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INVESTMENT DECISION OF BIOMEDICAL IMPLANT PRODUCTION UNDER UNCERTAINTY CONDITION: A MONTECARLO SIMULATION APPROACH

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ABSTRAK

PT. Langit Biru membuat rencana proyek investasi di bidang produksi implan biomedis untuk menangkap potensi pasar yang menarik dari implan biomedis dan untuk mendiversifikasi jejak bisnis di segmen medis. Keputusan investasi dibuat dengan mempertimbangkan dampak dari risiko diskrit dengan menggunakan analisis skenario, dan analisis simulasi montecarlo untuk mengeksplorasi konsekuensi dari risiko kontinu terhadap NPV proyek. Berdasarkan hasil analisis, proyek ini layak dan menunjukkan risiko yang relatif rendah di bawah risiko diskrit dan risiko kontinu di mana berdasarkan analisis skenario, NPV pada skenario terburuk adalah positif dengan nilai USD 433,621 (93% lebih rendah dari kasus dasar) dan simulasi montecarlo menunjukkan bahwa proyek ini memiliki probabilitas 100% dari NPV positif dari 1000 simulasi dengan rata-rata NPV USD 6.224.042 yang sangat dekat dengan NPV dasar USD 6.252.653 (-0,46% lebih rendah).

ABSTRACT

PT. Langit Biru make investment project plan in biomedical implant production to grab the attractive market potential of biomedical implant and to diversify the business footprint in medical segment. Investment decision is made by considering the impacts of discrete risks using scenario analysis, and montecarlo simulations analysis for exploring the consequences of continuous risk to the project NPV. Based on the analysis, the project is feasible and exhibits a relatively low risk under discrete and continuous risk where based on scenario analysis NPV in worst case scenario is positive with value USD 433.621 (93% lower than the base case) and montecarlo simulation expose that the project has 100% probability of positive NPV from 1000 simulation with NPV mean USD 6.224.042 that very close to the base NPV USD 6.252.653 (-0,46% lower).

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INTRODUCTION

PT. Langit Biru propose to make a new investment project for upgrading the facility to use additive manufacturing process in medical implant production. This initiative is part of business growth strategy of the company to diversify the business segment into medical segment and reduce the business exposure risk from the cyclical segment such as oil & gas segment, where currently more than third of the company revenues is contributed by oil and gas segment both upstream and downstream area. The market potential of medical implant itself is quite attractive, it is estimated on 2021 around US$ 20 million in Indonesia market and US$ 7,302 million in Asia market and by 2026 it will reach a value US$ 36,67 million and US$ 10,610 million in 2026 respectively. (Suganta Handaru, 2023)

In order to achieve the goals and grab the opportunities in the nice market, one of the business plan is to diversify the business into medical implant product, expand the production line and simultaneously upgrading manufacturing facilities with state-of-the-art additive manufacturing technologies to meet evolving demands. To do the financial feasibility analysis, capital budgeting method is commonly used to get the net present value (NPV) of the project. Typically, data that is used as input in financial feasibility analysis is based on financial model assumption (Xiong et al., 2016). There is a risk that in the actual project running, the financial data assumption is changing due to uncertainty conditions such as fluctuations of raw material cost, variance in actual CAPEX and OPEX, and variance in sales projection compared to budget (Dimian et al., 2014).

The necessity for informed investment decision-making prompts the imperative to conduct scenario analyses on Net Present Value (NPV) projections, particularly in extreme conditions – both worst and best-case scenarios. To enhance the robustness of NPV financial projections and gain a comprehensive understanding of project risk, the application of Monte Carlo analysis within simulation modeling has been adopted. This technique involves the random alteration of critical variable values across a range of potential changes (Kuppens et al., 2018). In alignment with contemporary financial methodologies, this study advocates for the incorporation of

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scenario analysis and NPV Monte Carlo Simulation to assess investment opportunities under conditions of uncertainty. Such an assessment becomes pivotal in determining the financial feasibility of investments, offering insights into expected returns, and aligning these opportunities with the long-term goals of the company within defined risk parameters. This approach, grounded in quantitative modeling and rigorous financial analysis, serves as a proactive strategy for navigating uncertainties in the investment landscape and fostering strategic decision-making for sustainable corporate growth.

LITERATURE REVIEW

Additive Manufacturing in Medical Application

The main value proposition of additive manufacturing (AM) in orthopedic and teeth implant is to provide better personalized treatment for patient with efficient and accurate digital design and manufacturing process. In addition, porous surface of AM parts provides faster patient recovery and better biocompatibility (Chunhua Sun, 2020). At this present, AM in medical device or specifically in orthopedic implants and dentistry is widely used and stepping into industrialization.

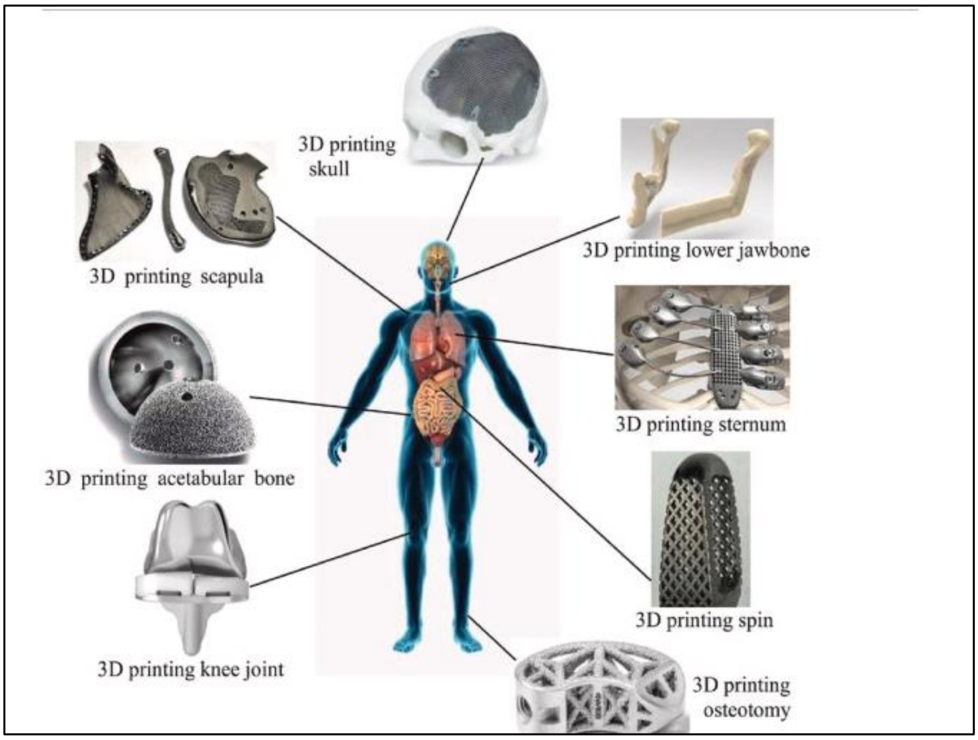

Figure 1 Medical Implants Produced using AM (Khanish Gupta, 2023)

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In clinical treatment, implant is one of the treatment methods of skeletal muscle system. It can replace joint, bone, cartilage, or musculoskeletal system in whole or part to avoid the mismatch of prosthesis size Figure 1 show some metal medical implant produced by AM. Implant produced by AM has the advantage of short cycle, low cost, customization, porous structure that create bone integration of implant. Some AM implant that launched and widely available in the market such as knee joint, meniscus tissue, spine, hip joint, bracket, teeth, etc (Chunhua Sun, 2020). The surgery result using AM implant hip joint (showed that the patient could walk independently, and the implant hip joint recovered very well and compatible with human interface tissue

Capital Budgeting

Capital budgeting is predominantly used to evaluate the feasibility of investment projects such as building new plant. As part of capital budgeting, a company might assess a prospective project's lifetime cash inflows and outflows to determine whether the potential returns would meet an indicator target / variable (Sartori et al., 2014). NPV can be used to decide project feasibility. The Net Present Value (NPV) can be defined as the present value of the future cash flows. It discounts by the appropriate cost of capital and reduces by the initial project expenditures. Project with positive NPV will be accepted and project with negative NPV will be rejected. (Gitman, 2015)

$$NPV = \sum_{t=1}^{n} \frac{CF_t}{(1+r)^t} - CF_0$$

Scenario Analysis

Scenario Analysis, a robust and extensively applied methodology in financial feasibility and risk management, is instrumental in assessing the repercussions of fluctuations in critical input variables on project Net Present Value (NPV) (Salling & Leleur, 2017). Recognized for its versatility, scenario analysis involves a systematic exploration of multiple scenarios by simultaneously adjusting various parameters. This method not only provides a comprehensive understanding of the potential outcomes but also aids decision-makers in navigating uncertainties and making informed choices. In a broader context, the utilization of scenario analysis is not confined to the financial domain alone. Researchers and practitioners across diverse fields have embraced this approach to gain insights into the multifaceted nature of decision-making under uncertainty. The concept of scenario analysis has permeated fields such as strategic planning, environmental impact assessments, and project management, emphasizing its adaptability and applicability (Gill, 2002; Van Der Heijden, 2005). The three fundamental scenarios crafted in scenario analysis are the base-case scenario, worst-case scenario, and best-case scenario (Pasqualino et al., 2021). Each of these scenarios serves a distinct purpose, contributing to a holistic risk assessment. The base-case scenario, often considered the benchmark, represents the most probable or typical conditions envisaged for a project. This scenario serves as a reference point for evaluating deviations in the worst and best-case scenarios. Contrastingly, the worst-case scenario unfolds the most extreme conditions that may materialize when unforeseen challenges disrupt the anticipated trajectory of the project. In the worst-case scenario, analysts and decision-makers explore the consequences of adverse events and deviations from the planned course. This exploration is crucial for risk mitigation and contingency planning, as it allows organizations to develop strategies that can withstand the most challenging circumstances (Schwartz, 1991). Conversely, the best-case scenario outlines the most favorable outcome achievable under optimal conditions. This scenario represents the ideal circumstances where everything unfolds seamlessly and according to plan. While the best-case scenario might seem optimistic, it is an essential component of scenario analysis, offering insights into the upper limits of success and potential opportunities that may arise under ideal conditions. Damodaran (2015) emphasizes the dynamic nature of scenario analysis, cautioning against treating it as a predictive tool. Scenario analysis does not provide a crystal ball for forecasting the future; instead, it serves as a dynamic framework for evaluating a spectrum of potential outcomes. As a result, it enhances decision-makers' ability to consider the range of possibilities and make strategic choices that are resilient in the face of uncertainty. The adoption of scenario analysis is underpinned by its ability to enhance decision-

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making processes by considering a range of plausible futures (Wack, 1985). In complex and uncertain environments, this method becomes particularly valuable, allowing decision-makers to explore and understand the implications of various factors on project outcomes. This approach aligns with the principles of strategic management, where a forward-looking perspective is essential for navigating the complexities of a rapidly changing business landscape (Schoemaker, 1995). In conclusion, scenario analysis is a versatile and indispensable tool for decision-makers in diverse fields. By fostering a comprehensive exploration of potential outcomes, it facilitates more informed decision-making in the face of uncertainty. The integration of multiple scenarios, including the base, worst, and best-case scenarios, enhances the robustness of risk assessments and strategic planning, providing organizations with the tools they need to adapt and thrive in dynamic and unpredictable environments.

NPV Simulation

While scenario analysis and decision trees prove valuable in assessing the impacts of discrete risks, simulations offer a method for exploring the consequences of continuous risk (Zio, 2018). Given that real-world risks often entail numerous potential outcomes, simulations afford a comprehensive examination of risk within an asset or investment (O'Donoghue & Somerville, 2018). In each simulation iteration, a single outcome is drawn from each distribution, generating a distinct set of cash flows and corresponding value. By conducting a substantial number of simulations, it becomes possible to derive a distribution for the investment or asset's value, providing a nuanced representation of the inherent uncertainty involved in estimating valuation inputs. The procedural steps for executing a simulation involve determining probabilistic variables, establishing probability distributions for these variables, and assessing correlations across variables. (Gitman, 2015)

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METHODS

This research uses both primary and secondary data. Primary data is acquired from author sources such as initial investment required, cash outflow projection. Secondary data was collected from reports, books, journal, article, and website. Secondary data, both qualitative and quantitative information are used as input for financial analysis to produce financial projection, capital budgeting and sensitivity analysis.

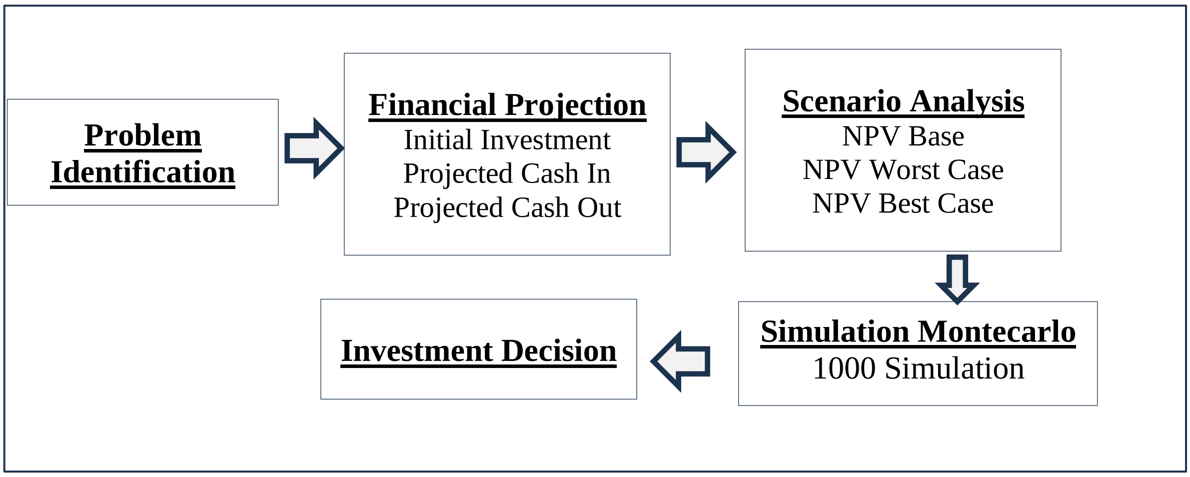

Figure 2. Research Methodology

The parameter used in the project feasibility are net present value. To assess the project risk, scenario analysis is carried out. Scenario analysis of this project is conducted by making two scenario worse case and best case. Worst case condition is created by setting unfavorable scenario at variables that reduce the NPV result. For example, to create the worst case, interest rate is set 12,5%, sales quantity 80% of the budget at all periods, selling price is 80% of the budget, OPEX 120% higher than budget and initial investment 120% higher than budget.

Meanwhile the best case is created by setting favorable value for all critical variables that increase NPV result. Detail of variable change in the scenario analysis is described in Table 1

Table 1 Scenario Analysis

Items	Worse	Base	Best
Interest Rate	12,5%	10,4%	8,3%
Sales Quantity	80%	100%	120%

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Selling Price	80%	100%	120%
OPEX	120%	100%	80%
Material Cost	120%	100%	80%
Financing Ratio	72%	60%	48%
Initial Investment	2.700.689	2.250.574	1.800.460

Further simulation is carried out using Montecarlo simulation to determine the impact of variables uncertainty by simulating with multiple probability of several variable change randomly and analyze the impact to the NPV. 1000 simulation will be carried out using distribution norm at the variables sales quantity, selling price, OPEX and interest rate. The output of Montecarlo analysis is NPV result distribution from 1000 simulation that illustrated in histogram chart. In addition from the simulation, statistical data of NPV will be generated such as maximum value, minimum value, mean and median value and comparison to the NPV based. Furthermore probability of the positive NPV can be analyzed.

RESULTS

Scenario Analysis

Table 2. Scenario Analysis Result

Items	Worse	Base	Best
WACC / Discount Rate	9,02%	7,75%	6,86%
Total PV Cash Inflow	3.134.310	8.503.227	15.259.116
NPV	433.621	6.252.653	13.534.351
IRR	11%	35%	59%
Payback Period	5,8	3,7	2,8
Discounted Payback Period	7,4	4,1	3,0
Profitability Index	1,2	3,8	5,7

Based on above scenario analysis, it is observed that the investment project still feasible or accepted even in the worst condition. where NPV is positive with value USD 433.621 although it is 93% lower than the base case. IRR is 11% and it is still bigger than cost of capital's worse case 9,02%. Although the discounted payback periods prolong notably into 5,8 years, it remains within reasonable proximity to initial 8 years project completion. Meanwhile at the best case or the most optimistic condition, the investment project deliver 116% higher NPV than the base case or

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USD 13.534.351. IRR increase into 59%, shorter payback period become 2.8 years and big number of profitability index 5,7 at best case.

Overall, the investment project consistently generates positive NPV across the entire spectrum of scenarios, ranging from USD 433.621 in the worst case to USD 13.534.351 in the best case. This not only showcases the project's financial resilience but also indicates a low-risk profile, with minimal likelihood of default. The project emerges as an attractive and prospective investment, capable of weathering unfavorable conditions while maximizing returns under optimal circumstances. The scenario analysis underscores the project's adaptability and solidifies its position as a sound financial decision with a favorable risk-return profile.

Montecarlo Simulation Analysis

Since it is unlikely that all factors condition from the worst case or best case occurred simultaneously. Montecarlo simulation expect to give full picture of the risk in this project investment that affected by random value from of several variables in best case and worse case then measure the probability of NPV results.

Table 3 Random Variable Swing – Montecarlo in one Simulation

	0	1	2	3	4	5	6	7	8
Variable	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Interest Rate	13,5%	13,5%	13,5%	13,5%	13,5%	13,5%	13,5%	13,5%	13,5%
Sales Quantity	0%	0%	98%	67%	100%	128%	77%	63%	98%
Selling Price	84%	84%	84%	84%	84%	84%	84%	84%	84%
OPEX	111%	108%	88%	85%	101%	95%	90%	85%	101%
Material Cost	127%	102%	119%	92%	86%	106%	93%	96%	113%
Financing Ratio									54%
Initial Investment									(1.913.137)
WACC / Discount Rate									**8,99%**

The Montecarlo simulation is conducted by running 1000 simulation. In this simulation, the values of seven critical parameters consist of selling price, sales quantity, OPEX, initial investment, material cost, financing and interest rate from the sensitivity model will be vary randomly with 1000 times simulation and different paring value for each variable. Table 3 above is one of the examples simulations of

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variable's swing. Each simulation of the variable change will provide variation in the NPV result. The NPV's distribution from the 1000 simulation is illustrated at below Histogram Chart

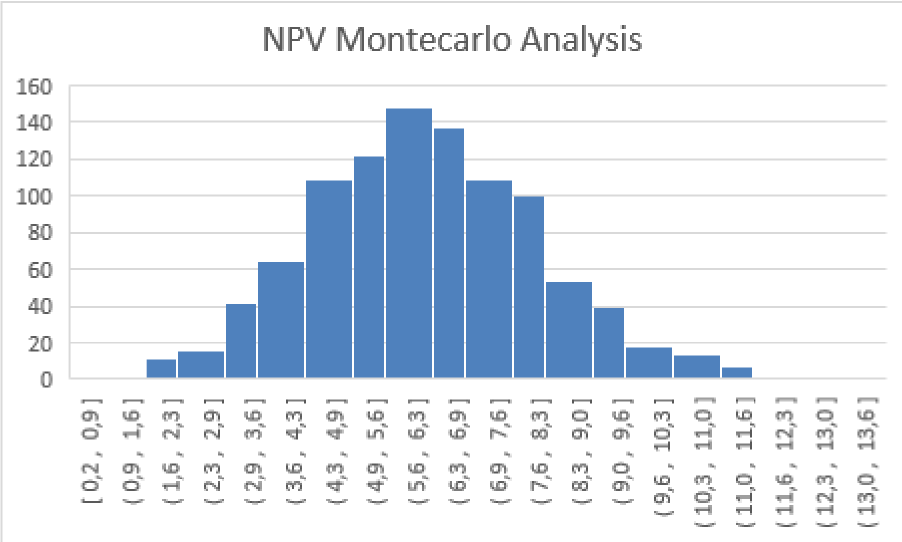

Figure 3 NPV Montecarlo Analysis

(Source: Author' Analysis)

Based on the simulation NPV's mean across all 1000 simulation is USD 6.224.042 and NPV's median is USD 6.174.140, both values are very close to the base NPV value USD 6.252.653 with the delta -0,46% lower for NPV mean and -1,26% lower for NPV's median. The lowest NPV measured in this simulation is USD 1.052.812 which is -83,16% lower than normal NPV and the maximum measured NPV is USD 12.428.360 or +98.7% higher than normal NPV. Moreover, probability ratio of positive NPV shows 100% positive NPV , with indicate that from 1000 simulation test the result has always NPV value > 0.

Table 4. NPV Simulation Statistic.

Parameter	Montecarlo	Δ Montecarlo vs Base NPV
NPV Mean	6.224.042	-0,46%
NPV Minimum	1.052.812	-83,16%
NPV Maximum	12.428.360	98,77%
NPV Median	6.174.140	-1,26%
NPV STD	1.932.027	-
Probability NPV > 0	100%	-

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Based on the this Montecarlo simulation, we can see the project performance and project risk where we can conclude that the risk profile of this project is low with high success rate of the financial performance result. The spread of NPV mean and median that indicate the most possible NPV result in uncertainty variable are very close to the NPV base. So, the investment project of biomedical implant production is feasible in term of financial aspects.

CONCLUSION AND SUGGESTION

In the worst-case scenario analysis, seven variables are altered to unfavorable condition covering 12,5% interest rate, sales quantity 80% of the budget, selling price 80% of the budget, OPEX 120% higher than budget, initial investment 120% higher than budget, material cost increase 120% and financing plan 72% from loan. Based on scenario analysis, it is observed that the investment project still feasible and accepted although in the set worst condition where NPV is positive with value USD 433.621 (93% lower than the base case). IRR is 11% and it is still bigger than based cost of capital 7.75% and WACC in worst scenario 9,02%. The payback periods prolong notably into 5,8 years and it remains within reasonable proximity to initial 8 years project completion.

In addition, based on the Montecarlo that represent about NPV result probability under uncertain variable condition show that NPV's mean of the project across 1000 simulation is USD 6.224.042 and NPV's median is USD 6.174.140, both values are very close to the NPV base value USD 6.252.653 with the delta variance -0,46% lower than NPV based and -1,26% lower than NPV based for NPV mean and NPV median respectively. The lowest NPV measured in this simulation is USD 1.052.812 which is -83,16% lower than normal NPV and the maximum measured NPV is USD 12.428.360 or +98.7% higher than normal NPV. Moreover, probability ratio of positive NPV shows 100% positive NPV , with indicate that from 1000 simulation test the result has always NPV value > 0. So, the risk profile of this project is low with high 100% of financial success rate.

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