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Research Article

Implementation Mapping of Integrated Cost Management Concepts with the Phases of Product Development

Satrio Samudro Aji Basuki¹, Dean Tirkaamiana²

¹Industrial and System Engineering, Institut Teknologi Sepuluh Nopember, 60111, Surabaya, Indonesia

²Industrial Engineering, Universitas Pembangunan Nasional “Veteran” Jawa Timur, 60294, Surabaya, Indonesia

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*Corresponding author:

E-mail:

dean.tirkaamiana.ft@upnjatim.ac.id

ABSTRACT

The alteration in the business environment is always dynamic, and the companies must respond to these issues. It is necessary for the management to always be conscious of the prevailing condition, especially in the cost aspect. Cost aspect is substantial for profit-oriented companies to lead to the profit as optimum as possible. Therefore, the cost management is requisite in order to manage cost in the proper manner. Cost management is considered as one of the essential tools to enhance the competitiveness of business potential. Through a well-defined cost management system, management is capable to acquire accurate information which prospective to be exploited for decision-making instruments and control the internal business process entirely. Many studies have been conducted to provide a more appropriate and proper cost management system for the companies. The current development includes integrating cost management with Kaizen, Target Cost Modeling, Target Value Design, Cost Effectiveness Analysis, and even with the Monte Carlo Simulation in order to accommodate the uncertainty factor in the cost. Therefore, this paper provides an overview related to the cost management implementation by mapping those current development into the modified Generic Product Development framework.

Keywords: *Cost Effectiveness, Cost Management, Kaizen Costing, Target Costing, Monte Carlo Simulation*

Introduction

Nowadays, technology is more advanced and guides the company turns sophisticated. Those modern companies are in the

circumstance of the business environment and this environment becomes more and more broad, miscellaneous, dynamic, and complex

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(Kozłowski & Matejun, 2011). The phenomenon basically necessitates the enhancement of technical flexibility. Technical flexibility is described as facing with variability and unpredictability in both supply and demand side and maintaining reliability at a satisfactory level at the appropriate cost over various period at once (Impram et al., 2020). Cost is one of the factors of flexibility, unsurprisingly the cost aspect is substantial for the company especially for a profit-oriented company. Therefore, cost management is requisite in order to manage cost in the proper manner. Cost management is the expansion and acquisition of financial information related to the costs, earnings, and non-financial information about customer engagement, productivity, quality, & other critical success indicators for the organization in order to execute its strategy (Blocher et al., 2019). The decision based on 'how the company deals with the cost' will influence the business activity control which is leading to the possibility of enhancing or diminishing the competitive advantage of the company. Competitive advantage is achieved when a company develops or adopts every aspect (or execution actions) to enhance their business efficiency such as speed, quality, price, creativity, and customer responsiveness and stay forward of their competitors (Azeem et al., 2021).

In line with the issue, studies on cost management began to be developed and adapted based on the characteristics and needs of the companies. Cost management strategy enables companies in managing costs and aligning with the business strategy in order to gain advantage in competitive market, which has different competitive characteristics. In this study, elaboration is performed to identify the development of cost management implementation which is integrated with the generic product development framework to map the potential for cost management implementation, started from the development stage to product realization.

This study aims to identify the characteristics and implications of cost management by analyzing several implementation cases. This research concern with the latest development related to the cost management through a comprehensive literature review. The literature

review shows that the implementation of the cost management is not only limited to control all financial resources employed in fulfilling customer's order in the core business process, but also can be implemented from the planning and development stage.

Literature Review

This chapter contains a theoretical framework that supported the preparation of this study.

2.1 Cost Management

Cost is the portion of the expense that is applied to the production or service. Also, cost is a measurement, in monetary terms, of the total of resources spent in the process of goods or service production (Banarjee, 2021). Cost is a critical issue within the company, as it may directly impact to profitability and existence.

Therefore, cost management has been closely linked to the current company's strategy and has become an important way for company to build competitive advantage and create core competitiveness (Wang, 2019).

Hansen, et al., (2006) stated that cost management refers to identification, information collection, measurement, classification, and reporting useful information to management to determine related costs of products, customers, and suppliers as well as for planning purposes, control, continuous improvement and decision making. Drury (2018) states that cost management aims to eliminate or minimize non value-added activities and develop ways to execute value-added activities which increase the overall value of the product or service. Furthermore, Wang (2019) stated the terminology as strategic cost management to identify cost drivers from the source of cost from a strategic perspective and to manage costs in the value chain to use cost data and information to provide strategic cost information for each critical step of strategic management.

Strategic cost management facilitates the formation of competitive advantage and the creation of core competitiveness.

While traditional cost management focuses on cost-cutting technologies and methods, strategic cost management focuses on getting as much value as possible with as little cost as

possible. In order to enhance the competitive advantage of company, strategic cost management is mainly guided by cost-effectiveness principle.

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2.2 Generic Product Development

The New Product Development (NPD) process diverges from one enterprise to the other. Moreover, there is no one-size-fits-all solution for all conditions or industries. The preferences of processes are commonly based on company's structure uses to dealing with risks and uncertainties (Unger and Eppinger, 2009). While product development is constantly iterative, it is sometimes depicted as a linear process such as Generic Product Development by Ulrich and Eppinger (2015) in Figure 1.

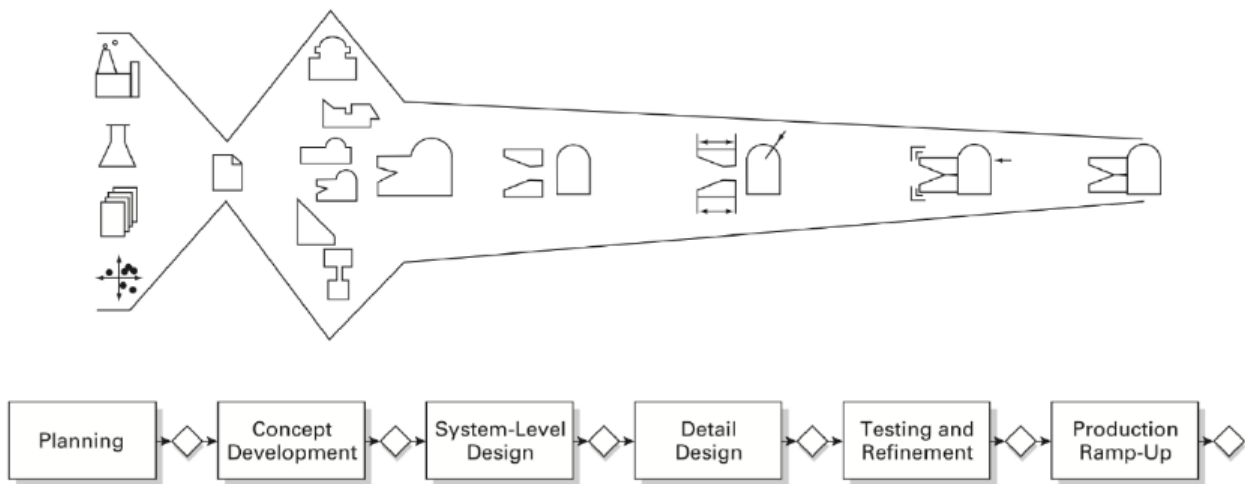


Figure 1. Generic Product Development Process (Ulrich & Eppinger, 2015)

The Generic Product Development has six phases, which are:

- a. **Planning** : Corporate strategy and assessment of technology development as well as market goals are initiated this phase. The project mission statement appears from the planning phase, and it outlines the product's target market, business goals, important assumptions, and restrictions.
- b. **Concept Development** : The target market's necessities are identified, alternative product concepts are generated and evaluated, and one or more concepts are chosen for future development and testing.
- c. **System Level Design** : The specification of the product architecture, as well as the deconstruction of the product into subsystems and components, are all part of the system-level design process. During this step, the final assembly scheme for the production system is usually specified as well.
- d. **Detail Design** : The comprehensive specification of the geometry, materials, and tolerances of all unique pieces in the product, as well as the identification of any standard parts to be obtained from suppliers, are all part of the detail design step.
- e. **Testing and Refinement**: The construction and evaluation of various preproduction variants of the product are part of the testing and refining process. Early (alpha) prototypes are typically made with production-intent pieces, which have the same geometry and material qualities as the production version of the product but are not necessarily created using the same procedures.
- f. **Production Ramp-Up** : The product is manufactured utilizing the proposed manufacturing system during the ramp-up phase. The goal of the ramp-up is to train the workforce and resolve any lingering issues

with the manufacturing process. Products manufactured during the ramp-up process are occasionally provided to favored clients and are thoroughly inspected for any residual faults.

Methods

Ulrich’s Generic Product Development Framework is used to map the potential implementation of cost management. There are 6 stages in the framework, starting from the

planning stage, concept development, system-level design, detail design, testing and refinement, and production ramp-up. In this study, in Figure 2, those 6 stages are then grouped into 3 main stages that is planning, new product development, and realization. Literature study is then executed to identify the cost management implementation on each main stages, based on the latest journals in the last 10 years between 2014 – 2024.

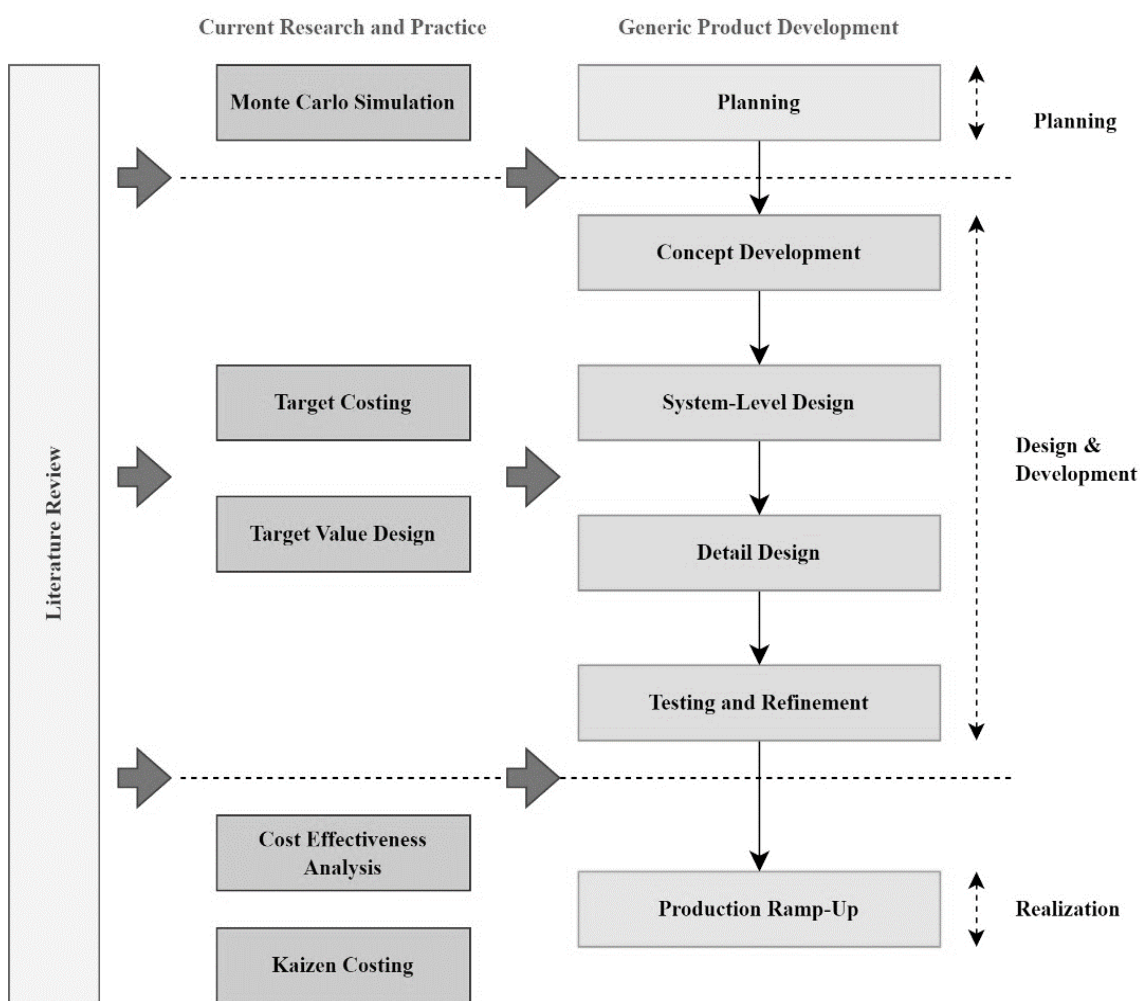


Figure 2. Literature Review Map

Results and Discussion

Based on the literature review on the last ten years journals (2014-2024), several cost management implementation cases are obtained. Figure 3 displays the integration of cost management concepts with the phase of product development. In the planning stage, cost management technique with the combination

of Monte Carlo simulation are founded. In the new product development stage, cost management technique such as target costing and target value design are founded. While in the realization stage, cost management technique such as cost effectiveness analysis and kaizen costing are founded.

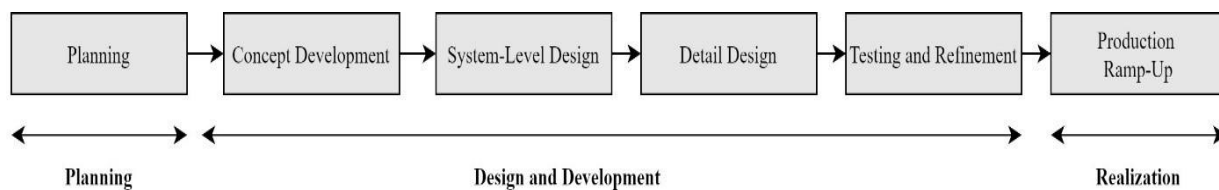


Figure 3. Integrated Cost Management Concepts with the Phases of Product Development

4.1 Cost Management Implementation in Planning Stage

In this study, cost management technique with the combination of Monte Carlo simulation are considered as an appropriate technique in the planning stage, especially to evaluate the uncertainty factors in the cost aspect to determine the feasibility of the new project.

4.1.1 Monte Carlo Simulation

Monte Carlo simulation is a statistical tool that is widely used in various fields. Monte Carlo simulation is classified as a static simulation model that uses random numbers to accommodate stochastic or deterministic problems, where the function of time is not substantive (Law & Kelton). The main purpose of Monte Carlo simulation is to simulate the uncertainty of an event. Monte Carlo simulation uses random numbers with uniform distribution $U(1,0)$ to generate random variates (probability distribution) that are relevant in representing the uncertainty of a parameter.

Heck, et al., (2016) conducted a study using Monte Carlo simulation to estimate the Levelized Cost of Electricity (LCOE) of several types of power plant. The standard LCOE formulation is used by modeling into a normal, log-normal, and triangular distribution to be simulated to produce possible LCOE output distribution. The result showed that the Monte Carlo simulation is able to provide LCOE distribution for each type of power plant, so that a more in-depth analysis can be carried out by studying the scenarios of each type of power plant.

Zhu, et al., (2016) revealed that the analysis of uncertainty on cost items can make project management easier. In this research, the integration of the Monte Carlo simulation method and market investigation then was carried out to estimate the Engineering Procure-

ment Cost (EPC) of chemical construction. Market investigation is used to identify what are the market drivers and how much influence on the cost of the item. The research showed that with the proposed cost estimation method, construction project costs are relatively more accurate than traditional methods.

Ioannou, et al., (2017) examined several uncertainty factors in the input variable for the LCOE calculation which include capital cost, annual operating cost, and annual energy production. The uncertainty factor is then defined in a range and probabilistic analysis through Monte Carlo simulation to discover how the distribution of LCOE from the Offshore Windfarm Technology use. The result showed that the Monte Carlo simulation can extend the deterministic cost model to accommodate the uncertainty factors of Offshore Windfarm cost component.

Keuffel, et al., (2019) investigated the relationship between controlling hypotension in ICU sepsi patients and hospital costs to evaluate the economic aspect. Monte Carlo simulation was developed to accommodate the probabilities of Acute Kidney Injury (AKI) complications and mortality on sepsis patients as well as the costs required for health services. The result demonstrated that Monte Carlo simulation can also be applied to estimate the economic parameters of several treatment alternatives scenarios.

Elfarra & Kaya (2021) examined the effect of wind speed on the distribution of annual energy production which is closely related to predictions in cost analysis. The complexity of the wind speed is modeled through several probabilistic functions including splines, weibull, and weibull & weibull, then generated through Monte Carlo simulation. The result showed that appropriate distribution determination has a significant effect on the cost estimation results of Monte Carlo simulation.

4.2 Cost Management Implementation in Design and Development Stage

In the design and development stage, budget becomes an essential issue during the product design and development, furthermore when the product is used in the future. In this study, cost management techniques such as target costing and target value design are considered as appropriate techniques in the design and development stage.

4.2.1 Target Costing

In determining the product prices, the company must conduct market research firstly to determine the selling price of new products. Engineers and cost analysts work together to design a product that can be produced at an acceptable cost, this process is called Target Costing (Hilton & Platt, 2016) The implementation of Target Costing means that the company's development project always begin based on the price preference by customer for a product. This price as the reference for company in developing the products to satisfy a certain profit margin, which categorized as target cost (Ansari, et al., 2006). Therefore, Target Costing is useful for cost optimization in improving performance, adding value to design or projects, and meeting customer demands.

Baraldi & Stromsten (2024) conduct research with focus on product development within IKEA's industrial network. This paper reveals the function of Target Costing as an accounting tool that has the potential to shape development efforts into either exploitative or explorative initiatives. The IKEA case studie displays the intricate connections between organizational and technical interfaces. It is categorized as complex due to the requirement for creating diverse control mechanisms, such as selecting the best-suited partners. Also, it is because to the establishment of key business relationships, to achieve even a single desired function or value, like "low weight" or "same appearance at a lower cost," which are the focus of result control.

Potkány et al., (2021) develops study with the purpose at the practical implemented of Target Costing in specific product (a wood-aluminium window) with the situation of the woodworking industry with the focus in

customer needs and the value analysis related to single component and functions of the specific product. The study explores functional cost analysis. The Target Costing methodology is performed in order to determine the target price which is EUR 513.19 and the level of target cost for the product. It is known that the most important cost is production cost (EUR 379.31). After that, they compute the target cost index for each component and produce the target cost chart while accepting the q parameter at level of 5% and 10% assumptions were formulated to the evaluating of possible alternative and potential corrections.

Al-hosban et al., (2023) explore the effect of Target Costing (steps and characteristic) with aim to reducing cost in Tourism companies at Aqaba Economic Area. In Aqaba Economic Area, the issue is based on high operational costs which lead to high prices of the tourism product. Another issue is the lack of tourism programs and the short promotion of them. All of these issues are an obstacle to its competitiveness as a tourist destination for Jordanians and in the region. The data used is a study questionnaire and theoretical framework. Based on the method, it is known that the value of tourism in the city of Aqaba should make the relationship between the target cost method and the cost restructuring process which can gain the competitive advantage and reduce the production cost. Also, when pricing the goods and service, the company should consider the customer's perspective.

Hattami et al., (2020) investigate the usage of target costing in manufacturing firm (furniture). Data are gathered through observation, narration and interview and by sampling in Al Amal factory which located in Hodeida City, Republic of Yemen. The result of the research is the implementation of target costing on products (a,b) respectively is \$0.424, \$1.693. While, the use of both tear-down analysis and Value Engineering impact the target reduction by 118.2%, 97.5% for products (a,b) respectively.

Stadtherr & Wouters (2021) execute study which extend the scope of target costing through development and implementation of the method in three-year case study at a car company. The output of this method is market-based cost targets for R&D cost by simply

including the cost of capital and investment for manufacturing assets especially product modularity and other product design strategies. For modular design and the use of target costing during product development, a coordinated approach could be the most appropriate and feasible.

4.2.2 Design to Target Cost – Target Value Design

Target Value Design (TVD) is target cost applied to a construction project (Ballard, 2008). TVD is classified as a management technique which is utilized in design and construction to encourage a value that can be offered to customers through a scheme within the project's boundary. Historically, the building is designed according to discussion between customer-architect then after the design is finished, the cost is estimated. The cost is incorporated with the result of the design, and not the proponent of the design. TVD establishes cost driver (such as time and location) to provide value.

(Orihuela et al., 2015) presented a protocol for the implementation of target value design throughout Project Definition and Design, and appropriate cost structure with building projects especially the construction of offices and housing. The Project designer is used to enlarge isolated work. Afterward, workflow mapping is conducted with Value Stream Mapping and workflow. Each design stage, which is guided by the architect, is possible to be monitored and evaluated its target cost through a group of economic ratios. The proposed cost structured in this paper enables the existence of progressive economic assessment that will continue to be improved as the project progresses. This will prevent the occurrence of failure in computation of target cost in project design, which in many cases create re-calculation to obtain the target cost.

Russell-Smith et al., (2015) explained that building designers, contractors and owners have several methods to effectively control a building's life cycle energy and environmental impact during the design phase. This research combined life cycle assessment (LCA) and target value design (TVD) methods in parallel to produce a more sustainable building design. This research showed that buildings can be

designed to deliver higher environmental standards, compared to those designed without targets.

Olivia et al., (2016) discussed about adoption process of target value design elements, in order to deliver benefit to the real estate developer in Brazil. However, the characteristic of Brazil real estate contradicts with the benchmark of success TVD. In this research, exploratory single case study and interview with the product developer are performed. The preliminary research showed that real estate developer recognizes the primary advantage of TVD such as escalate the competitive advantage through the addition of target in order to diminish the time to market. Also, TVD is able to educate real estate developers to deliver products that appropriate to them as well as to their buyers. These findings lead to an initial discussion of the suitability of the current benchmark TVD process (in this context) and provide direction for future research.

Torp (2019) focused on the discussion on the process of determining the target cost in the target value design. Critical issues with those principals such: how target costs are set, how mutual benefits are agreed and become transparent, and how production costs are led target costs and tracked. This paper discusses how stochastic prediction is exerted in TVD. A Literature review is the applied method in this research. Also, it is combined with the case study of cost estimation principal in two Norwegian public institutes. The findings suggest that stochastic cost estimates can be used both as inputs for setting allowable costs and estimating market costs. When it is used to decide the allowable cost, the probability distribution of project cost/value before design can be developed and used. This thing is related to the preference of how high is the expected probability to gain the a higher value than the allowable cost. On the other hand, when it is used to estimate market costs, probability distributions can be applied to analyze the probability of market costs ending up below the allowable costs for a particular identified design alternative. If select expected market cost, there is an opportunity of 50% ending up below the allowable cost. With the purpose to gain a successful project, not only set realistic

targets is important but also to direct design and construction to targets is a high priority.

Johansen, *et al.*, (2021) described cost growth and project cost overruns as a well-researched topic, but still a recurring problem. Some of the problems in these cases were caused by the difficulty in determining realistic cost estimation at the initial stage of the project. The object of this research focused on four large and complex infrastructure projects in the context of the Norwegian construction industry. The research method was semi-structured interview and document study. The results of the study identified that when determine a target cost for a project, both the allowable cost and the target cost are must be considered. This study concluded that it is important to decide the target cost in 12 - 20% below the allowable cost, therefore it is possible to drive innovation through the design process and be able to manage risks during construction.

4.3. Cost Management Implementation in Realization Stage

In the realization stage, cost incurred during the production become the focal point to be controlled and optimized. In this study, cost management technique such as Cost Effectiveness Analysis and Kaizen Costing are considered as an appropriate technique in the realization stage.

4.3.1 Cost Effectiveness Analysis

Cost-Effectiveness Analysis, which has an understanding that refers to an evaluation that considers the costs and consequences of existing alternatives. Read & Muth (2021) discover there are four representative nationwide interventions of food waste reduction such as customer education, public awareness campaigns, packaging to prevent spoilage of produce and meat, standardizing date labels, and waste tracking systems for foodservice. The annual cost of each intervention approximately varied from \$126 to \$595 million. While the estimated green cost effectiveness of the intervention varied two-or threefold (for example, 6 to 16kg CO₂ reduced per invested). Their research is conducted with aim to evaluate green improvement relative to cost to discover the preference

and decision making for waste reduction. Cost effectiveness differences between the interventions which is took into account are relatively minor but have both positive green and cost advantages which more than the cost of implementation. Also, they add that food waste reduction may be a cost-effective way to battle the climate crisis.

The research which is conducted by Paltiel *et al.*, (2020) based on there is increasing demand of an effective SARS-CoV-2 monitoring strategy of student for the safe return to residential colleges. They find that constant screening with a test of modest sensitivity and a shifting time of 8 hours are necessary for this purpose. The main challenge is handling the large number of false positives which absolutely occur from frequent screening for low prevalence conditions. The false positives risk overwhelming the availability of isolation house capacity, the problem becomes more serious as screening frequency increases. In study the appropriate period of screening reveals which is screening every 2 days using a rapid, inexpensive, and poorly sensitive (70%) test, combined with strict interventions that maintain reproduction number below than 2.5, it is projected to result in a manageable number of infections and to be cost-effective.

In Iran there is most important issue of electricity access for the entire population obstacle due to the rural electrification. Rad *et al.*, (2020) conduct research which focuses on discovering optimal renewable energy system to satisfy the load of a small village by renewable resources. They found that using solar, wind, and biogas is the most affordable method and that incorporating a fuel cell into this configuration would raise costs by 33-37%, but also enhance the system flexibility. Utilize a reformer is more efficient and about 6% less costly, unfortunately generate more pollution. The cost of energy only with reformer is calculated to be 0.154 to 0.233 \$/kWh. Meanwhile, the cost of energy for the on-grid system ranged from \$0.096 to \$0.125 per kWh.

Research by Zanghelini *et al.*, (2020) was to estimate the Cost Effectiveness and the budgetary impact of providing tolterodine, solifenacin, oxybutynin (OXY), darifenacin, and mirabegron for the treatment of UUI in the Brazilian

public health system. Therefore, it can be acknowledged which drug is the most effective based on its cost and effect. Cost Effectiveness Analysis with budget impact is calculated based on the results of three types of outcomes from six scenarios at once per patient in a year. These six scenarios were all drugs with each outcome. The outcomes were changes in UIEs (Urinary Incontinence Episodes), changes in urgency episodes, and changes in urinary frequency. These results also show that OXY and solifenacin have the lowest ICER per patient-year and have the lowest budget impact when compared to other drugs.

This study is conducted by Beller *et al.*, (2021) based on the demand for research to evaluate the Cost Effectiveness of the two different management strategies for the timing of implantation of a new permanent pacemaker of heart block after valve surgery. The incremental cost-effectiveness ratio of vigilant monitoring was \$12,724 per life with yearly quality adjustments. The results were sensitive to differences in survival adjusted for quality and rate of recovery of atrioventricular node function. Careful monitoring for pacemaker insertion is a cost-effective management strategy compared to initial placement for acute atrioventricular block after valve surgery. While this is cost-effective from a population perspective, clinical risk scores in predicting recovery will aid in personalized decision-making.

4.3.2 Cost Management with Kaizen Costing

Kaizen Costing is a method of cost reduction process during the manufacturing phase of a product or service. The word kaizen in Japanese refers to continuous and gradual cost reduction, not radical improvement through innovation or major investment in technology. A simple idea, improvement is the goal and responsibility of every worker, from CEO to worker in every activity, every day, all the time (Hilton & Platt, 2017).

Omotayo *et al.*, (2020) apply kaizen costing in construction project delivery systems in developing countries. The data used in this research were analyzed using the Analytic Hierarchy Process (AHP) and system thinking approaches. In the implementation of causal loop diagram, it is exposed that the concept of

mitigating waste for procurement cost, tendering, and on-site supervision must be considered by standardization of the process. The kaizen costing can be acquired in government and regulatory agencies, independently owned construction firms and in a construction project. The importance rank in construction companies, aligned with kaizen costing requirement, are effective organisation structure then followed by government regulation. (Deniz & Armagan, 2016) conducted another study on cost and time overruns in the small-scale construction companies in Nigeria. This study focused on how to improve the performance of cost management in the post-contract phase of Nigerian construction companies by using Kaizen costing. The result showed that overhead costs related to supplier, sub-contractor, and worker payments can be reduced continuously during the construction phase to keep the project costs within budget, as the most critical activity for sustainable cost reduction during the Kaizen Costing process.

Deniz & Armagan, (2016) conducted a research on the problem of declining profit values in airline cargo companies. Technological development and increasing competition have reduced airline profit margin. This situation encourages companies to analyze the cost and set target to make continuous improvement. The result showed that the Kaizen method can be used by adjusting the flight business activities including reduce flight operation and logistics costs, plant improvement, reduce direct and indirect personnel costs, as well as reduction in maintenance, advertisement promotion, and general administration cost.

Yigit (2022) apply kaizen costing in order to make declining in the costs of a plywood Manufacturing enterprise in Ordu province and gain the targeted profit. Data are collected by interview directly with production manager, accounting manager, and those have important role in other departments and perform the necessary investigations in the business area. The company's sales and production cost in 2020 are discussed. While for kaizen costing based on the estimated budget studies for 2021. From the kaizen costing computation, it is known that the plywood order lead to 13% profitability in 2021 with a sales price target per unit is

2,900 TL. In order to produce with a total target cost of 126,150,000 TL, the allocation rates are executed to reduce its cost by 2,100,000 TL in total including peeling, drying, pressing, and storage section are 1,050,000 TL, 630,000 TL, 315,000 TL, and 105,000 TL. Research by Al-Barghuthi *et al.*, (2020) conduct a study to explore the impact of using Kaizen Costing for reducing cost, achieving competitive advantage, and rationalizing strategic cost management for industrial companies listed on the Amman Stock Exchange in Jordan. This study assessed the development of the industrial sector to improve the local economy through the application of continuous improvement approach with the ability to provide high quality and low cost product. The result showed that Kaizen can be used to reduce production costs and improve product quality.

Conclusion

This paper provides a comprehensive picture of cost management implementation according to the framework developed by Ulrich and Eppinger, namely Generic Product Development Process. The study shows that each of the main stages (planning, design and development, realization), there are potential to implement cost management based on the collected literatures. In the planning stage, Monte Carlo simulation can be implemented to evaluate the uncertainty factors in the cost aspect to determine the feasibility of the new project. In the design and development stage, Target Costing and Target Value Design can be implemented to deal with the budget issue during the product design and development, and furthermore when the product is used in the future. Finally in the realization stage, Cost Effectiveness Analysis and Kaizen Costing can be implemented to control and optimize cost incurred during the production.

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