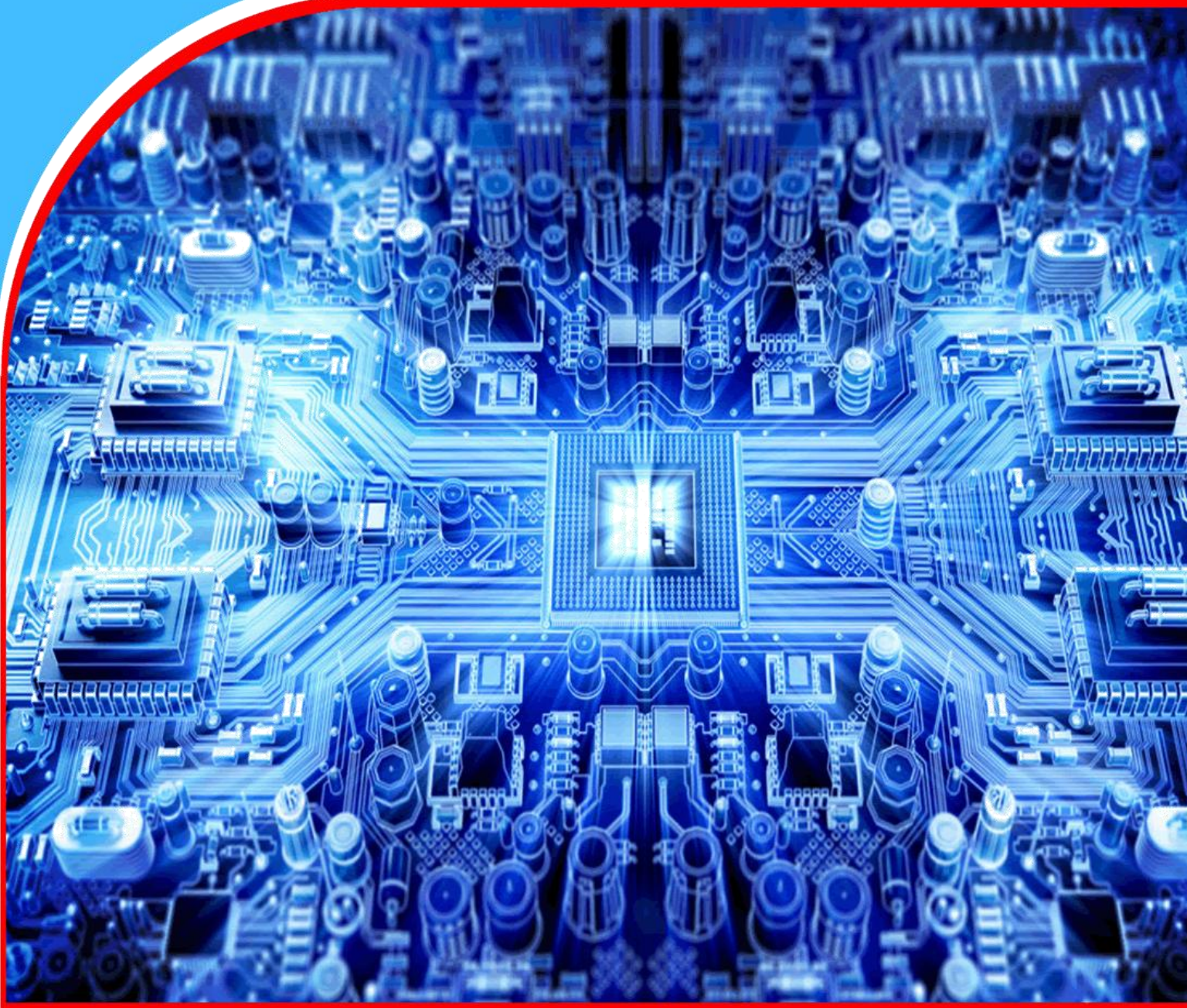
American Journal of
Computing and Engineering
(AJCE)



Optimising Product Enhancements Strategic Approaches to Managing Complexity

Chethan Sriharsha Moore, Suneel Babu Boppana, Varun Bodepudi, Krishna Madhav Jha, Srinivasa Rao Maka, Gangadhar Sadaram

American Journal of Computing and Engineering
ISSN 2790-5586 (Online)
Vol.4, Issue 2, pp 52 – 72, 2021

www.ajpojournals.org

Optimising Product Enhancements Strategic Approaches to Managing Complexity

Chethan Sriharsha Moore[1*], Suneel Babu Boppana[2], Varun Bodepudi[3], Krishna Madhav Jha[4], Srinivasa Rao Maka[5], Gangadhar Sadaram[6]

[1]Impetus Technologies, Sr Software Engineer
[2]iSite Technologies, Project Manager
[3]Applab Systems Inc, Computer Programmer
[4]Topbuild Corp, Sr Business Analyst
[5]North Star Group Inc, Software Engineer
[6]Bank of America, DevOps/ OpenShift Admin Engineer

Article history

Submitted 12.10.2021 Revised Version Received 07.11.2021 Accepted 03.12.2021

ABSTRACT

Purpose: This paper examines the strategic importance of product enhancements in competitive global markets. This research addresses the dual characteristics of product enhancement strategies by examining their incremental and transformational aspects. This research explores challenges because product development complexity increases due to advancing technology and pressing stakeholder needs along with reducing product lifespan durations.

Materials and Methods: The paper takes a conceptual approach, analyzing complexities in product development and reviewing tools such as Agile methodologies, PLM systems, modular design, and additive manufacturing. The study investigates customer insights alongside market trend analysis while exploring advanced technologies to tackle these challenges in the delivery sector.

Findings: Enhancements drive competitiveness, but complexities arise from rapid technology changes and demands. Tools like Agile and modular design improve processes, while customer insights foster innovation. Recommendations: Adopt Agile and PLM tools, leverage modular design, use customer feedback, and invest in sustainable, technology-driven solutions to balance innovation with efficiency.

Keywords*: Product Enhancement, Managing Complexity, Product Development, Agile methodologies, Product strategy*

American Journal of Computing and Engineering
ISSN 2790-5586 (Online)
Vol.4, Issue 2, pp 52 – 72, 2021

INTRODUCTION

Today's cutthroat global markets and ever-increasing change, more so in the current centralised economy, product improvements cannot be termed as mere by products but rather as a major strategic imperative for any firm. Ongoing enhancement of product attributes, their functions and effectiveness help to meet customer needs and expectations, maintain product market standing and respond to new opportunities. However, the process of optimisation of products is becoming more complicated because of integration of the modern initiatory technologies, multifaceted demands of stakeholders, and the reduced product cycle.

This highlights the complexity is not only a technical challenge but also a significant operational and managerial issue in the product development (PD) process. Every stage in a product's life cycle design, development, and implementation introduces new sources of supply chain dependency, amplifying complexity[1]. If left unmanaged, these factors appear as increased costs, extended schedules, decreased employee throughput, and possible quality issues in the product. To overcome these difficulties, managers should use tactical management techniques that accommodate the requirement for innovation and the necessity for reasonable complexity control.

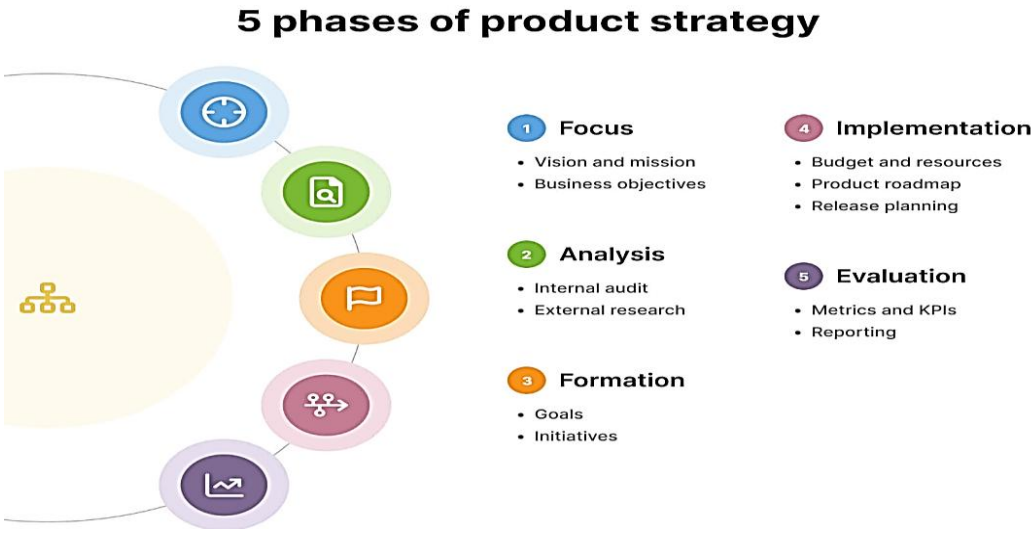


Figure 1 Five Phases of Product Strategy

Strategic frameworks are essential in navigating these challenges. For instance, frameworks like Agile, Lean and others, together with other practices like business intelligence, can be very beneficial for product development. AI digital twin and simulation technologies represent additional approaches through which complications can be handled effectively while optimization performance improves. These approaches help firms to create a match between product strategies and business goals and objectives, control risks, and increase productivity[2].

A. Artificial Intelligence (AI) in Product Enhancement

The following areas are help to product enhancement with artificial intelligence technology:

- Predictive Analytics: Through analysis of broad datasets AI enables accurate predictions about forthcoming market dynamics and user interactions and product challenges [3]. The process generates better quality decisions regarding product feature development along with improvements. Recommendation engines driven by AI technology use user responses and historical learning to design products whose features evolve in sync with market requirements.

- Automated Design Optimization: AI system automation carries out repetitive design procedures including material selection and design validation while producing multiple design solution options. The integration of AI in design tasks lowers human mistakes while speeding up design durations and enhancing product modeling precision[4]. Activities Outside Commercial Settings demonstrate how AI-driven generative design tools assist engineers at Autodesk and other organizations to optimize products for automotive and aerospace applications.
- AI in Quality Control: AI systems operate in real time to find deviations and detect manufacturing process defects in a constantly active monitoring system. Continuous quality control procedure improvement is enabled by machine learning algorithms which ensures products meet higher consistency standards[5]. BMW along with Tesla implements AI-based quality assurance systems at their manufacturing lines both to boost product quality standards and reduce production errors.

B. Digital Twins in Product Enhancement

The following areas are help to product enhancement with artificial intelligence technology:

- Real-Time Monitoring and Simulation: The technology of Digital Twin creates virtual duplicates that mirror physical products and process elements and systems. Through digital twins businesses can replicate real-world functioning and track product performance all through the lifecycle [6]. The system enables producers to find data-driven solutions that enable them to foresee possible issues or containment areas. Digital twins from General Electric (GE) track turbine operation in real-time which helps maintain optimal performance while blocking costly equipment breakdowns.
- Predictive Maintenance: The integration of Digital Twins helps organizations make performance predictions about products and systems using current operational data combined with accumulated historical information. The envisioned benefits extend to safety-critical sectors such as aerospace and automotive because product failure consequences become significant[7]v. The aircraft engine maintenance predictions of Rolls-Royce benefit from Digital Twin technology which optimizes operational efficiency by minimizing downtime.
- Product Lifecycle Management (PLM): Through the integration of Digital Twin technology with PLM systems companies track their products through their entire lifecycle while maintaining operational performance alignment throughout[8]. Product design benefits from ongoing feedback loops and refinements made possible by integration between these databases throughout the product lifecycle.

The integration of these technologies allows organizations to handle rising product development complexities allowing them to deliver innovative competitive products. Together AI systems and Digital Twins create a full portrait of product development activities to help companies improve their planning and operational flow and product reliability.

The review paper explores optimal product design practices and complexity minimization strategies based on general knowledge, prior research, and effective practices from diverse fields. It aims to present a clear model for how firms can design and enhance their offerings while navigating the complex development processes of the twenty-first century[9]. The theoretical part of the paper outlines the concept of complexity in product development, reviews strategies for addressing it, and overviews tools and techniques for improving product optimisation.

i. Motivation of the Study

Thus, it is clear that the continual increase in product differentiation and proliferation of technological features in products now in the market and issues of consumer satisfaction call for effective, innovative strategies. Thus, the purpose of this research is to identify such best practices in the enhancement logic for complex products that will allow the organisation to grow sustainably within the current complex and competitive environment.

ii. Structure of the Paper

The paper is structured as follows: Section II explains product enhancements, including their types and challenges. Section III addresses managing complexity in product development, covering dimensions, sources, and frameworks. Section IV explores tools and techniques for optimising product development, such as agile methodologies and PLM tools. Section V outlines strategic approaches, focusing on customer needs, market trends, and leveraging technology. Important conclusions and areas for further study are presented in Section VI.

Understanding Product Enhancements

The practice of significantly enhancing a product to raise its value, usefulness, or functionality for end customers is known as "product enhancement." That's the tactic companies use to hold on to current clients, draw in new ones, and maintain market dominance [10]. Improving products has been around since the beginning of trade. Businesses realized that they needed to constantly be innovating and improving their products and services, especially in the face of heightened competition and market shifts [11]. Product improvement has been a common practice in companies around the globe as a result of the rapid speed of technological advancement and digital product sales.

The following are essential parts of a better product

- Feature Additions: Enhancing the product with more features. For example, smartphones have continuously added features like video calling to keep up with the demand for more versatile communication tools.
- Usability Improvements: Clarifying the product's interface for easier use. Microsoft Word, for instance, underwent a major usability improvement with the introduction of the Ribbon interface, which organized tools more clearly compared to the older, text-based menu system, making it much easier for users to find and use various features.
- Performance Optimisation: Improving the product's dependability, efficiency, or speed [12]. Tesla, for example, uses over-the-air software updates to enhance vehicle performance, enabling improvements in things like battery efficiency or autopilot capabilities without the need for users to visit a service center.
- Design Upgrades: Enhancing the visual appeal and usability of the product. The MacBook Pro is a prime example, where the introduction of a sleeker design and the Retina Display provided not only a more attractive look but also a higher-quality viewing experience.

Types of Enhancements: Incremental vs. Transformational

Product enhancements can be broadly categorised into two types: incremental and transformational (also known as radical) innovations. To ensure that product development is on target and strategic planning is sound there is need to establish the differences between these two methods [13].

1. Incremental Enhancements

When it comes to incremental changes these are incremental changes, making a product, process or service slightly better than before. These changes are to increase effectiveness, productivity or customer satisfaction but are not likely to cause a shift in the basic roles or structure of the product. Such innovations are often characterized by:

- Continuous Improvement: Applying continuous minor adjustments that, when accumulated, produce marked improvements in efficiency in the long run. These are minor adjustments applied regularly, which, over time, lead to significant improvements in efficiency and effectiveness. For example, a smartphone brand improving its battery life or camera quality in each new model.
- Lower Risk: Because change is gradual and based on existing products and services, it is often accompanied by less risk than radical innovations [14]. Since the changes are gradual and based on existing products or services, incremental enhancements typically come with lower risk compared to radical innovations. For instance, car manufacturers making improvements in fuel efficiency or safety features with each model year.
- Resource Efficiency: Usually, incremental innovations involve less expenditure, due to which SMEs can accommodate these innovations. For example, the literature reveals that growth and survival in SMEs depend on incremental innovations [15]. Incremental innovations generally involve lower expenditures and are more resource-efficient. Small and medium-sized enterprises (SMEs) often find it easier to implement these types of innovations.

Real-World Example: Apple's annual updates to its iPhone models often include incremental changes such as improved cameras, faster processors, and better battery life without drastically changing the phone's overall design.

2. Transformational Enhancements

Radical improvements include innovations that make the product distinct or dramatically modify it, which brings out a completely distinct product or a drastically different product. These innovations often lead to the development of new markets or the disruption of existing ones and are characterised by

- High Impact: Transformational innovations can significantly alter the market, customer expectations, and business operations. For instance, the introduction of the first iPhone created a completely new market for smartphones, revolutionizing how we communicate, work, and entertain ourselves.
- Increased Risk and Reward: They are normally associated with higher risks given their ideas and concepts are new to the market, but in equal measure, they come with the advantage of high returns [16]. Because these innovations involve new, untested ideas or concepts, they often come with higher risks. However, if successful, they yield high returns. The launch of Tesla's electric vehicles is an example of a transformational product that revolutionized the automobile industry, despite significant risks and challenges involved in the development.
- Resource Intensiveness: Radical innovations typically require considerable investment in research and development, which can be costly. Companies investing in transformational enhancements often face high upfront costs but stand to reap substantial rewards if the innovation succeeds. A prime example is the development of the first

electric vehicle by Tesla, which required significant investment in technology, infrastructure, and brand positioning.

Real-World Example: The advent of cloud computing represents a transformational enhancement in IT infrastructure. Companies like Amazon Web Services (AWS) and Microsoft Azure completely transformed how businesses store and manage data, replacing traditional on-premise servers with scalable cloud solutions.

Strategic Considerations

The type of innovation that is desirable depends on a number of factors, which include the organizational objectives, the external environment, and the resources available to the firm. Some key considerations include

- **Market Position:** The incumbent firms, hence, may adopt more incremental innovations in order to defend their position in the market, while entrants may introduce radical innovations to the market. Market entrants create game-changing ideas to seize market share, while incumbent businesses focus on incremental enhancements to lower manufacturing costs, according to product evolution research.
- **Organisational Culture:** Risk-taking is more associated with transformational enhancements compared to cultures which embrace creative inputs [17].
- **Customer Needs:** Knowing whether customers are willing to receive incremental innovations or novelty products and services is critical for innovation management [18].

In conclusion, both incremental and transformational enhancements play vital roles in product development. A balanced approach tailored to the organization's context and market environment can lead to sustained success and competitiveness.

Key Challenges in Product Enhancement Strategies

The identification of sound product improvement solutions is critical for organizations that wish to remain relevant and respond to ever-changing consumer needs. However, several key challenges can impede the successful implementation of these strategies;

i. **High Failure Rates and Associated Costs:** Improving or initiating products is high-risk since the success and failure rate ranges from 40% to 80%. Such costs are significant; to launch a new product into the market could cost roughly about $15 million. It is therefore clear why market research plays a very significant role when it comes to managing risks that may lead to enormous losses [19].

ii. **Resource Constraints:** Small businesses have constrained resources of capital, manpower and information technology infrastructure that challenge their product development processes. Efficient use of these scarce resources is crucial to survive the challenges arising from product improvement [20].

iii. **Market Saturation and Competition:** Some of the problems associated with the maturity stage include market stagnation and competition from other players. Mingling growth during this phase calls for special strategies to maintain market competitiveness and profitability.

iv. **Organizational and Process Integration*:*** Product improvements require intense cooperation between different functional teams and should follow a specific process. Some risks are in relation to teaming, including recognising different teams, gaining top management support, and creating a sustainable environment for innovation [21].

v. **Technological and Market Uncertainties:** This has major challenges especially when there is ambiguity on the feasibility of the technology and the market. Agreeing that these uncertainties are inevitable, establishing a sound new product development framework that blends agility and design thinking is useful.

vi. **Software Product Management Complexities**: The software industry presents particular issues like new technologies' introduction, new customer demands, and frequent product modification. Managing complexities of software products therefore requires subscribing to effective software product management practices [22].

Managing Complexity In Product Development

Product development is not a single step process but a series of activities which involve conception, design, modeling, testing and making of the product. As used here, the term complexity is defined as a state wherein a number of factors are involved and are mutually dependent on each other within the design, utility of the product and market acceptability[23]. Appreciation of complexity is useful for managing challenges and ensuring that complex products which are competitive and innovative are developed[24]. The key dimensions of product development complexity are as follows:

Dimensions of Complexity in Product Development

- Technical Complexity: Complexity of product formations, additions of new sophisticated technologies, and its ability to interface or replace other systems[25]. For example, Tesla faces significant technical complexity as it integrates cutting-edge technologies into its electric vehicles (EVs), such as advanced battery systems, autopilot features, and AI-based driving capabilities.
- Process Complexity: Involves the coordination of relationships between diverse tasks of product development and distribution. A practical example is Apple, which has successfully streamlined its product development processes across multiple global teams to ensure seamless coordination from design to manufacturing, ultimately delivering products like the iPhone efficiently. Microsoft exemplifies this, with its product development teams working across different time zones and disciplines. Effective collaboration tools and clear communication protocols help mitigate this challenge.
- Organizational Complexity: The management of multiple teams, participants and departments in an organisation where people may work from different geographic regions[26].
- Market Complexity: Fluctuations in the needs of customers, competition, market needs and expectations, and standards that a product needs to meet. Samsung navigates market complexity by continuously adapting its smartphones and consumer electronics to meet changing consumer preferences and technological advancements.

Sources of Complexity

- Customization and Personalization: As consumers demand unique services and products, designs and architectures become more complicated. For example, Nike offers customized sneakers through its Nike By You platform, which requires the company to manage intricate production and design processes to meet individual customer preferences.
- Integration of Emerging Technologies: Integrating any AI, IoT, or any other advanced technology raises the stakes[27]. General Electric (GE), for instance, integrates IoT

sensors into its machinery and equipment to provide predictive maintenance and real-time data analytics, creating complex product ecosystems.

- Regulatory and Compliance Requirements: Policies regarding local and international standardisation can pose some challenges to the advancement in development of the technology[28]. Pharmaceutical companies like Pfizer must adhere to stringent regulations across various markets, which significantly affects their product development timelines and processes.
- Evolving Market Trends: In this process, it has been challenging to meet the pace of the customers and at the same time guarantee the stability of the product. Amazon exemplifies this with its ability to adapt to market trends in e-commerce and logistics, constantly optimizing its systems to meet evolving customer demands.

Challenges Associated with Complexity

- Resource Allocation: Striking the time, cost, and personnel optimisation when it comes to complex issues. For example, Toyota has developed sophisticated lean manufacturing techniques to ensure optimal resource allocation while developing new vehicle models, ensuring high-quality production without overextending resources.
- Communication and Collaboration: Effective communication across various disciplines and specializations [29]. Google manages this challenge by fostering an open culture and using collaborative tools like Google Docs and Hangouts, which enable real-time communication across its global teams.
- Risk of Delays: Interactions between components may indicate complex interdependence, which may block the pipeline and drain fluid from the product's market timetable[30]. For instance, Boeing experienced delays in its 787 Dreamliner project due to complexities in supply chain coordination and integration of various systems. Addressing these complexities through modular design and better integration strategies could have reduced these delays.
- Decision-Making: The measuring of the priority levels of goals and objectives as well as making decisions on the likelihood of achieving different goals and objectives based on a set of criteria such as time, cost and quality[31]. Amazon relies heavily on data-driven decision-making processes, using insights from customer behavior and operational metrics to determine the most effective course of action.

The Need for Complexity Management

- Failure to manage complexity can lead to increased costs, extended time-to-market, and limited market applicability. For instance, Intel faced delays in releasing new semiconductor products due to complexity in its manufacturing process, which caused the company to lose ground to competitors like AMD.
- Understanding is a strong defence against risk because it gives organisations an early clue on possible problems that can be countered using different mitigation measures[32].
- Managing complexity provides organizations with early insights into potential problems, allowing for timely mitigation measures. This helps in creating durable, scalable products aligned with long-term business strategies, preventing costly redesigns and missed market opportunities.

Frameworks for Understanding Complexity

- Systems Thinking: An initial attempt to grasp specific interactions and dependencies of the product as a component of the bigger structure[33]. For example, Tesla's integration of electric powertrains, self-driving technologies, and energy management systems is a clear application of systems thinking.
- Complexity Theory: For example, current theories of emergence, self-organisation and flexibility in complex systems may be used when developing a product[34]. Google's Android operating system is an example of a complex, self-organizing system that has evolved over time, integrating multiple hardware and software components seamlessly.
- Modular Design: Dividing large systems into finer sub-systems to ease the issues of design and production. IKEA employs modular design in its furniture, allowing for easy customization and cost-effective production while catering to various customer needs.

Tools and Techniques for Optimizing Product Development

Product development combines creativity with technical and strategic management. Effective tools and methods enhance competitiveness, meet customer needs, and align with business goals while reducing costs and improving communication.

1) Modular Design for Flexibility and Efficiency

- Flexibility: Simplifies updates and improvements without altering the entire system. For instance, Sony uses modular design in its PlayStation consoles, enabling hardware upgrades and backward compatibility.
- Cost-Efficiency: Reduces development costs by reusing standardized modules. Dell has utilized modular components in its computers for years, reducing production costs and increasing customization options.
- Parallel Development: Allows teams to work on different product aspects simultaneously[35]. For example, BMW uses parallel development processes in designing new car models, ensuring faster and more efficient production cycles.

2) Digital Prototyping and Simulation

- Early Issue Detection: Identifies design flaws before physical production. Ford uses digital prototyping and simulation in vehicle design to detect and resolve issues early, significantly reducing costs and time-to-market.
- Cost Reduction: Minimizes dependency on physical prototypes. Siemens utilizes digital twins and virtual prototypes to simulate industrial processes and reduce physical testing costs.
- Iterative Design: Enables quick refinements and performance testing. Nike leverages digital prototypes for iterative design of footwear, testing different designs virtually before producing physical samples.

3) Agile Methodologies for Iterative Development

- Customer-Centric: Incorporates stakeholder feedback at every stage. Spotify employs agile practices to continuously update and improve its music streaming platform based on user feedback, enhancing customer satisfaction.

- Team Collaboration: Integrates designers, engineers, and marketers. Netflix uses agile development to ensure that cross-functional teams work seamlessly on product improvements.
- Rapid Adaptability: Responds quickly to market and technology changes. Zara, a global fashion retailer, uses agile supply chain management to quickly adapt to changing trends and consumer demands.

4) Product Lifecycle Management (PLM) Tools

- Centralized Data Management: Ensures consistency across teams. Caterpillar uses PLM tools to manage complex data across its product development teams, ensuring design consistency.
- Improved Collaboration: Aligns goals across design, engineering, and manufacturing. Boeing uses PLM software to collaborate between teams working on different aspects of aircraft design and production.
- Workflow Optimization: Tracks progress and mitigates delays. Siemens integrates PLM with workflow management tools to optimize its manufacturing processes and avoid delays.

5) Additive Manufacturing for Rapid Prototyping

- Speed and Agility: Enables quick validation of designs[36]. Lockheed Martin uses additive manufacturing to create rapid prototypes of aerospace components, enabling quick validation of designs before mass production.
- Cost-Effective Iteration: Eliminates the need for moulds or tools. General Electric has adopted additive manufacturing for turbine parts, which reduces costs and enhances efficiency in product iterations.
- Customization: Facilitates complex, tailored designs. Stratasys provides customized 3D printing solutions to industries like healthcare, where tailored prosthetics are created rapidly using additive manufacturing.

By employing modular design strategies, these companies can effectively manage market complexity and remain competitive while offering customizable solutions that meet the ever-changing needs of their customers.

Strategic Approaches To Product Enhancements

Product improvements are important in retaining market position, increasing consumers' satisfaction, and responding to new requirements. Tactical approaches consider approaches to product improvement in the light of professed customer requirements, technological trends, and business goals[37]. All these strategies focus on how to plan, how to come up with creative solutions, and how to implement meaningful upgrades to help both the business and the users. Figure 2 depicts the product enhancement strategies.

Figure 2 Product Enhancement Strategies

i.Focus on Customer Needs

Positioning the value created by the customer reflects the great importance of identifying customer pains as targets for subsequent product improvements. Customers, for instance, give feedback, conduct surveys and engage on social media platforms where they are informed about some areas that need to be worked on or on new areas of added value. Organizations that consider customers' needs and wants in their processes present solutions that go beyond the expectations of the users, hence making them loyal[38]. It is a practice that engages with customers in order to check their changing needs to ensure that the product meets the current market standards. A notable example is how Amazon continuously enhances its customer experience, incorporating customer feedback through reviews and direct surveys to optimize product features and logistics services. By prioritizing customer needs and expectations, businesses can deliver solutions that exceed user demands, fostering customer loyalty. Regularly engaging with customers ensures that products stay relevant and aligned with evolving market standards.

ii.Analyze Market Trends

Products need to be developed and enhanced based on the activities in the market, hence requiring monitoring of the market events and competitor's activities[39]. Market research helps in getting insights into changing consumer behavior patterns and evolving technologies that enable organizations to begin learning needs when they are not actualized by many people[40]. It also fosters introduction of various features, which help realize product differentiation and leadership in a given sector. With the help of competitor analysis businesses get to know what strategies are effective and what strategies are not to be taken anymore. For instance, Tesla uses market data to innovate and improve its electric vehicle lineup by integrating advanced technologies like autonomous driving and self-charging features, staying ahead of competitors. Competitor analysis reveals effective strategies to emulate and ineffective ones to avoid. These insights foster the introduction of differentiated features, establishing product leadership within specific sectors.

iii.Embrace Agile Development

Using agile methodologies brings a distinct focus and cyclic form of approaches suitable for enhancing product changes in organizations' centers. When development is split into features, teams can introduce, measure, and improve changes within a production environment without much danger. This results in positive feedback cycles that guarantee improvements meet the

customer needs and the current market conditions on each cycle[41][42]. Design and development of improvement is done across organizations where designers, developers, and marketers are some of the functional teams used; this is because the improvement affects various dimensions of the product. Agile development not only facilitates the process of delivering enhancement quickly but also makes it possible for organizations to be flexible in responding to complaints and or new calls[43]. An example of this is Spotify, which frequently releases small, iterative updates to its music streaming platform, based on user feedback, to refine user interfaces and improve features like recommendations. This iterative process ensures that enhancements align with customer needs and market conditions while enabling rapid responses to feedback and emerging demands. Through cross-functional teamwork between designers, developers and marketers Agile development ensures improvements target different dimensions of a product. The methodology allows fast delivery and builds organizational adaptability while speeding up time to market.

iv. Leverage Technology

Applying applied technologies is one of the most important principles of strategic product improvement. Application of artificial intelligence, machine learning and other automation tools allow organizations to control processes, predict customers' behavior and provide new features. Prediction analytics enables businesses to find problem areas where user-focused improvements would generate more appeal. Related to operational optimisation, technology also increases productivity by relieving routine tasks for innovative solutions. Through the participation of innovative solutions, organizations can provide people with unique and valuable functionalities that will help them adapt to the competitive environments of today's world and make the necessary improvements to become associated with innovation and quality. Through machine learning algorithms Netflix delivers customized content suggestions that build user satisfaction as well as viewing engagement. Artificial intelligence systems that perform predictive analytics help organizations detect areas which need improvement and developing trends to make relevant updates which users will appreciate. Machine learning technologies break down customer behaviors to suggest customized product choices and automated procedures optimize business operations by releasing personnel for innovative work. Leveraging these technologies positions organizations as innovation leaders and allows them to adapt swiftly to competitive environments.

Literature Review

Table I summarises previous studies on strategic approaches and tools for optimising product enhancements and managing complexity in various domains, as discussed below:

In, Li and Lau (2018) analysed the issues with the present "new" product development process in manufacturing sectors and investigated how a four-step smart product development strategy may enhance the safety of toy products any further. There are several stages to the new product development process that various manufacturing companies use while making consumer goods. There is already an integration of IT with smart-related elements in Industry 4.0 to increase transparency and productivity, but the safety of toy products is only evaluated during the new product development phase[44].

In, Cui, Chan and Calantone (2014) research shows that a company's prior knowledge can have a dual impact: increasing its capacity to profit from fresh information and decreasing its incentive to learn. Compared to companies that depend either too little or too much on existing knowledge, those that use a reasonable amount of current knowledge gain more from new information. The "learning zone" describes this ideal situation. In addition, they discover that

for less unique new items that offer a comparable learning environment, the moderating effects of prior knowledge are more pronounced[45].

In, Rangu, Chatterjee and Valluru (2017) tries to extrapolate useful information from asset evaluations in order to improve asset Text mining, sometimes called text data mining, is a method for discovering relevant and non-trivial information or patterns within text sources. tries to extrapolate useful information from asset evaluations in order to improve asset Text mining, sometimes called text data mining, is a method for discovering relevant and non-trivial information or patterns within text sources. An ever-developing technology, text mining aids businesses in gaining a deep understanding of their consumers and redefining their demands[10].

In, Iyer et al. (2017) they have acquired the reviews for six different phone models by scraping the Amazon website. After cleaning the data, they founded that it contains people's opinions expressed in various ways. Our system will compile product reviews, analyse each word's emotion score, and then decide if the phrase is generally good or negative. They have created a dashboard that allows the consumer to readily see the mobile's individual characteristics. Based on the needs of our users, they have also forecasted comparable items. The charts show how the product's popularity has changed over time. The system's end result will be 1) a review timeline 2) Suggesting Products[46].

In, Xiu and Muro (2017) in the manufacturing sector, analysing faulty manufacturing data is critical for improving product quality. A unique ID issued to each product allows for the retrieval of manufacturing data used in defect investigation. Unfortunately, individual IDs cannot be added to current machining operations in production lines, such as the sintering and cutting procedures. This leads to the issue of not being able to prepare manufacturing data for fault investigation[47- 59].

Table 1 Presents a Summary of Previous Study Based on Product Enhancements Strategic Approaches to Managing Complexity

References	Objectives	Key Findings	Challenges	Limitations	Future Work
[44]	Improve toy product safety through smart product development approach.	Smart-related aspects of Industry 4.0 improve productivity but lack emphasis on toy product safety.	Limited integration of toy safety assessment in Industry 4.0 processes.	Focuses only on toy product safety without addressing broader applications.	Broaden the smart development approach to other manufacturing sectors.
[45]	Examine the effects of existing knowledge on firm's ability to leverage new information.	Moderate use of existing knowledge provides optimal benefit, termed the "learning zone."	Balancing the use of existing knowledge to avoid learning inhibition.	Stronger effects observed in products of lower novelty; limited to specific contexts.	Expand studies to explore learning zones in high-novelty products.
[10]	Enhance asset management using text mining for extracting valuable patterns from text.	Text mining aids in understanding customer needs and redefining their requirements.	Transforming unstructured text into structured data for analysis.	Dependency on advanced algorithms and tools for accurate text mining.	Develop more robust NLP techniques for broader text mining applications.
[46]	Analyse product reviews and sentiment for better recommendations and insights.	Sentiment analysis can predict product popularity and recommend similar items effectively.	Scraping, cleaning, and analysing diverse sentiment data accurately.	Relies on customer reviews, which may not represent all user perspectives.	Incorporate more features for product review analysis and sentiment prediction.
[47]	Analyse defect manufacturing data to improve product quality.	Existing machining processes limit defect data analysis due to lack of individual IDs.	Lack of individual product identifiers in certain manufacturing processes.	Cannot analyse defect data for processes without individual product identifiers.	Innovate methods to assign unique identifiers in all manufacturing processes.

i. Research Gaps and Direction

The reviewed studies highlight diverse strategic approaches and tools for optimizing product enhancements and managing complexity across various industries. In the manufacturing sector, smart product development strategies have been shown to enhance productivity but often lack focus on integrating safety measures during the development process. Organizations need to

close these gaps to achieve comprehensive innovation processes. New technological capabilities in text mining combined with sentiment analysis hold promise to extract deep product development insights from unorganized data sources that include customer review content. The effectiveness of these methods relies on complex algorithms and advanced tools but their precise accuracy suffers when working with subpar data resources. Quality improvement in manufacturing depends on analyzing defect data. Complex production environments create barriers for today's systems to assign dedicated identifiers to products which prevents them from tracking and resolving defects efficiently.

The research provides insightful information about strategic methods and operational tools yet fails to bridge the gaps around comprehensive implementation of safety, innovation and quality in product development sequences. Current frameworks restrict universal application because they concentrate on individual industries and technological areas. The present research aims to fill this gap by proposing a comprehensive approach that combines advanced tools, such as modular design and predictive analytics, with strategies to balance innovation and efficiency. The comprehensive framework optimizes product creation at all levels of industry operations making products adaptable to emerging obstacles and technological innovations. Future investigations should research enhanced prediction analytics together with AI-based choice processes along with real-time data cohesion to achieve increased product improvement efficiency and adaptability. Further research must focus on exploring new tracking techniques for product quality throughout production and the modular exploration of innovation versus cost-effectiveness balance.

CONCLUSION AND RECOMMENDATIONS

Conclusion

Product enhancements serve as fundamental elements that preserve market competitiveness together with customer satisfaction under changing market conditions. Firms can optimize processes and reduce risks by adopting strategic approaches along with Agile methodologies and modular design and emerging technological tools during complex product development projects. Organizations can sustain steady growth by combining incremental and transformational innovation approaches to manage resource constraints and market saturation and technological uncertainties. Through effective inclusion of customer input alongside market data businesses guarantee their products stay appropriate with their organization's goals.

The findings of the analyzed studies deliver concrete information which decision-makers across different sectors can turn into measurable actions. Our focus on safety in smart product development will make organizations guide their design phases toward quality and regulatory compliance which defines current safety standards. Prior knowledge research demonstrates how practitioners should use "learning zone" strategies to create innovative learning opportunities. Through their text mining applications for customer insights companies can enhance product design while delivering better satisfaction rates to their consumers. Sentiment analysis systems provide businesses with market trend insight tools to develop better marketing strategies. Research into defect analysis demonstrates the importance of better traceability systems which drives organizations to develop improved manufacturing quality through technological innovation and policy initiatives. These combined research findings create the groundwork to implement data-driven approaches integrated with customer orientation and sustainability in real-world innovation initiatives.

Recommendations

Future research should explore the integration of AI and machine learning to enhance product optimisation, particularly in predictive analytics and real-time complexity management. Additionally, studies should focus on developing cost-effective frameworks for leveraging emerging technologies like digital twins and additive manufacturing. There is also a need for cross-industry collaboration to establish standardised practices for managing complexity in product development. Lastly, the sustainability of product enhancements should be examined, ensuring that innovation aligns with environmental and societal goals.

REFERENCES

[1] A. S. Hosseini, S. Soltani, and M. Mehdizadeh, "Competitive advantage and its impact on new product development strategy (Case study: Toos Nirro technical firm)," *J. Open Innov. Technol. Mark. Complex.*, 2018, doi: 10.3390/joitmc4020017.

[2] E. P. Garina, V. P. Kuznetsov, N. S. Andryashina, E. V. Romanovskaya, and S. N. Kuznetsova, "Exploring alternative strategies for managing the complexity of a product," in *Lecture Notes in Networks and Systems*, 2019. doi: 10.1007/978-3-030-00102-5_78.

[3] J. F. Hair, "Knowledge creation in marketing: The role of predictive analytics," *Eur. Bus. Rev.*, 2007, doi: 10.1108/09555340710760134.

[4] M. Möller and C. Vuik, "A conceptual framework for quantum accelerated automated design optimization," *Microprocess. Microsyst.*, 2019, doi: 10.1016/j.micpro.2019.02.009.

[5] T. Wang, Y. Chen, M. Qiao, and H. Snoussi, "A fast and robust convolutional neural network-based defect detection model in product quality control," *Int. J. Adv. Manuf. Technol.*, 2018, doi: 10.1007/s00170-017-0882-0.

[6] A. Sanglub, P. Nilsook, and P. Wannapiroon, "Imagineering on augmented reality and digital twin for digital competence," *Int. J. Inf. Educ. Technol.*, 2019, doi: 10.18178/ijiet.2019.9.3.1201.

[7] P. Aivaliotis, K. Georgoulias, and G. Chryssolouris, "The use of Digital Twin for predictive maintenance in manufacturing," *Int. J. Comput. Integr. Manuf.*, 2019, doi: 10.1080/0951192X.2019.1686173.

[8] Y. Tchana, G. Ducellier, and S. Remy, "Designing a unique Digital Twin for linear infrastructures lifecycle management," in *Procedia CIRP*, 2019. doi: 10.1016/j.procir.2019.04.176.

[9] V. Krishnan and K. T. Ulrich, "Product development decisions: A review of the literature," 2001. doi: 10.1287/mnsc.47.1.1.10668.

[10] C. Rangu, S. Chatterjee, and S. R. Valluru, "Text mining approach for product quality enhancement: (Improving product quality through machine learning)," in *Proceedings - 7th IEEE International Advanced Computing Conference, IACC 2017*, 2017. doi: 10.1109/IACC.2017.0100.

[11] V. V. Kumar and F. T. S. Chan, "A superiority search and optimisation algorithm to solve RFID and an environmental factor embedded closed loop logistics model," *Int. J. Prod. Res.*, 2011, doi: 10.1080/00207543.2010.503201.

[12] V. V. Kumar, F. W. Liou, S. N. Balakrishnan, and V. Kumar, "Economical impact of RFID implementation in remanufacturing: a Chaos-based Interactive Artificial Bee Colony approach," *J. Intell. Manuf.*, 2015, doi: 10.1007/s10845-013-0836-9.

[13] A. Azmi, N. A. Ahmad, L. K. Yiew, and Z. Abdul-Malek, "The use of enhancement material in grounding system: A review," 2019. doi: 10.11591/ijeecs.v13.i2.pp453-460.

[14] V. V. Kumar, M. K. Pandey, M. K. Tiwari, and D. Ben-Arieh, "Simultaneous optimization of parts and operations sequences in SSMS: A chaos embedded Taguchi particle swarm optimization approach," *J. Intell. Manuf.*, 2010, doi: 10.1007/s10845-008-0175-4.

[15] B. Li and L. Huang, "The Effect of Incremental Innovation and Disruptive Innovation on the Sustainable Development of Manufacturing in China," *Sage Open*, vol. 9, no. 1, Jan. 2019, doi: 10.1177/2158244019832700.

[16] V. V Kumar, M. Tripathi, M. K. Pandey, and M. K. Tiwari, "Physical programming and conjoint analysis-based redundancy allocation in multistate systems: A Taguchi embedded algorithm selection and control (TAS&C) approach," *Proc. Inst. Mech. Eng. Part O J. Risk Reliab.*, vol. 223, no. 3, pp. 215–232, Sep. 2009, doi: 10.1243/1748006XJRR210.

[17] C. Davis and Y. Tomoda, "Competing incremental and breakthrough innovation in a model of product evolution," *J. Econ. Zeitschrift fur Natl.*, 2018, doi: 10.1007/s00712-017-0568-y.

[18] V. V. Kumar, S. R. Yadav, F. W. Liou, and S. N. Balakrishnan, "A digital interface for the part designers and the fixture designers for a reconfigurable assembly system," *Math. Probl. Eng.*, 2013, doi: 10.1155/2013/943702.

[19] M. G. Luchs, K. S. Swan, and M. E. H. Creusen, "Perspective: A Review of Marketing Research on Product Design with Directions for Future Research," in *Journal of Product Innovation Management*, 2016. doi: 10.1111/jpim.12276.

[20] V. V. Kumar, F. T. S. Chan, N. Mishra, and V. Kumar, "Environmental integrated closed loop logistics model: An artificial bee colony approach," in *SCMIS 2010 - Proceedings of 2010 8th International Conference on Supply Chain Management and Information Systems: Logistics Systems and Engineering*, 2010.

[21] V. V. Kumar, A. Sahoo, and F. W. Liou, "Cyber-enabled product lifecycle management: A multi-agent framework," in *Procedia Manufacturing*, 2019. doi: 10.1016/j.promfg.2020.01.247.

[22] V. V Kumar, M. Tripathi, S. K. Tyagi, S. K. Shukla, and M. K. Tiwari, "An integrated real time optimization approach (IRTO) for physical programming based redundancy allocation problem," *Proc. 3rd Int. Conf. Reliab. Saf. ...*, no. August, 2007.

[23] V. Kumar, V. V. Kumar, N. Mishra, F. T. S. Chan, and B. Gnanasekar, "Warranty failure analysis in service supply Chain a multi-agent framework," in *SCMIS 2010 - Proceedings of 2010 8th International Conference on Supply Chain Management and Information Systems: Logistics Systems and Engineering*, 2010.

[24] A. Trattner, L. Hvam, C. Forza, and Z. N. L. Herbert-Hansen, "Product complexity and operational performance: A systematic literature review," 2019. doi: 10.1016/j.cirpj.2019.02.001.

[25] V. V Kumar, "An interactive product development model in remanufacturing environment : a chaos-based artificial bee colony approach," *Spring*, 2014, [Online]. Available: https://scholarsmine.mst.edu/cgi/viewcontent.cgi?article=8243&context=masters_theses

[26] J. R. San Cristóbal, L. Carral, E. Diaz, J. A. Fraguela, and G. Iglesias, "Complexity and project management: A general overview," 2018. doi: 10.1155/2018/4891286.

[27] M. Danilovic and T. R. Browning, "Managing complex product development projects with design structure matrices and domain mapping matrices," *Int. J. Proj. Manag.*, 2007, doi: 10.1016/j.ijproman.2006.11.003.

[28] M. R. Kishore Mullangi, Vamsi Krishna Yarlagadda, Niravkumar Dhameliya, "Integrating AI and Reciprocal Symmetry in Financial Management: A Pathway to Enhanced Decision-Making," *Int. J. Reciprocal Symmetry Theor. Phys.*, vol. 5, no. 1, pp. 42–52, 2018.

[29] S. K. R. A. Sai Charan Reddy Vennapusa, Takudzwa Fadziso, Dipakkumar Kanubhai Sachani, Vamsi Krishna Yarlagadda, "Cryptocurrency-Based Loyalty Programs for Enhanced Customer Engagement," *Technol. Manag. Rev.*, vol. 3, no. 1, pp. 46–62, 2018.

[30] I. Gorzeń-Mitka and M. Okręglicka, "Managing Complexity: A Discussion of Current Strategies and Approaches," *Procedia Econ. Financ.*, 2015, doi: 10.1016/s2212-5671(15)01018-7.

[31] V. K. Y. Mohamed Ali Shajahan, Nicholas Richardson, Niravkumar Dhameliya, Bhavik Patel, Sunil Kumar Reddy Anumandla, "AUTOSAR Classic vs. AUTOSAR Adaptive: A Comparative Analysis in Stack Development," *Eng. Int.*, vol. 7, no. 2, pp. 161–178, 2019.

[32] W. Vogel and R. Lasch, "Complexity drivers in manufacturing companies: a literature review," 2016. doi: 10.1007/s12159-016-0152-9.

[33] V. K. Y. Nicholas Richardson, Rajani Pydipalli, Sai Sirisha Maddula, Sunil Kumar Reddy Anumandla, "Role-Based Access Control in SAS Programming: Enhancing Security and Authorization," *Int. J. Reciprocal Symmetry Theor. Phys.*, vol. 6, no. 1, pp. 31–42, 2019.

[34] J. KIM and D. WILEMON, "COMPLEXITY AND THE MULTIPLE IMPACTS ON NEW PRODUCT DEVELOPMENT: RESULTS FROM A FIELD STUDY," *Int. J. Innov. Technol. Manag.*, vol. 09, no. 06, p. 1250043, Dec. 2012, doi: 10.1142/S0219877012500435.

[35] J. Kim and D. Wilemon, "An empirical investigation of complexity and its management in new product development," *Technol. Anal. Strateg. Manag.*, 2009, doi: 10.1080/09537320902819296.

[36] D. Olausson and C. Berggren, "Managing uncertain, complex product development in high-tech firms: In search of controlled flexibility," *R D Manag.*, 2010, doi: 10.1111/j.1467-9310.2010.00609.x.

[37] K. Sultan, S. Akram, S. Abdulhaliq, D. Jamal, and R. Saleem, "A Strategic Approach to the Consumer Perception of Brand on the Basis of Brand Awareness and Brand Loyalty," *Int. J. Res. Bus. Soc. Sci. (2147- 4478)*, 2019, doi: 10.20525/ijrbs.v8i3.259.

[38] C. S. Katsikeas, C. N. Leonidou, and A. Zeriti, "Eco-friendly product development strategy: antecedents, outcomes, and contingent effects," *J. Acad. Mark. Sci.*, 2016, doi: 10.1007/s11747-015-0470-5.

[39] M. Kodama, "Developing strategic innovation in large corporations The dynamic capability view of the firm," *Knowl. Process Manag.*, 2017, doi: 10.1002/kpm.1554.

[40] M. Z. Hasan, R. Fink, M. R. Suyambu, and M. K. Baskaran, "Assessment and improvement of intelligent controllers for elevator energy efficiency," in *IEEE International Conference on Electro Information Technology*, 2012. doi: 10.1109/EIT.2012.6220727.

[41] Y. H. Percival Zhang, M. E. Himmel, and J. R. Mielenz, "Outlook for cellulase improvement: Screening and selection strategies," 2006. doi: 10.1016/j.biotechadv.2006.03.003.

[42] M. Z. Hasan, R. Fink, M. R. Suyambu, and M. K. Baskaran, "Assessment and improvement of elevator controllers for energy efficiency," in *Digest of Technical Papers - IEEE International Conference on Consumer Electronics*, 2012. doi: 10.1109/ISCE.2012.6241747.

[43] M. Z. Hasan, R. Fink, M. R. Suyambu, M. K. Baskaran, D. James, and J. Gamboa, "Performance evaluation of energy efficient intelligent elevator controllers," in *IEEE International Conference on Electro Information Technology*, 2015. doi: 10.1109/EIT.2015.7293320.

[44] C. H. Li and H. K. Lau, "Toy product safety enhancement using smart product development," in *ISPCE-CN 2018 - IEEE International Symposium on Product Compliance Engineering - Asia*, 2018. doi: 10.1109/ISPCE-CN.2018.8805755.

[45] A. S. Cui, K. Chan, and R. Calantone, "The Learning Zone in New Product Development," *IEEE Trans. Eng. Manag.*, vol. 61, no. 4, pp. 690–701, Nov. 2014, doi: 10.1109/TEM.2014.2331757.

[46] R. Iyer, R. Mandrekar, A. Aggarwal, P. Chaphekar, and G. Bhatia, "RecoMob: Opinion mining for product enhancement," in *2017 International Conference on Computer Communication and Informatics, ICCCI 2017*, 2017. doi: 10.1109/ICCCI.2017.8117687.

[47] Q. Xiu and K. Muro, "Robust inference traceability technology for product quality enhancement," in *IEEE International Conference on Industrial Engineering and Engineering Management*, 2017. doi: 10.1109/IEEM.2017.8290181.

[48] Sarisa, M., Boddapati, V. N., Patra, G. K., Kuraku, C., Konkimalla, S., & Rajaram, S. K. (2020). An Effective Predicting E-Commerce Sales & Management System Based on Machine Learning Methods. *Journal of Artificial Intelligence and Big Data*, *1*(1), 75–85.

[49] Gollangi, H. K., Bauskar, S. R., Madhavaram, C. R., Galla, E. P., Sunkara, J. R., & Reddy, M. S. (2020). Exploring AI Algorithms for Cancer Classification and Prediction Using Electronic Health Records. *Journal of Artificial Intelligence and Big Data*, *1*(1), 65–74. Retrieved from

[50] Manikanth Sarisa, Venkata Nagesh Boddapati, Gagan Kumar Patra, Chandrababu Kuraku, Siddharth Konkimalla, Shravan Kumar Rajaram.Navigating the Complexities of Cyber Threats, Sentiment, and Health with AI/ML. (2020). *JOURNAL OF RECENT TRENDS IN COMPUTER SCIENCE AND ENGINEERING (JRTCSE)*, *8*(2), 22-40. https://doi.org/10.70589/JRTCSE.2020.2.3

[51] Gollangi, H. K., Bauskar, S. R., Madhavaram, C. R., Galla, E. P., Sunkara, J. R., & Reddy, M. S. (2020). Unveiling the Hidden Patterns: AI-Driven Innovations in Image Processing and Acoustic Signal Detection. (2020). *JOURNAL OF RECENT TRENDS IN COMPUTER SCIENCE AND ENGINEERING (JRTCSE)*, *8*(1), 25-45. https://doi.org/10.70589/JRTCSE.2020.1.3.

[52] Hemanth Kumar Gollangi, Sanjay Ramdas Bauskar, Chandrakanth Rao Madhavaram, Eswar Prasad Galla, Janardhana Rao Sunkara and Mohit Surender Reddy.(2020). "Echoes in Pixels: The intersection of Image Processing and Sound detection through the lens of AI and Ml", International Journal of Development Research. 10,(08),39735-39743. https://doi.org/10.37118/ijdr.28839.28.2020.

[53] Manikanth Sarisa, Venkata Nagesh Boddapati, Gagan Kumar Patra, Chandrababu Kuraku, Siddharth Konkimalla and Shravan Kumar Rajaram. "The power of sentiment: big data analytics meets machine learning for emotional insights", International Journal of Development Research, 10, (10), 41565-41573. https://doi.org/10.37118/ijdr.28840.10.2020

[54] Mohit Surender Reddy, Manikanth Sarisa, Siddharth Konkimalla, Sanjay Ramdas Bauskar, Hemanth Kumar Gollangi, Eswar Prasad Galla, Shravan Kumar Rajaram, 2021. "Predicting tomorrow's Ailments: How AI/ML Is Transforming Disease Forecasting", ESP Journal of Engineering & Technology Advancements, 1(2): 188-200.

[55] K. Gollangi, S. R. Bauskar, C. R. Madhavaram, P. Galla, J. R. Sunkara, and M. S. Reddy, "ECHOES IN PIXELS: THE INTERSECTION OF IMAGE PROCESSING AND SOUND OPEN ACCESS ECHOES IN PIXELS: THE INTERSECTION OF IMAGE PROCESSING AND SOUND DETECTION," Int. J. Dev. Res., vol. 10, no. 08, pp. 39735–39743, 2020, doi: 10.37118/ijdr.28839.28.2020.

[56] Gollangi, H. K., Bauskar, S. R., Madhavaram, C. R., Galla, E. P., Sunkara, J. R., & Reddy, M. S. (2020). Unveiling the Hidden Patterns: AI-Driven Innovations in Image Processing and Acoustic Signal Detection. (2020). JOURNAL OF RECENT TRENDS IN COMPUTER SCIENCE AND ENGINEERING (JRTCSE), 8(1), 25- 45. https://doi.org/10.70589/JRTCSE.2020.1.3.

[57] Gollangi, H. K., Bauskar, S. R., Madhavaram, C. R., Galla, E. P., Sunkara, J. R., & Reddy, M. S. (2020). Exploring AI Algorithms for Cancer Classification and Prediction Using Electronic Health Records. Journal of Artificial Intelligence and Big Data, 1(1), 65–74. Retrieved from https://www.scipublications.com/journal/index.php/jaibd/article/view/1109

[58] Gagan Kumar Patra, Shravan Kumar Rajaram, & Venkata Nagesh Boddapati. (2019). Ai And Big Data In Digital Payments: A Comprehensive Model For Secure Biometric Authentication. *Educational Administration: Theory and Practice*, *25*(4), 773–781. https://doi.org/10.53555/kuey.v25i4.7591

[59] Chandrababu Kuraku, Hemanth Kumar Gollangi, & Janardhana Rao Sunkara. (2020). Biometric Authentication In Digital Payments: Utilizing AI And Big Data For Real-Time Security And Efficiency. *Educational Administration: Theory and Practice*, *26*(4), 954–964. https://doi.org/10.53555/kuey.v26i4.7590