costs (Company Valuation)
- **Annual Profit:** (Cumulative Net Income/Rounds (Rounds Completed (Company Valuation)) * 12 that represents the months of a year (Company Valuation)
- **Company Valuation (Company Valuation Model):** Annual Profit/Applicable Interest Rate

A detailed table of variables and formulas is included to describe how each element is calculated and how it contributes to the overall valuation framework.

Table 3

Variable	**Type**	**Description**
Rounds	Input	Number of simulation periods (e.g., 4 rounds)
Days/Round	Input	Number of days in each round (fixed at 20)
Daily Initial Interest	Input / Outflow	Fixed daily loan interest from ZCK11 (fixed costs)
Starting Loan	Input	Initial loan amount, scenario-based
Payment Amount	Input / Outflow	Manual input: repayment amount at start of each round
Avg Price/Unit	Input	Manual input: average unit sales price
Actual Sales Qty	Input	Manual input: units sold
Avg Unit Cost	Input	Manual input: unit cost of production
Rounds Completed (Company Valuation)	Input	Manual Input: Number of rounds played.
Total Days	Output	Total simulation time
Total Initial Interest	Output / Outflow	Interest cost if no repayments
Initial Interest Rate	Output	Initial Interest rate
New Loan Balance	Output	Loan balance after payment
Daily Interest Expense	Output / Outflow	Daily interest after repayment
Round Interest	Output / Outflow	Total interest per round
Total Interest Paid	Output / Outflow	Cumulative interest across all rounds
Net Debt	Output	Net liabilities
Applicable Interest Rate	Output	Used as discount rate; depends on credit rating and risk

Revenue	Output / Inflow	Total sales
COGS	Output / Outflow	Cost of goods sold
Additional Net Income	Output / Inflow	Interest savings due to repayment
Annualized Net Income	Output / Inflow	Projected net income per year (×3 for 4 rounds)
Company Valuation (Loan Repayment)	Output	Valuation from loan savings
Income Statement	Input/Output	Profit before fixed costs
Fixed Costs	Input/Output	Total of depreciation, labor, overheads, and SG&A
Cumulative Net Income	Output / Inflow	Net income across rounds
Annual Profit	Output / Inflow	Annualized profit
Company Valuation (Full Model)	Output	Final enterprise value

Moreover, additional Variables were created in order to make the model more user friendly.

1. Model Node Variable that includes the whole model
2. Text Node Variable that Split the variables to inputs-calculation-Outputs
3. User input Nodes in order the user to be able to key in data
4. User Output Nodes in order the user to be able to click on the result

Scenarios and Uncertainty Handling

The loan repayment and company valuation models are designed to simulate and analyze different financial outcomes based on variations in repayment strategy, operational performance, and market conditions. Due to the limitations of the Analytica Free Edition, probabilistic distributions could not be used. However, scenario-based analysis has been implemented to assess the sensitivity of the models to key input parameters.

Scenario Approach

Three main scenarios were created to explore how different loan repayment levels and operational assumptions influence company valuation:

Scenario 1 – Conservative Repayment

- **Payment Amount**: Low repayment at each round

- **Impact**: Higher loan balance maintained, leading to higher total interest paid, lower net income, and reduced valuation.
- **Objective**: Explore the impact of cash preservation strategy at the cost of higher financing expense.

Scenario 2 – Moderate Repayment (Base Case)

- **Payment Amount**: Balanced repayment strategy
- **Impact**: Reduces interest burden while maintaining some financial flexibility.
- **Objective**: Reflects a realistic scenario in line with the simulation game's second case.

Scenario 3 – Aggressive Repayment

- **Payment Amount**: High or full repayment early in the simulation
- **Impact**: Drastically reduces interest costs, increases net income and valuation, but limits liquidity.
- **Objective**: Analyze the benefits of minimizing debt early, assuming sufficient internal cash generation.

Due to the use of the **Free Edition of Analytica**, built-in uncertainty modeling via probability distributions (e.g., Monte Carlo) is not available. As an alternative:

- **Discrete scenario testing** was used to analyze a limited set of conditions.
- **Sensitivity analysis** was conducted manually by changing individual inputs and observing the model's outputs.

Model Validation

The model was validated through a comparative approach. In Analytica, loan repayment strategies were tested against simulation rules and observed results from the ERP game. In parallel, Excel was used to replicate repayment plans using Solver for optimizing repayment speed under interest cost minimization and Goal Seek to determine break-even repayment levels for maintaining liquidity. The consistency of results across both platforms confirmed the robustness of the model and highlighted the added value of combining strategic modeling with numerical optimization

Limitations and Refinement Opportunities

A. Loan Repayment Model

Limitations

1. Tool Constraints (Analytica Free Edition)

   The model is developed using the free edition of Analytica, which limits the total number of variables (to 101) and excludes the use of probability distributions and influence diagrams, reducing the model's ability to incorporate uncertainty and conduct sensitivity analysis.

2. Manual Inputs for Key Financials

   Variables such as payment amount, daily interest, and starting loan are manually input and not dynamically linked to financial statements or cash flows. This introduces a risk of inconsistency and limits the model's scalability.

3. Fixed Interest Rate Assumption

   The model assumes a fixed daily interest rate throughout the repayment period. In reality, interest rates may vary due to economic or credit-related factors.

4. Simplified Repayment Logic

   Payments are assumed to be made only once at the start of each round. Real-world repayment schedules often involve more flexible or frequent payments (e.g., monthly or variable installments).

Refinement Opportunities

1. Integrate with Transactional Data

   Dynamically link to data from simulation game transactions (e.g., ZCK11) for automatic updates of fixed costs and loan terms.

2. Enable Probabilistic Scenario Analysis

   If using a licensed version of Analytica, apply probability distributions to model uncertainty in interest rates, payment behaviors, or macroeconomic variables.

3. Improve Cash Flow Tracking

   Expand the model to track cash balances and financing needs more granularly to reflect working capital impacts.

B. Company Valuation Model

Limitations

1. No Feedback Loop Between Models

   Although logically related, the Loan Repayment Model and Company Valuation Model are not mathematically linked. For instance, additional net income from reduced interest expense is not directly reflected in the valuation unless manually carried over.

2. Fixed Revenue and Cost Structure

   The model assumes fixed values for revenue and cost variables, leading to constant cumulative net income across all scenarios. This limits the ability to explore operational efficiency or cost optimization effects.

Refinement Opportunities

1. Introduce Operational Variability

   Allow inputs like sales quantity, price per unit, and unit costs to vary across scenarios or rounds, making the model more realistic and sensitive to business decisions.

2. Add Visualization Features

   Include comparative charts and graphs that illustrate how repayment strategies impact valuation, helping users better interpret model results

3.2.4 Production Improvement Model

Objective and Scope

The primary objective of the *Production Improvement Model* is to evaluate how strategic investments in **production capacity** and **setup time efficiency** influence a company's profitability and valuation. Specifically, the model examines how operational enhancements can reduce unit costs, increase output, and thereby boost the estimated profit and company value over time.

This model supports decision-making in a simulation-based business environment by quantifying the financial impact of productivity investments. It integrates both

operational and financial metrics—such as total production capacity, fixed cost per unit, and running profit—to determine their effect on **net income**, **annualized income**, and ultimately the **company's valuation**. The scope of the model includes:

- Four rounds of decision-making, each consisting of 20 operational days.
- Daily production capacity adjustments based on capital investment.
- Setup time reduction through targeted investments.
- The calculation of productivity improvements and their financial benefits.
- Loan implications and resulting effects on net debt and discount rate.
- Output in the form of estimated net income and company valuation.

Conceptual Framework

The model links production performance with financial outcomes by modeling the effects of capacity and setup time investments on production output, cost structure, and net income.

At its core, the model simulates how investing in:

- **Production capacity** (e.g., purchasing new machinery) and
- **Setup time reduction** (e.g., hiring consultants)

…impacts key business metrics over four rounds of operation.

The conceptual flow is as follows:

1. **Inputs** are made for each round in terms of capital invested in capacity and setup time.
2. These investments affect:
    - **Total capacity**, depending on the amount invested.
    - **Setup time (in hours)**, also influenced by investment.
3. The resulting **total production** is determined by the available capacity, adjusted for setup requirements and average production run size.
4. The **productivity estimate** is derived from the ratio of actual production to potential capacity.

5. Productivity improvements reduce the **fixed cost per unit**, thus increasing the **running profit**.
6. The **estimated net income** accounts for total production and profit per unit, net of the investment in setup time.
7. This estimated profit is **annualized** and used to derive the **company valuation**, which also considers financial leverage through **net debt** and the applicable discount rate.

The framework assumes diminishing setup time and increasing capacity will lead to more production runs, greater throughput, and improved cost efficiency. By quantifying these benefits, the model allows decision-makers to evaluate the ROI of operational improvements and their effect on long-term company value

Model Structure in Analytica

The model is implemented in Analytica using the following main components:

Production Efficiency Improvement

- **Capacity Investment**: Manual input per round representing capital allocated to expand production capacity.
- **Setup Time Investment**: Manual input per round representing capital allocated to reduce machine setup time.
- **Capacity in H per Day** : Fixed at 24 hours/day as a base constraint.
- **Days per Round**: Set at 20 days, determining the operating period within each round.
- **Total Days**: Product of rounds and days per round; used to scale total production capacity.
- **Total Capacity**: Determined by capacity investment.
- **Setup Time (H)**: Determined by the level of setup investment.
- **Capacity per Setup**: Converts setup time into usable production capacity.
- **Capacity per Run**: It represents the total capacity needed to complete one full production cycle, accounting for both setup and operational output.
- **Possible Runs**: Number of feasible runs in total capacity available.

- **Total Production**: Output based on runs and average production run.
- **Productivity Estimate (%)**: Ratio of total production to total potential capacity.

Cost & Profit Calculation

- **Starting Loan:** The initial debt amount before any repayments are made
- **Total Daily Cost**: Manual input based on fixed daily operating expenses.
- **Initial Allocation Basis**: Baseline measure using initial capacity (24,000) and 75% productivity.
- **Fixed Cost per Unit**: Total daily cost divided by the allocation basis.
- **Base Fixed/Unit**: Benchmark unit cost using the initial allocation basis.
- **Target Unit Profit**: Fixed at $1.00 as a reference target.
- **Running Profit**: Difference between target profit + base cost and actual fixed cost per unit.
- **Estimated Profit / Net Income**: Net earnings from production improvement after deducting setup investment.

Financial Output & Valuation

- **Annualized Net Income**: Scaled-up version of estimated profit to reflect 12-month performance, adjusted for setup time.
- **Net Debt**: Loan amount less any offsetting cash or receivables.
- **Applicable Interest Rate**: Derived based on the net debt level, interest premium, and risk premium, aligned with the simulation game's credit rating table.
- **Company Valuation**: Calculated by discounting the annualized net income using the applicable interest rate.

Key Variables, Formulas and Variable's Description Table

This section summarizes the key input, intermediate, and output variables used in the **Production Improvement Model**. It also outlines the core formulas used for calculating capacity, setup time, productivity, profits, and firm valuation. The model links investment decisions (capacity and setup time investments) to their impact on production, costs, profits, and overall company valuation.

These formulas form the basis of the **Production Improvement Model**, which integrates the investment in capacity and setup time to enhance productivity, reduce costs, and improve the company's valuation based on the simulated performance over the defined rounds

Capacity Module:

- **Units/Day**= Includes all the possible units that can be produced in a day based on capacity investment
- **Capacity Cost**= Includes all the possible amounts of money that can be invested to improve productivity
- **Capacity Investment**= Manual Input of investment on production improvements
- **Total Cum Capacity Investment**= Cumulation of the values keyed in the capacity investment per round
- **Capacity:** Output of daily capacity based on invested money

Total Capacity Module:

- **Days per Round= Fixed value representing the days per round**
- **Total Days** = Rounds * Days/Round
- **Total Capacity = Capacity* Total Days**

Setup Time Module:

Setup Time= Includes all the possible hours of setup time

- **Setup Time Cum Investment= Includes all the possible amounts of money that can be invested to decrease setup time**
- **Setup Time Investment= Manual Input of investment on Setup time reduction**
- **Total Cum Investment= Cumulation of the values keyed in the Setup Time investment per round**
- **Setup Time (H)= Output of daily Setup time based on invested money**

Total Production Module:

- **Capacity in H per Day**= Fixed Value representing the initial capacity per Day

- **Capacity per Setup** = Capacity / (Capacity in H per Day * Setup Time Investment)
- **Average Production Run**= Fixed Value representing the initial capacity per Day
- **Capacity per Run** = Capacity per Setup + Average Production Run
- **Possible Runs** = Total Capacity / Capacity per Run
- **Total Production** = Possible Runs * Average Production Run

Fixed Cost per Unit Module:

- **Productivity Estimate (%) =** Total Production / Total Capacity
- **Allocation Basis =** Capacity * Productivity Estimate
- **Total Daily Cost=** Includes the sum of all the daily fixed costs (Manual Input)
- **Fixed Cost per Unit =** Total Daily Cost / Allocation Basis
- **Initial Productivity Estimate=** Fixed Value
- **Initial Capacity=** Fixed Value
- **Initial Allocation Basis=** Initial Productivity Estimate * Initial Capacity
- **Base Fixed Cost per Unit=** Total Daily Cost/Initial Allocation Basis

Profit Module:

- **Target Unit Profit=** Fixed Value
- **Running Profit =** Base Fixed Cost per Unit +Target Unit Profit - Fixed Cost per Unit
- **Estimated Profit/Net Income** = (Total Production * Running Profit) - Setup Time Investment
- **Annualized Net Income =** (((Estimated Profit/Net Income + Setup Time Investment) / Rounds) * 12) - Setup Time Investment

Net Debt Module:

- **Starting Loan=** Manual Input of Loan Amount of each round from Balance Sheet
- **Cash=** Manual Input of available Cash from Balance Sheet
- **Accounts Receivables=** Manual Input from Balance Sheet

- **Accounts Payable=** Manual Input from Balance Sheet
- **Net Debt=** Cash+ Accounts Receivables- Accounts Payable – Starting Loan
- **Applicable Interest Rate=** Interest Rate based on the Net Debt
- **Company Valuation =** Annualized Net Income / Applicable Interest Rate

Table 4

Module	Variable Name	Type	Description
Capacity Module	Units/Day	-	Total units that can be produced in one day based on capacity investment
	Capacity Cost	-	Cost tiers representing productivity improvement through investment
	Capacity Investment	Input	Manual input: Investment per round to increase daily production capacity
	Total Cum Capacity Investment	Output	Cumulative sum of capacity investments across rounds
	Capacity	Output	Daily production capacity derived from investment amount
Total Capacity Module	Days per Round	Fixed	Fixed value (e.g., 20) representing days per round
	Total Days	Input/Output	Rounds * Days per Round: Total simulation time
	Total Capacity	Output	Capacity * Total Days: Overall production capacity available
Setup Time Module	Setup Time	-	Hours needed for setup based on investment
	Setup Time Cum Investment	-	Investment in setup time reduction
	Setup Time Investment	Input	Manual input: Investment in setup time optimization
	Total Cum Investment	Output	Cumulative setup time investment across all rounds
	Setup Time (H)	Output	Setup time in hours, determined by investment tiers
Total Production Module	Capacity in H per Day	Fixed	Operational hours per day (e.g., 24 hours)
	Capacity per Setup	Output	Number of units that can be prepared for production during each setup phase
	Average Production Run	Fixed	Standard run size (e.g., 24,000 units)
	Capacity per Run	Input/Output	Indicates units produced per run

	Possible Runs	Input/Output	Total number of production cycles possible given total capacity and run size
	Total Production	Output	Total units produced based on the number of possible runs and average run size
Fixed Cost per Unit	Productivity Estimate (%)	Output	Efficiency percentage
	Allocation Basis	Output	Effective capacity utilized for production, based on actual productivity
	Total Daily Cost	Input	Manual input: Sum of daily fixed operational costs
	Fixed Cost per Unit	Output	Cost allocated to each unit produced
	Initial Productivity Estimate	Fixed	Initial productivity estimate (e.g., 75%)
	Initial Capacity	Fixed	Initial capacity baseline (e.g., 24,000 units)
	Initial Allocation Basis	Output	Baseline for comparison
	Base Fixed Cost per Unit	Output	Basis: Benchmark unit cost
Profit Module	Target Unit Profit	Input	Profit goal per unit (e.g., $1)
	Running Profit	Output	Profit per unit
	Estimated Profit / Net Income	Output	Net earnings from production improvement after deducting setup investment
	Annualized Net Income	Output	Projects the estimated profit over a full year, scaling the model's results beyond the 4-round simulation
Net Debt Module	Starting Loan	Input	Manual input from balance sheet
	Cash	Input	Manual input: Cash on hand from balance sheet
	Accounts Receivables	Input	Manual input from balance sheet
	Accounts Payable	Input	Manual input from balance sheet
	Net Debt	Output	(Cash + Receivables) - (Payables + Starting Loan): Leverage level
	Applicable Interest Rate	Output	Derived rate based on net debt level and credit profile
	Company Valuation	Output	Enterprise value

Scenarios and Uncertainty Handling

The **Production Improvement Model** assesses how strategic investments in capacity and setup time influence productivity, cost efficiency, and ultimately, firm valuation. Due to the limitations of the **Analytica Free Edition**, advanced probabilistic

tools (e.g., Monte Carlo simulation) were not used. Instead, a **scenario-based analysis** was implemented to explore performance under varying investment and profitability strategies.

Scenario Approach

Three scenarios were created to evaluate the impact of different investment strategies:

Scenario 1 – Low Investment

- **Capacity Investment**: Minimal per round
- **Setup Time Investment**: Minimal per round
- **Target Unit Profit**: Conservative (low margin)
- **Impact**: Limited production output, fewer production runs, higher unit costs, and reduced profitability and valuation
- **Objective**: Reflects a conservative strategy focused on preserving capital

Scenario 2 – Moderate Investment (Base Case)

- **Capacity Investment**: Balanced across rounds
- **Setup Time Investment**: Moderate improvement in efficiency
- **Target Unit Profit**: Mid-range (aligned with competitive pricing)
- **Impact**: Increased output and operational efficiency lead to lower unit costs and improved net income
- **Objective**: Represents a realistic, balanced growth path

Scenario 3 – High Investment

- **Capacity Investment**: High, aggressive investment
- **Setup Time Investment**: Aggressive reduction efforts
- **Target Unit Profit**: Optimized for higher margin
- **Impact**: Maximum production utilization, lower cost per unit, increased profitability and valuation — but with higher upfront investment
- **Objective**: Explore the return potential of aggressive operational scaling

Uncertainty Handling Approach

Since probabilistic modeling could not be applied, the following strategies were used to assess variability and uncertainty:

- **Discrete Scenario Testing**: Structured combinations of investment and profitability assumptions were tested manually across the three scenarios
- **Manual Sensitivity Analysis**: Key input variables were adjusted individually to measure their influence on model outputs, including:
    - Capacity Investment
    - Setup Time Investment
    - Total Daily Cost
    - Target Unit Profit (adjustable by the user to reflect pricing or margin strategy)
    - Loan levels (which influence Net Debt and the Applicable Interest Rate)

Model Validation

Validation was conducted by aligning model outputs with observations from the ERP simulation game and replicating production efficiency calculations in **Excel**. Using **Solver**, optimal lot sizes were determined to minimize costs while maintaining responsiveness. **Goal Seek** was also applied to identify required efficiency levels to meet demand under limited capacity. The consistency between Analytica and Excel confirmed the robustness of the Production Improvement Model.

Limitations and Refinement Opportunities

While the Production Improvement Model provides a structured framework for analyzing the relationship between capacity investments, setup time reduction, and profitability, several limitations exist that constrain its predictive accuracy and flexibility

Limitations

1. Limits of the Free Analytica Tool

   The model was built in the free version of Analytica, which only allows a limited number of variables and doesn't support features like probability distributions or influence diagrams. This means we can't easily include uncertainty in our calculations or visualize the bigger cause-and-effect picture of how production and finance interact.

2. Manual Data Entry

   Key figures—like how much we invest in capacity or setup time, our daily operating costs, and loan amounts—are typed in by hand for each round. This works, but it leaves room for typos, inconsistencies, and makes it harder to quickly test multiple scenarios.

3. Simple Assumptions for Capacity and Setup Time

   The model treats the link between investments and improvements (in capacity or setup time) as straightforward and fixed.

4. No Real Randomness or Risk Analysis

   We explore different strategies through set scenarios, but we can't factor in unpredictable changes—like swings in market demand, sudden cost increases, or equipment failures—because the model doesn't handle probabilistic inputs.

5. Fixed Profit Target

   The profit per unit is set at a fixed level in each scenario. This doesn't reflect how pricing or margins might change in response to competition, demand shifts, or how full our production lines are running.

6. Liquidity Constraints Not Modeled

   While the model tracks net income improvements from production changes, it does not integrate cash flow constraints that could limit feasible investment levels in practice

7. No Cross-Product Capacity Allocation

   Capacity improvements are modeled at an aggregate level rather than optimized for a specific product mix, which could influence profitability differently.

Refinement Opportunities

1. Add Risk and What-If Analysis

   With the full version of Analytica, we could introduce probability ranges for uncertain inputs and run simulations to see how results might vary, making the model more robust and realistic.

2. Connect Directly to Data

   Linking the model to the game's actual capacity, cost, and loan data would remove the need for manual entry, speed up updates, and cut down on errors.

3. Make Pricing Flexible

   Build in the ability for the target profit or price per unit to change depending on costs, competition, or how much of our capacity we're using—so profitability projections respond to real-world pressures.

4. Tie Finance and Production Closer Together

   Link the production improvements more directly to cash flow, debt repayment, and company value, so we can clearly see how each operational decision affects the bigger financial picture.

5. Product Mix Optimization

   Extending the model to allocate improved capacity across different products based on profitability and demand forecasts would enhance decision-making accuracy

3.2.5 Profitability Analysis Model

Objective and Scope

The Profitability Analysis submodel aims to calculate and compare the **Total Cost per Unit** for each of the company's six products. It combines the **Fixed Cost per Unit** (derived from the production improvement module) with **Variable Costs per Unit** (manual input for each product and round) to produce a unified cost metric. The scope covers all six products and operates on a per-round basis, with outputs available for scenario comparison and sensitivity testing

Conceptual Framework

The model applies a straightforward **cost build-up approach**:

$$\textit{Total Cost per Unit} = \textit{Fixed Cost per Unit} + \textit{Variable Cost per Unit}$$

Where:

- **Fixed Cost per Unit** → Allocated cost from production capacity and setup cost allocation.

- **Variable Cost per Unit** → Direct manufacturing cost that varies with the production volume of each product.

Conceptual Flow:

- Retrieve **Fixed Cost per Unit** from production improvement model.

1. Input **Variable Cost per Unit** manually for each product and round.
2. Sum both to calculate **Total Cost per Unit**.
3. Use results in profitability dashboards and valuation calculations

Model Structure in Analytica

The submodel contains:

- **Variable Cost / Unit:** manual entry per round, Direct production costs per unit for each product
- **Fixed Cost / Unit**: Allocated fixed manufacturing cost per unit for each product
- **Total Cost / Unit:** Sum of fixed and variable costs per unit for each product

The model structure is built around a product index that holds six distinct product categories, ensuring costs are calculated and compared consistently across all product lines. Inputs include Variable Cost per Unit (manual entry per round) and Fixed Cost per Unit (linked from the production improvement module). A simple summation node calculates the Total Cost per Unit for each product, which is then used as the primary output for profitability comparison and scenario analysis.

Key Variables, Formulas and Variable‘s Description Table

This section summarizes the key input, intermediate, and output variables used in the **Profitability Analysis Model**. It also outlines the core formulas used for calculating unit-level costs, combining fixed and variable components, and deriving per-unit and total profitability. The model’s logic flows from cost structure inputs—such as fixed cost per unit and variable cost per unit—through aggregation across multiple products to estimate total cost per unit, target margins, and resulting profit outcomes. This structure enables tracking cost efficiency, monitoring cost trends across products, and assessing profitability under different operational and market scenarios.

- Fixed Cost per Unit: Derived from production capacity and setup time modules; represents fixed cost allocation per unit
- Variable Cost per Unit: Manual input for each product per round, representing direct variable expenses (e.g., materials, utilities)
- Total Cost per Unit: Sum of Fixed Cost per Unit and Variable Cost per Unit; key metric for profitability analysis

Table 5

Variable	**Type**	**Description**
Fixed Cost per Unit	Input/Output	Total fixed costs allocated to each unit produced
Variable Cost per Unit	Input	Cost that varies directly with the production volume
Total Cost per Unit	Output	Sum of fixed and variable costs per unit, representing the full production cost of one unit

Scenarios and Uncertainty Handling

Due to the constraints of the Analytica Free Edition, probabilistic distributions could not be implemented. Instead, scenario-based analysis is used to test the effect of varying cost structures:

- **Scenario 1 — Stable Costs:** Variable and fixed costs remain constant across all rounds.
- **Scenario 2 — Variable Cost Increase:** Simulates raw material price increases affecting variable cost per unit.
- **Scenario 3 — Fixed Cost Reduction:** Simulates productivity gains or efficiency improvements that reduce fixed cost per unit.

Sensitivity testing is performed manually by adjusting either variable cost or fixed cost inputs and observing the resulting change in total unit cost and product-level profitability.

While the Profitability Analysis Model offers valuable insights into the relationship between fixed costs, variable costs, and total cost per unit across different products, its ability to incorporate uncertainty is constrained by software and data limitations.

Uncertainty Handling

Due to the limitations of the Analytica Free Edition, the model does not use continuous probabilistic distributions (e.g., Monte Carlo simulations) to reflect uncertainty in costs or demand. Instead, uncertainty is addressed through:

1. **Discrete Scenario Testing**: Users can define different cost assumptions (e.g., variable cost increases due to raw material price spikes or decreases from supplier discounts) and assess the resulting impact on total cost per unit and profitability.
2. **Manual Sensitivity Analysis**: Individual inputs such as fixed and variable cost per unit or product-specific volumes can be altered to observe changes in total unit cost.
3. **Product-Specific Variations**: The index variable for the six products allows separate testing of cost fluctuations by product line, helping evaluate how sensitive profitability is to cost volatility in specific items.
4. **Cross-Scenario Comparison:** Observing how different combinations of fixed and variable costs influence total cost per unit across products and over multiple rounds.

Model Validation

The model was validated exclusively within Analytica, using internal consistency checks and comparisons across scenarios. For each scenario, the model was executed using identical demand conditions while adjusting only the cost parameters. The consistency of these outputs across scenarios confirmed that the model correctly captures the logical and mathematical relationships between financial inputs and profitability outcomes.

Limitations and Refinement Opportunities

The Profitability Analysis Model effectively integrates fixed cost per unit and variable cost per unit to determine the total unit cost for six distinct products. However, certain constraints and assumptions limit its precision and range of applications.

Limitations

1. Static Cost Inputs

   Fixed and variable costs are entered manually and assumed constant within a scenario, without accounting for real-time fluctuations in raw material prices, labor rates, or production efficiency changes during a round.

2. No Demand or Revenue Integration

   The model calculates costs only; it does not directly connect them to sales volume, price per unit, or resulting profitability, limiting its use in profit forecasting.

3. Limited Uncertainty Representation

   The Analytica Free Edition prevents the use of probabilistic distributions, meaning variability in costs can only be tested through manual adjustments or discrete scenarios.

4. No Cumulative GL Account Tracking

   Due to tool constraints, the model cannot create a variable to automatically accumulate General Ledger (GL) account data per round, which limits long-term cost trend analysis

Refinement Opportunities

1. Integration with Revenue Model

   Link the output of this model to sales and pricing data to generate direct profitability and margin calculations per product.

2. Advanced Uncertainty Modeling

   Upgrade to Analytica Professional or integrate with external Monte Carlo simulation tools to capture a broader range of potential cost outcomes.

3. Product-Specific Fixed Cost Allocation

   Refine allocation methods based on actual machine time, labor usage, or production setup requirements for each product.

4. Automated GL Data Accumulation

   Enhance the model's structure to capture and sum GL account data over multiple rounds, allowing for historical tracking and analysis

By addressing these limitations, the model could evolve from a cost-tracking tool into a more comprehensive profitability planning system, supporting more accurate decision-making under varying operational conditions.

4. Analysis and Presentation of the Results

For simplicity, only the Base Scenario results are presented here. Additional model inputs are provided in Section 7.4, while all extended scenario analyses, including moderate and high-investment (or Optimistic and Pessimistic) scenarios, are included in Section 7.5.

4.1 Liquidity Planning Model – Results

4.1.1 Outputs & Visualization (Analytica)

The Liquidity Planning Model was executed in Analytica to evaluate the company's cash position under three alternative conditions: Base, Pessimistic, and Optimistic scenarios. The model provided an overview of the organization's monthly liquidity performance, highlighting trends in cash inflows, outflows, and the resulting balance over time. For simplicity reasons only in the 1st scenario the table's details are depicted for Receivables, Payables, Marketing Expenses, Overhead Expenses, Interest Expenses, Total cash Outflows and Net Cash Flow.

Base Case Inputs (values in €)

Table 6

Round	Week	Receivables	Payables	Marketing	Overhead + Interest	Interst Expenses	Closing Balance
1	1	10,000	3,000	1,800	3,000	200	2,000
	2	9,800	5,300	2,100	3,000	200	1,200
	3	10,500	5,200	1,950	3,000	200	1,350
	4	9,600	5,000	2,050	3,000	200	700
2	1	10,200	4,900	2,000	3,000	200	800
	2	10,000	4,800	2,200	3,000	200	600
	3	10,700	4,900	2,100	3,000	200	1,100
	4	10,300	5,200	2,000	3,000	200	1,000
3	1	9,700	5,100	1,900	3,000	200	500
	2	10,000	5,100	2,050	3,000	200	150
	3	10,400	5,300	2,200	3,000	200	-150
	4	9,900	5,400	2,100	3,000	200	-950
4	1	10,600	5,000	2,100	3,000	200	-650
	2	10,200	5,000	2,300	3,000	200	-950
	3	9,800	5,100	2,050	3,000	200	-1,500
	4	10,500	5,300	2,250	3,000	200	-1,750

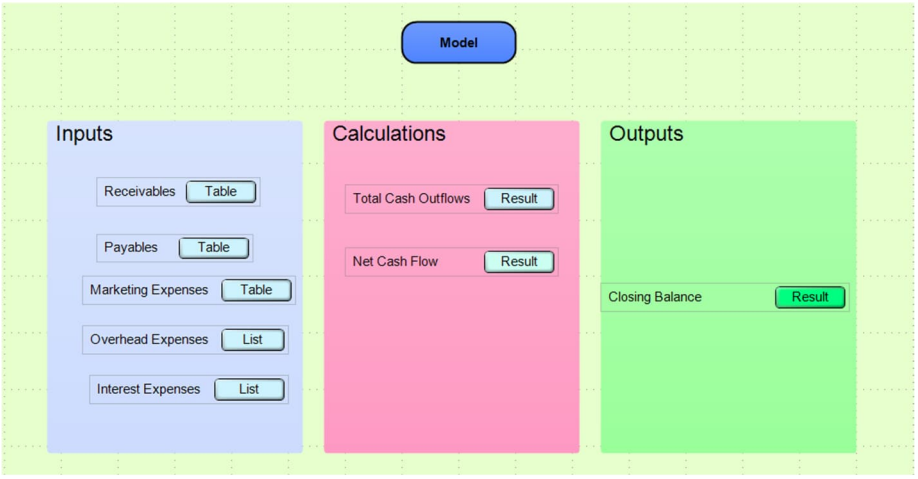
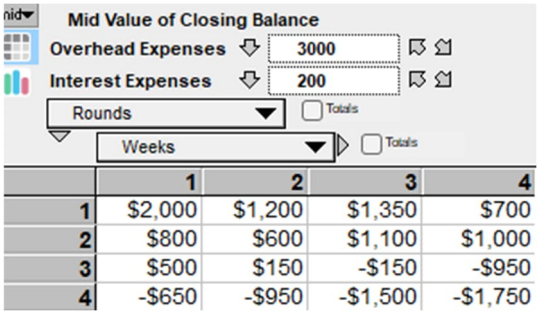


Figure 4-1 Liquidity Planning Model Overview in Analytica

Closing Balance Results:



	1	2	3	4
1	$2,000	$1,200	$1,350	$700
2	$800	$600	$1,100	$1,000
3	$500	$150	-$150	-$950
4	-$650	-$950	-$1,500	-$1,750

Figure 4-2 Closing Balance Variable

Graph:

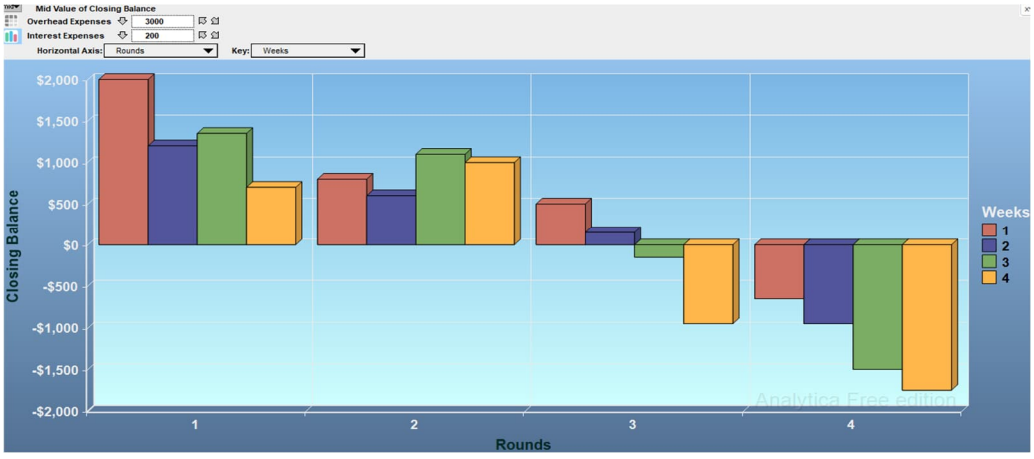


Figure 4-3 Graph of Closing Balance

In the **Base scenario**, liquidity remained stable, ensuring consistent coverage of short-term obligations.

4.1.2 Excel-Based Validation & Optimization (Solver & Goal Seek)

Excel versions of the models were developed to validate the outputs from the Analytica models, and to allow for quick application of advanced spreadsheet features such as Goal Seek and Data Tables. This dual-platform approach ensures that calculations are correct and enables scenario optimization beyond the limitations of the Analytica Free Edition.

The **Liquidity Planning Model** was also implemented in Excel to validate outputs from the Analytica model and to leverage advanced spreadsheet tools for scenario optimization. All three scenarios—**Base Case** (default inputs), **Optimistic Case** (higher revenues or lower costs), and **Pessimistic Case** (lower revenues and higher costs)—are included on a single sheet for side-by-side comparison.

The Excel layout tracks **Receivables, Payables, Marketing, Overhead, Interest**, and **Closing Balance** for each week within each scenario. Conditional formatting highlights weeks with cash shortfalls, while formulas ensure each week's opening balance matches the previous week's closing balance. This setup enables quick "what-if" analysis, including adjustments to cash flow drivers, and allows the use of Goal Seek-Solver to identify the minimum receivables or expense reductions required to maintain positive liquidity.

For demonstration purposes, the Excel version of the Liquidity Planning Model was used to run a **targeted liquidity optimization** scenario. In this showcase, the objective was to ensure that the **Closing Balance in the final week** reached a minimum of **€20,000**, while keeping every weekly balance non-negative.

Using **Solver for the Base Case Scenario**, Receivables, Payables, Marketing, and Overhead were adjusted within realistic operational limits to meet this goal. Constraints were set to reflect supplier payment terms, marketing budget caps, and allowable overhead adjustments. Solver then iteratively recalculated the weekly cash flows until the target final balance was achieved without violating any constraints.

Solver Parameters:

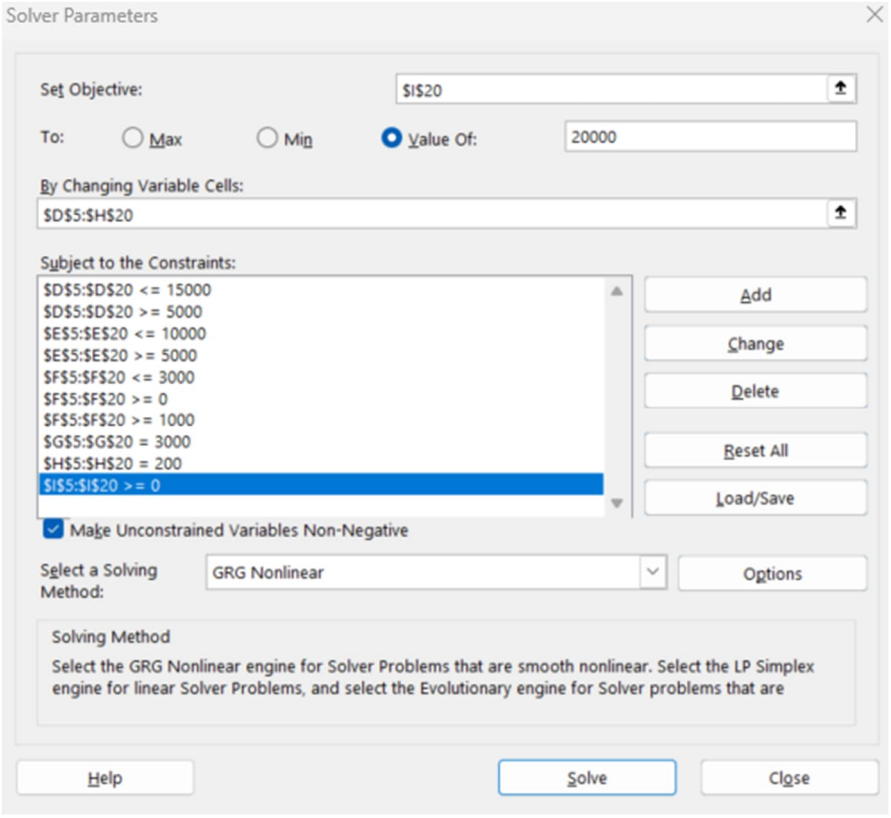
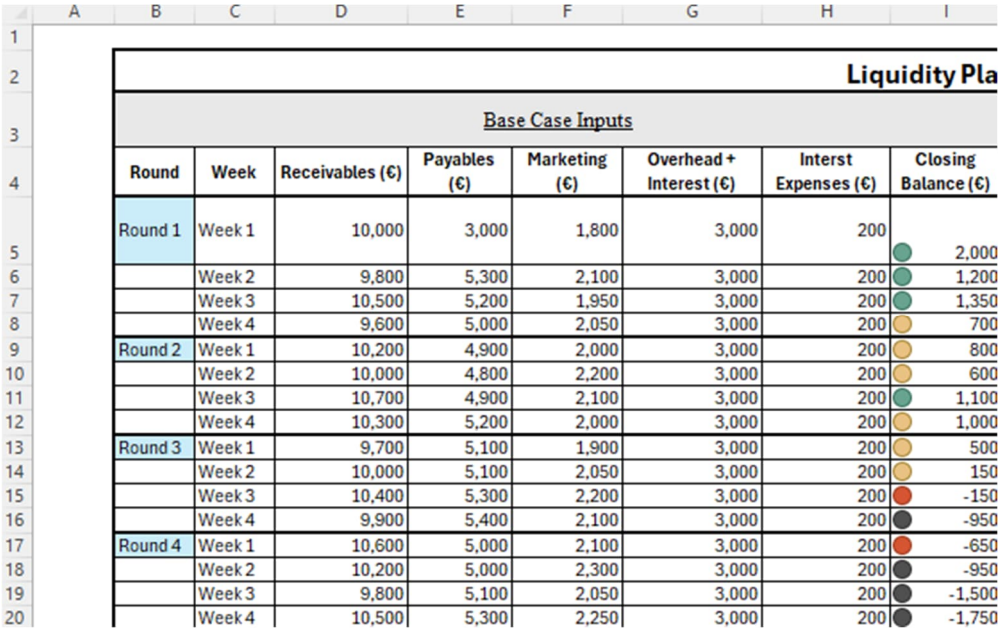


Figure 4-4 Solver for the Base Case Scenario

The constraints ensure all variables remain within realistic operational ranges for example, Receivables between €5,000 and €15,000, Payables between €5,000 and €10,000, Marketing between €1,000 and €3,000, and Overhead fixed at €3,000. Interest expenses are fixed at €200, and the Closing Balance cannot drop below zero in any week, preventing liquidity shortfalls.

Excel View (Liquidity Planning Sheet) before Solver:



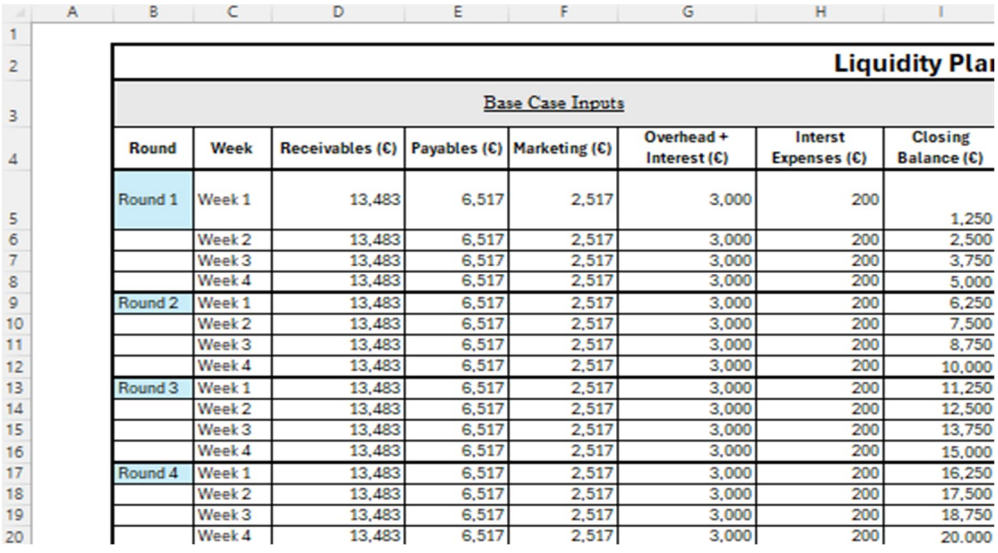
Liquidity Pla

Base Case Inputs

Round	Week	Receivables (€)	Payables (€)	Marketing (€)	Overhead + Interest (€)	Interst Expenses (€)	Closing Balance (€)
Round 1	Week 1	10,000	3,000	1,800	3,000	200	2,000
	Week 2	9,800	5,300	2,100	3,000	200	1,200
	Week 3	10,500	5,200	1,950	3,000	200	1,350
	Week 4	9,600	5,000	2,050	3,000	200	700
Round 2	Week 1	10,200	4,900	2,000	3,000	200	800
	Week 2	10,000	4,800	2,200	3,000	200	600
	Week 3	10,700	4,900	2,100	3,000	200	1,100
	Week 4	10,300	5,200	2,000	3,000	200	1,000
Round 3	Week 1	9,700	5,100	1,900	3,000	200	500
	Week 2	10,000	5,100	2,050	3,000	200	150
	Week 3	10,400	5,300	2,200	3,000	200	-150
	Week 4	9,900	5,400	2,100	3,000	200	-950
Round 4	Week 1	10,600	5,000	2,100	3,000	200	-650
	Week 2	10,200	5,000	2,300	3,000	200	-950
	Week 3	9,800	5,100	2,050	3,000	200	-1,500
	Week 4	10,500	5,300	2,250	3,000	200	-1,750

Figure 4-5 Excel View (Liquidity Planning Sheet) before Solver

Excel View (Liquidity Planning Solver Sheet) after Solver has run:



Liquidity Plan

Base Case Inputs

Round	Week	Receivables (€)	Payables (€)	Marketing (€)	Overhead + Interest (€)	Interst Expenses (€)	Closing Balance (€)
Round 1	Week 1	13,483	6,517	2,517	3,000	200	1,250
	Week 2	13,483	6,517	2,517	3,000	200	2,500
	Week 3	13,483	6,517	2,517	3,000	200	3,750
	Week 4	13,483	6,517	2,517	3,000	200	5,000
Round 2	Week 1	13,483	6,517	2,517	3,000	200	6,250
	Week 2	13,483	6,517	2,517	3,000	200	7,500
	Week 3	13,483	6,517	2,517	3,000	200	8,750
	Week 4	13,483	6,517	2,517	3,000	200	10,000
Round 3	Week 1	13,483	6,517	2,517	3,000	200	11,250
	Week 2	13,483	6,517	2,517	3,000	200	12,500
	Week 3	13,483	6,517	2,517	3,000	200	13,750
	Week 4	13,483	6,517	2,517	3,000	200	15,000
Round 4	Week 1	13,483	6,517	2,517	3,000	200	16,250
	Week 2	13,483	6,517	2,517	3,000	200	17,500
	Week 3	13,483	6,517	2,517	3,000	200	18,750
	Week 4	13,483	6,517	2,517	3,000	200	20,000

Figure 4-6 Excel View (Liquidity Planning Solver Sheet) after Solver has run

The outcome was a smooth liquidity trajectory that met the €20,000 target in the final week while maintaining a consistent cash surplus throughout the 16-week period. This example highlights how the Excel model can be used not only for validation but also for **rapid scenario testing and actionable decision support** within the constraints of the SAP ERPSim environment.

GRG Nonlinear was selected as the Solver method for its flexibility in handling complex financial relationships and potential non-linearities that may arise if the model is expanded. However, the current structure of the Liquidity Planning Model is also compatible with the Simplex LP method. All key drivers Receivables, Payables, Marketing, Overhead, and Interest—are entered as direct inputs, and the rolling cash balance calculation is purely additive, without non-linear functions, conditional logic, or products of multiple changing variables. This makes the model inherently linear in its present form, meaning Simplex LP could be applied to achieve the same optimization results more quickly and efficiently, as long as the model structure remains unchanged.

This setup effectively demonstrates how Solver can be used for **cash flow target planning** identifying the minimum adjustments needed in operational cash drivers to meet a strategic liquidity goal while staying within realistic business constraints.

4.2 Loan Repayment & Company Valuation Model — Results

4.2.1 Outputs & Visualization (Analytica)

To ensure the integrity and logic of the Loan Repayment and Company Valuation models, the following validation steps were conducted:

- **Formula Cross-Check**: All formulas were reviewed for internal consistency. Calculations for interest, loan balance, and company valuation were manually verified and compared against financial logic.
- **Step-by-Step Output Verification**: Key intermediate values (e.g., Round Interest, Net Income, Cumulative Loan Balance) were validated for correctness through controlled single-variable changes.
- **Scenario Coherence**: All three scenarios (Conservative, Moderate, Aggressive) were tested to ensure the model behaves consistently with financial expectations:
    - Higher payments led to lower interest and higher valuations.
    - Lower payments resulted in higher cumulative interest and lower valuations.
- **Boundary Testing**: Extreme inputs (e.g., 0 repayment, 100% repayment) were used to test model robustness and identify any breakdowns in logic or output.

Scenario 1 – Conservative Repayment

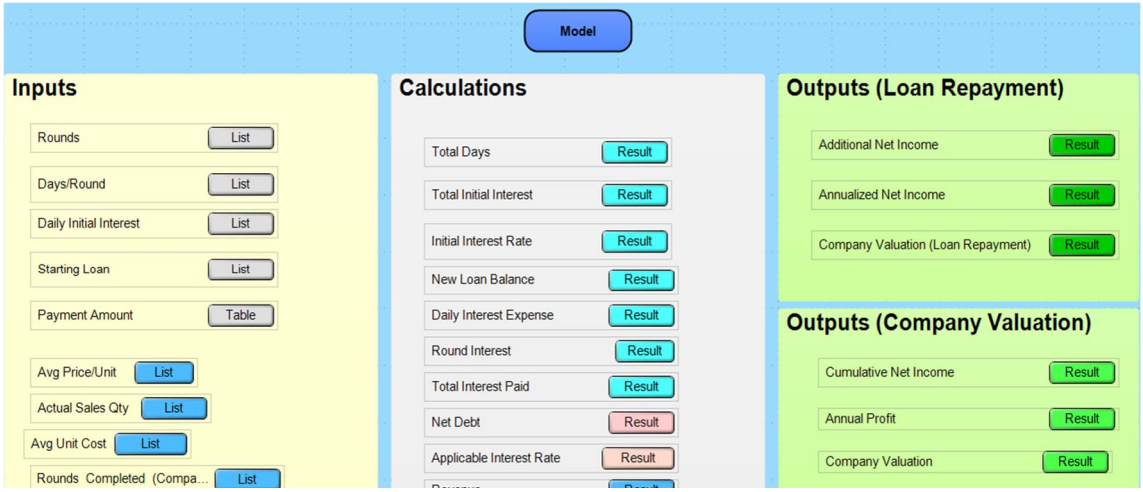


Figure 4-7 Loan Repayment Model Overview in Analytica

In this scenario, a conservative strategy was applied by setting a relatively low loan repayment amount for each round. The model was tested to ensure that this minimal repayment behavior led to a higher retained loan balance and consequently increased cumulative interest payments over the simulation period. The **New Loan Balance** remained high across all four rounds, which directly affected the **Daily Interest Expense** and **Round Interest** calculations.

Validation focused on confirming that:

- **Total Interest Paid** increased proportionally as expected with lower repayments.
- The **Additional Net Income** (calculated as savings from interest reduction) remained relatively low due to limited debt reduction.
- The **Annualized Net Income** and **Loan-Based Valuation** showed the weakest financial performance among the tested scenarios, validating the sensitivity of the model to conservative repayment policies.

Overall, the model accurately captured the expected financial consequences of under-repaying debt and demonstrated logical alignment between input behavior and resulting outputs.

Inputs:

Rounds to be played=4

Days/Round=20

Daily Initial Interest= 2644.8

Starting Loan=8,000,000

Manual input of loan Payment Amount:

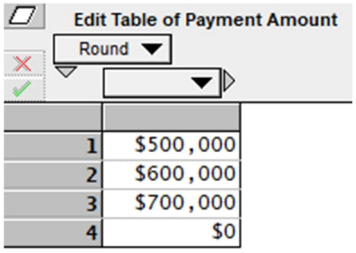


Figure 4-8 Manual input of loan Payment Amount

Graph:

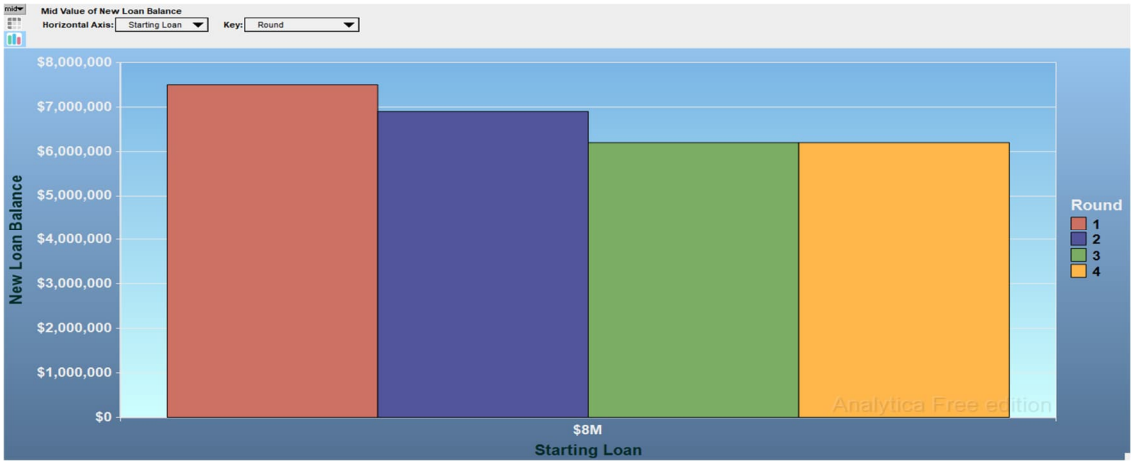
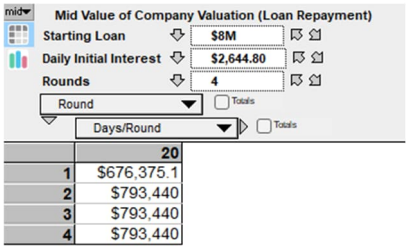


Figure 4-9 Graph of New Loan Balance

Company Valuation:



	20
1	$676,375.1
2	$793,440
3	$793,440
4	$793,440

Figure 4-10 Company Valuation

Observations:

1. Round Interest was slightly decreased per round and dropped from 2,644.8 € To 2,049.7
2. Total Interest paid at the end of the game was decreased from 211,584 € to 177,202 €
3. The additional Net Income from Loan repayment is 211,584-177,202= 34,382 €
4. Company Valuation increased by 793.440 €
5. Applicable interest rate is affected by the loan repayment amount and it is decreased when new loan balance is reduced

Company Valuation Model

Objective: To estimate the overall value of the business by combining operational results and financial structure.

We'll assume the following **constant values** for all scenarios:

- **Avg Price/Unit** = $6
- **Actual Sales Qty** = 25,000 units
- **Avg Unit Cost** = $3.5
- **Fixed Costs** (sum of depreciation, labor, overhead, SGA) = 25,000€
- **Rounds** = 4
- **Accounts Payable** = 3,000,000€
- **Accounts Receivable** = 1,000,000€
- **Cash** = 2,000,000€

The only thing that varies is the **remaining loan balance per scenario**, which impacts **Net Debt** and therefore the **Applicable Interest Rate** and **Valuation.**

Company Valuation of scenario 1:

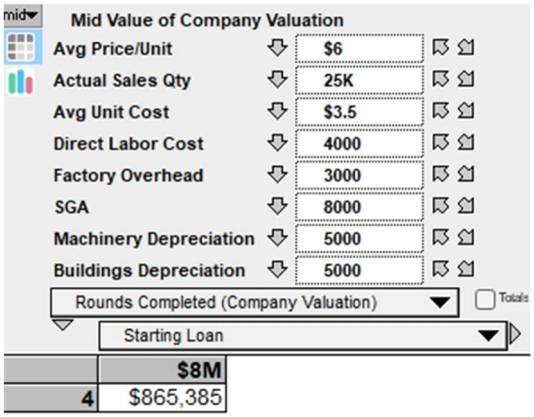


Figure 4-11 Company Valuation

Conclusions – Company Valuation Model

In the Company Valuation Model, the only variable that changes across scenarios is the loan repayment amount. This affects the Net Debt, which directly influences the Applicable Interest Rate (used as the discount rate). While Revenue and COGS remain constant, the change in discount rate leads to different company valuations, even though cumulative income stays the same.

1. **Valuation is Driven by Operational Efficiency**
   The model highlights that company valuation is directly influenced by operational performance—particularly net income, which is affected by revenue, COGS, and fixed costs.
2. **Loan Repayment Improves Net Income Indirectly**
   Although not included directly, better loan repayment strategies from Model 1 reduce interest expenses, resulting in higher net income, which improves the company's valuation in this model.
3. **Net Debt Affects the Discount Rate**
   The applicable interest rate used as a discount rate is influenced by the company's net debt level. Lower net debt improves credit standing, reducing the discount rate and increasing company valuation.
4. **Fixed Costs Significantly Impact Profitability**
   Since fixed costs are deducted from the income statement, they have a substantial effect on cumulative net income and annual profit—key drivers of valuation.
5. **Scenario Analysis Confirms Sensitivity**
   The valuation model responded well to different repayment strategies. For example, in Scenario 2, improved repayment and lower net debt led to a valuation of **1, 125, 000**, validating the sensitivity of the model to financing and operational inputs.
6. **Simplicity and Assumptions Matter**
   Due to limitations in the free version of Analytica, the model is deterministic and relies on manual inputs for key variables. This simplicity allows clarity but limits

the model's ability to account for uncertainty and dynamic feedback between variables

4.2.2 Excel-Based Validation & Optimization (Solver & Goal Seek)

To complement the Analytica model, the Loan Repayment Scenario1Solver was replicated in Excel and optimized using Solver. The objective was to determine the minimum total repayment amount across four rounds while still achieving a target Additional Net Income and respecting a maximum payment cap per round.

Setup

- **Decision variables:** Payment amounts in Rounds 1–4 (B12:B15).
- **Objective:** Minimize Total Payments (I20).
- **Constraints:**
    - Additional Net Income (F18) ≥ Target (I18).
    - Payment Amount ≥ 0.
    - Payment Amount ≤ Max payment per Round (I19).
    - New Loan Balance ≥ 0.

Method: Simplex LP (chosen due to linear relationships between payments, interest savings, and net income).

Results

Solver provided a repayment plan that meets the profitability target **at the lowest possible total repayment**. This balance allows the company to **preserve liquidity** for other operational priorities while still benefiting from interest savings.

Solver Parameters:

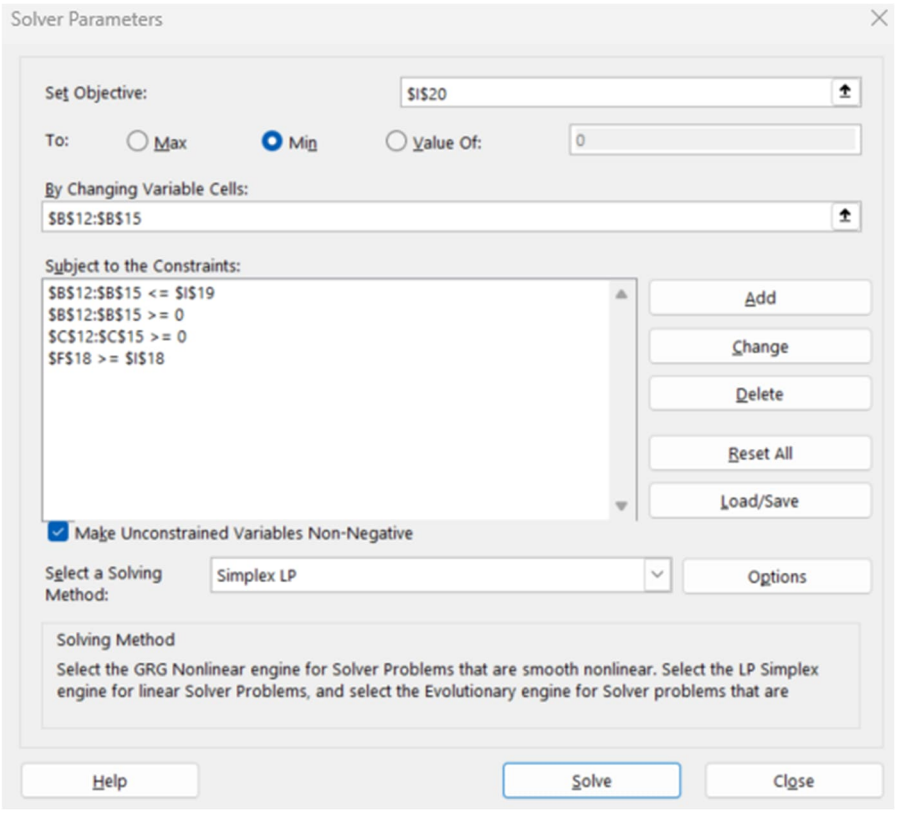
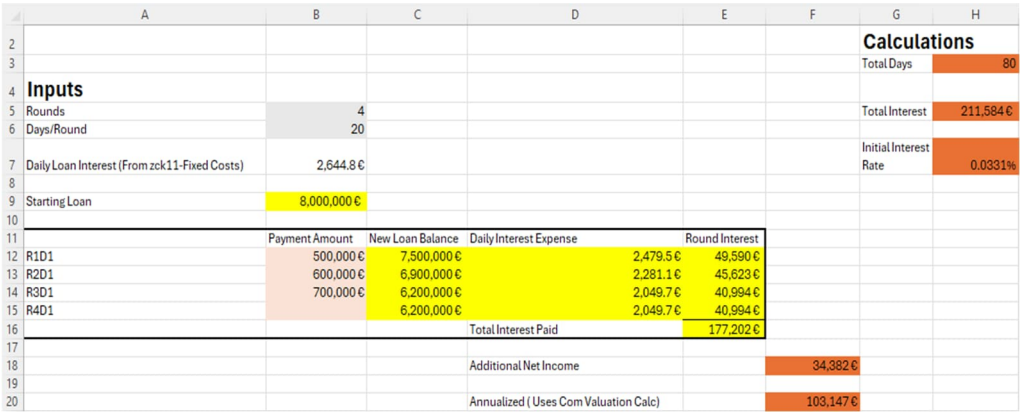


Figure 4-12Solver Parameters for Loan Repayment Model

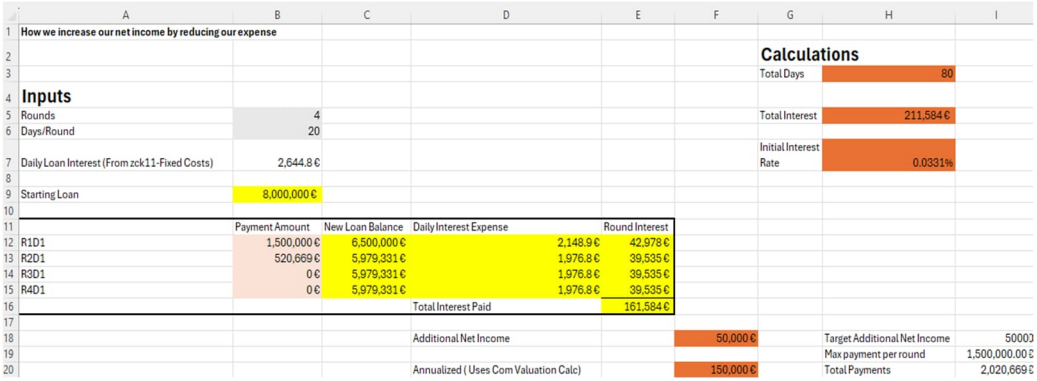
Excel View (Loan Repayment Scenario 1 Sheet) before Solver:



	A	B	C	D	E	F	G	H
2							**Calculations**	
3							Total Days	80
4	**Inputs**							
5	Rounds	4					Total Interest	211,584 €
6	Days/Round	20						
7	Daily Loan Interest (From zck11-Fixed Costs)	2,644.8 €					Initial Interest Rate	0.0331%
8								
9	Starting Loan	8,000,000 €						
10								
11		Payment Amount	New Loan Balance	Daily Interest Expense	Round Interest			
12	R1D1	500,000 €	7,500,000 €	2,479.5 €	49,590 €			
13	R2D1	600,000 €	6,900,000 €	2,281.1 €	45,623 €			
14	R3D1	700,000 €	6,200,000 €	2,049.7 €	40,994 €			
15	R4D1		6,200,000 €	2,049.7 €	40,994 €			
16				Total Interest Paid	177,202 €			
17								
18				Additional Net Income		34,382 €		
19								
20				Annualized (Uses Com Valuation Calc)		103,147 €		

Figure 4-13 Excel View (Loan Repayment Scenario 1 Sheet) before Solver

Excel View (Loan Repayment Scenario1Solver Sheet) after Solver has run:



	A	B	C	D	E	F	G	H	I
1	How we increase our net income by reducing our expense								
2							Calculations		
3							Total Days	80	
4	Inputs								
5	Rounds	4					Total Interest	211,584 €	
6	Days/Round	20							
7	Daily Loan Interest (From zck11-Fixed Costs)	2,644.8 €					Initial Interest Rate	0.0331%	
8									
9	Starting Loan	8,000,000 €							
10									
11		Payment Amount	New Loan Balance	Daily Interest Expense	Round Interest				
12	R1D1	1,500,000 €	6,500,000 €	2,148.9 €	42,978 €				
13	R2D1	520,669 €	5,979,331 €	1,976.8 €	39,535 €				
14	R3D1	0 €	5,979,331 €	1,976.8 €	39,535 €				
15	R4D1	0 €	5,979,331 €	1,976.8 €	39,535 €				
16				Total Interest Paid	161,584 €				
17									
18				Additional Net Income		50,000 €		Target Additional Net Income	50000
19								Max payment per round	1,500,000.00 €
20				Annualized (Uses Com Valuation Calc)		150,000 €		Total Payments	2,020,669 €

Figure 4-14 Excel View (Loan Repayment Scenario1Solver Sheet) after Solver has run

4.2.3 Excel-Based Validation & Optimization (Solver & Goal Seek)- Company Valuation

For the **Company Valuation Model (1)**, Goal Seek was applied to determine the sales quantity required to reach a predefined company valuation target. In this example, the target was set in cell **C22** at 2.000,000 and Goal Seek was instructed to adjust the **Actual Sales Quantity** input until the model produced the desired valuation. This approach is useful in the SAP ERPSim context because it translates a strategic financial goal (e.g., achieving a specific enterprise value) into an operational target for sales performance. It allows decision-makers to quickly understand the volume needed to hit valuation objectives without manually testing multiple scenarios.

Goal Seek Parameters:

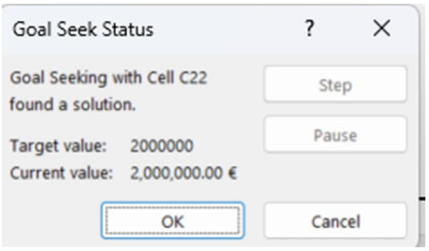
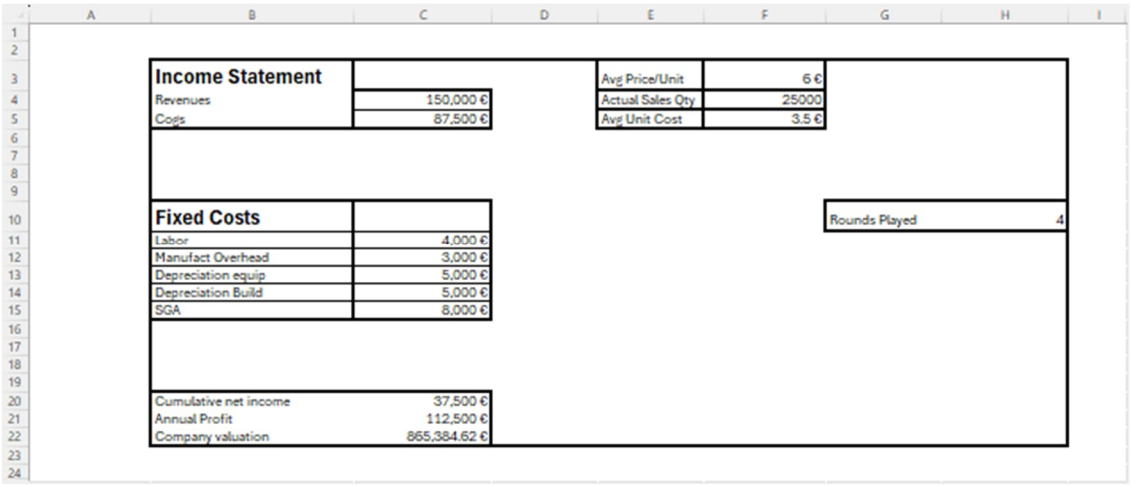


Figure 4-15 Goal Seek Parameters for Company Valuation Model

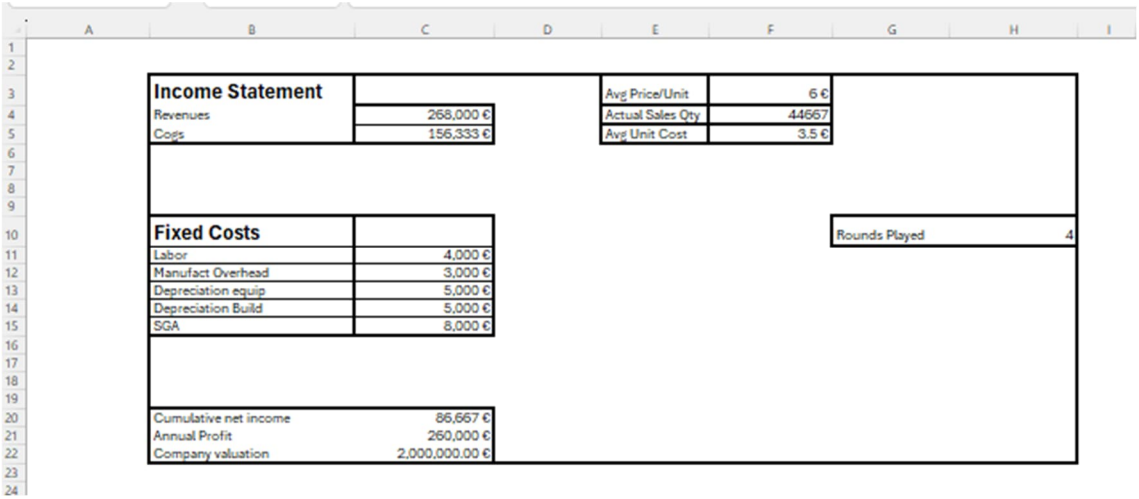
Excel View (Company Valuation (1) Sheet) before Goal Seek:



Income Statement			Avg Price/Unit	6 €	
Revenues	150,000 €		Actual Sales Qty	25000	
Cogs	87,500 €		Avg Unit Cost	3.5 €	
Fixed Costs					Rounds Played 4
Labor	4,000 €				
Manufact Overhead	3,000 €				
Depreciation equip	5,000 €				
Depreciation Build	5,000 €				
SGA	8,000 €				
Cumulative net income	37,500 €				
Annual Profit	112,500 €				
Company valuation	865,384.62 €				

Figure 4-16Excel View (Company Valuation (1) Sheet) before Goal Seek

Excel View (Company Valuation (1) Goalseek Sheet) after Goal Seek has run:



Income Statement			Avg Price/Unit	6 €	
Revenues	268,000 €		Actual Sales Qty	44667	
Cogs	156,333 €		Avg Unit Cost	3.5 €	
Fixed Costs					Rounds Played 4
Labor	4,000 €				
Manufact Overhead	3,000 €				
Depreciation equip	5,000 €				
Depreciation Build	5,000 €				
SGA	8,000 €				
Cumulative net income	86,667 €				
Annual Profit	260,000 €				
Company valuation	2,000,000.00 €				

Figure 4-17 Excel View (Company Valuation (1) Goalseek Sheet) after Goal Seek has run

In the **Company Valuation Model (1)**, Solver was applied to maximize the company's valuation (cell **C22**) by simultaneously adjusting the **Actual Sales Quantity** and **Average Price per Unit** within realistic operational and market constraints. The objective function was set to maximize the enterprise value, while constraints ensured that sales volume did not exceed production capacity and that pricing remained within competitive limits. Using the GRG Nonlinear solving method allowed the model to account for the nonlinear relationship between sales, price, and profitability. This approach demonstrates how decision-makers in the SAP ERPSim context can use Solver to determine the optimal balance between pricing strategy and sales volume to achieve the highest possible company valuation without violating operational boundaries.

Solver Setup

- **Set Objective:** C22 *(Company Valuation)*
- **To: Max**
- **By Changing Variable Cells:**
    - E4 *(Actual Sales Quantity)*
    - E3 *(Average Price per Unit)*
- **Subject to Constraints:**
    - E4 ≤ *Production Capacity* (e.g., **2,000,000 units**)
    - E3 ≥ *Avg Unit Cost*
    - E3 ≤ *Upper Market Price* (e.g., **4**)
- **Solving Method: GRG Nonlinear** *(chosen for its ability to handle nonlinear interactions between price, sales, and valuation)*

Solver Parameters:

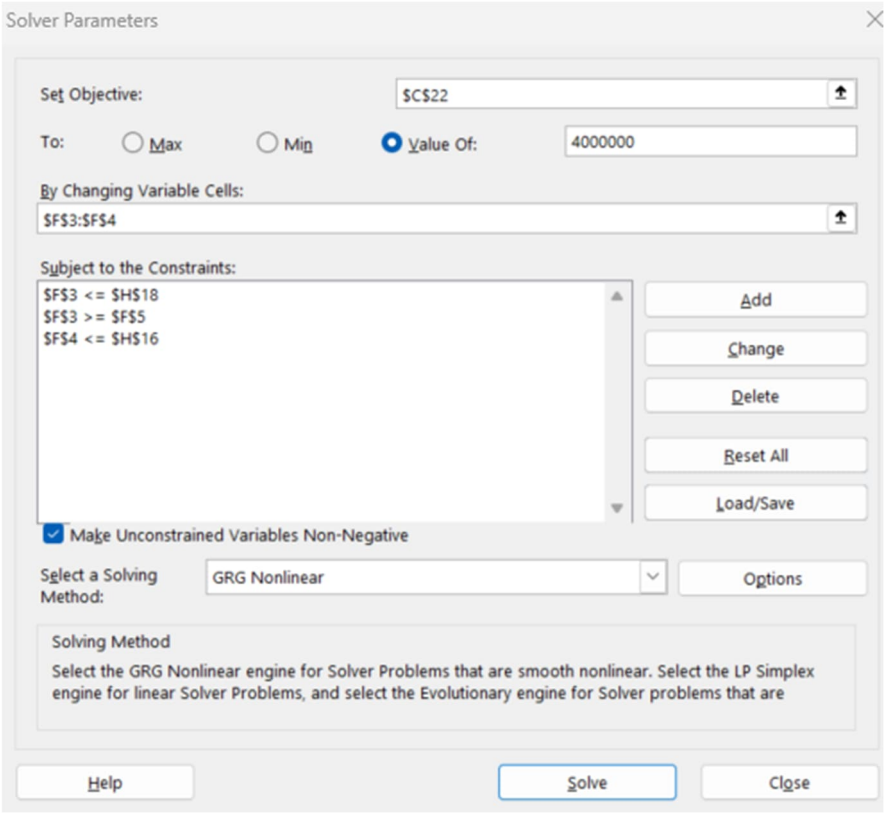


Figure 4-18 Solver Parameters for Company Valuation Model

Excel View (Company Valuation (1) Sheet) before Solver:

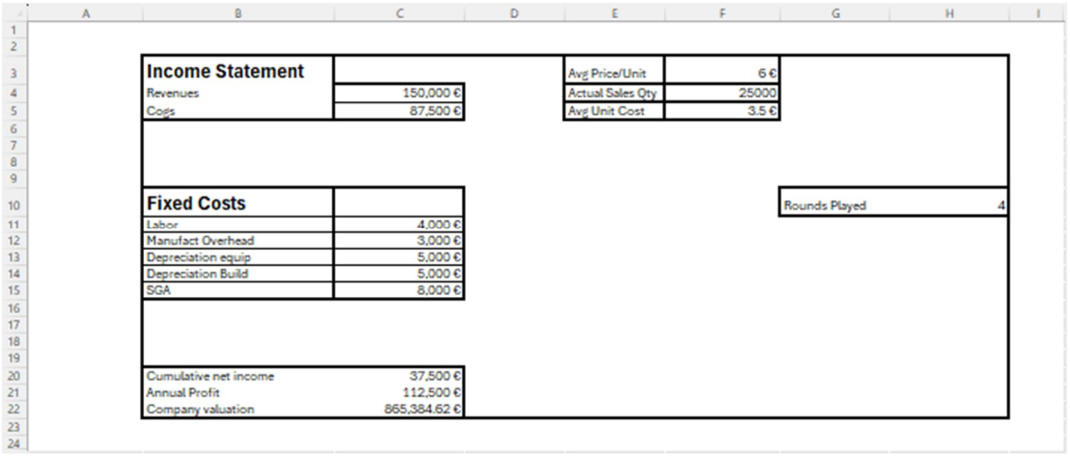
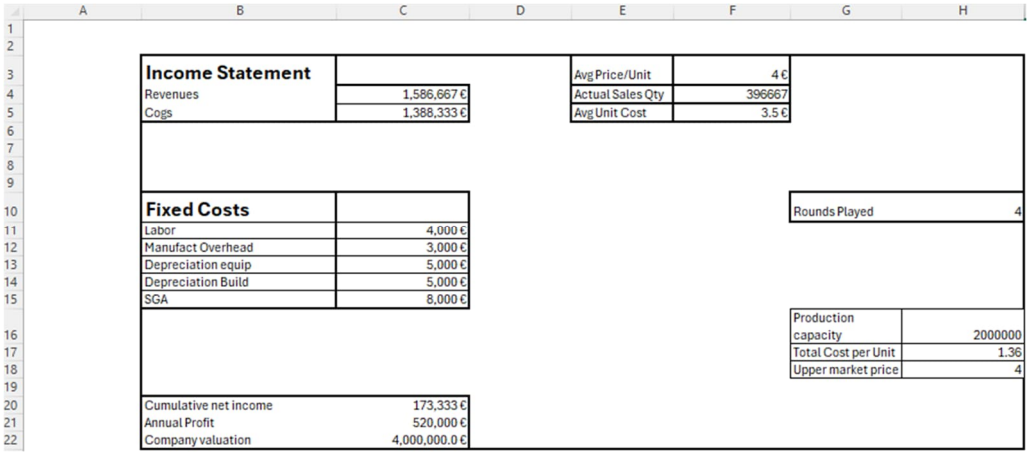


Figure 4-19 Excel View (Company Valuation (1) Sheet) before Solver

Excel View (Company Valuation (1) Solver Sheet) after Solver has run:



Income Statement	
Revenues	1,586,667 €
Cogs	1,388,333 €

Avg Price/Unit	4 €
Actual Sales Qty	396667
Avg Unit Cost	3.5 €

Fixed Costs	
Labor	4,000 €
Manufact Overhead	3,000 €
Depreciation equip	5,000 €
Depreciation Build	5,000 €
SGA	8,000 €

Rounds Played	4

Production capacity	2000000
Total Cost per Unit	1.36
Upper market price	4

Cumulative net income	173,333 €
Annual Profit	520,000 €
Company valuation	4,000,000.0 €

Figure 4-20 Excel View (Company Valuation (1) Solver Sheet) after Solver has run

4.3 Production Improvement Model— Results

4.3.1 Outputs & Visualization (Analytica)

The **Production Improvement Model** was validated by running multiple scenarios and manually reviewing the consistency and logic of intermediate and final outputs. Key parameters such as production capacity, setup time, total production, and valuation were monitored across rounds to ensure coherence with business logic and expected financial outcomes. The results of the Production Improvement Model show how targeted investments in capacity and setup-time reduction influence production performance and financial outcomes under each Scenario. The model indicates that even moderate improvements in operational efficiency lead to higher total production volumes, lower fixed cost per unit, and an increase in estimated company valuation. These findings highlight the direct link between production-related decisions and the firm's overall profitability within the simulation environment, providing clear evidence of the strategic benefits of well-planned operational investments.

Validation Approach

- **Manual Walkthrough of Calculations**: Step-by-step tracing of formulas within Analytica to confirm the integrity of production logic (e.g., capacity scaling with investment, proper cost allocation).
- **Cross-Scenario Comparison**: Each scenario was run using the same initial assumptions (except for investment levels and target unit profit), ensuring consistency in structure and clarity in output variation.
- **Output Consistency Checks**: Derived metrics such as productivity, allocation basis, unit cost, and valuation were checked for expected trends (e.g., more investment → more production → lower cost/unit).

Production Improvement Model:

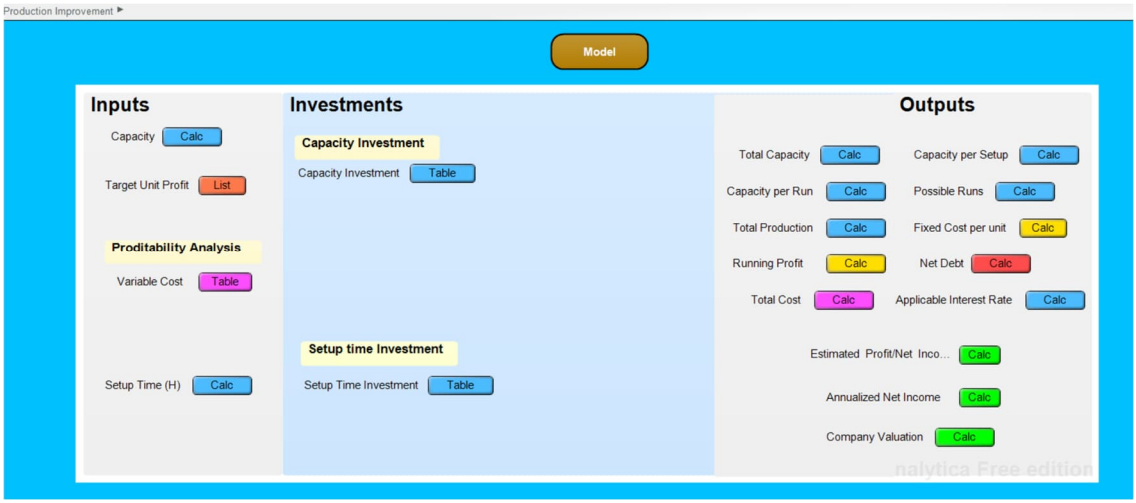


Figure 4-21 Production Improvement Model

Low Investment Scenario : (More input variables are included in 7.4.4 Section)

Capacity Investment:

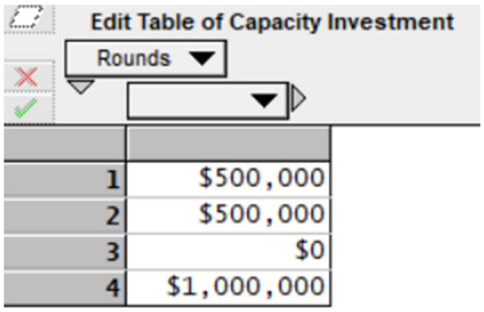


Figure 4-22 Capacity Investment

Setup Time Investment:

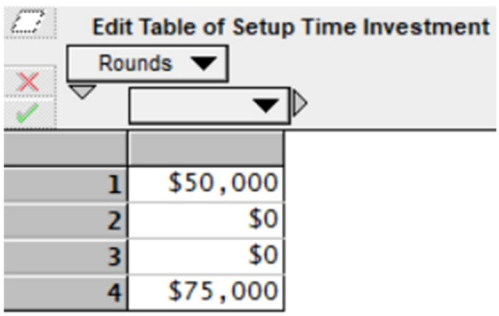
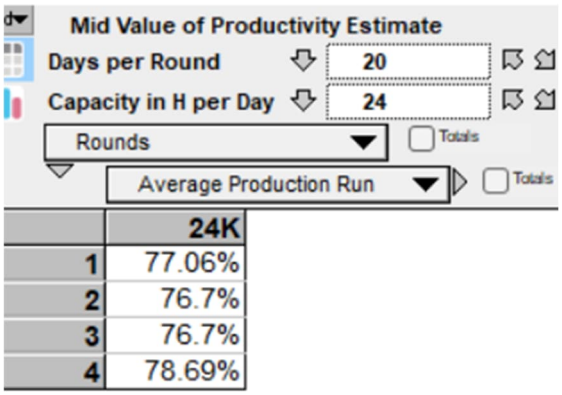


Figure 4-23 Setup Time Investment

Productivity Estimate:



	24K
1	77.06%
2	76.7%
3	76.7%
4	78.69%

Figure 4-24 Productivity Estimate

Graph: Showing productivity gains per round as setup time improves

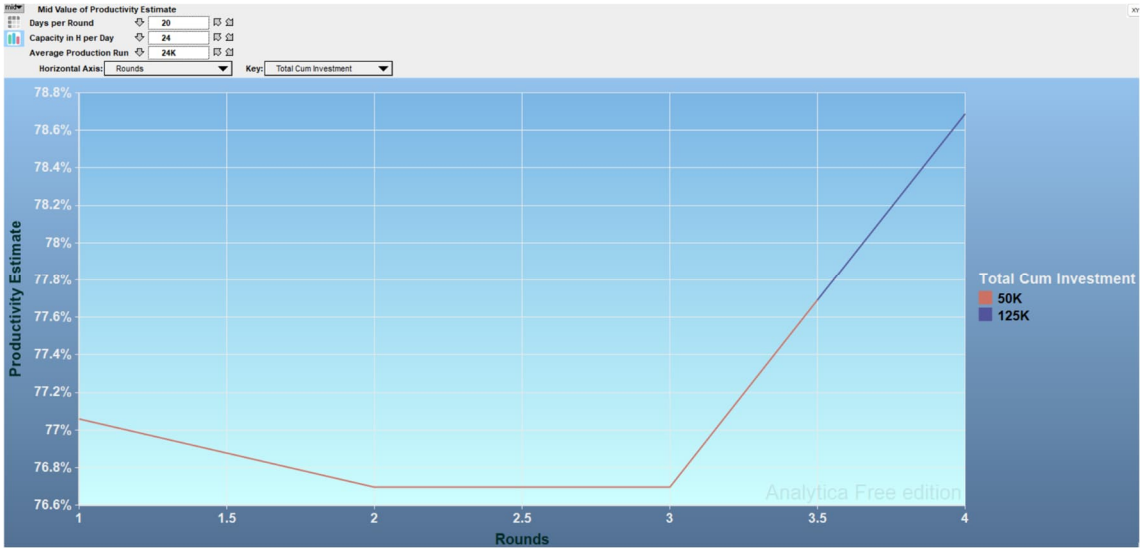


Figure 4-25 Graph: Showing productivity gains per round as setup time improves

- As **setup time (H)** decreases, **productivity (%)** increases.
- Shows how setup-time-focused investment improves overall production efficiency.
- This helps justify future investments in setup time reduction.

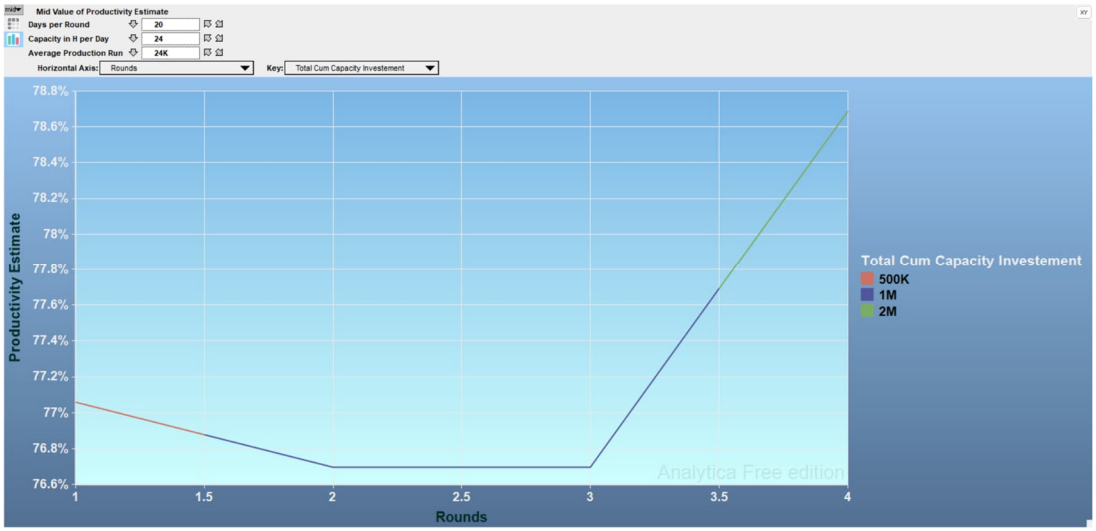


Figure 4-26 Graph: Showing productivity gains per round as capacity investment improves

Capacity:

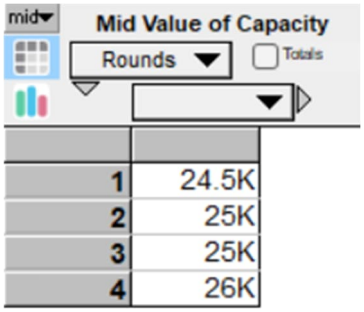


Figure 4-27 Capacity

Setup Time (H):

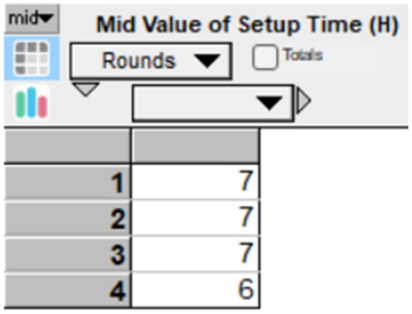
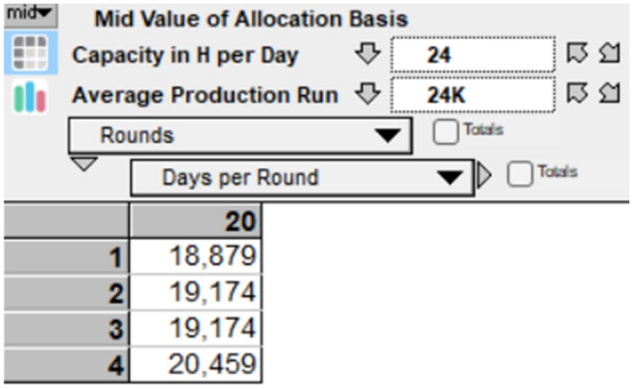


Figure 4-28 Setup Time (H)

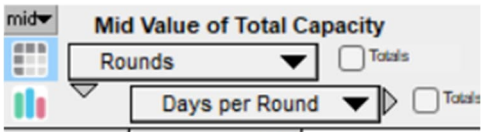
Allocation Basis:



	20
1	18,879
2	19,174
3	19,174
4	20,459

Figure 4-29 Allocation Basis

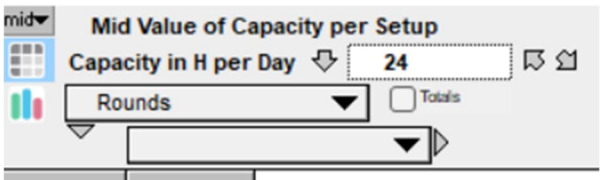
Total Capacity:



	20
1	490,000
2	1,000,000
3	1,500,000
4	2,080,000

Figure 4-30 Total Capacity

Capacity Per Setup:



1	7,146
2	7,292
3	7,292
4	6,500

Figure 4-31 Capacity Per Setup

Capacity per Run:

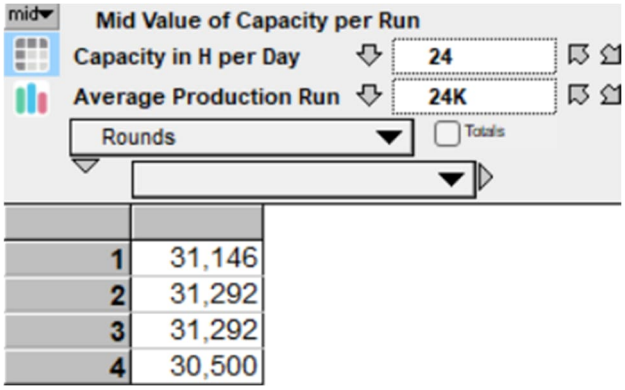


Figure 4-32 Capacity per Run

Possible Runs:

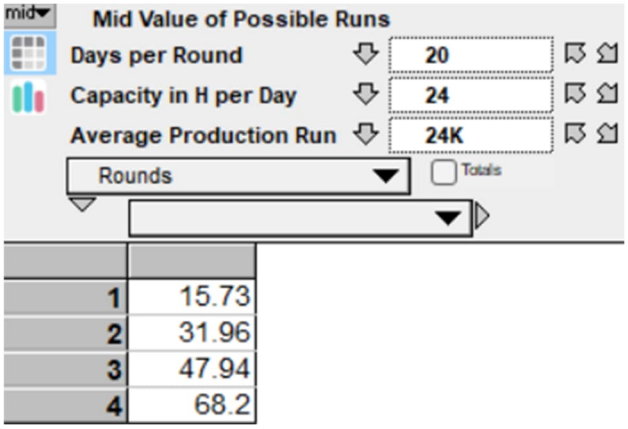


Figure 4-33 Possible Runs

Total Production:

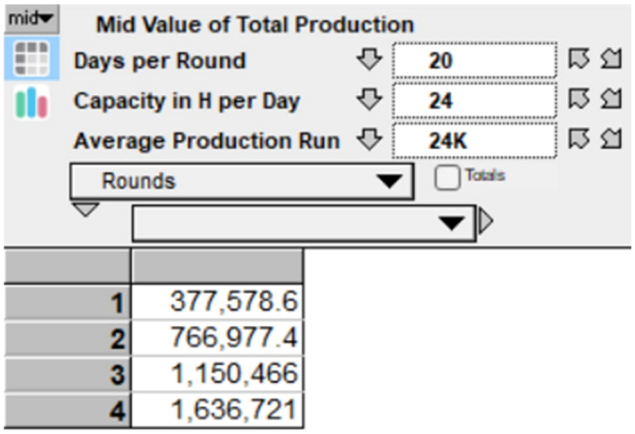


Figure 4-34 Total Production

Graph:

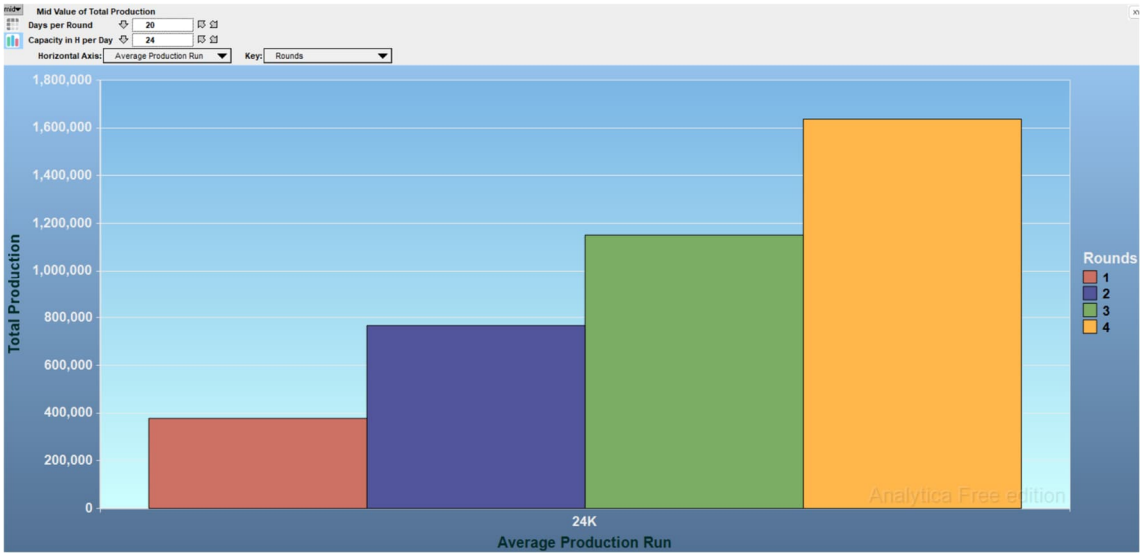


Figure 4-35 Graph of Total Production

Starting Loan:

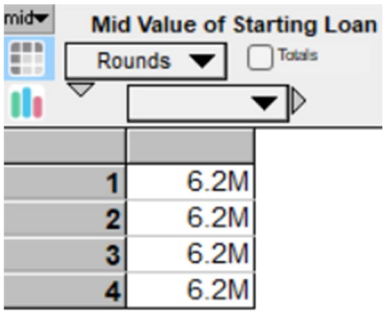


Figure 4-36 Starting Loan

Target Unit Profit:

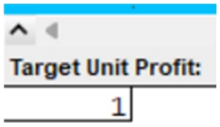
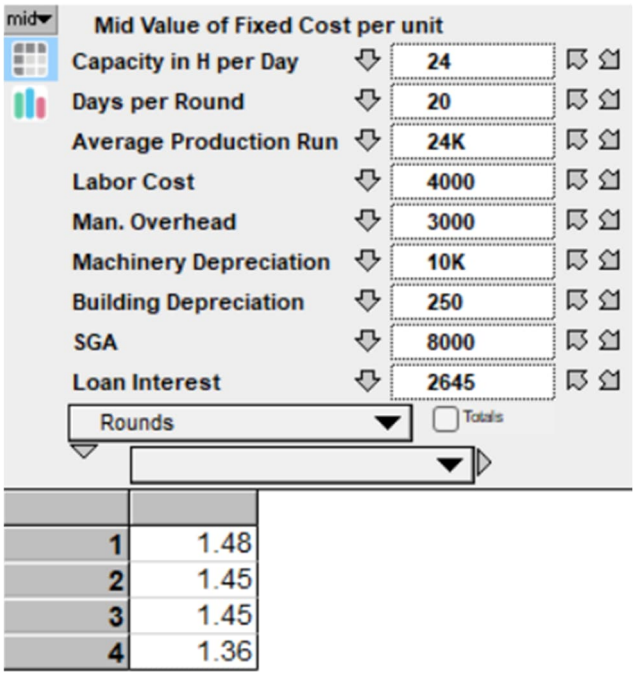


Figure 4-37 Target Unit Profit

Fixed Cost per unit:



1	1.48
2	1.45
3	1.45
4	1.36

Figure 4-38 Fixed Cost per unit

Graph: Fixed Cost per Unit Reduction as Capacity & Setup Time Investment Increases

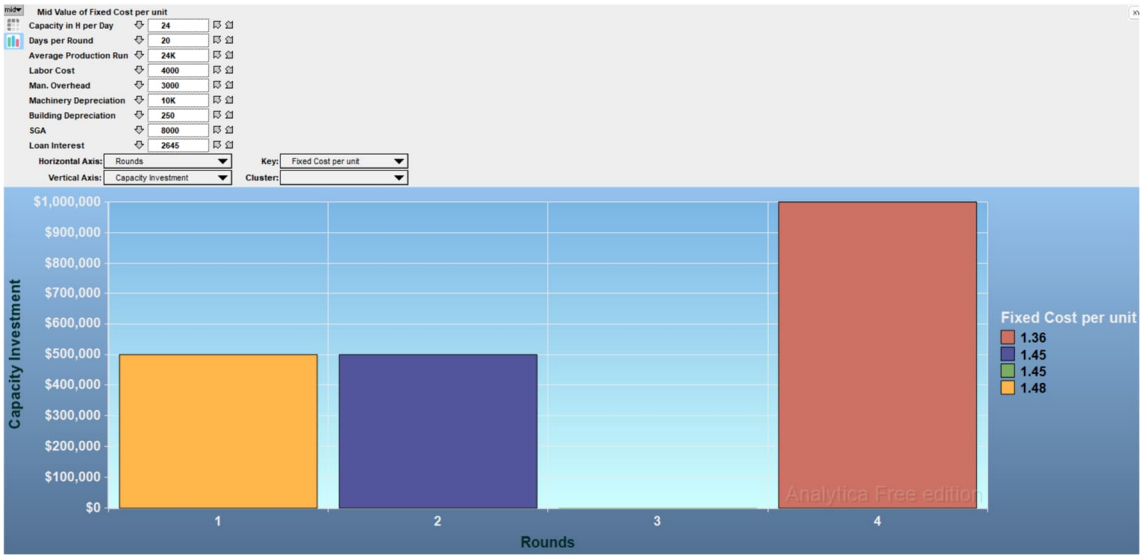


Figure 4-39 Graph: Fixed Cost per Unit Reduction as Capacity Investment Increases

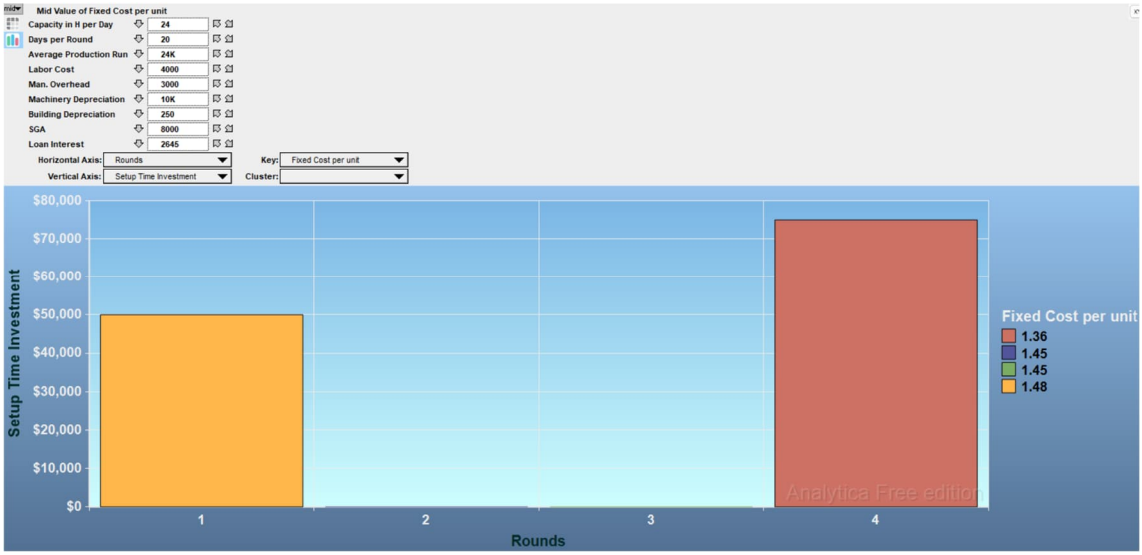


Figure 4-40 Fixed Cost per Unit Reduction as Setup Time Investment Increases

Base Fixed Cost per Unit:

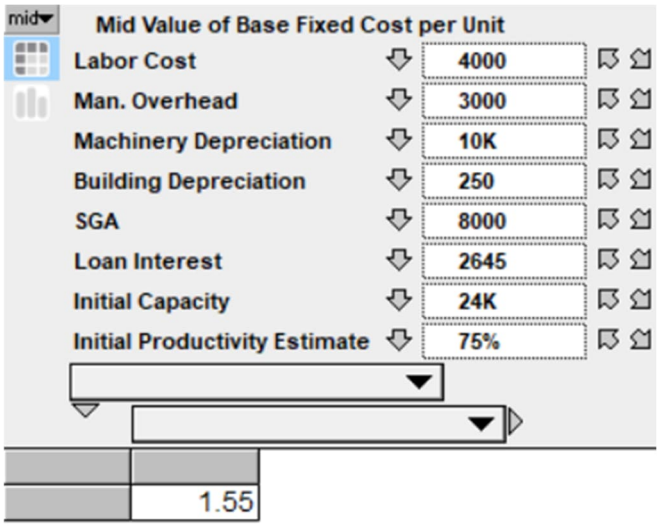


Figure 4-41 Base Fixed Cost per Unit

Running Profit:

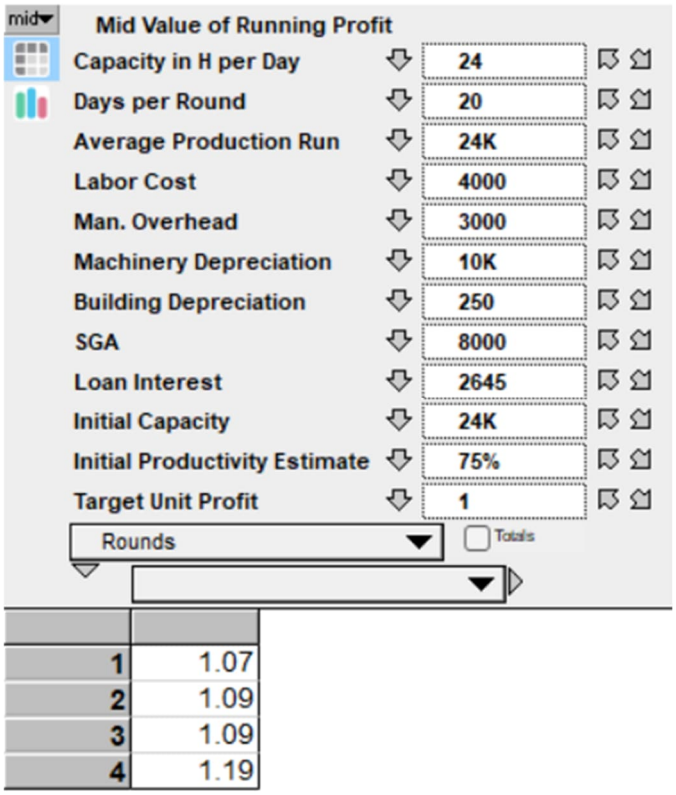


Figure 4-42 Running Profit

Estimated Profit/Net Income:

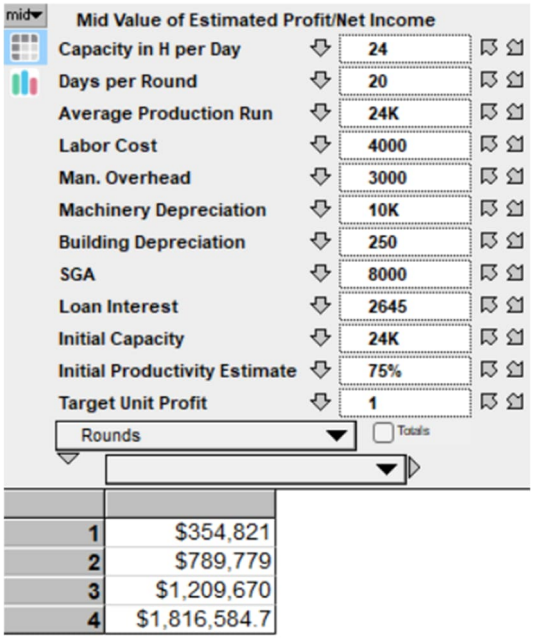


Figure 4-43 Estimated Profit/Net Income

Annualized Net Income:

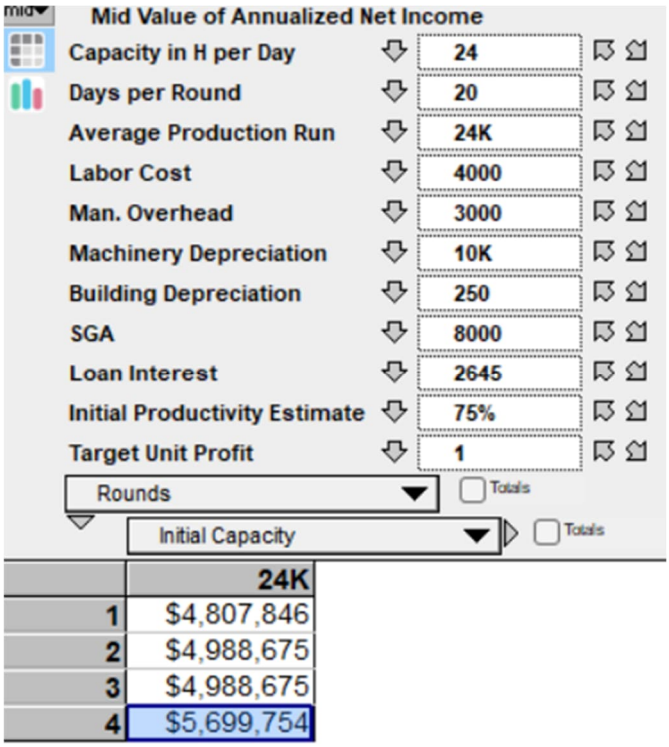


Figure 4-44 Annualized Net Income

Graph: Tracking cumulative investment and resulting profitability

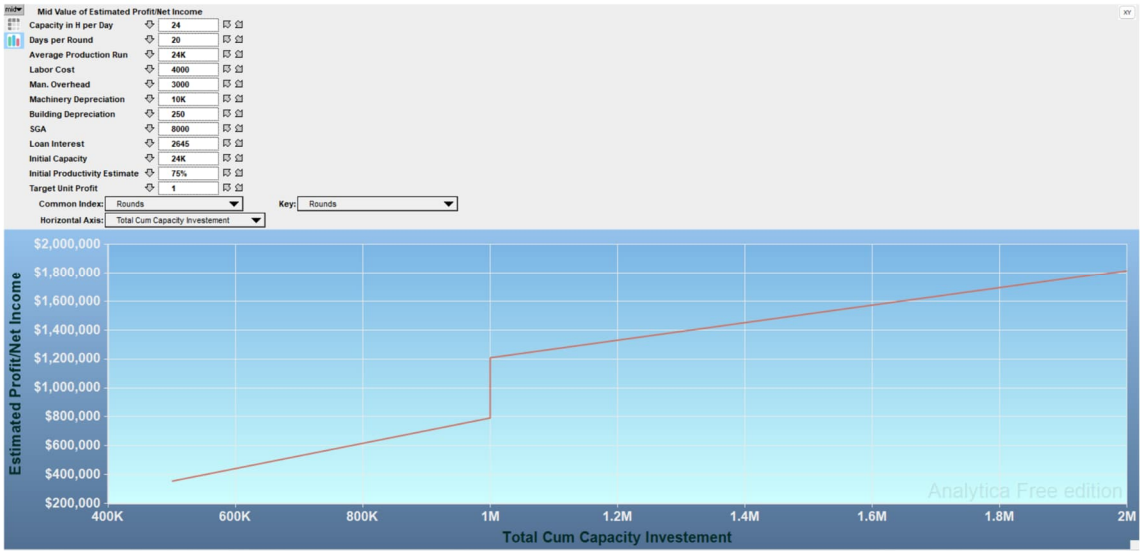


Figure 4-45 Graph: Tracking cumulative capacity investment and resulting profitability

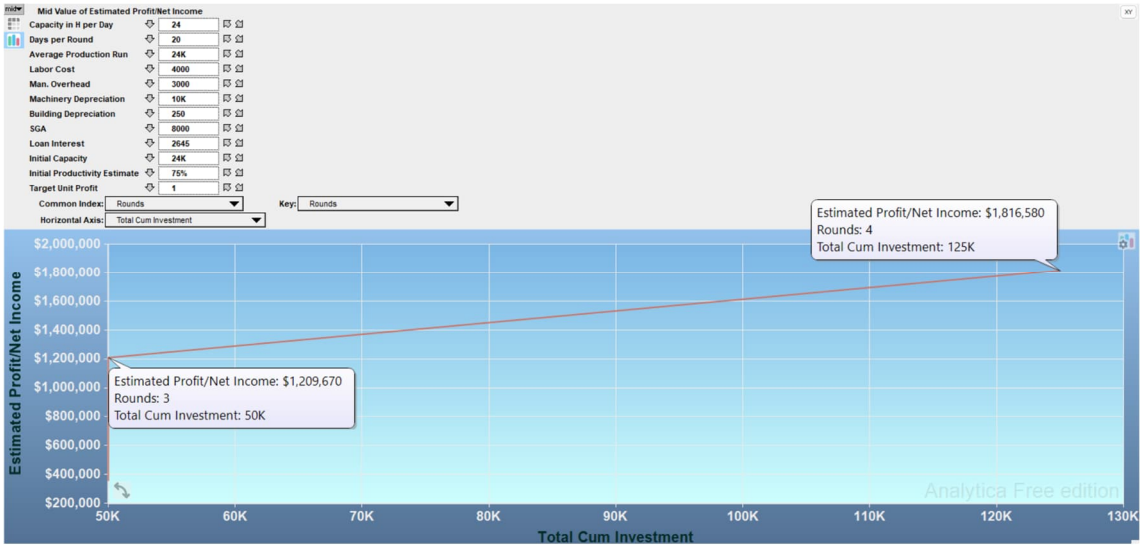


Figure 4-46 Graph: Tracking cumulative investment and resulting profitability

Cash:

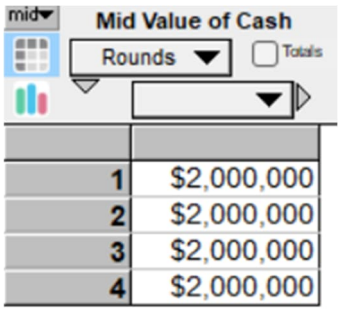


Figure 4-47 Cash

Accounts Receivables:

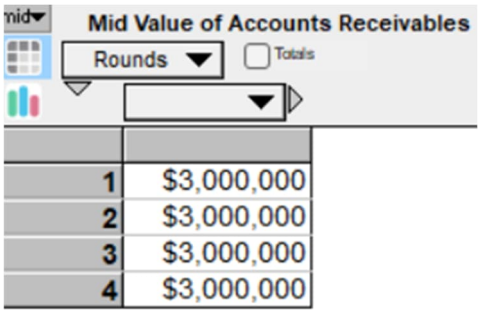


Figure 4-48 Accounts Receivables

Accounts Payable:

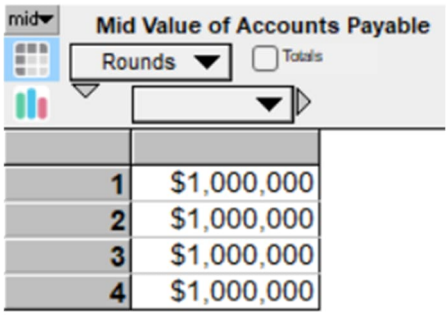


Figure 4-49 Accounts Payable

Net Debt:

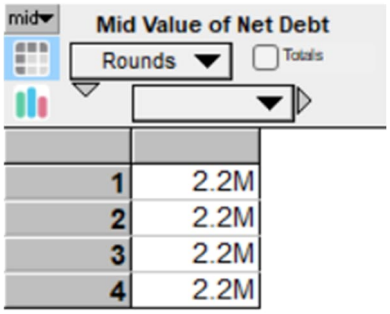


Figure 4-50 Net Debt

Applicable Interest Rate:

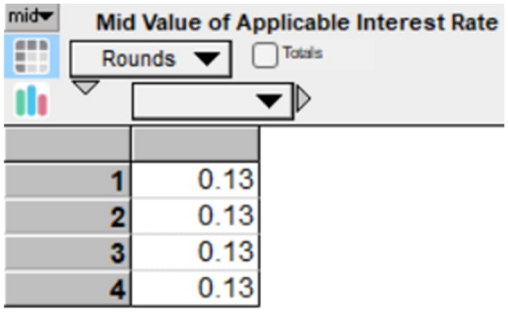
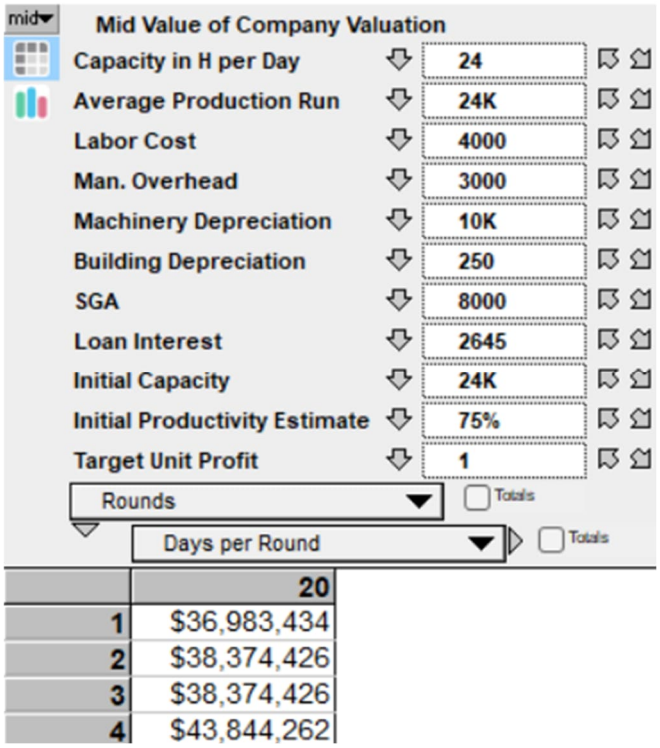


Figure 4-51 Applicable Interest Rate

Company Valuation:



	20
1	$36,983,434
2	$38,374,426
3	$38,374,426
4	$43,844,262

Figure 4-52 Company Valuation

Graph:

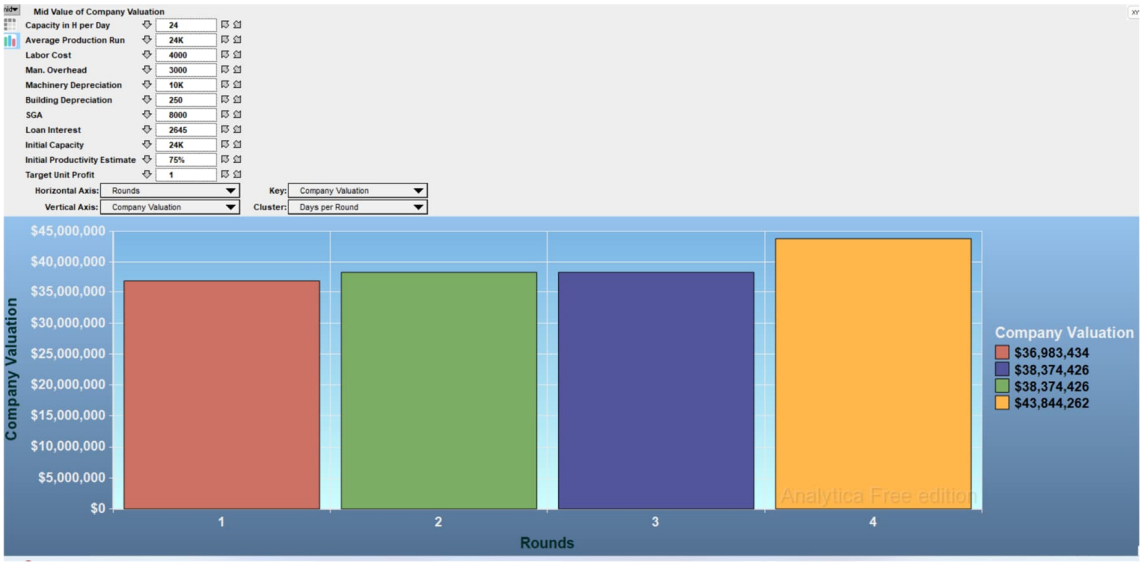


Figure 4-53 Graph of Company Valuation

4.3.2 Excel-Based Validation & Optimization

For the Production Improvement Model, a What-If Scenario was implemented in Excel to explore how different levels of capacity investment affect key financial outcomes. In this setup, one column contains the investment amounts, which are linked to the Capacity Investment cell. Using Excel's Data Table feature, we can automatically observe how changes in investment flow through the model.

As capacity investment increases, the model calculates the resulting capacity expansion (with every €1 million invested translating into an additional 1,000 units of daily capacity). This in turn lowers the Fixed Cost per Unit, since fixed costs are spread over a larger production base. As unit costs decrease, Running Profit improves, leading to higher Net Income. Finally, the effect on Company Valuation is tracked in a dedicated column, showing the incremental change in valuation for each investment step.

The analysis clearly illustrates that continued investment in capacity drives higher profitability and valuation. However, one limitation is that capacity depreciation was not included in this version of the model due to restrictions in the free edition of Analytica. For reference, each €1 million of investment would realistically involve a depreciation cost of about €33,333, which should be considered in a more advanced version of the model.

Investment	Capacity	Fixed Cost per unit	Running Proffit	Estimated Profit/Net Income	Company Valuation	Diff
Capacity	24000	1.55 €	1.00 €	1,440,000.00 €	31,418,181.82 €	
1,000,000.00 €	25000	1.50 €	1.05 €	1,553,554.14 €	33,895,726.79 €	2,477,544.97 €
2,000,000.00 €	26000	1.46 €	1.09 €	1,664,790.86 €	36,322,709.61 €	4,904,527.79 €
3,000,000.00 €	27000	1.42 €	1.13 €	1,773,780.36 €	38,700,662.48 €	7,282,480.66 €

Figure 4-54 What-If Scenario for Capacity Investment

For the Production Improvement Model, a second What-If Scenario was implemented in Excel focusing on Setup Time Investment. The same approach was applied with capacity: a Data Table was created where the investment amounts feed into the Setup Time Investment cell, and a new column tracks the incremental changes in Company Valuation.

In this case, increasing investment reduces Setup Time, which in turn lowers the Fixed Cost per Unit. As fixed costs fall, Running Profit rises, leading to higher Net Income. However, unlike capacity investment, the results are not strictly monotonic. At

certain levels—specifically €500,000 and €1,250,000 of investment—net income and valuation do not continue to increase. In fact, at €1,250,000 the company valuation begins to decline, indicating diminishing or even negative returns from additional setup time reductions.

This analysis highlights that while capacity investment consistently improves profitability (as long as all output can be sold), setup time investment has an optimal level beyond which further spending does not yield proportional gains. Using this approach, users can identify the point at which setup time investment maximizes profitability and valuation, avoiding over-investment that erodes returns.

Investment	Capacity	Fixed Cost per unit	Running Proffit	Estimated Profit/Net Income	Company Valuation	Diff
Setup Time	8	1.55 €	1.00 €	1,440,000.00 €	31,418,181.82 €	
50000	7	1.50 €	1.05 €	1,508,438.19 €	33,638,651.50 €	2,220,469.68 €
125000	6	1.45 €	1.10 €	1,559,772.27 €	35,849,576.73 €	4,431,394.91 €
250000	5	1.40 €	1.15 €	1,569,819.03 €	37,886,960.75 €	6,468,778.93 €
500000	4	1.36 €	1.19 €	1,464,512.00 €	39,225,716.36 €	7,807,534.55 €
1250000	3	1.31 €	1.24 €	869,922.96 €	37,161,955.56 €	5,743,773.74 €

Figure 4-55 What-If Scenario for Setup Time Investment

Finally, the model explores a combined What-If Scenario that evaluates both Capacity Investment and Setup Time Investment simultaneously. In this setup, the capacity investment levels are placed in the columns and the setup time investment levels are placed in the rows. Using Excel's Data Table function, the Company Valuation cell is selected as the corner output, since this represents the ultimate result of interest.

This approach allows us to observe how different combinations of capacity and setup time investments jointly affect company valuation. To make comparisons clearer, a second table was constructed to capture the incremental effect of each scenario, calculated as Company Valuation After Investment – Company Valuation Before Investment.

The results illustrate how valuation responds to varying strategies: while capacity investment generally produces steady gains, setup time investment yields benefits only up to an optimal level, after which valuation growth slows or even reverses. By combining the two dimensions, the analysis helps identify the most profitable mix of capacity and setup time investments, providing a clearer view of how capital should be allocated for maximum enterprise value.

Estimated Company Valuation:

Estimated Company Valuation					
31,418,181.82 €	50000	125000	250000	500000	1250000
1,000,000 €	36,281,252.61 €	38,674,296.50 €	40,913,297.35 €	42,476,054.31 €	40,662,120.35 €
2,000,000 €	38,875,045.80 €	41,452,709.39 €	43,896,767.98 €	45,688,152.98 €	44,130,173.54 €
3,000,000 €	41,421,370.87 €	44,185,944.83 €	46,838,277.01 €	48,862,683.25 €	47,566,555.02 €

Figure 4-56 Estimated Company Valuation

Difference Between the Base and the Future value

Diff between current & future value					
31,418,181.82 €	50000	125000	250000	500000	1250000
1,000,000 €	4,863,070.80 €	7,256,114.68 €	9,495,115.53 €	11,057,872.49 €	9,243,938.53 €
2,000,000 €	7,456,863.98 €	10,034,527.57 €	12,478,586.17 €	14,269,971.17 €	12,711,991.73 €
3.000.000 €	10.003.189.05 €	12.767.763.02 €	15.420.095.19 €	17.444.501.44 €	16.148.373.20 €

Figure 4-57 Difference Between the Base and the Future value

This model provides a way for participants to quantify the impact of different investment strategies, but it does not imply that the investment level with the highest valuation gain (e.g., €3 million) should always be chosen. In practice, decisions are constrained by factors such as warehouse capacity and the availability of cash. If sufficient cash is not available, a loan would need to be taken, which in turn would reduce the company's valuation due to additional debt.

This effect can be further tested in the Loan Repayment Model, where, for example, introducing a new €10 million loan would increase liabilities and lower net valuation. Moreover, such borrowing would likely trigger a higher interest rate, which is not yet incorporated into the current model but would further decrease profitability and valuation.

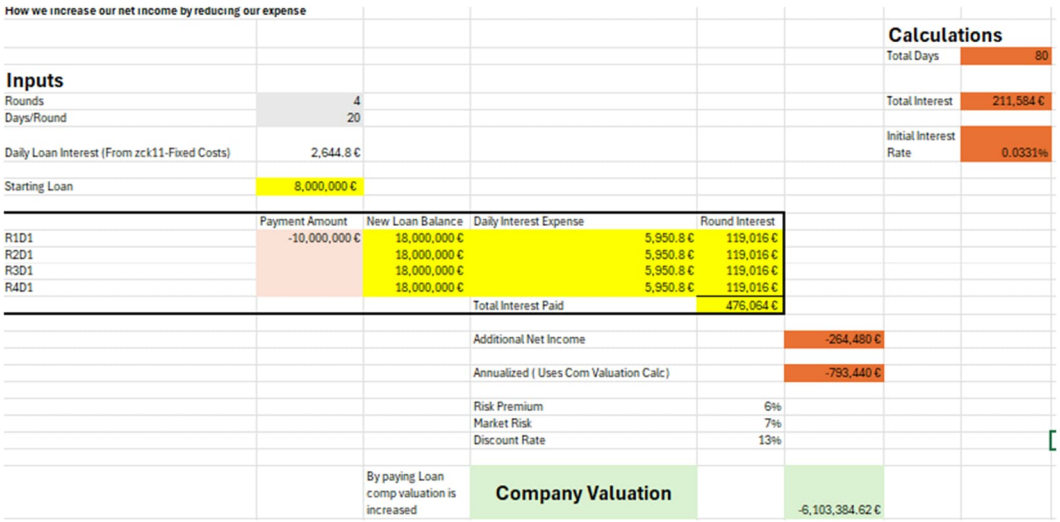


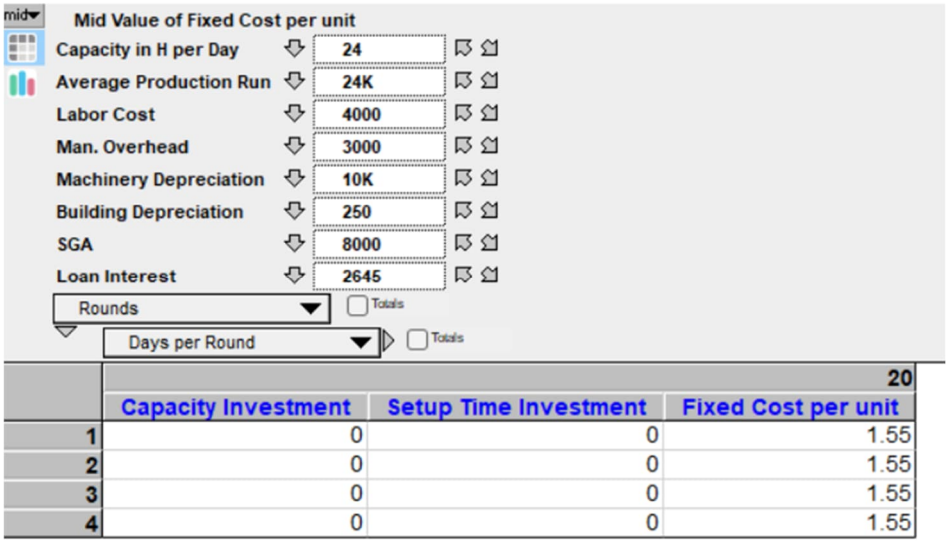
Figure 4-58 How net income is increased by reducing the expenses

4.4 Profitability Analysis Model— Results

4.4.1 Outputs & Visualization (Analytica)

Scenario 1 — Fixed Costs

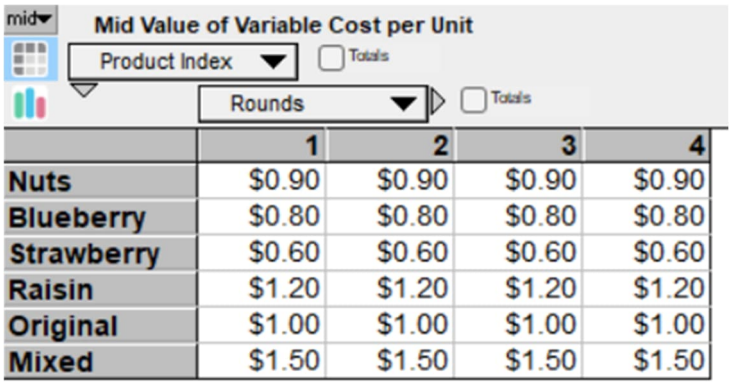
There is no investment in Setup Time and Capacity Improvement.



	20		
	Capacity Investment	Setup Time Investment	Fixed Cost per unit
1	0	0	1.55
2	0	0	1.55
3	0	0	1.55
4	0	0	1.55

Figure 4-59 Fixed Cost per Unit

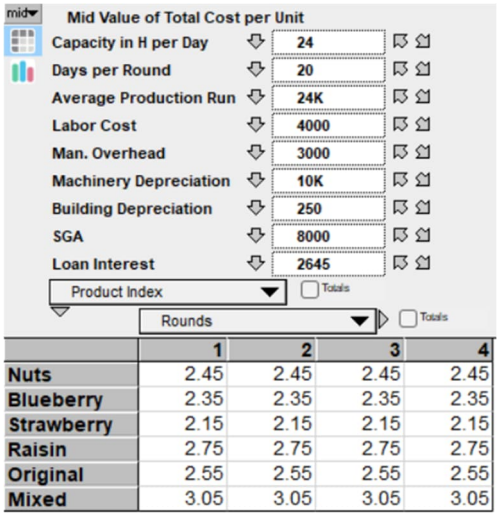
Variable Cost per Unit remains stable across all rounds:



	1	2	3	4
Nuts	$0.90	$0.90	$0.90	$0.90
Blueberry	$0.80	$0.80	$0.80	$0.80
Strawberry	$0.60	$0.60	$0.60	$0.60
Raisin	$1.20	$1.20	$1.20	$1.20
Original	$1.00	$1.00	$1.00	$1.00
Mixed	$1.50	$1.50	$1.50	$1.50

Figure 4-60 Variable Cost per Unit

Total Cost per Unit:



Mid Value of Total Cost per Unit

Capacity in H per Day	24
Days per Round	20
Average Production Run	24K
Labor Cost	4000
Man. Overhead	3000
Machinery Depreciation	10K
Building Depreciation	250
SGA	8000
Loan Interest	2645

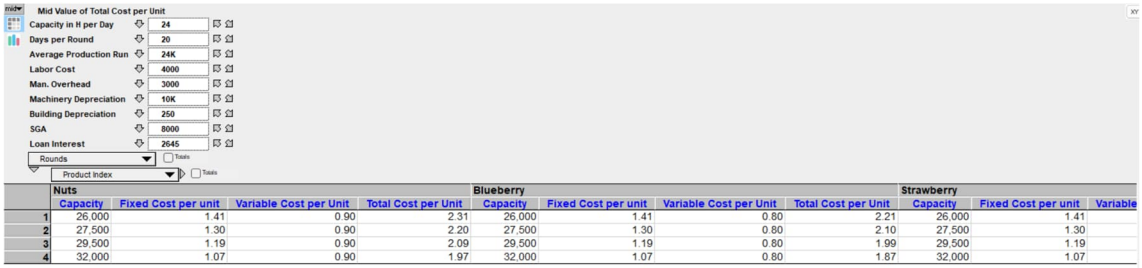
Product Index ☐ Totals

Rounds ☐ Totals

	1	2	3	4
Nuts	2.45	2.45	2.45	2.45
Blueberry	2.35	2.35	2.35	2.35
Strawberry	2.15	2.15	2.15	2.15
Raisin	2.75	2.75	2.75	2.75
Original	2.55	2.55	2.55	2.55
Mixed	3.05	3.05	3.05	3.05

Figure 4-61 Total Cost per Unit

Comparison between Capacity, Total Cost per Unit per Product



Mid Value of Total Cost per Unit

Capacity in H per Day	24
Days per Round	20
Average Production Run	24K
Labor Cost	4000
Man. Overhead	3000
Machinery Depreciation	10K
Building Depreciation	250
SGA	8000
Loan Interest	2645

Rounds ☐ Totals

Product Index ☐ Totals

	Nuts				Blueberry				Strawberry		
	Capacity	Fixed Cost per unit	Variable Cost per Unit	Total Cost per Unit	Capacity	Fixed Cost per unit	Variable Cost per Unit	Total Cost per Unit	Capacity	Fixed Cost per unit	Variable
1	26,000	1.41	0.90	2.31	26,000	1.41	0.80	2.21	26,000	1.41	
2	27,500	1.30	0.90	2.20	27,500	1.30	0.80	2.10	27,500	1.30	
3	29,500	1.19	0.90	2.09	29,500	1.19	0.80	1.99	29,500	1.19	
4	32,000	1.07	0.90	1.97	32,000	1.07	0.80	1.87	32,000	1.07	

Figure 4-62 Comparison between Capacity, Total Cost per Unit per Product

Graph: Fixed cost/unit decreases with volume, variable cost/unit stays flat, and total cost/unit follows the sum. E.g Blueberry

Figure 4-63 Fixed Cost per Unit-Total Cost per Unit-Capacity

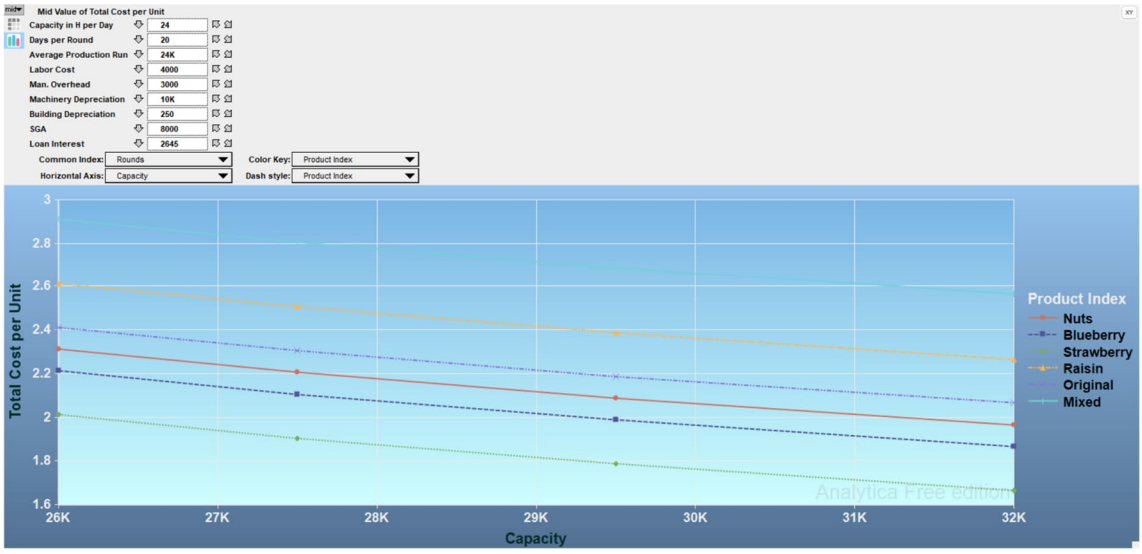


Figure 4-64 Total Cost per Unit- Capacity per product

5. Conclusions and Proposals

5.1 Interpretation of Results

The purpose of this thesis was to analyze and support strategic decision-making within the ERPSim environment, focusing on the case of Muesli AG, a manufacturing company operating in an SAP S/4HANA system. To achieve this, three decision-support models were developed to provide structured insight into liquidity management, production planning efficiency, and profitability under variable cost conditions. These models were constructed using Analytica as a standalone environment for defining system relationships and running scenario-based simulations, and Excel as a tool for numerical validation, scenario exploration, and optimization using Solver, Goal Seek, and Scenario Manager.

The Liquidity Planning Model enabled the examination of cash flow behavior and the implications of different repayment strategies on financial stability. The Production Improvement Model highlighted the operational trade-offs between setup time, production batch sizing, and the ability to respond to changing demand. The Profitability Analysis Model provided insight into contribution margins and profit sensitivity under varying cost and demand scenarios. Through scenario comparisons and sensitivity analysis, the models demonstrated how different strategic decisions influence outcomes in interconnected operational environments.

Overall, the study showed that structured modeling enhances the clarity and quality of strategic decision-making, particularly in settings characterized by uncertainty, interdependence of processes, and evolving market conditions.

5.2 Main Conclusions

This research concludes that combining ERP process understanding with independent decision-support modeling tools provides significant value for strategic business planning. ERPSim served as the operational context, while Analytica and Excel supported analytical reasoning and strategic evaluation. The separation between operational execution and analytical exploration allowed for clearer interpretation of how decisions propagate across financial and operational dimensions.

The models developed in this work do not replace managerial decision-making, but support it, by making the consequences of alternative strategies explicit and

measurable. Scenario-based analysis allowed assumptions to be tested before action, while sensitivity analysis identified which variables have the greatest influence on outcomes. This reinforces the importance of evidence-based decision-making in business environments where uncertainty and interdependencies are present. The findings highlight that even marginal improvements in production planning, financing decisions, and cost structuring can lead to cumulative performance benefits when decision-making is informed, systematic, and model-driven.

5.3 Limitations of the Work

Several limitations should be acknowledged. First, the models developed in this work are simplified representations of real operational and financial systems. They do not capture the complete set of constraints that would arise in a real manufacturing environment, such as workforce scheduling policies, machine maintenance planning, or long-term capacity investments. Additionally, cost and demand behaviors were modeled based on simulation data and assumptions, which may differ from real market conditions.

A further methodological limitation relates to the use of the free edition of Analytica, which restricts the number of variables and objects that can be included in a model. This constraint required selective abstraction and grouping of model components, preventing a more detailed decomposition of certain operational processes. Although the core structure and decision logic were maintained, greater model granularity would allow for deeper insight into interdependencies.

Moreover, the free edition of Analytica does not include built-in Monte Carlo simulation capabilities, which limited the ability to incorporate probabilistic uncertainty directly into the model runs. Monte Carlo simulation would have allowed the systematic exploration of probability distributions for uncertain variables (e.g., demand fluctuations, raw material prices) and would provide a more robust view of risk exposure and decision resilience. The absence of this feature meant that scenario analysis was performed using deterministic scenario comparisons, rather than full stochastic simulation. Future access to a licensed version of Analytica would enable this methodological enhancement.

Finally, the ERPSim environment operates in an accelerated and simplified timeframe, which reduces insights into long-term strategies such as product lifecycle

evolution, competitive dynamics, and cumulative learning effects. Therefore, results should be interpreted within the scope of an educational and analytical simulation context.

5.4 Proposals for Future Research

Several directions for extending this work are identified, especially in relation to operational complexity and strategic decision-making elements that were present in the ERPSim simulation but not analyzed in full depth.

First, the integration of multi-warehouse logistics planning could be examined in greater detail. The Manufacturing Advanced scenario introduces three regional distribution centers and transportation scheduling decisions. Extending the production and profitability models to include optimal shipment frequency, regional demand variability, and storage cost trade-offs would provide a fuller representation of supply chain decision-making. Second, procurement strategy could be modeled dynamically, incorporating seasonal price fluctuations and supplier cost variability observed in the simulation. A procurement sub-model could evaluate purchasing triggers, hedge timing, or safety stock policies to minimize cost exposure while maintaining production continuity. Third, more sophisticated demand forecasting approaches could be applied. While the simulation provides general demand signals, predictive models (e.g., regression-based forecasting or smoothing methods) could support more accurate alignment between production volume and expected sales, reducing both stockouts and excess inventory. Fourth, the models could be expanded to include elastic pricing effects. Since the ERPSim environment allows pricing adjustments across customer segments and regions, incorporating a price–demand sensitivity structure would provide deeper insight into revenue optimization decisions.

Finally, with access to a full Analytica license, Monte Carlo simulation could be used to evaluate uncertainty across multiple interacting parameters simultaneously. This would allow decision-makers to assess strategy robustness under fluctuating demand, variable production times, and volatile raw material costs, producing probability-based performance outcomes rather than deterministic scenario results. These extensions would contribute to a more comprehensive and realistic representation of the strategic decision-making challenges that arise within the ERPSim environment and comparable real-world production settings.

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7. Appendices

7.1 Appendix A: Justification for the Use of Analytica

Analytica is particularly well-suited for modeling case studies because it facilitates clear, structured, and collaborative model development through its unique visual approach. Unlike traditional tools such as spreadsheets or scripting languages (e.g., Python or R), which require users to focus on low-level details like individual cells or lines of code, Analytica encourages users to think conceptually about the problem. This shift in perspective is essential when dealing with complex decision-making scenarios involving multiple variables, uncertainties, objectives, and data sources. At the core of Analytica's modeling environment are influence diagrams, which visually represent the structure of a model. These diagrams distinguish between different types of variables—such as decisions, objectives, uncertainties, and constraints—using unique shapes and colors. Arrows between nodes illustrate how variables influence one another, making relationships explicit and intuitive. This visual structure not only supports the creation of models but also serves as a powerful tool for communicating model logic and assumptions to stakeholders, including collaborators, managers, and clients.

Analytica provides a drag-and-drop interface for building models, enabling users to create variables and define their relationships with ease. When defining a variable, selecting from existing influences helps ensure that all dependencies are clear and accurate. The software automatically updates influence arrows based on the definitions, providing immediate visual feedback on the model structure. Another key advantage is Analytica’s support for both deterministic and probabilistic modeling. Influences between variables can represent simple algebraic relationships or more complex causal and statistical dependencies. Where data is unavailable, expert judgment can be used to estimate relationships, which is often necessary in case studies involving forecasts, risk analysis, or market behavior. Furthermore, Analytica allows users to manage complexity by organizing models into hierarchical modules. Each module can contain its own influence diagram, enabling users to break down large models into smaller, manageable components. This modularity enhances model transparency, ease of navigation, and scalability, making it particularly effective for large or evolving case studies. Finally, Analytica’s visual and modular design greatly enhances communication and

collaboration. Because the model structure is immediately visible and intuitive, it becomes easier to discuss, critique, and refine models with both technical and non-technical audiences. This shared understanding is especially valuable in collaborative settings where clarity and consensus are critical.

In summary, Analytica enables a higher-level, conceptual approach to model building that is especially beneficial for case studies. Its visual influence diagrams, clear variable distinctions, support for uncertainty, and modular architecture collectively provide a powerful platform for structuring, analyzing, and communicating complex decision problems. (Analytica (n.d.)).

7.2 Appendix B: Variables' Dictionary

Liquidity Planning Model:

Table 7

Variable Description	Variable ID	Input/ Output	Variable Type	Definition/Formula
Rounds	Rounds	-	Index	Sequence (1, 4, 1)
Weeks	Weeks	-	Index	Sequence (1, 4, 1)
Receivables	Receivables	Input	General	Indexed by Rounds, Weeks
Payables	Payables	Input	General	Indexed by Rounds, Weeks
Marketing Expenses	Marketing_ Expenses	Input	General	Indexed by Rounds, Weeks
Overhead Expenses	Overhead_E xpenses	Input	General	List
Interest Expenses	Interest_Exp enses	Input	General	List
Total Cash Outflows	Total_Cash_ Outflows	Input/ Output	General	Expression: Overhead_Expenses+Payable s+Marketing_Expenses+Inter est_Expenses
Net Cash Flow	Net_Cash_F low	Input/ Output	General	Expression: Receivables-Total_Cash_Outflows
Cumulative Cash Balance	Cumulative _Cash_Bala nce	Output	General	Expression: if rounds=X And weeks=Y Then Net_Cash_Flow[rounds=X, weeks=Y] Else if rounds=X And weeks=Y+1 then Net_Cash_Flow[rounds=X, weeks=Y]+ Net_Cash_Flow[rounds=X, weeks=Y+1] etc.

Loan Repayment & Company Valuation Model:

Table 8

Variable Description	Variable ID	Input/ Output	Variable Type	Definition/Formula
Rounds	Rounds	Input	General	List
Round	Round1	-	Index	Sequence (1, 4, 1)
Day	Day	-	Index	Sequence (1, 20, 1)
Days/Round	Days_Round	Input	General	List
Daily Initial Interest	Daily_Initial_Interest	Input	General	List
Starting Loan	Starting_Loan	Input	General	List
Payment Amount	Payment_Amount	Input	General	Indexed by Round
Avg Price/Unit	Avg_Price_Unit	Input	General	List
Actual Sales Qty	Actual_Sales_Qty	Input	General	List
Avg Unit Cost	Avg_Unit_Cost	Input	General	List
Rounds Completed (Company Valuation)	Rounds1	Input	General	List
Total Days	Total_Days	Output	General	Expression: Rounds*Days_Round
Total Initial Interest	Total_Initial_Interest	Output	General	Expression: Total_Days*Daily_Initial_Interest
Initial Interest Rate	Initial_Interest_Rate	Output	General	Expression: Daily_Initial_Interest/Starting_Loan
New Loan Balance	New_Loan_Balance	Output	General	Expression: cumulate(If Round1 = 1 Then Starting_Loan - Payment_Amount Else - Payment_Amount,Round1)
Daily Interest Expense	Daily_Interest_Expense	Output	General	Expression: New_Loan_Balance* Initial_Interest_Rate

Round Interest	RoundInterest	Output	General	Expression: Sum(Daily_Interest_Expense,Day)
Total Interest Paid	Total_Interest_Paid	Output	General	Expression: Sum(RoundInterest,Round1)
Cash	Cash	Input	General	Expression: Array(Round1,[Value, Value, Value,Value])
Accounts Receivable	Acc_Receivable	Input	General	Expression: Array(Round1,[Value, Value, Value,Value])
Accounts Payable	Acc_Payable	Input	General	Expression: Array(Round1,[Value, Value, Value, Value])
Net Debt	Net_Debt	Output	General	Expression: Acc_Payable+New_Loan_Balance-Cash-Acc_Receivable
Credit Rating Index	Credit_Rating_Index	-	Index	List
Net Debt From	Net_Debt_From	-	General	Expression: Array(Credit_Rating_Index,[-100000000,1000001,2000001,3000001,4000001,5000001,6000001,7000001,8000001,9000001,10000001,11000001,12000001,13000001,14000001,15000001,16000001,17000001,18000001,19000001,20000001])
Net Debt To	Net_Debt_To	-	General	Expression: Array(Credit_Rating_Index,[1000000,2000000,3000000,4000000,5000000,6000000,7000000,8000000,9000000,10000000,11000000,12000000,13000000,14000000,15000000,16000000,17000000,18000000,19000000,20000000,100000000])
Interest Premium	Interest_Premium	-	General	Expression: Array(Credit_Rating_Index,[0.01,0.15,0.02,0.025,0.0275,0.03,0.0325,0.0375,0.04,0.0425,0.0475,0.05,0.0525,0.0575,0.06,0.0625,0.0675,0.07,0.0725,0.08,0.09])
Risk Premium	Risk_Premium	-	General	Expression: Array(Credit_Rating_Index,[0.03,0.0375,0.04,0.0425,0.04

				75,0.05,0.0525,0.0575,0.06,0.0625,0.0675,0.07,0.0725,0.0775,0.08,0.0825,0.09,0.1,0.11,0.12,0.15])
Interest Rate	Interest_Rate	-	General	Expression: Array(Credit_Rating_Index,[0.06,0.065,0.07,0.0725,0.0775,0.08,0.0825,0.0875,0.09,0.0925,0.0975,0.1,0.1025,0.1075,0.11,0.1125,0.1175,0.12,0.1225,0.13,0.14])
Discount Rate	Discount_Rate	-	General	Expression: Array(Credit_Rating_Index,Interest_Premium+Risk_Premium+Interest_Rate)
Applicable Interest Rate	Applicable_Interest_Rate1	Output	General	Expression: Sum(if Net_Debt>= Net_Debt_From AND Net_Debt<=Net_Debt_To THEN Discount_Rate ELSE 0,Credit_Rating_Index)
Revenue	Revenue	Input/Output	General	Expression: Avg_Price_Unit*Actual_Sales_Qty
Cogs	Cogs	Input/Output	General	Expression: Avg_Unit_Cost*Actual_Sales_Qty
Additional Net Income	Additional_Net_Income	Output	General	Expression: Total_Initial_Interest-Total_Interest_Paid
Annualized Net Income	Annualized_Net_Income	Output	General	Expression: Additional_Net_Income*3
Company Valuation (Loan Repayment)	Company_Valuation1	Output	General	Expression: Annualized_Net_Income/Applicable_Interest_Rate1
Buildings Depreciation	Buildings_Depreciation	Input	General	List
Machinery Depreciation	Machinery_Depreciation	Input	General	List
Direct Labor Cost	Direct_Labor_Cost	Input	General	List
Factory Overhead	Factory_Overhead	Input	General	List
SGA	SGA	Input	General	List

Cumulative Net Income	Cumulative_ Net_Income1	Output	General	Expression: Revenue-Cogs-Buildings_Depreciation-Machinery_Depreciation-Direct_Labor_Cost-Factory_Overhead-SGA
Annual Profit	Annual_Profi t	Output	General	Expression: (Cumulative_Net_Income1/Rounds1)*12
Company Valuation (Full Model)	Company_V aluation	Output	General	Expression: Annual_Profit/Applicable_Interest_Rate1

Production Improvement Model:

Table 9

Variable Description	**Variable ID**	**Input/ Output**	**Variable Type**	**Definition/Formula**
Capacity Cost Index	Capacity_Co st_Index	-	Index	List
Units/Day	Units_Day	Input	General	Expression: Array(Capacity_Cost_Index, [24000,24500,25000,25500,26000,26500,27000,27500,28000,28500,29000,29500,30000,30500,31000,31500,32000,32500,33000,33500])
Capacity Cost	Capacity_Co st	Input	General	Expression: Array(Capacity_Cost_Index, [0,500000,1000000,1500000,2000000,2500000,3000000,3500000,4000000,4500000,5000000,5500000,6000000,6500000,7000000,7500000,8000000,8500000,9000000,9500000])
Capacity Investment	Capacity_In vestment	Input	General	Indexed by Rounds
Total Cum Capacity Investement	Total_Cum_ Capacity_In vestement	Input/Output	General	Expression: Cumulate(Capacity_Investment,Rounds)
Capacity	Capacity	Input/Output	General	Expression: Sum(if Total_Cum_Capacity_Investement=Capacity_Cost then Units_Day else 0,Capacity_Cost_Index)

Days per Round	Days_per_Round	Input	Constant	List
Rounds	Rounds	-	Index	Sequence (1, 4, 1)
Total Days	Total_Days	Input/Output	General	Expression: Days_per_Round*Rounds
Total Capacity	Total_Capacity	Output	General	Expression: Total_Days*Capacity
Setup Time Index	Setup_Time_Index	-	Index	List
Setup Time	Setup_Time	Input	General	Expression: Array(Setup_Time_Index,[8,7,6,5,4,3])
Setup Time Cum Investment	Setup_Time_Cum_Investment	Input	General	Expression: Array(Setup_Time_Index,[0,50000,125000,250000,500000,1250000])
Setup Time Investment	Setup_Time_Investment1	Input/Output	General	Expression: Table, Indexed by Rounds
Total Cum Investment	Total_Cum_Investment	Input/Output	General	Expression: Cumulate(Setup_Time_Investment1,Rounds)
Setup Time (H)	Setup_Time1	Input/Output	General	Expression: If Total_Cum_Investment >= 1250000 Then 3 Else If Total_Cum_Investment >= 500000 Then 4 Else If Total_Cum_Investment >= 250000 Then 5 Else If Total_Cum_Investment >= 125000 Then 6 Else If Total_Cum_Investment >= 50000 Then 7 Else 8
Capacity in H per Day	Capacity_in_H_per_Day	Input	Constant	List
Capacity per Setup	Capacity_per_Setup	Input	General	Expression: Capacity/Capacity_in_H_per_Day*Setup_Time1
Capacity per Run	Capacity_per_Run	Input/Output	General	Expression: Capacity_per_Setup+Average_Production_Run

Average Production Run	Average_Production_Run	Input	Constant	List
Possible Runs	Possible_Runs	Input/Output	General	Expression: Total_Capacity/Capacity_per_Run
Total Production	Total_Production	Input/Output	General	Expression: Possible_Runs*Average_Production_Run
Productivity Estimate	Productivity_Estimate	Input/Output	General	Expression: Total_Production/Total_Capacity
Allocation Basis	Allocation_Basis	Input/Output	General	Expression: Capacity*Productivity_Estimate
Total Daily Cost	Total_Daily_Cost	Input/Output	General	Expression: Labor_Cost+Man_Overhead+Machinery_Depreciation+Building_Depreciation+SGA+Loan_Interest
Labor Cost	Labor_Cost	Input	General	List
Man. Overhead	Man_Overhead	Input	General	List
Machinery Depreciation	Machinery_Depreciation	Input	General	List
Building Depreciation	Building_Depreciation	Input	General	List
SGA	SGA	Input	General	List
Loan Interest	Loan_Interest	Input	General	List
Fixed Cost per unit	Fixed_Cost_per_unit	Input/Output	General	Expression: Total_Daily_Cost/Allocation_Basis
Initial Productivity Estimate	Initial_Productivity_Estimate	Input	Constant	List
Initial Allocation Basis	Initial_Allocation_Basis	Input/Output	Constant	Expression: Initial_Capacity*Initial_Productivity_Estimate
Initial Capacity	Initial_Capacity	Input	Constant	List
Running Profit	Running_Profit	Output	General	Expression: Base_Fixed_Cost_per_Unit+Target_Unit_Profit-Fixed_Cost_per_unit

Target Unit Profit	Target_Unit_Profit	-	Constant	List
Estimated Profit/Net Income	Estimated_Profit_Net_Income	Input/Output	General	Expression: (Running_Profit*Total_Production)-Total_Cum_Investment
Annualized Net Income	Annualized_Net_Income	Input/Output	General	Expression: ((((Estimated_Profit_Net_Income+Total_Cum_Investment)/Rounds)*12)-Total_Cum_Investment)
Starting Loan	Starting_Loan	Input	General	Expression: Array(Rounds,[X,X,X,X])
Cash	Cash	Input	General	Expression: Array(Rounds,[X,X,X,X])
Accounts Receivables	Receivables	Input	General	Expression: Array(Rounds,[X,X,X,X])
Accounts Payable	Accounts_Payable	Input	General	Expression: Array(Rounds,[X,X,X,X])
Net Debt	Net_Debt	Input/ Output	General	Expression: (-Cash-Receivables+Accounts_Payable+Starting_Loan)
Credit Rating Index	Credit_Rating_Index	-	Index	List
Net Debt From	Net_Debt_From	Input	General	Expression: Array(Credit_Rating_Index,[-100000000,1000001,2000001,3000001,4000001,5000001,6000001,7000001,8000001,9000001,10000001,11000001,12000001,13000001,14000001,15000001,16000001,17000001,18000001,19000001,20000001])
Net Debt To	Net_Debt_To	Input	General	Expression: Array(Credit_Rating_Index,[1000000,2000000,3000000,4000000,5000000,6000000,7000000,8000000,9000000,10000000,11000000,12000000,13000000,14000000,15000000,16000000,17000000,18000000,19000000,20000000,100000000])
Interest Premium	Interest_Premium	Input	General	Expression: Array(Credit_Rating_Index,[0.01,0.15,0.02,0.025,0.0275,

				0.03,0.0325,0.0375,0.04,0.0425,0.0475,0.05,0.0525,0.0575,0.06,0.0625,0.0675,0.07,0.0725,0.08,0.09])
Risk Premium	Risk_Premium	Input	General	Expression: Array(Credit_Rating_Index,[0.03,0.0375,0.04,0.0425,0.0475,0.05,0.0525,0.0575,0.06,0.0625,0.0675,0.07,0.0725,0.0775,0.08,0.0825,0.09,0.1,0.11,0.12,0.15])
Interest Rate	Interest_Rate	Input	General	Expression: Array(Credit_Rating_Index,[0.06,0.065,0.07,0.0725,0.0775,0.08,0.0825,0.0875,0.09,0.0925,0.0975,0.1,0.1025,0.1075,0.11,0.1125,0.1175,0.12,0.1225,0.13,0.14])
Discount Rate	Discount_Rate	Input/Output	General	Expression: Array(Credit_Rating_Index,Interest_Premium+Risk_Premium+Interest_Rate)
Applicable Interest Rate	Applicable_Interest_Rate	Input/Output	General	Expression: Sum(if Net_Debt>=Net_Debt_From AND Net_Debt<=Net_Debt_To THEN Discount_Rate ELSE 0,Credit_Rating_Index)
Company Valuation	Company_Valuation	Output	General	Expression: Annualized_Net_Income/Applicable_Interest_Rate

Profitability Analysis Model:

Table 10

Variable Description	**Variable ID**	**Input/ Output**	**Variable Type**	**Definition/Formula**
Product Index	Product_Index	-	Index	List
Variable_Cost_per_Unit	Variable_Cost_per_Unit	Input	General	Indexed by Rounds, Product Index
Total Cost per Unit	Total_Cost	Output	General	Expression: Fixed_Cost_per_unit+ Variable_Cost_per_Unit

7.3 Appendix C: Key Functions-Formulas in Analytica

Table 11

Function	Purpose	Example Usage	Example (Use case)
Sequence	Creates a sequence of numbers or labels across an index.	`Sequence(1, 4,1)`	Generates the values 1, 2, 3, 4. Useful to define weeks, rounds, or other ordered indices.
Indexed by	Defines how a variable depends on one or more indices.	`Receivables [Rounds, Weeks]`	Declares that receivables are stored across both the Rounds and Weeks dimensions.
List	Stores a collection of specific values.	`List(100, 200, 300)`	Creates a list with the values 100, 200, 300 (not necessarily ordered). Useful for manual data entry.
If Then Else	Implements conditional logic.	`If Weeks=1 Then 100 Else 200`	Returns 100 if it is week 1, otherwise 200.
Cumulate	Calculates cumulative totals along an index.	`Cumulate(Net_Cash_Flow, Weeks)`	Adds up weekly net cash flows over time to get cumulative cash flow.
Sum	Aggregates values across an index.	`Sum(Receivables, Weeks)`	Returns the total receivables across all weeks.
Array	Constructs a multidimensional array from values across indices.	`Array(Rounds, List(100,200,300,400))`	Assigns a value for each round in a structured way.
Table (Indexed by …)	Stores input or output values in tabular format tied to one or more indices.	`Table(Rounds)(100,200, 300,400)`	A table of values where each entry corresponds to a round. Often used for user inputs.

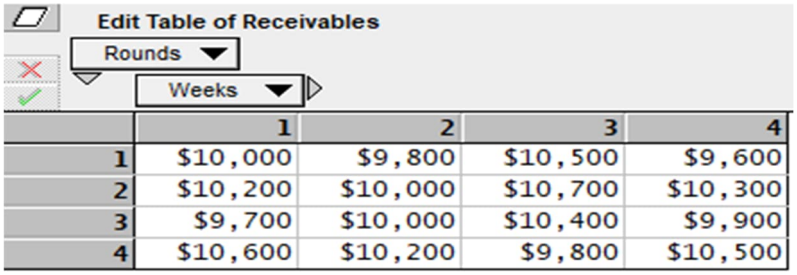
7.4 Appendix D: Base Scenario Input Screenshots

Section 7.4 provides the complete set of input data and supporting material used for the Base Scenario across all models. These tables and screenshots complement the results presented in Section 4 by showing the underlying values, assumptions, and structural elements used during model execution. Although the Base Scenario results are fully interpreted in the main body of the thesis, the detailed model inputs are included here for transparency and reproducibility, allowing readers to verify how production, liquidity, loan repayment, and profitability outcomes were generated.

7.4.1 D.1 Liquidity Planning Model – Supporting Material

Analytica

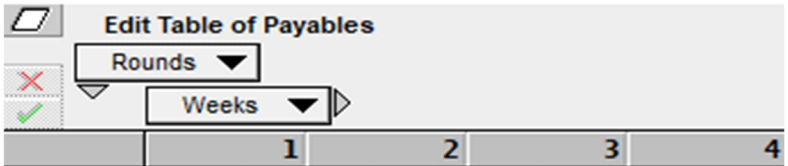
Receivables Table:



	1	2	3	4
1	$10,000	$9,800	$10,500	$9,600
2	$10,200	$10,000	$10,700	$10,300
3	$9,700	$10,000	$10,400	$9,900
4	$10,600	$10,200	$9,800	$10,500

Figure 7-1 Receivables Variable

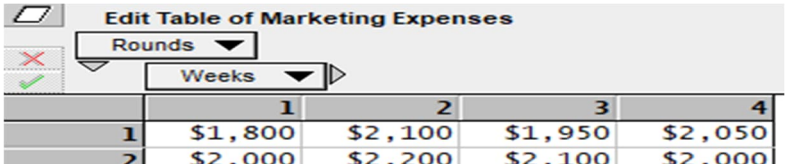
Payables Table:



	1	2	3	4
1	$3,000	$5,300	$5,200	$5,000
2	$4,900	$4,800	$4,900	$5,200
3	$5,100	$5,100	$5,300	$5,400
4	$5,000	$5,000	$5,100	$5,300

Figure 7-2 Payables Variable

Marketing Expenses Table:



	1	2	3	4
1	$1,800	$2,100	$1,950	$2,050
2	$2,000	$2,200	$2,100	$2,000
3	$1,900	$2,050	$2,200	$2,100
4	$2,100	$2,300	$2,050	$2,250

Figure 7-3 Marketing Expenses Variable

Overhead Expenses:

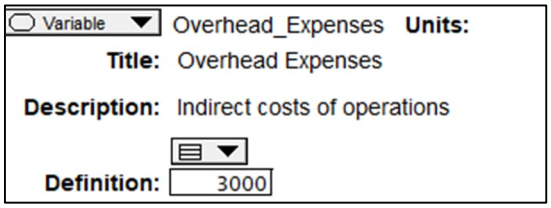


Figure 7-4 Overhead Expenses Variable

Interest Expenses:

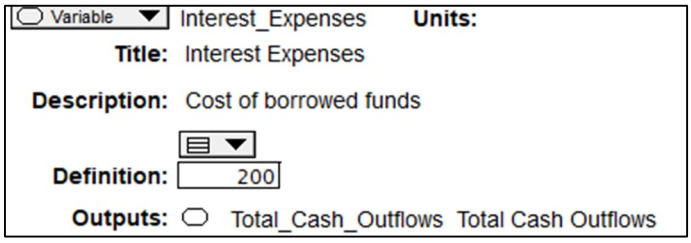
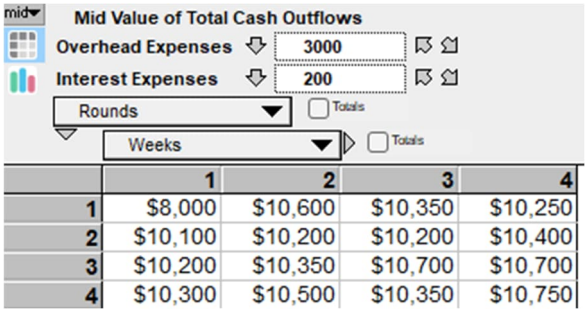


Figure 7-5 Interest Expenses Variable

Total Cash Outflows results:



	1	2	3	4
1	$8,000	$10,600	$10,350	$10,250
2	$10,100	$10,200	$10,200	$10,400
3	$10,200	$10,350	$10,700	$10,700
4	$10,300	$10,500	$10,350	$10,750

Figure 7-6 Total Cash Outflows Variable

Graph:

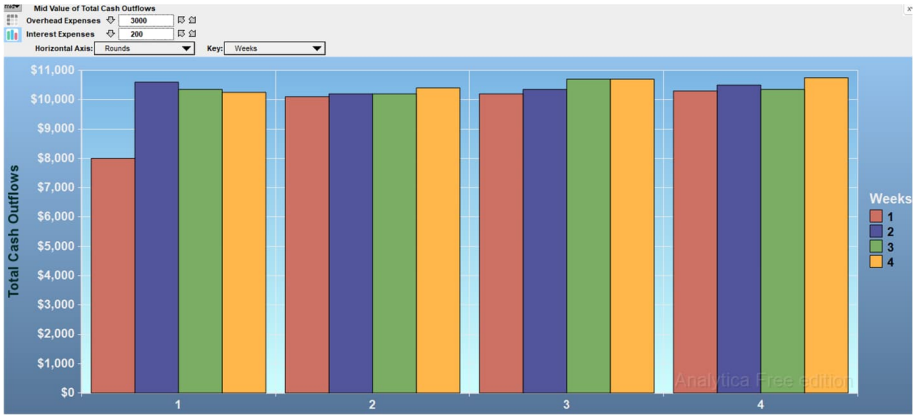


Figure 7-7 Graph of Total Cash Outflows

Users can click on the bars to view more information:

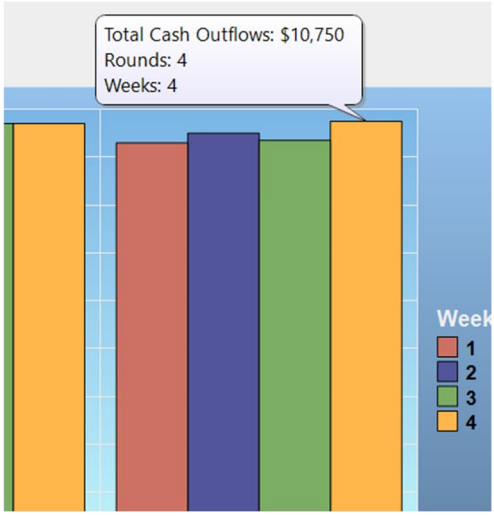
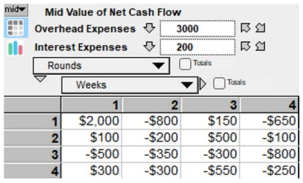


Figure 7-8 Total Cash Outflows in Details

Net Cash flow results:



	1	2	3	4
1	$2,000	-$800	$150	-$650
2	$100	-$200	$500	-$100
3	-$500	-$350	-$300	-$800
4	$300	-$300	-$550	-$250

Figure 7-9 Net Cash Flow Variable

Graph:

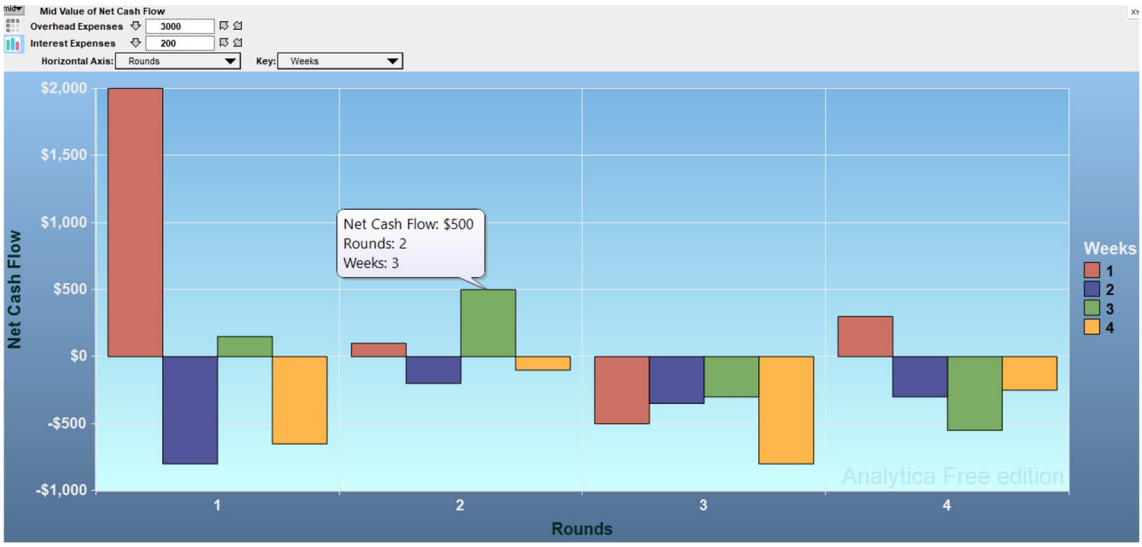


Figure 7-10 Graph of Net Cash Flow

7.4.2 D.2 Loan Repayment Model – Supporting Material

D.2.1 Analytica

Inputs:

Rounds to be played=4

Days/Round=20

Daily Initial Interest= 2644.8

Starting Loan=8,000,000

Manual input of loan Payment Amount:

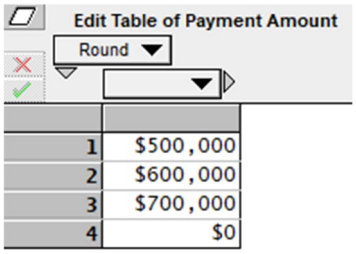


Figure 7-11 Manual input of loan Payment Amount

Calculations:

Total Days:

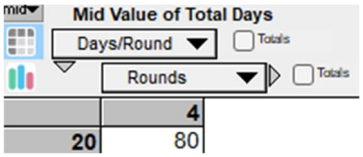


Figure 7-12 Total Days

Total Initial Interest:

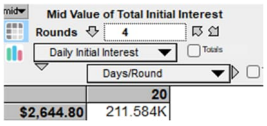


Figure 7-13 Total Initial Interest

Initial Interest Rate:

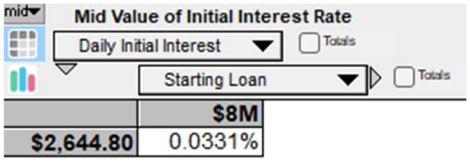


Figure 7-14 Initial Interest Rate

New Loan Balance per Round:

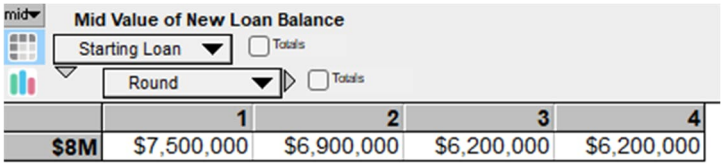


Figure 7-15 New Loan Balance per Round

Daily Interest Expense after payment:

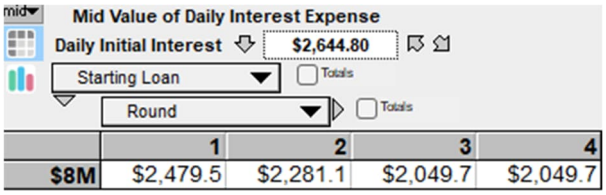


Figure 7-16 Daily Interest Expense after payment

Round Interest per Round:

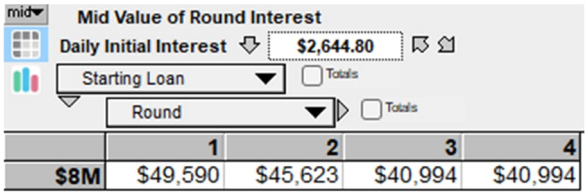


Figure 7-17 Round Interest per Round

Total Interest Paid:

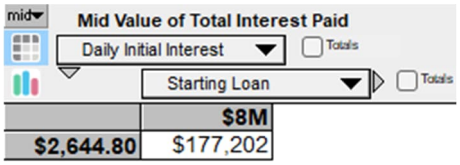


Figure 7-18 Total Interest Paid

Additional Net Income:

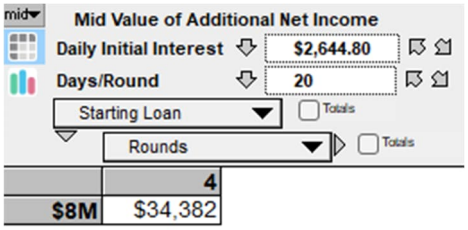


Figure 7-19 Additional Net Income

Annualized Net Income

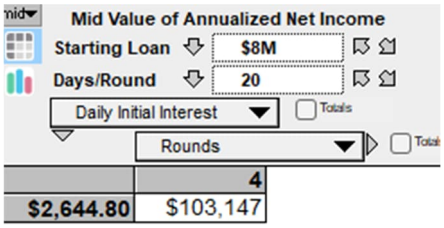


Figure 7-20 Annualized Net Income

Net Debt: Accounts Payable + New Loan Balance – Cash – Accounts Receivable

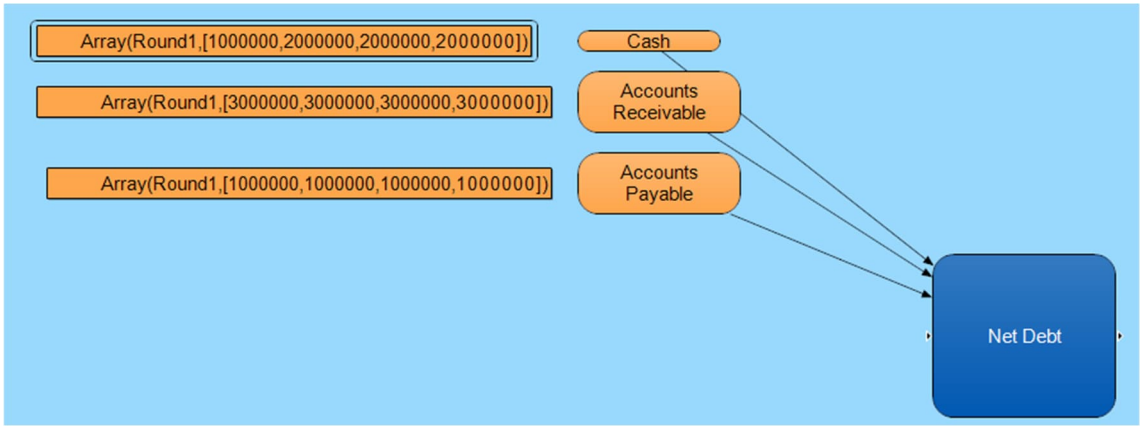


Figure 7-21 Net Debt: Accounts Payable + New Loan Balance – Cash – Accounts Receivable

Net Debt's Calculation per Round based on the above manual inputs:

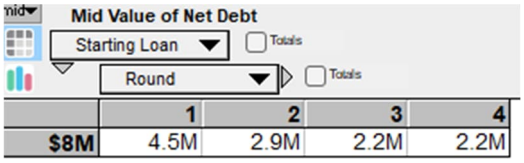


Figure 7-22 Net Debt's Calculation per Round based on the above manual inputs

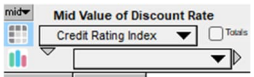
Applicable Interest Rate calculated based on the discount rate and the Net Debt:

Table 3.2: Credit Ratings, Interest and Risk Premiums

CREDIT RATINGS	NET DEBT FROM (≥)	TO (<)	INTEREST PREMIUM	RISK PREMIUM	INTEREST RATE
AAA+	∞	€1m	+1%	+3%	6%
AA+	€1m	€2m	+1.5%	+3.75%	6.5%
AA	€2m	€3m	+2%	+4%	7%
AA-	€3m	€4m	+2.25%	+4.25%	7.25%
A+	€4m	€5m	+2.75%	+4.75%	7.75%
A	€5m	€6m	+3%	+5%	8%
A-	€6m	€7m	+3.25%	+5.25%	8.25%
BBB+	€7m	€8m	+3.75%	+5.75%	8.75%
BBB	€8m	€9m	+4%	+6%	9%
BBB-	€9m	€10m	+4.25%	+6.25%	9.25%
BB+	€10m	€11m	+4.75%	+6.75%	9.75%
BB	€11m	€12m	+5%	+7%	10%
BB-	€12m	€13m	+5.25%	+7.25%	10.25%
B+	€13m	€14m	+5.75%	+7.75%	10.75%
B	€14m	€15m	+6%	+8%	11%
B-	€15m	€16m	+6.25%	+8.25%	11.25%
CCC+	€16m	€17m	+6.75%	+9%	11.75%
CCC	€17m	€18m	+7%	+10%	12%
CCC-	€18m	€19m	+7.25%	+11%	12.25%
CC	€19m	€20m	+8%	+12%	13%
C	€20m	∞	+9%	+15%	14%

Figure 7-23 Interest Rate calculated based on the discount rate and the Net Debt, screenshot from Participants Guide

Discount Rate based on Credit Rating:



AAA+	0.1
AA+	0.1175
AA	0.13
AA-	0.14
A+	0.1525
A	0.16
A-	0.1675
BBB+	0.1825
BBB	0.19
BBB-	0.1975
BB+	0.2125
BB	0.22
BB-	0.2275
B+	0.2425
B	0.25
B-	0.2575
CCC+	0.275
CCC	0.29
CCC-	0.305
CC	0.33
C	0.38

Figure 7-24 Discount Rate based on Credit Rating

Applicable Interest Rate:

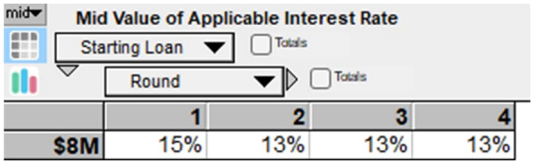


Figure 7-25 Applicable Interest Rate

Table 12

Aspect	Scenario 1 – Conservative	Scenario 2 – Balanced	Scenario 3 – Aggressive
Payment Pattern	500k,600k,700k,0	$1M, $1.4M, $1.6M, $2M	$2M × 4
Total Repaid	$2M	$6M	$8M (fully repaid)
Loan Reduction Speed	Very slow	Moderate	Very fast
Remaining Loan in Round 4	$6M	$2M	$0
Interest Expense	Highest	Moderate	Lowest
Additional Net Income	Low	Medium	High
Net Debt Improvement	Minimal	Noticeable	Significant
Applicable Interest Rate	High (due to high net debt)	Medium	Lowest (due to low net debt)
Company Valuation Impact	Low	Improved	Highest
Liquidity Required	Low	Moderate	High
Use Case	When cash is tight	Balanced approach	When aiming to maximize valuation

The model shows a **clear trade-off**:

- More aggressive repayment requires greater liquidity but results in **better profitability and company valuation**.
- Conservative strategies protect cash but result in **higher financing costs**.

7.4.3 D.3 Company Valuation Model – Supporting Material

D.3.1 Analytica

Model Outputs

Revenue:

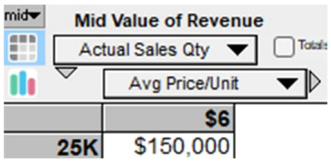


Figure 7-26 Revenue

Cogs:

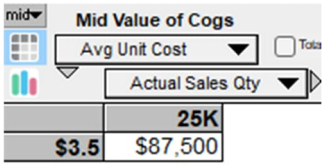


Figure 7-27CoGS

Cumulative Net Income:

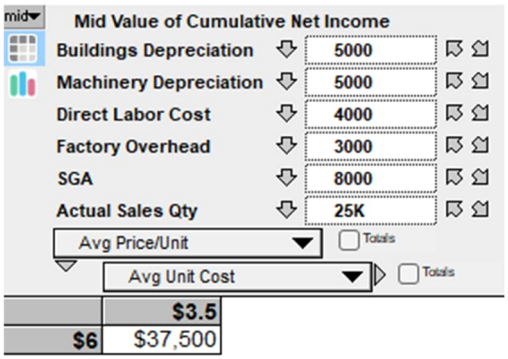


Figure 7-28 Cumulative Net Income

Annual Profit:

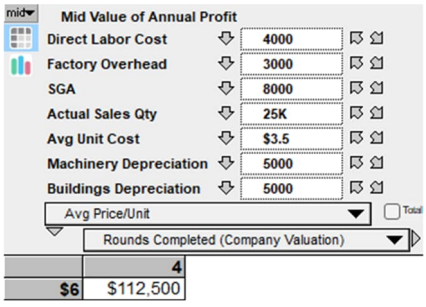


Figure 7-29 Annual Profit

7.4.4 D.4 Production Improvement Model – Supporting Material

D.4.1 Analytica

Low Investment Scenario:

Capacity in H per Day:

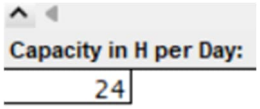


Figure 7-30 Capacity in H per Day

Days per Round:

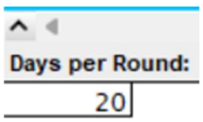


Figure 7-31 Days per Round

Total Days:

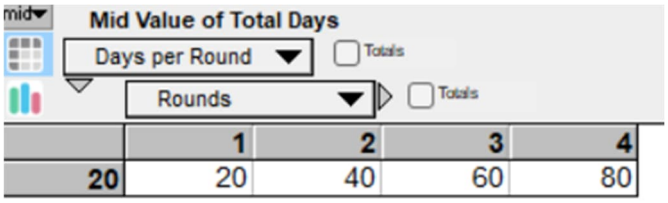


Figure 7-32 Total Days

Total Daily Cost:

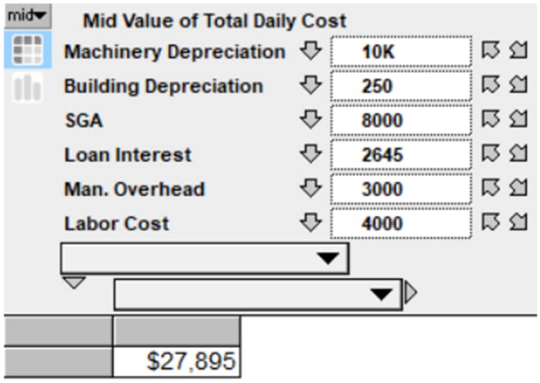


Figure 7-33 Total Daily Cost

Initial Capacity:

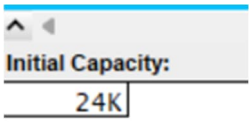


Figure 7-34 Initial Capacity

Initial Productivity:

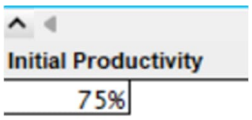


Figure 7-35 Initial Productivity

Initial Allocation Basis:

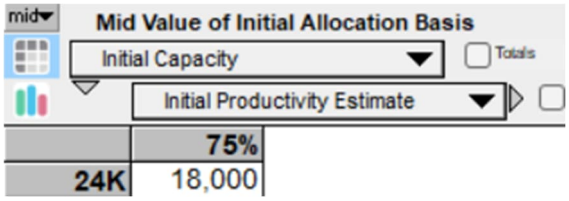


Figure 7-36 Initial Allocation Basis

Average Production Run:

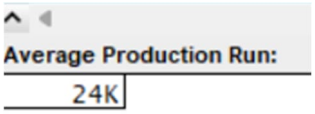


Figure 7-37 Average Production Run

7.5 Appendix E: Alternative Scenarios (Optimistic & Pessimistic)

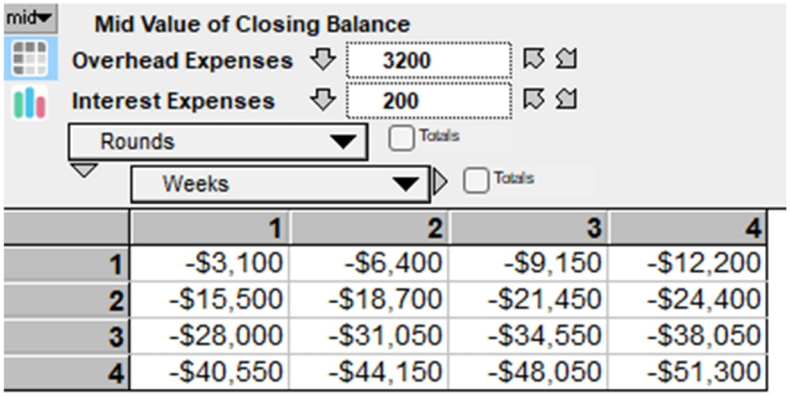
7.5.1 E.1: Liquidity Planning Model – Alternative Scenarios

E.1.1 Pessimistic Case Inputs

Table 13

Round	Week	Receivables	Payables	Marketing	Overhead + Interest	Interst Expenses	Closing Balance
1	1	8,000	5,500	2,200	3,200	200	-3,100
	2	7,800	5,400	2,300	3,200	200	-6,400
	3	8,500	5,600	2,250	3,200	200	-9,150
	4	7,900	5,200	2,350	3,200	200	-12,200
2	1	8,200	5,700	2,400	3,200	200	-15,500
	2	8,000	5,300	2,500	3,200	200	-18,700
	3	8,700	5,600	2,450	3,200	200	-21,450
	4	8,300	5,500	2,350	3,200	200	-24,400
3	1	7,700	5,800	2,100	3,200	200	-28,000
	2	8,000	5,400	2,250	3,200	200	-31,050
	3	8,400	5,900	2,600	3,200	200	-34,550
	4	7,900	5,500	2,500	3,200	200	-38,050
4	1	8,600	5,300	2,400	3,200	200	-40,550
	2	8,200	5,700	2,700	3,200	200	-44,150
	3	7,800	6,000	2,300	3,200	200	-48,050
	4	8,500	5,800	2,550	3,200	200	-51,300

Closing Balance results:



	1	2	3	4
1	-$3,100	-$6,400	-$9,150	-$12,200
2	-$15,500	-$18,700	-$21,450	-$24,400
3	-$28,000	-$31,050	-$34,550	-$38,050
4	-$40,550	-$44,150	-$48,050	-$51,300

Figure 7-38 Pessimistic Scenario - Closing Balance Variable

Graph:

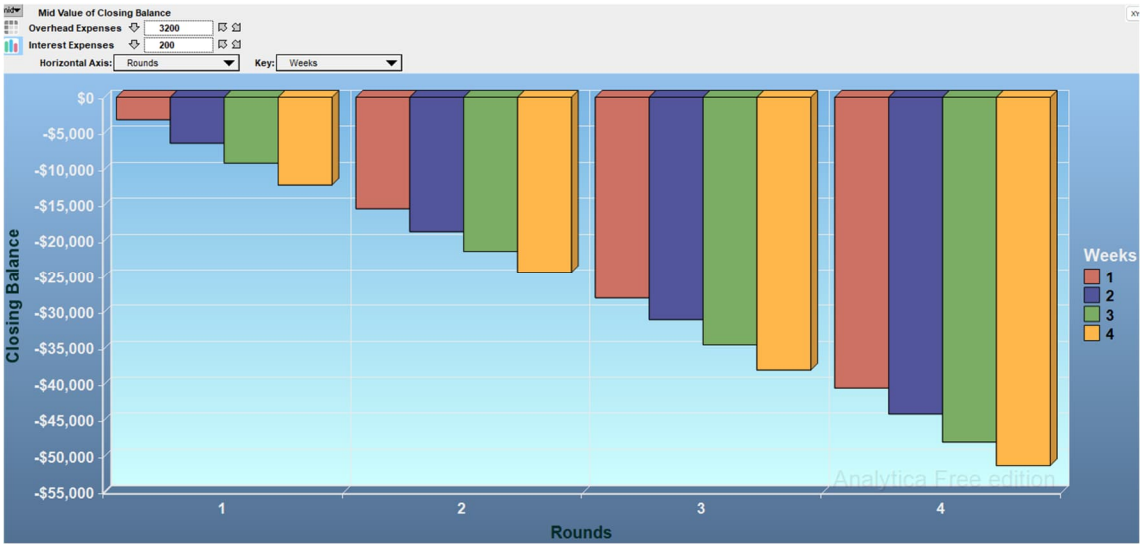


Figure 7-39 Pessimistic Scenario - Graph of Closing Balance

E.1.2 Optimistic Case Inputs

Table 14

Round	Week	Receivables	Payables	Marketing	Overhead + Interest	Interst Expenses	Closing Balance
1	1	12,000	4,900	1,600	3,000	150	2,350
	2	11,800	4,700	1,700	3,000	150	4,600
	3	12,500	4,800	1,650	3,000	150	7,500
	4	11,900	4,600	1,750	3,000	150	9,900
2	1	12,200	4,950	1,600	3,000	150	12,400
	2	12,000	4,600	1,850	3,000	150	14,800
	3	12,700	4,750	1,700	3,000	150	17,900
	4	12,300	4,700	1,600	3,000	150	20,750
3	1	11,700	4,900	1,500	3,000	150	22,900
	2	12,000	4,700	1,650	3,000	150	25,400
	3	12,400	5,000	1,800	3,000	150	27,850
	4	11,900	4,800	1,700	3,000	150	30,100
4	1	12,600	4,650	1,650	3,000	150	33,250
	2	12,200	4,900	1,900	3,000	150	35,500
	3	11,800	5,000	1,600	3,000	150	37,550
	4	12,500	4,950	1,750	3,000	150	40,200

Closing Balance results:

mid

Mid Value of Closing Balance

Overhead Expenses 3000

Interest Expenses 150

Rounds Totals

Weeks Totals

	1	2	3	4
1	$2,350	$4,600	$7,500	$9,900
2	$12,400	$14,800	$17,900	$20,750
3	$22,900	$25,400	$27,850	$30,100
4	$33,250	$35,500	$37,550	$40,200

Figure 7-40 Optimistic Scenario - Closing Balance Variable

Graph:

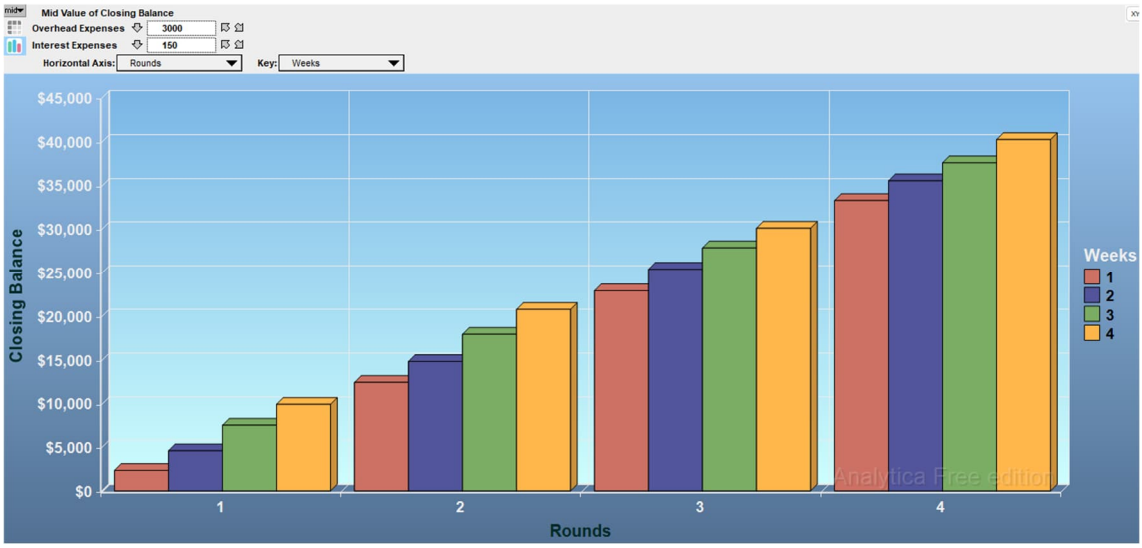


Figure 7-41 Optimistic Scenario - Graph of Closing Balance

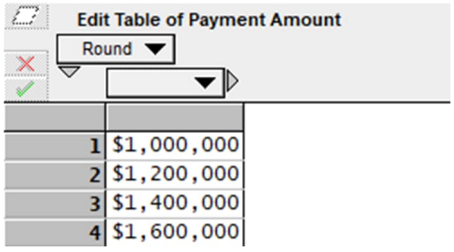
The **Pessimistic scenario** simulated reduced revenues or increased expenses, resulting in periodic cash shortages and the need for corrective actions. Conversely, the **Optimistic scenario** demonstrated a healthier cash flow, with higher end-of-period balances that could be reinvested or used for loan repayment. These outputs allowed visual monitoring of liquidity resilience under varying financial conditions. The clear distinction between scenarios supported the identification of periods requiring strategic adjustments in production or financial management.

7.5.2 E.2: Loan Repayment Model – Alternative Scenarios

E.2.1: Scenario 2 – Balanced Repayment

In this scenario, a moderate and balanced repayment approach was applied with payment amounts increasing steadily across rounds. The following repayment schedule was used:

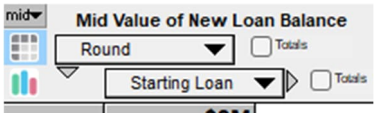
Manual input of loan Payment Amount:



1	$1,000,000
2	$1,200,000
3	$1,400,000
4	$1,600,000

Figure 7-42 Manual input of loan Payment Amount

New Loan Balance per Round:



	$8M
1	$7,000,000
2	$5,800,000
3	$4,400,000
4	$2,800,000

Figure 7-43 New Loan Balance per Round

Graph:

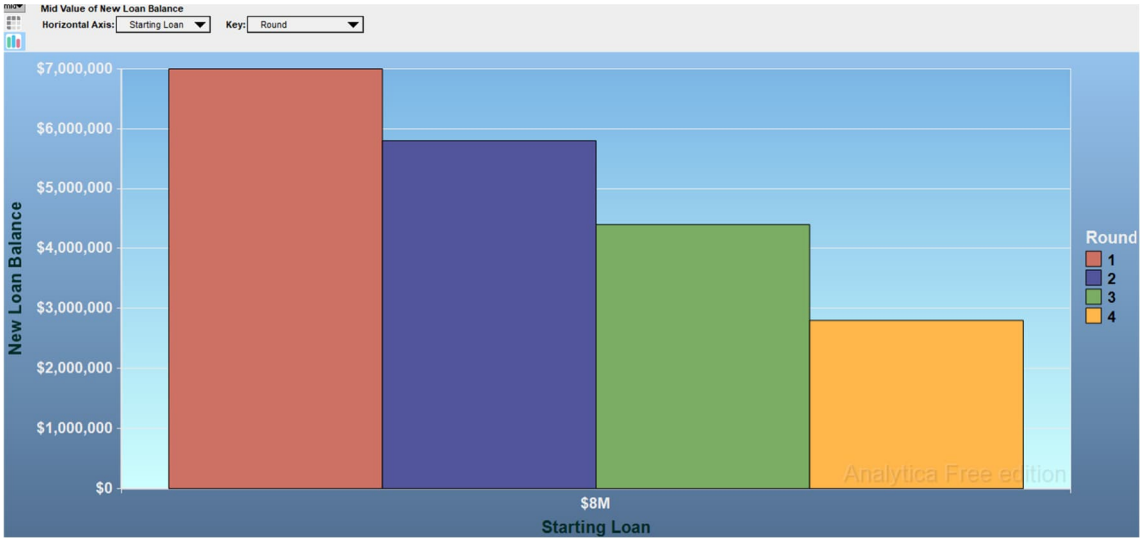


Figure 7-44Graph of New Loan Balance

Daily Interest Expense after payment:

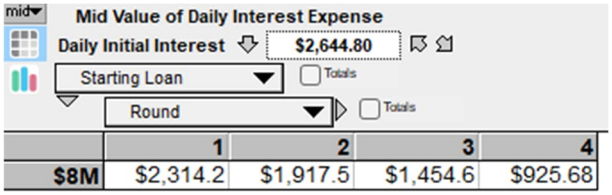


Figure 7-45 Daily Interest Expense after payment

Round Interest per Round:

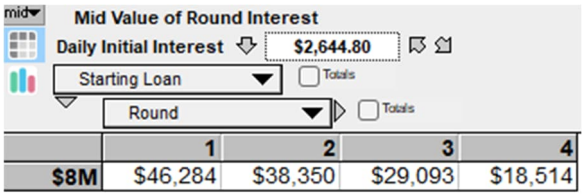


Figure 7-46 Round Interest per Round

Total Interest Paid:

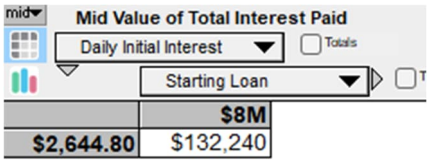


Figure 7-47 Total Interest Paid

Net Debt:

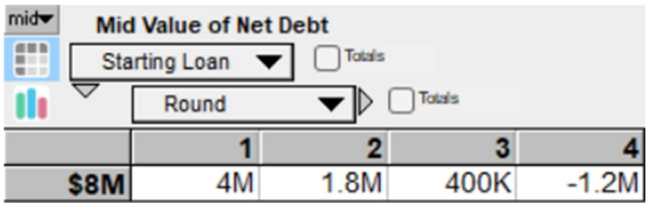


Figure 7-48 Net Debt

Applicable Interest Rate:

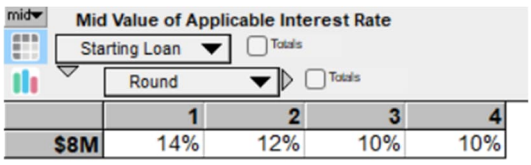


Figure 7-49 Applicable Interest Rate

Additional Net Income:

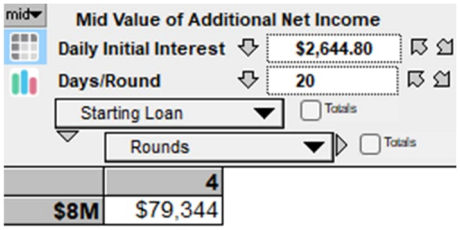


Figure 7-50 Additional Net Income

Annualized Net Income

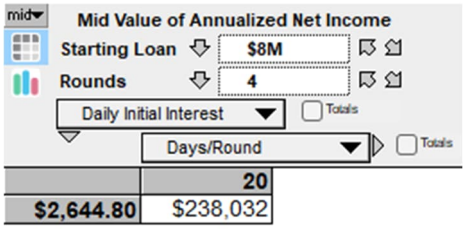


Figure 7-51 Annualized Net Income

Company Valuation:

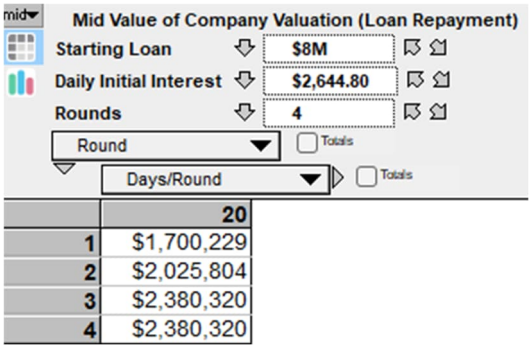


Figure 7-52 Company Valuation

Observations:

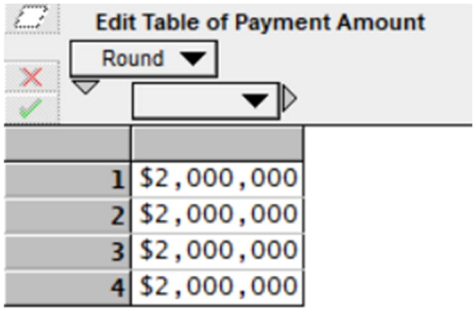
1. Round Interest was slightly decreased per round and dropped from 2,644.8 € To 925.68
2. Total Interest paid at the end of tha game was decreased from 211,584 € to 132,240 €
3. The additional Net Income from Loan repayment is 211,584-132,240 = 79,344 €
4. Company Valuation increased by $2,380,320€

Applicable interest rate is affected by the loan repayment amount and it is decreased when new loan balance is reduced.

E.2.2: Scenario 3 – Aggressive Repayment

In this scenario, an aggressive loan repayment strategy was tested by distributing equal and significant payments across all four rounds, fully repaying the $8 million loan by the end of the simulation period.

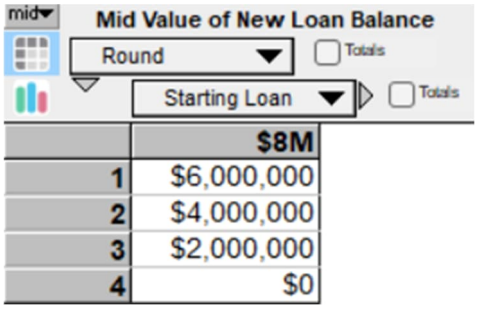
Manual input of loan Payment Amount:



1	$2,000,000
2	$2,000,000
3	$2,000,000
4	$2,000,000

Figure 7-53 Manual input of loan Payment Amount

New Loan Balance per Round:



	$8M
1	$6,000,000
2	$4,000,000
3	$2,000,000
4	$0

Figure 7-54 New Loan Balance per Round

Graph:

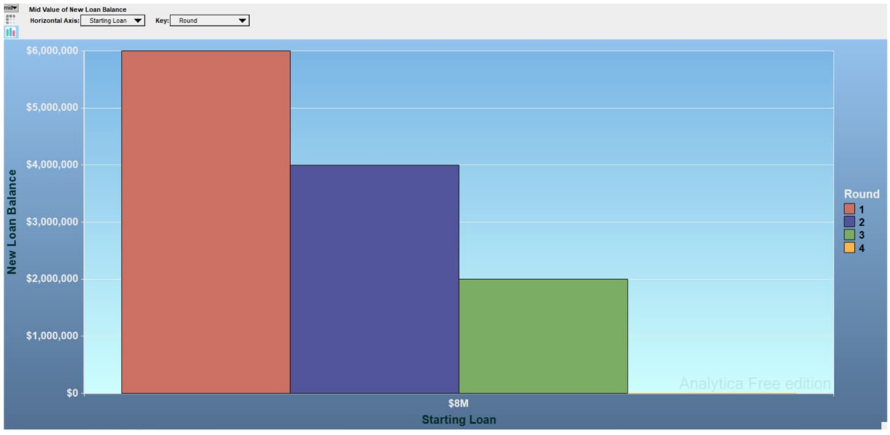


Figure 7-55 Graph of New Loan Balance

Daily Interest Expense after payment:

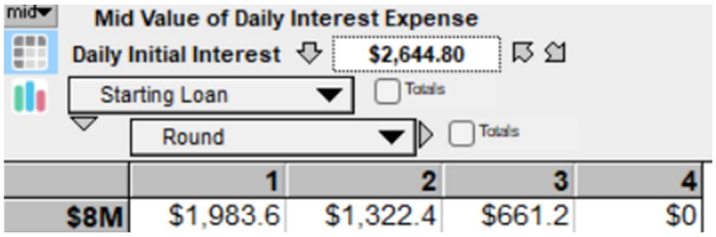


Figure 7-56 Daily Interest Expense after payment

Round Interest per Round:

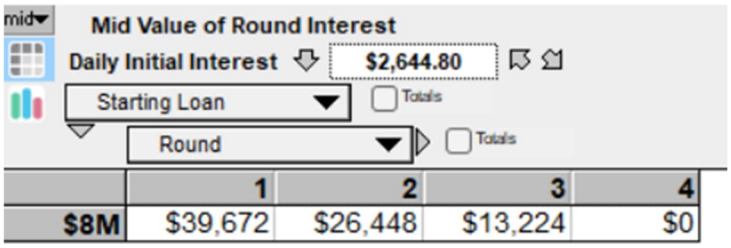


Figure 7-57 Round Interest per Round

Total Interest Paid:

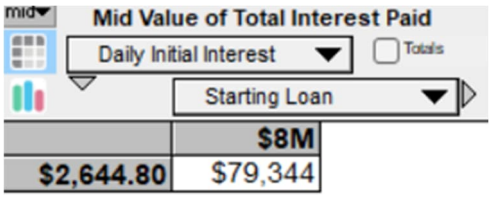


Figure 7-58 Total Interest Paid

Net Debt: A negative value signifies a financial surplus.

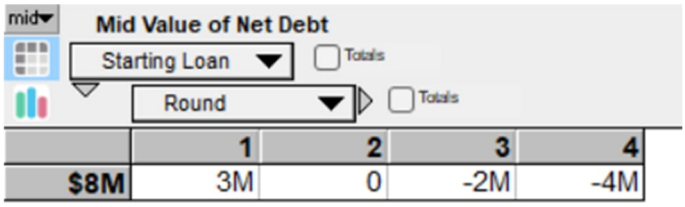
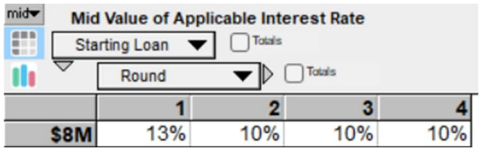


Figure 7-59 Net Debt: A negative value signifies a financial surplus.

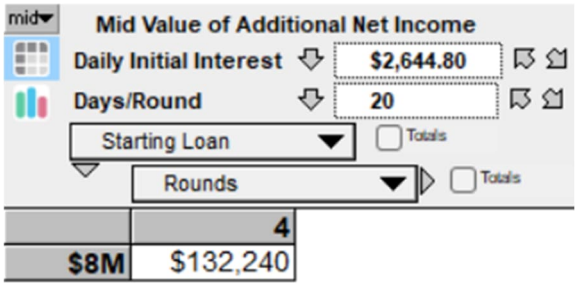
Applicable Interest Rate:



	1	2	3	4
$8M	13%	10%	10%	10%

Figure 7-60 Applicable Interest Rate

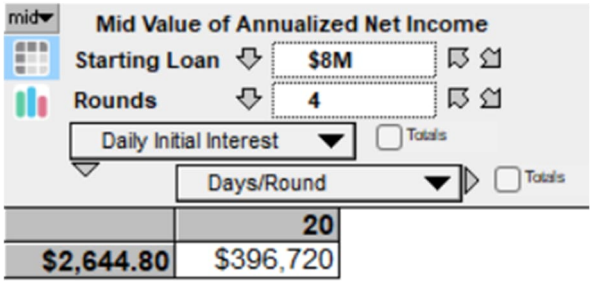
Additional Net Income:



	4
$8M	$132,240

Figure 7-61 Additional Net Income

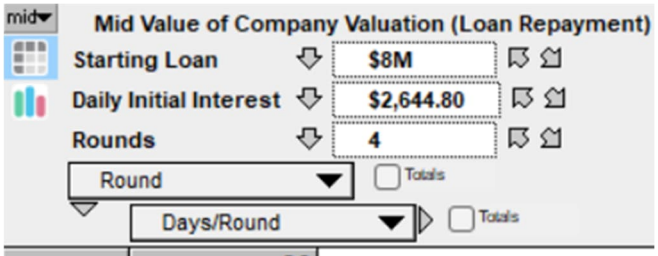
Annualized Net Income



	20
$2,644.80	$396,720

Figure 7-62 Annualized Net Income

Company Valuation:



	20
1	$3,051,692
2	$3,967,200
3	$3,967,200
4	$3,967,200

Figure 7-63 Company Valuation

Observations:

1. New Loan Balance: The loan decreased by $2M each round, reaching zero by Round 4. The model correctly recalculated balances and used them to update interest costs.
2. Round Interest was significantly decreased per round and dropped from 2,644.8 € to 0€
3. Total Interest paid at the end of tha game was decreased from 211,584 € to 0 €
4. The additional Net Income from Loan repayment is 211,584-132,240 = 79,344 €
5. Company Valuation increased by 3,967,200 €
6. Applicable interest rate is affected by the loan repayment amount and it is decreased to the lowest possible interest rate ultimately increasing **company valuation**

7.5.3 E.3: Company Valuation Model – Alternative Scenarios

E.3.1: Company Valuation of scenario 2

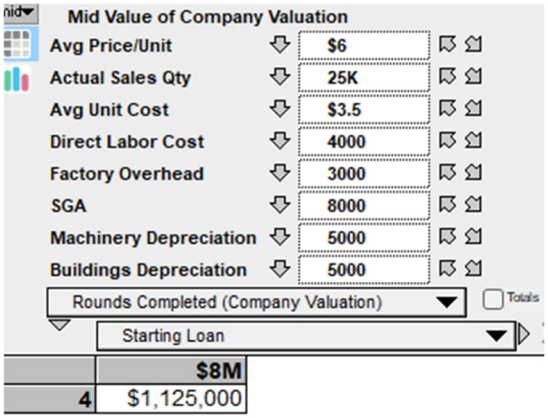


Figure 7-64 Company Valuation

E.3.2: Company Valuation of scenario 3

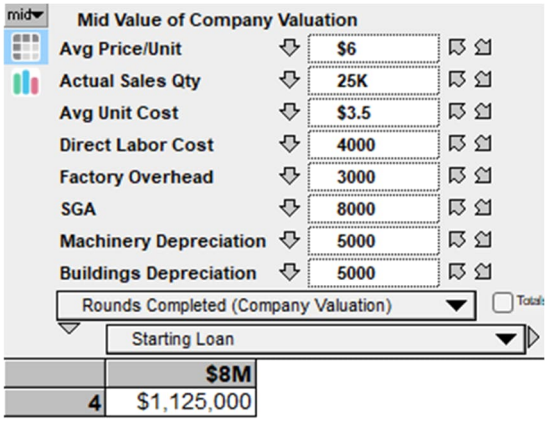


Figure 7-65 Company Valuation

7.5.4 E.4: Production Improvement Model – Alternative Scenarios

Moderate Investment Scenario:

Capacity Investment:

Edit Table of Capacity Investment

Rounds

1	$1,500,000
2	$500,000
3	$2,000,000
4	$0

Figure 7-66 Capacity Investment

Setup Time Investment:

Edit Table of Setup Time Investment

Rounds

1	$50,000
2	$0
3	$75,000
4	$125,000

Figure 7-67 Setup Time Investment

Productivity Estimate:

mid

Mid Value of Productivity Estimate

Capacity in H per Day 24

Average Production Run 24K

Rounds Totals

Days per Round Totals

	20			
	Setup Time (H)	Total Cum Capacity Investement	Total Cum Investment	Productivity Estimate
1	7	$1,500,000	50,000	76.34%
2	7	$2,000,000	50,000	75.99%
3	6	$4,000,000	125,000	77.42%
4	5	$4,000,000	250,000	80.45%

Figure 7-68 Productivity Estimate

Graph: Showing productivity gains per round as setup time improves

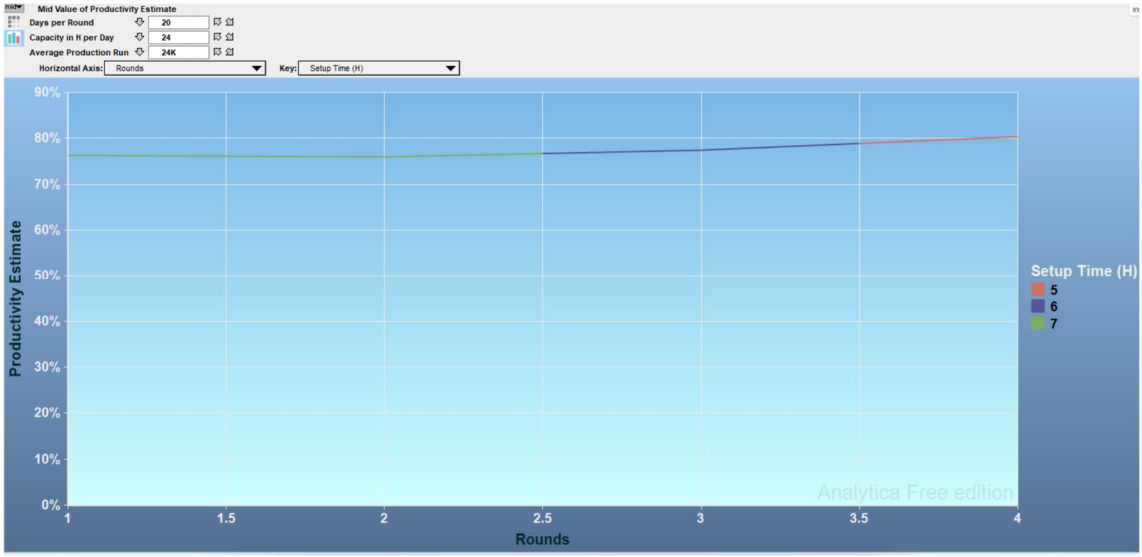


Figure 7-69 Graph: Showing productivity gains per round as setup time improves

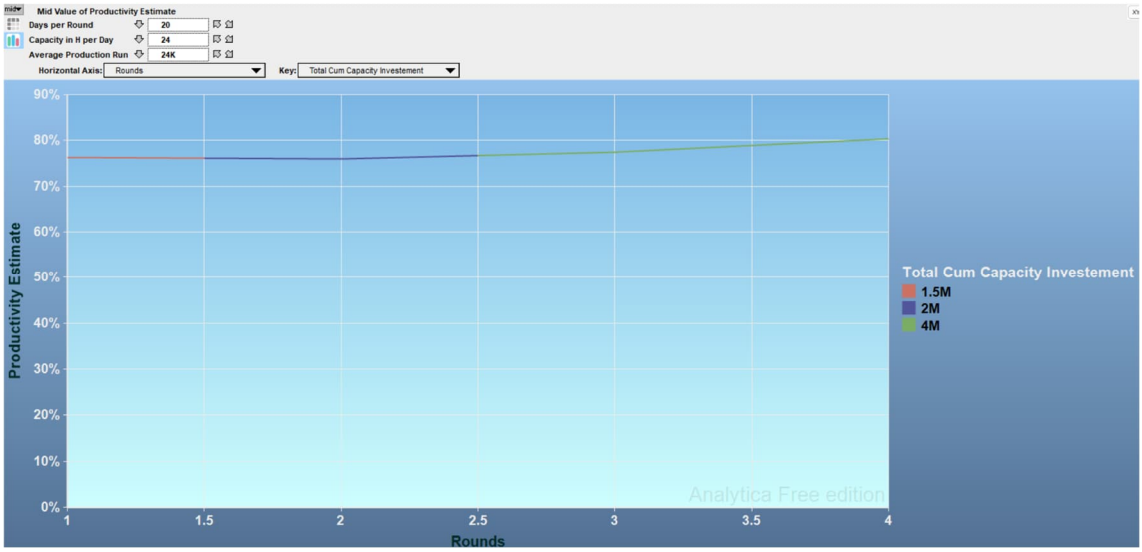


Figure 7-70 Graph: Showing productivity gains per round as capacity improves

Capacity:

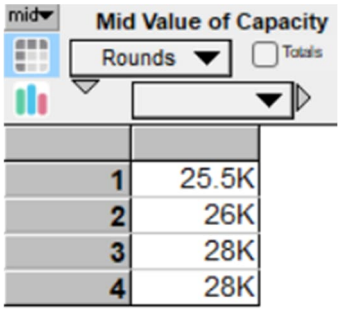


Figure 7-71 Capacity

Setup Time (H):

mid

Mid Value of Setup Time (H)

Rounds Totals

1	7
2	7
3	6
4	5

Figure 7-72 Setup Time (H)

Allocation Basis:

mid

Mid Value of Allocation Basis

Capacity in H per Day 24

Average Production Run 24K

Rounds Totals

Days per Round Totals

	20
1	19,467
2	19,757
3	21,677
4	22,525

Figure 7-73 Allocation Basis

Total Capacity:

mid

Mid Value of Total Capacity

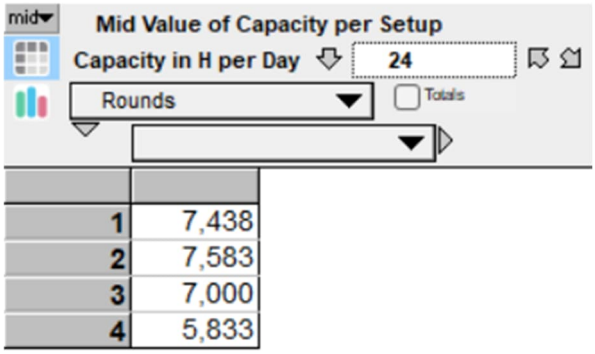
Rounds Totals

Days per Round Totals

	20
1	510,000
2	1,040,000
3	1,680,000
4	2,240,000

Figure 7-74 Total Capacity

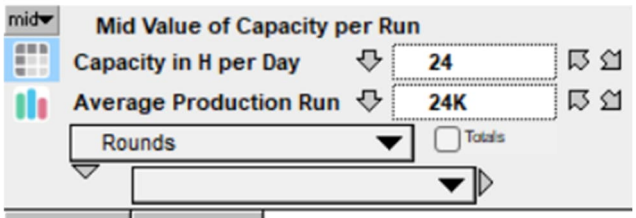
Capacity Per Setup:



1	7,438
2	7,583
3	7,000
4	5,833

Figure 7-75 Capacity Per Setup

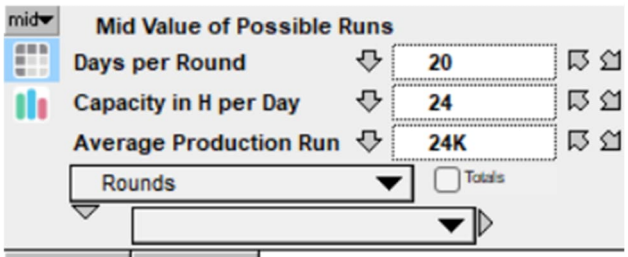
Capacity per Run:



1	31,438
2	31,583
3	31,000
4	29,833

Figure 7-76 Capacity per Run

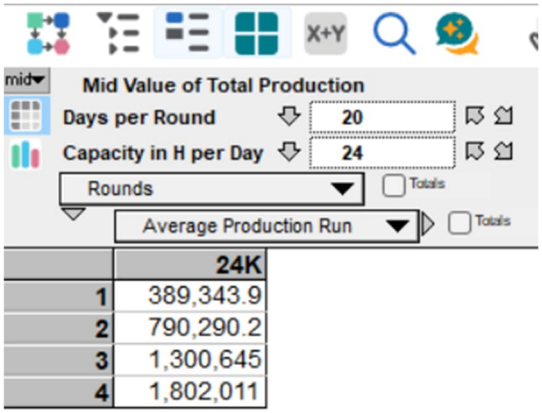
Possible Runs:



1	16.22
2	32.93
3	54.19
4	75.08

Figure 7-77 Possible Runs

Total Production:



	24K
1	389,343.9
2	790,290.2
3	1,300,645
4	1,802,011

Figure 7-78 Total Production

Graph:

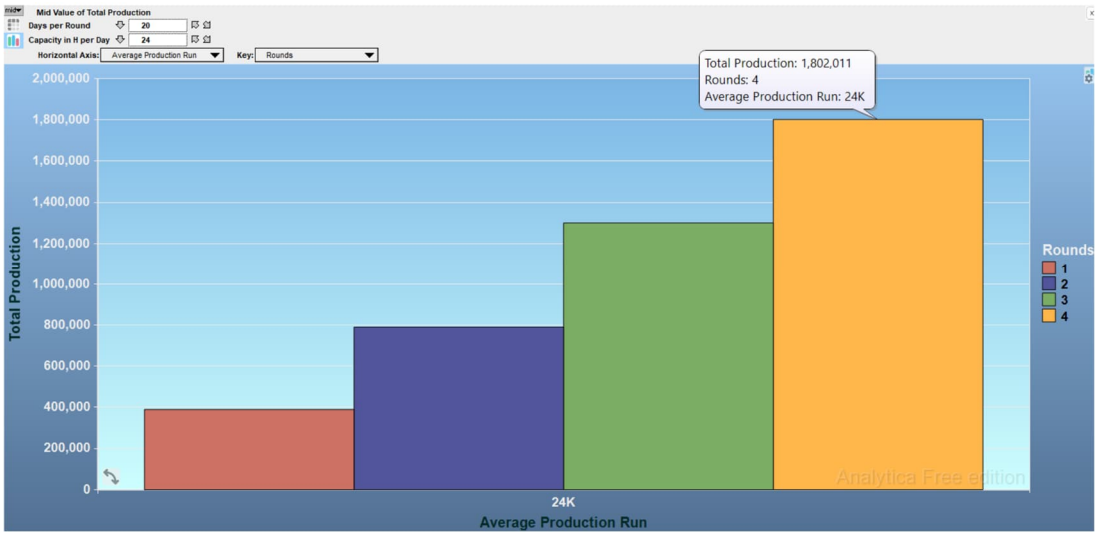
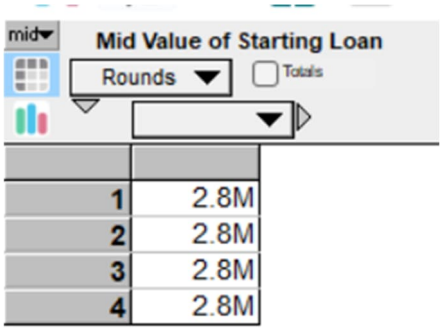


Figure 7-79 Graph of Avg Production Run

Starting Loan:



1	2.8M
2	2.8M
3	2.8M
4	2.8M

Figure 7-80 Starting Loan

Target Unit Profit:

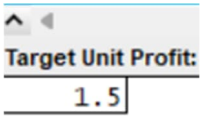
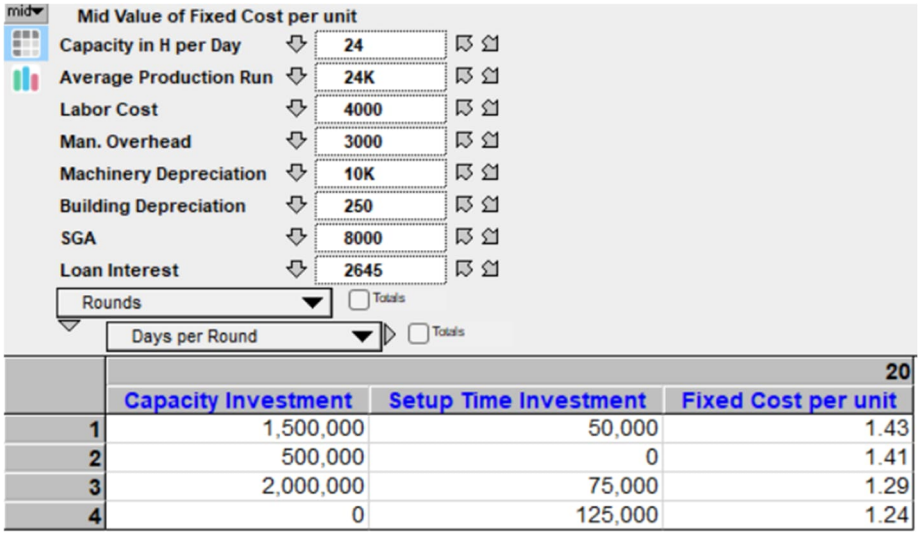


Figure 7-81 Target Unit Profit

Fixed Cost per unit:



	20		
	Capacity Investment	Setup Time Investment	Fixed Cost per unit
1	1,500,000	50,000	1.43
2	500,000	0	1.41
3	2,000,000	75,000	1.29
4	0	125,000	1.24

Figure 7-82 Fixed Cost per unit

Graph: Fixed Cost per Unit Reduction as Capacity & Setup Time Investment Increases

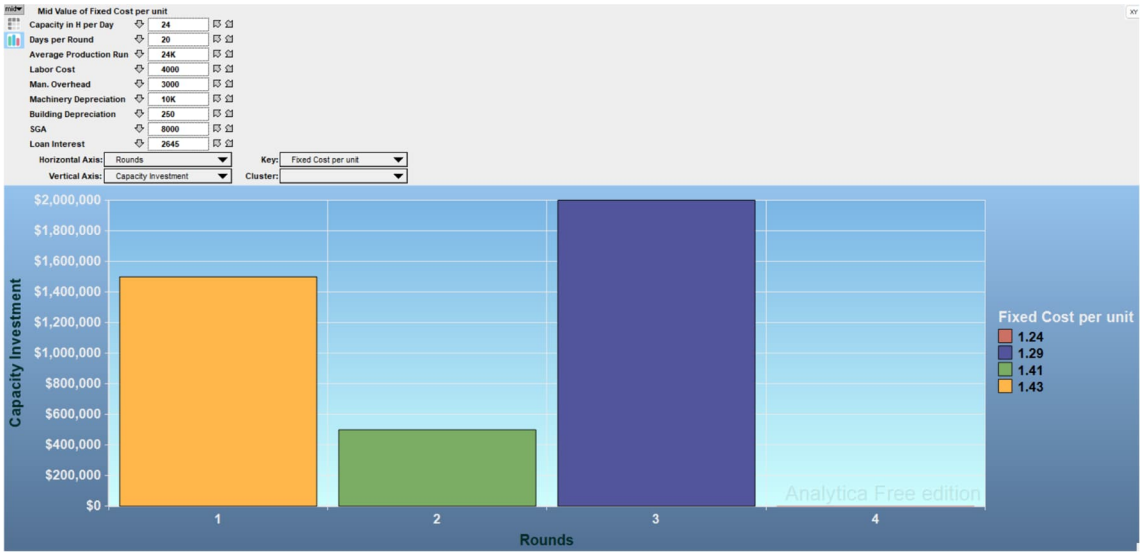


Figure 7-83 Graph: Fixed Cost per Unit Reduction as Capacity Investment Increases

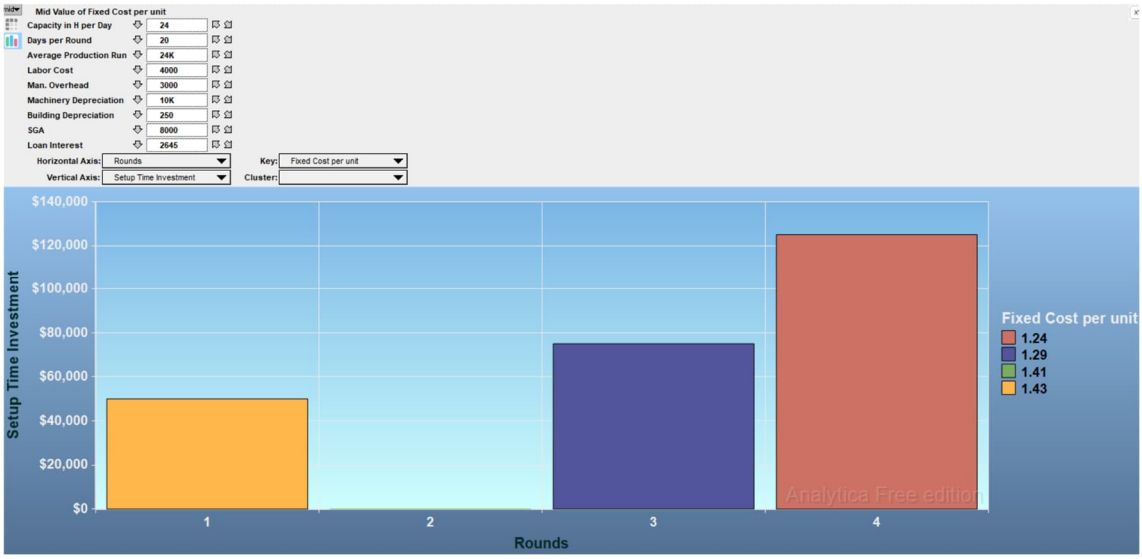


Figure 7-84 Graph: Fixed Cost per Unit Reduction as Setup Time Investment Increases

Running Profit:

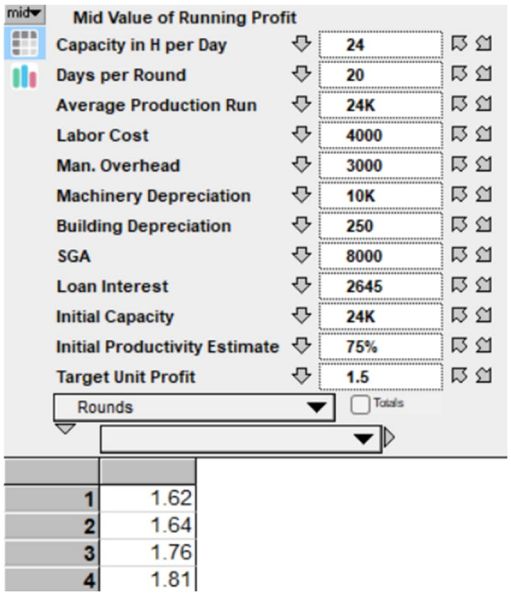
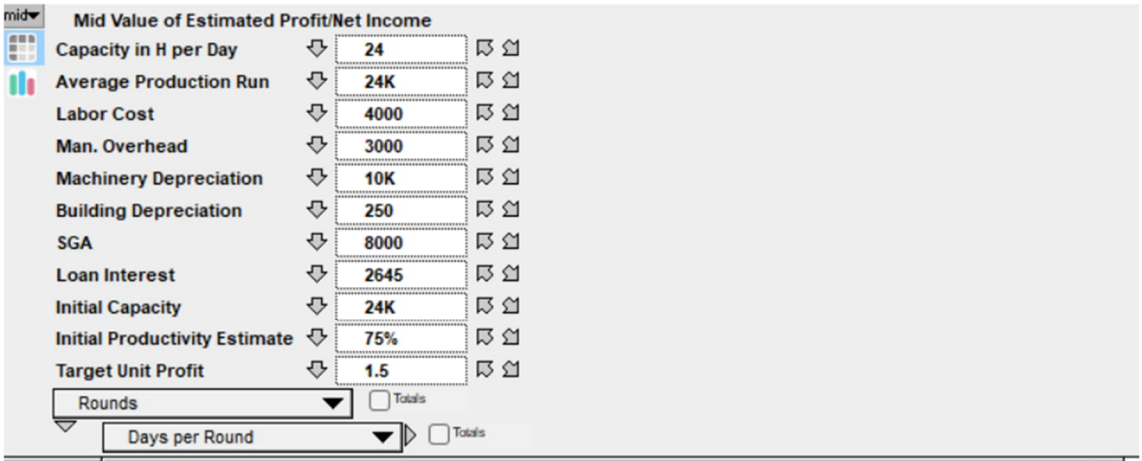


Figure 7-85 Running Profit

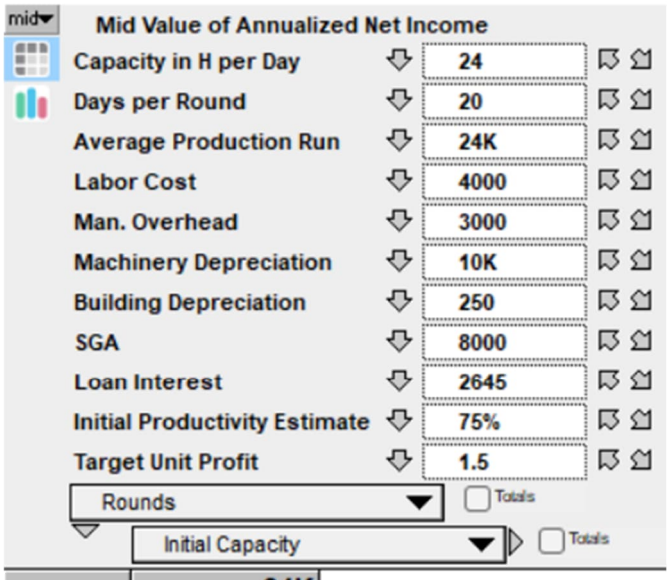
Estimated Profit/Net Income:



	20		
	Total Cum Capacity Investement	Total Cum Investment	Estimated Profit/Net Income
1	$1,500,000	$50,000	$579,491
2	$2,000,000	$50,000	$1,244,370
3	$4,000,000	$125,000	$2,167,910
4	$4,000,000	$250,000	$3,014,033.5

Figure 7-86 Estimated Profit/Net Income

Annualized Net Income:



	24K
1	$7,503,890
2	$7,716,194
3	$9,046,626
4	$9,542,101

Figure 7-87 Annualized Net Income

Graph: Tracking cumulative investment and resulting profitability

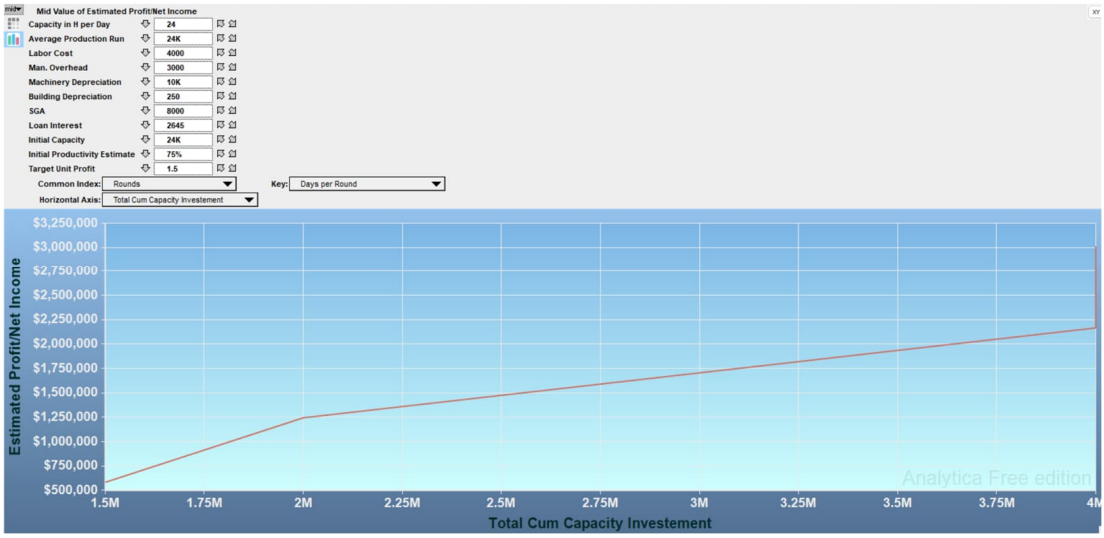


Figure 7-88 Graph: Tracking cumulative capacity investment and resulting profitability

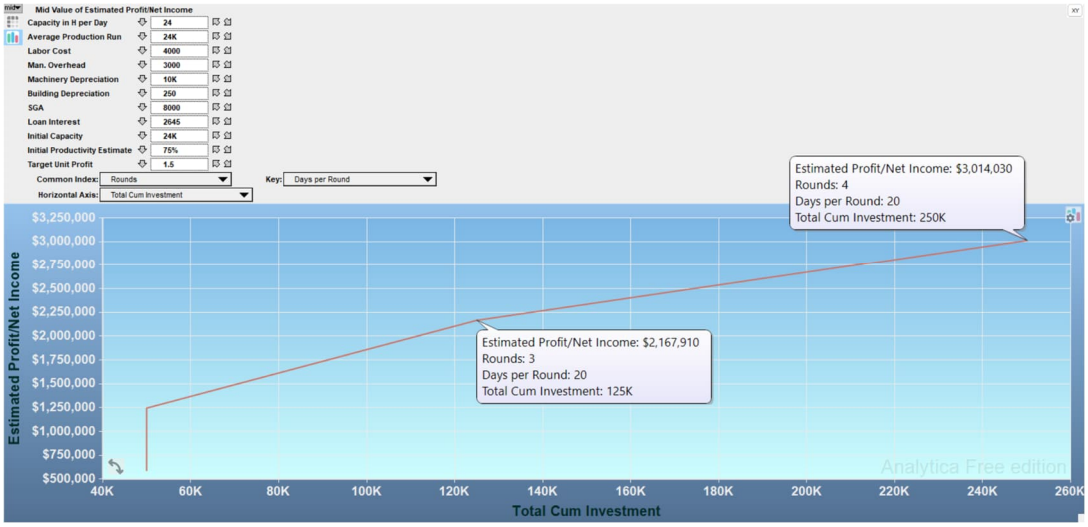


Figure 7-89 Graph: Tracking cumulative investment and resulting profitability

Net Debt:

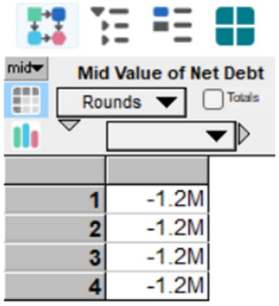
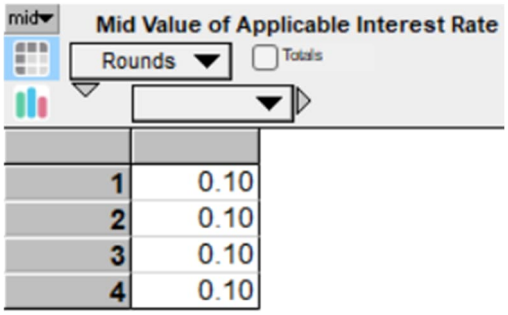


Figure 7-90 Net Debt

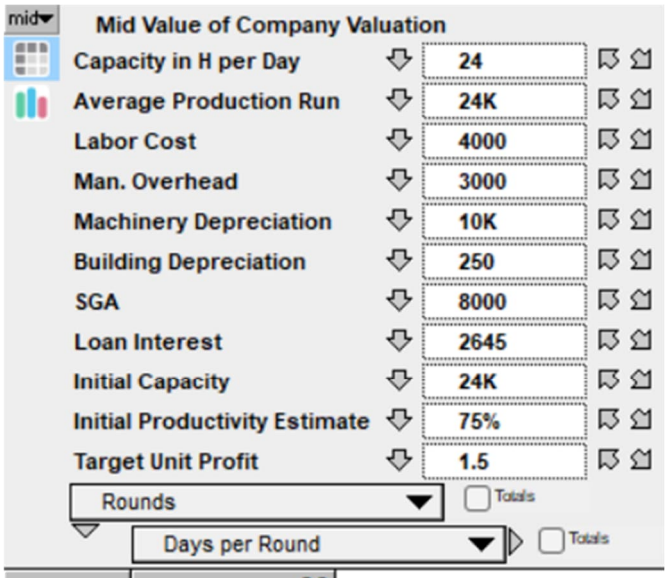
Applicable Interest Rate:



1	0.10
2	0.10
3	0.10
4	0.10

Figure 7-91 Applicable Interest Rate

Company Valuation:



	20
1	$75,038,903
2	$77,161,942
3	$90,466,258
4	$95,421,006

Figure 7-92 Company Valuation

Graph:

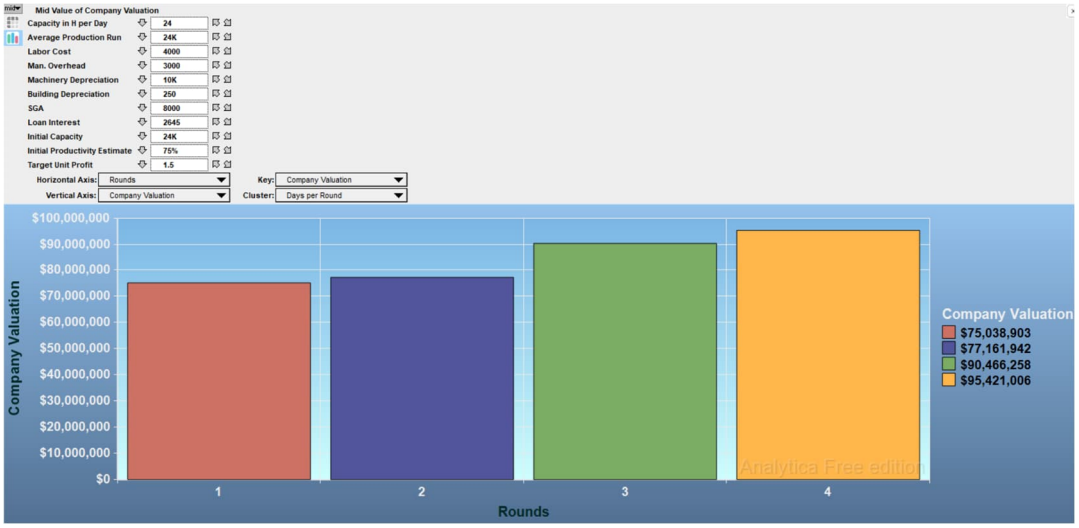


Figure 7-93 Graph of Company Valuation

High Investment Scenario:

Capacity Investment:

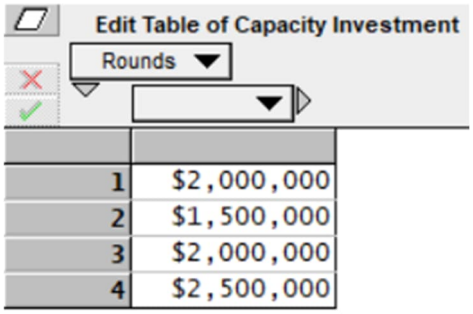


Figure 7-94 Capacity Investment

Setup Time Investment:

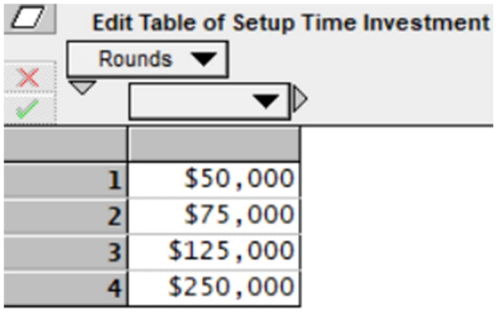


Figure 7-95 Setup Time Investment

Productivity Estimate:

Mid Value of Productivity Estimate

Capacity in H per Day: 24

Average Production Run: 24K

Rounds | Totals

Days per Round | Totals

	Setup Time (H)	Total Cum Capacity Investement	Total Cum Investment	Productivity Estimate
				20
1	7	$2,000,000	50,000	75.99%
2	6	$3,500,000	125,000	77.73%
3	5	$5,500,000	250,000	79.61%
4	4	$8,000,000	500,000	81.82%

Figure 7-96 Productivity Estimate

Graph: Showing productivity gains per round as setup time improves

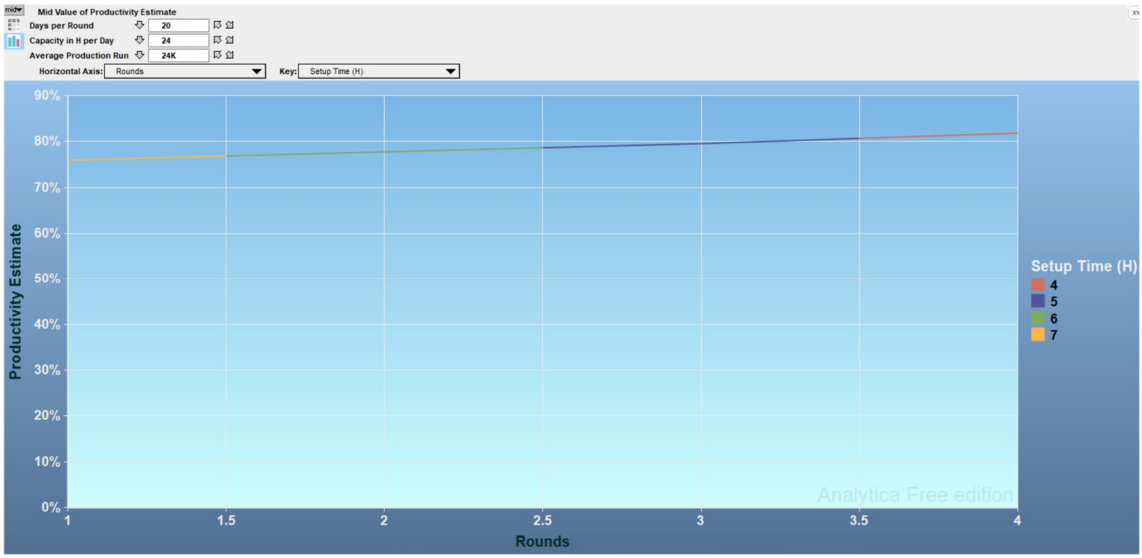


Figure 7-97 Graph: Showing productivity gains per round as setup time improves

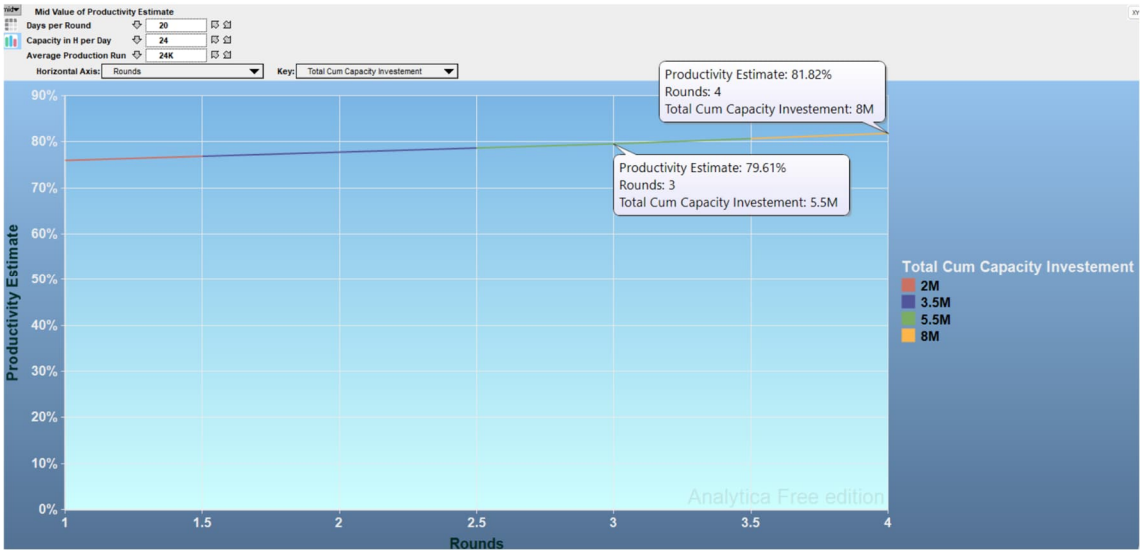
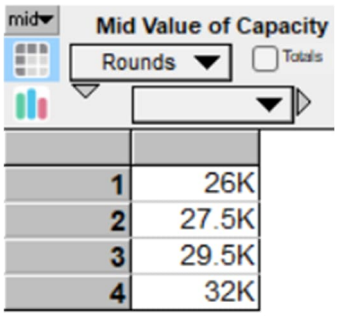


Figure 7-98 Graph: Showing productivity gains per round as capacity improves

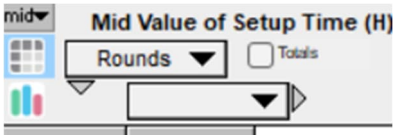
Capacity:



1	26K
2	27.5K
3	29.5K
4	32K

Figure 7-99 Capacity

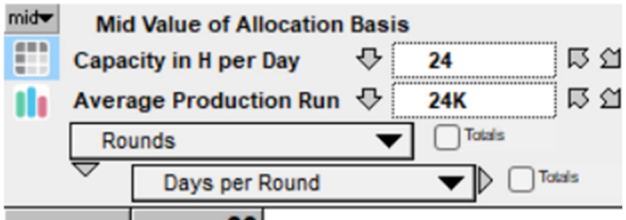
Setup Time (H):



1	7
2	6
3	5
4	4

Figure 7-100 Setup Time (H)

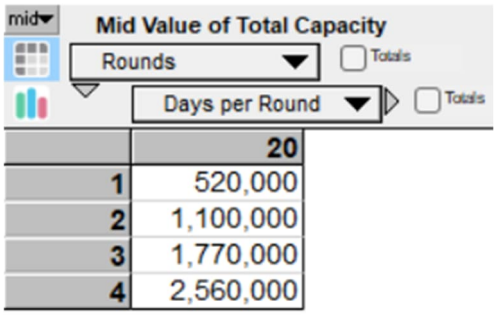
Allocation Basis:



	20
1	19,757
2	21,377
3	23,486
4	26,182

Figure 7-101 Allocation Basis

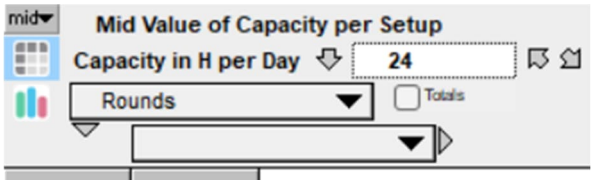
Total Capacity:



	20
1	520,000
2	1,100,000
3	1,770,000
4	2,560,000

Figure 7-102 Total Capacity

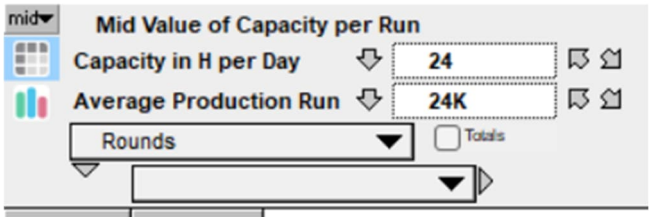
Capacity Per Setup:



1	7,583
2	6,875
3	6,146
4	5,333

Figure 7-103 Capacity Per Setup

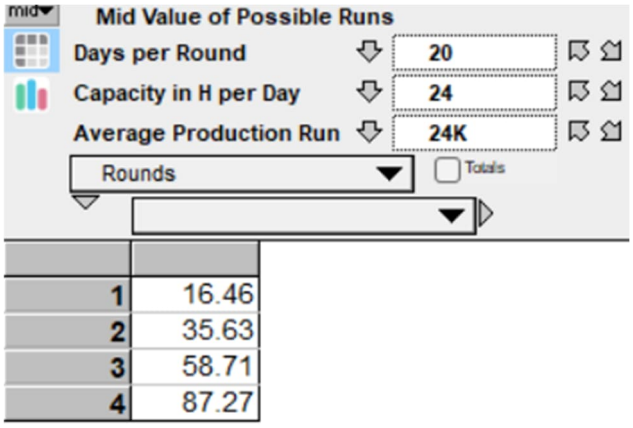
Capacity per Run:



1	31,583
2	30,875
3	30,146
4	29,333

Figure 7-104 Capacity per Run

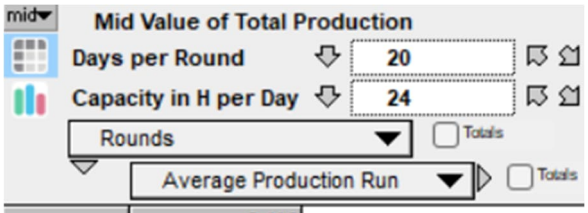
Possible Runs:



1	16.46
2	35.63
3	58.71
4	87.27

Figure 7-105 Possible Runs

Total Production:



	24K
1	395,145.1
2	855,060.7
3	1,409,150
4	2,094,545

Figure 7-106 Total Production

Graph:

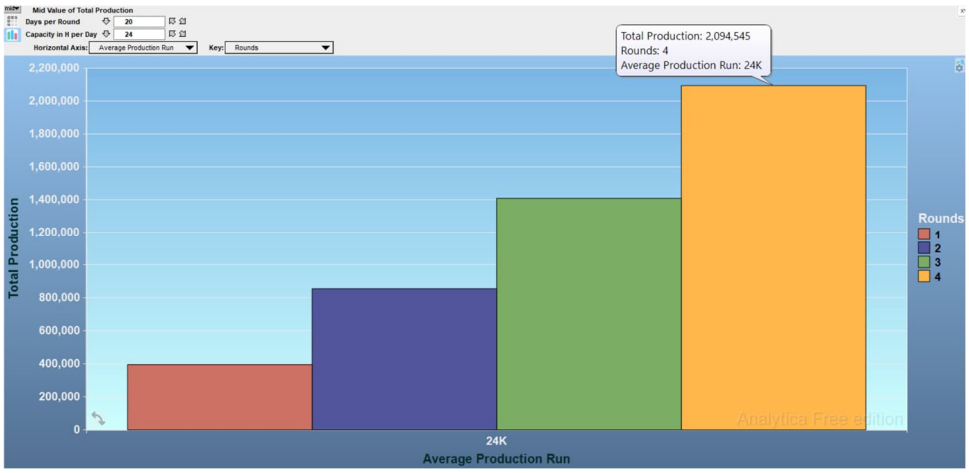
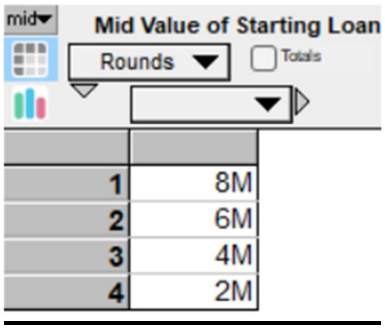


Figure 7-107 Graph of Avg Production Run

Starting Loan:



1	8M
2	6M
3	4M
4	2M

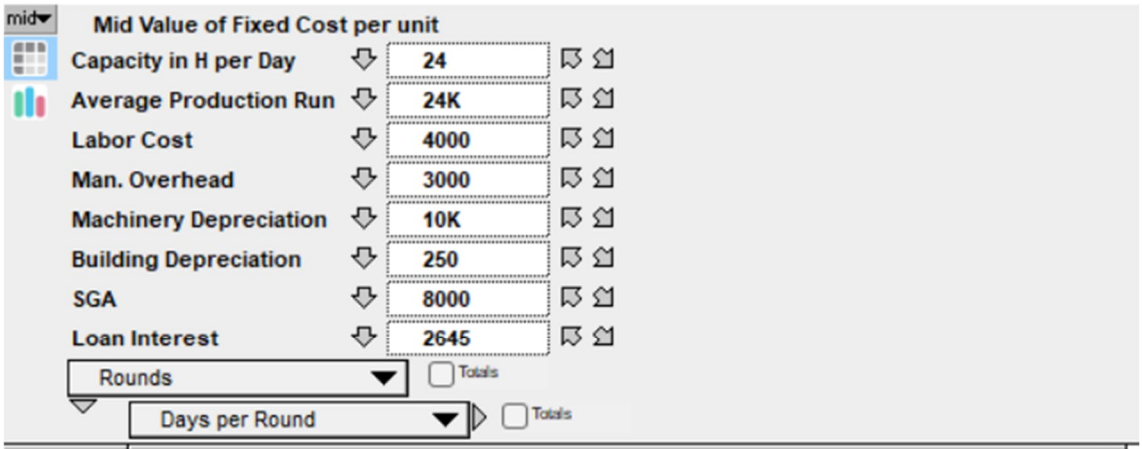
Figure 7-108 Starting Loan

Target Unit Profit:

Target Unit Profit:
1.8

Figure 7-109 Target Unit Profit

Fixed Cost per unit:



	20		
	Capacity Investment	Setup Time Investment	Fixed Cost per unit
1	2,000,000	50,000	1.41
2	1,500,000	75,000	1.30
3	2,000,000	125,000	1.19
4	2,500,000	250,000	1.07

Figure 7-110 Fixed Cost per unit

Graph: Fixed Cost per Unit Reduction as Capacity & Setup Time Investment Increases

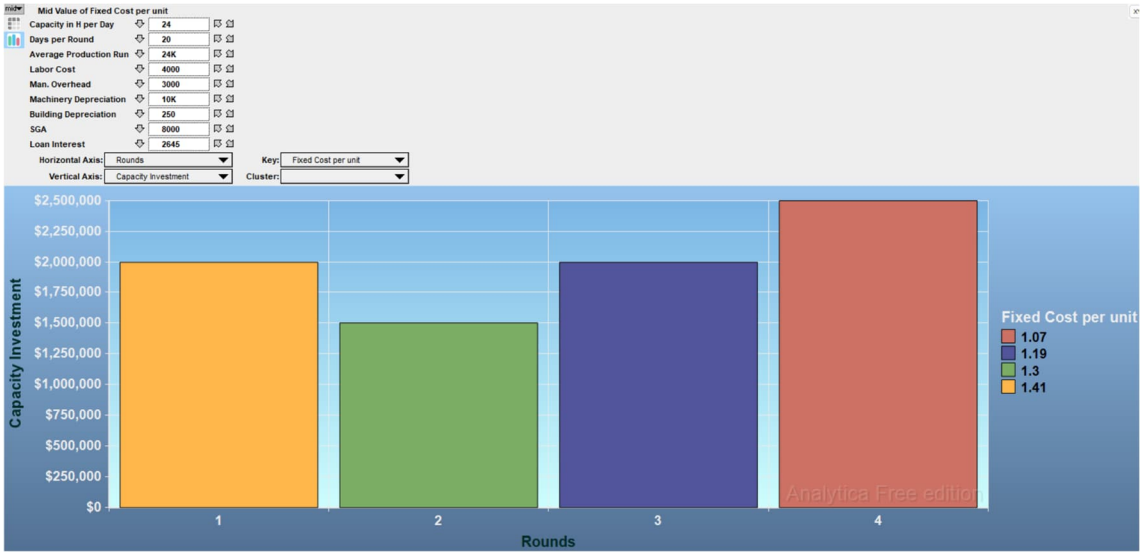


Figure 7-111 Graph: Fixed Cost per Unit Reduction as Capacity Investment Increases

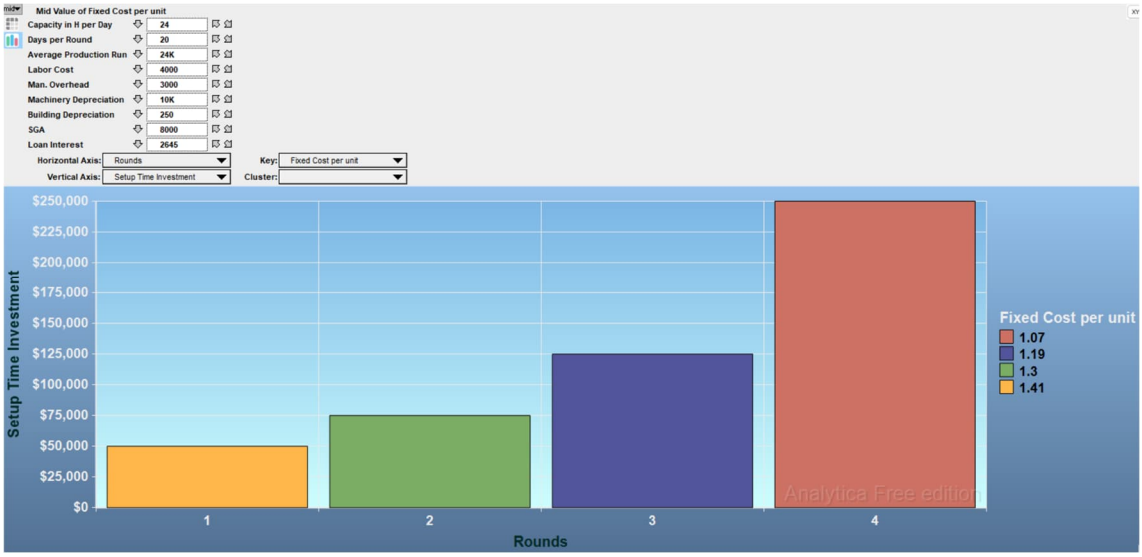


Figure 7-112 Graph: Fixed Cost per Unit Reduction as Setup Time Investment Increases

Running Profit:

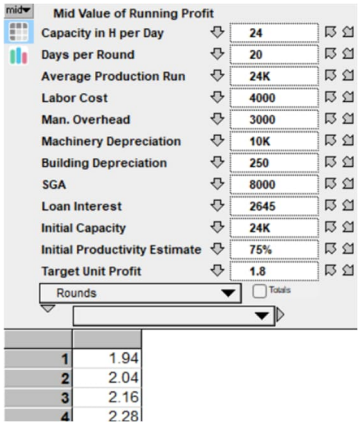
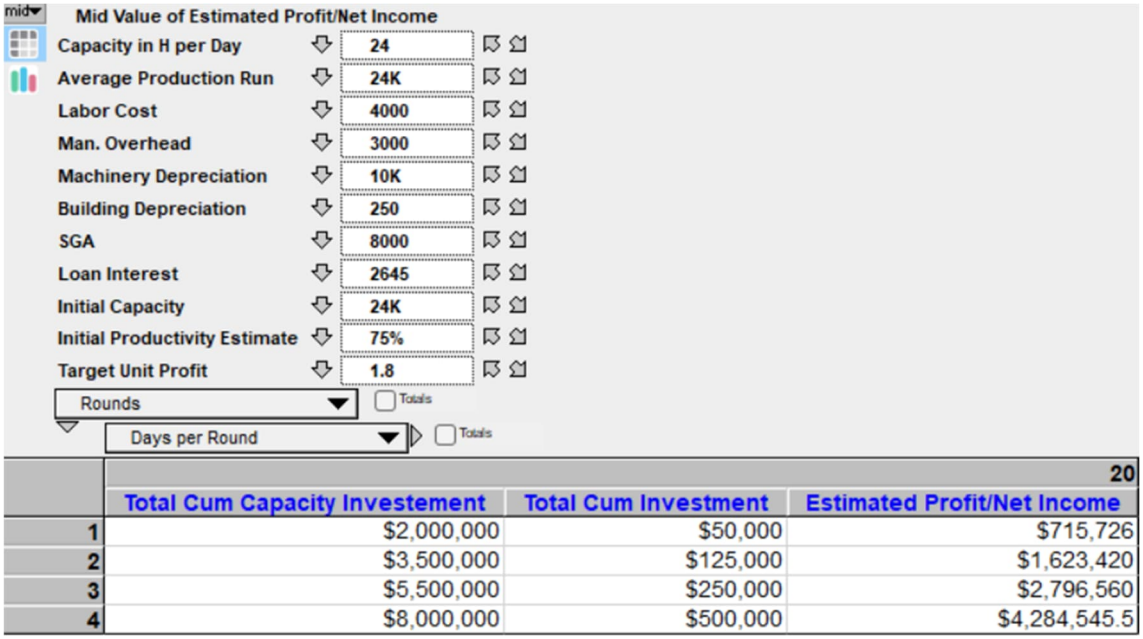


Figure 7-113 Running Profit

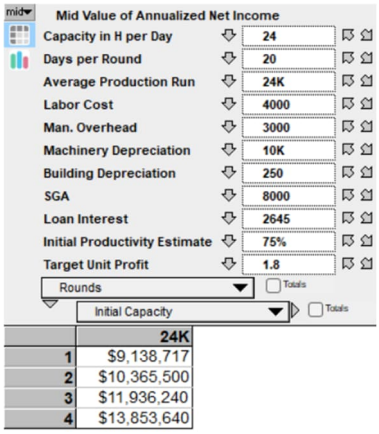
Estimated Profit/Net Income:



	20		
	Total Cum Capacity Investement	Total Cum Investment	Estimated Profit/Net Income
1	$2,000,000	$50,000	$715,726
2	$3,500,000	$125,000	$1,623,420
3	$5,500,000	$250,000	$2,796,560
4	$8,000,000	$500,000	$4,284,545.5

Figure 7-114 Estimated Profit/Net Income

Annualized Net Income:



	24K
1	$9,138,717
2	$10,365,500
3	$11,936,240
4	$13,853,640

Figure 7-115 Annualized Net Income

Graph: Tracking cumulative investment and resulting profitability

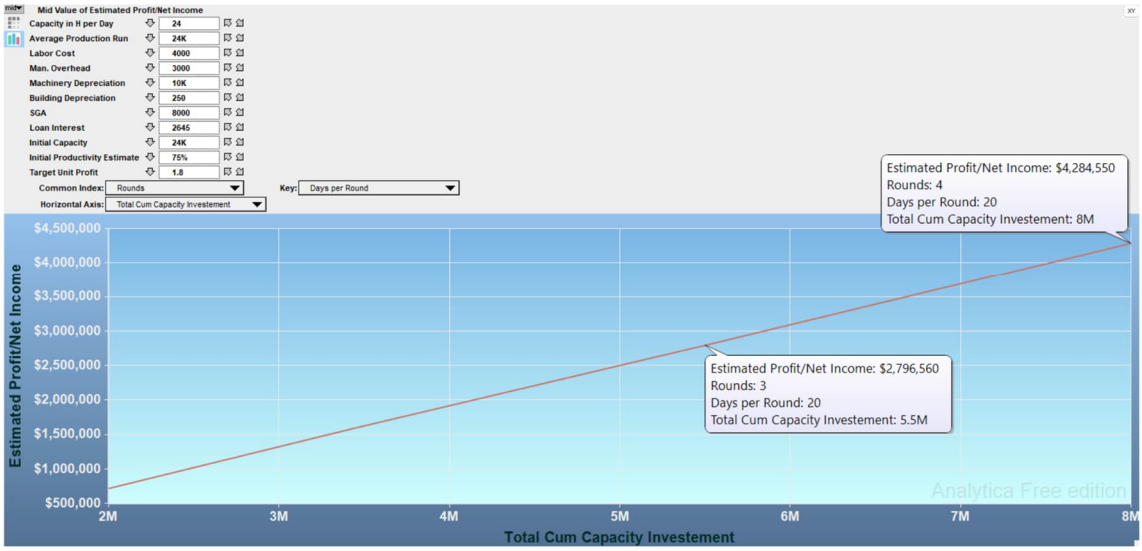


Figure 7-116 Graph: Tracking cumulative capacity investment and resulting profitability

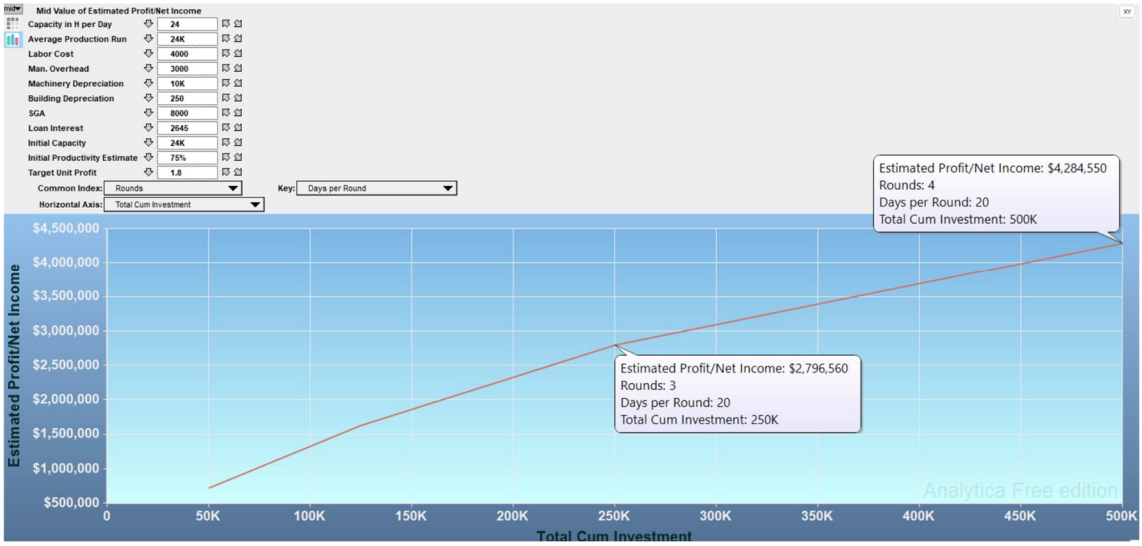


Figure 7-117 Graph: Tracking cumulative investment and resulting profitability

Net Debt:

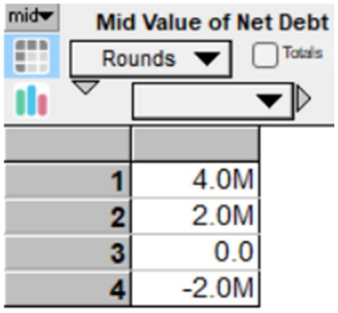


Figure 7-118 Net Debt

Applicable Interest Rate:

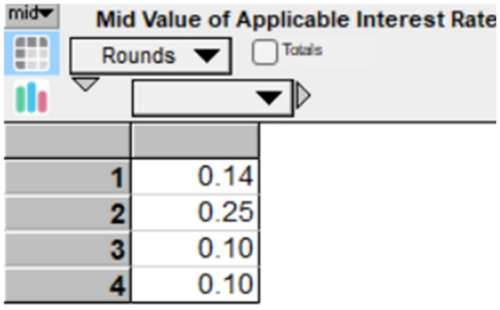
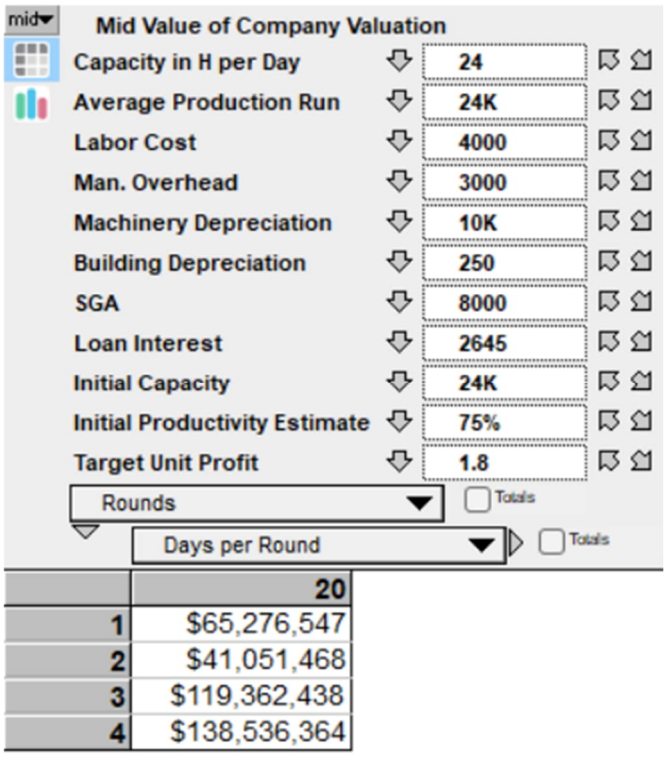


Figure 7-119 Applicable Interest Rate

Company Valuation:



	20
1	$65,276,547
2	$41,051,468
3	$119,362,438
4	$138,536,364

Figure 7-120 Company Valuation

Graph:

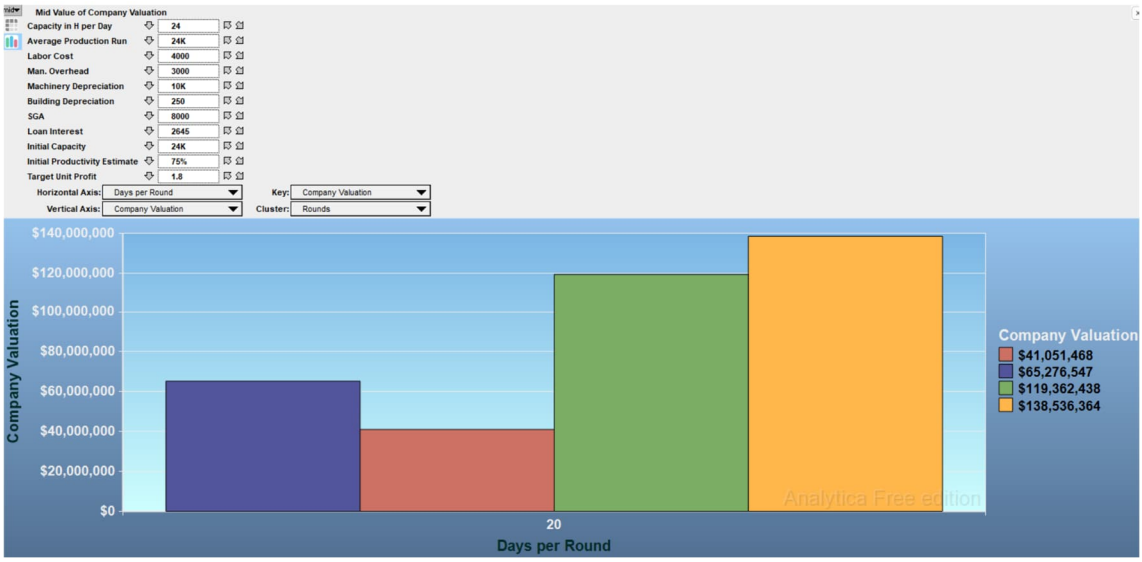
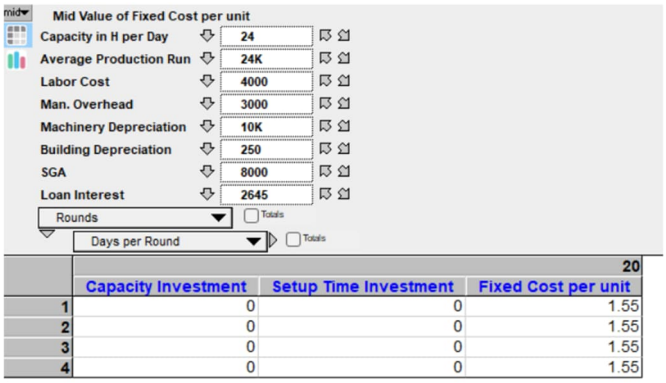


Figure 7-121 Graph of Company Valuation

7.5.5 E.5: Profitability Analysis Model – Alternative Scenarios

Scenario 2 — Variable Cost Increase

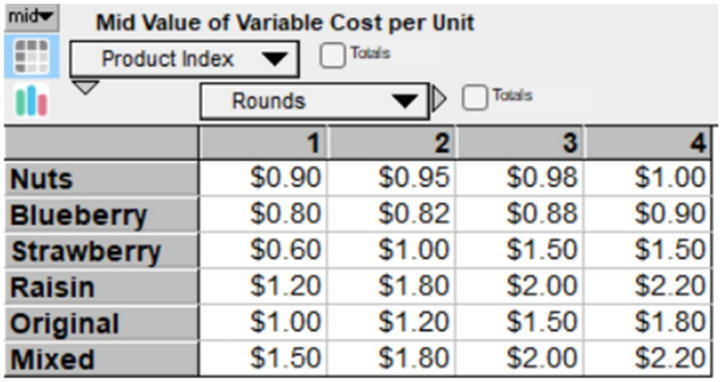
There is no investment in Setup Time and Capacity Improvement:



			20
	Capacity Investment	Setup Time Investment	Fixed Cost per unit
1	0	0	1.55
2	0	0	1.55
3	0	0	1.55
4	0	0	1.55

Figure 7-122 Fixed Cost per Unit

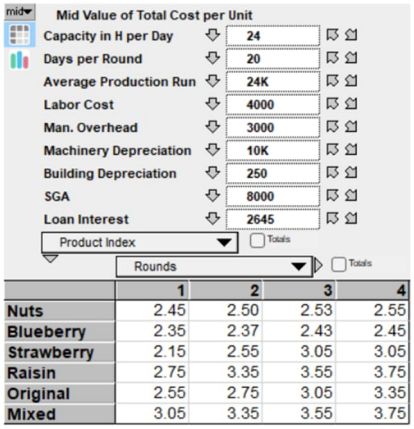
Variable Cost per Unit increases:



	1	2	3	4
Nuts	$0.90	$0.95	$0.98	$1.00
Blueberry	$0.80	$0.82	$0.88	$0.90
Strawberry	$0.60	$1.00	$1.50	$1.50
Raisin	$1.20	$1.80	$2.00	$2.20
Original	$1.00	$1.20	$1.50	$1.80
Mixed	$1.50	$1.80	$2.00	$2.20

Figure 7-123 Variable Cost per Unit

Total Cost per Unit:

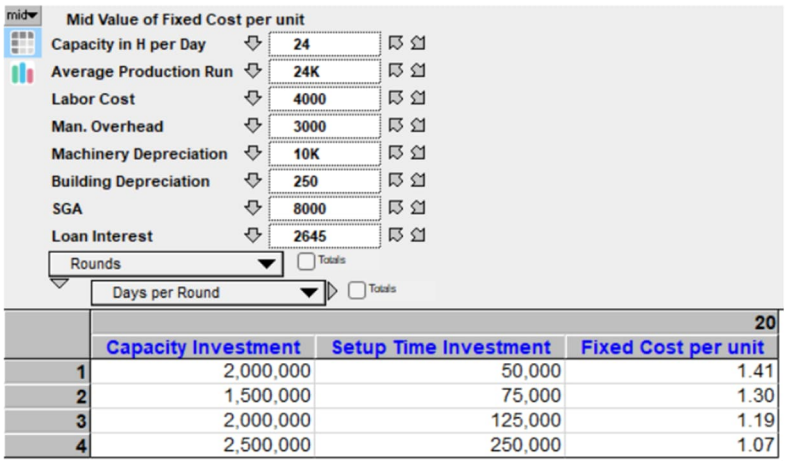


	1	2	3	4
Nuts	2.45	2.50	2.53	2.55
Blueberry	2.35	2.37	2.43	2.45
Strawberry	2.15	2.55	3.05	3.05
Raisin	2.75	3.35	3.55	3.75
Original	2.55	2.75	3.05	3.35
Mixed	3.05	3.35	3.55	3.75

Figure 7-124 Total Cost per Unit

Scenario 3 — Fixed Cost Reduction

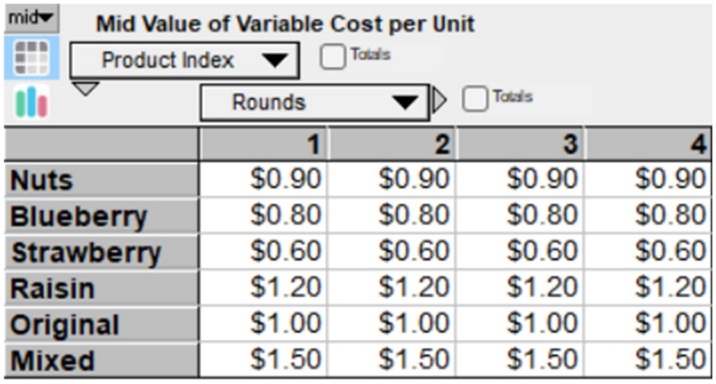
Invested in Setup Time and Capacity Improvement, fixed cost per unit decreased:



	20		
	Capacity Investment	Setup Time Investment	Fixed Cost per unit
1	2,000,000	50,000	1.41
2	1,500,000	75,000	1.30
3	2,000,000	125,000	1.19
4	2,500,000	250,000	1.07

Figure 7-125 Fixed Cost per Unit

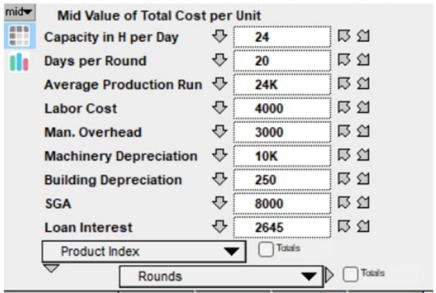
Variable Cost per Unit remains stable across all rounds:



	1	2	3	4
Nuts	$0.90	$0.90	$0.90	$0.90
Blueberry	$0.80	$0.80	$0.80	$0.80
Strawberry	$0.60	$0.60	$0.60	$0.60
Raisin	$1.20	$1.20	$1.20	$1.20
Original	$1.00	$1.00	$1.00	$1.00
Mixed	$1.50	$1.50	$1.50	$1.50

Figure 7-126 Variable Cost per Unit

Total Cost per Unit:



	1	2	3	4
Nuts	2.31	2.20	2.09	1.97
Blueberry	2.21	2.10	1.99	1.87
Strawberry	2.01	1.90	1.79	1.67
Raisin	2.61	2.50	2.39	2.27
Original	2.41	2.30	2.19	2.07
Mixed	2.91	2.80	2.69	2.57

Figure 7-127 Total Cost per Unit

7.6 Appendix F: Supplementary Model Files

To support transparency and reproducibility, all computational models developed in this thesis are provided in digital format alongside the document. These include:

Analytica Models

- Liquidity Planning Model Analytica
- Loan Repayment Model Analytica
- Production Impovement Model Analytica

Excel-Based Optimization Models

- Excel Model