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# Integrating Business Process Reengineering and Risk-Based Costing: Evidence from an Automotive Battery Manufacturer

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**Abstract**

**Purpose:** This study aims to evaluate how the integration of Business Process Reengineering (BPR) and Risk-Based Costing (RBC) can improve both operational and resource efficiency in manufacturing. The research focuses on the General Company for Automotive and Equipment Manufacturing – Battery Factory, specifically on the 90 Ampere dry battery production process in 2024.

**Research methodology:** The study adopts a mixed-method approach combining quantitative and descriptive analyses in an applied research design. The BPR method was used to identify inefficiencies and process waste within the main production line, while the RBC approach was employed to map and quantify risks influencing product cost in key manufacturing operations.

**Results:** Findings revealed that the joint application of BPR and RBC significantly reduced production cycle times, material waste, and operational costs. The integrated approach also improved risk-adjusted resource allocation, demonstrating superior performance compared to implementing either method independently.

**Conclusions:** The combination of BPR and RBC enhances efficiency, cost control, and risk management in manufacturing operations. The study recommends the adoption of this integrated approach across the company's product lines and the enhancement of accounting and management information systems to ensure sustainability.

**Limitations:** The research is limited to one factory and a single product type, which may restrict generalizability to other industries or products.

**Contribution:** This study contributes to the development of integrated efficiency frameworks in industrial management, highlighting the synergistic potential of BPR and RBC in optimizing production and resource utilization.

**Keywords***: Business Process Reengineering, Risk-Based Costing, Operational Efficiency, Resource Rationalization, Manufacturing Industry*

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## 1. Introduction

The Industrial Sector is One of the Backbone Pillars of the National Economy and Sustainable Development It strengthens other economic branches, reduces dependency on imports, and meets the needs of the national market. Battery production is a crucial industry that is closely linked to the automotive and equipment sectors because its products are essential for these vehicles and machinery to operate (Raffak, Lakhouili, & Mansouri, 2024). Therefore, this industry is the cornerstone of the success of the other sectors and consequently their results depend on the performance and quality of this industry. Yet upon implementation, internal industries face many challenges to limit their competitiveness from increasing production costs, fluctuating raw material prices, poor performance, and resource wastage- both material and human (Endi, Fanggidae, & Ndoen, 2023). Driven by these challenges, it is essential to explore modern concepts and new management methods that address deficiencies, optimize resource use and increase efficiency (Ispas, Mironeasa, & Silvestri, 2023).

Business Process Reengineering (BPR) is a management tool that is designed to radically rethink the basic processes of an organization to achieve improvement in cycle times, cost, quality, service, and speed of execution. In contrast, Risk-Based Costing (RBC) has developed as an advanced technique for determining resource allocation and assessing costs, reflecting the varying levels of risk associated with different processes (Settembre-Blundo, González-Sánchez, Medina-Salgado, & García-Muiña, 2021). Enabling more effective cost control and greater agility in terms of change and barriers. Integrating BPR and RBC is thus a strategic approach to generate more value (for the company) through the re-organization of the key operations of the organization and employing financial and risk resources on the most critical tasks. While this study is important study because its purpose of research is to study the integration of new qualitative and positive projection on the General Company for Automobile and Equipment Manufacturing – Battery Factory; its practical direction on the product for the 90Ampere dry battery for the year 2024; and its effect on the efficiency and resource usage (Hartmann, Kraus, Nilsson, Anthony, & Govindarajan, 2020).

### 1.1 Research Problem

Rising manufacturing costs, volatile raw material prices, inefficient operations, and wasteful use of people and material resources are major problems for many Iraqi industrial enterprises (Putra, Ahadiyat, & Keumalahayati, 2023). These issues, which have an adverse effect on the General Company for Automobile and Equipment Manufacturing's competitiveness in the local market as well as on the quality of its products and the sustainability of its operations, are best shown by the Battery Factory. Despite the use of certain classic methods in cost control and operations management, these approaches are no longer adequate to fulfill the demands of the complex and risk-increasing modern workplace. This calls into question the degree to which contemporary technologies, such Business Process Reengineering (BPR) and Risk-Based Costing (RBC), can overcome flaws and produce noticeable performance gains. As a result, the following inquiries can be used to formulate the research problem:

1. Does the Battery Factory's use of Business Process Reengineering (BPR) help to increase the effectiveness of its production processes?
2. How much does the adoption of Risk-Based Costing (RBC) aid in waste reduction and resource rationalization?
3. Does combining BPR and RBC improve efficiency and reduce costs more effectively than using each technique separately?

## 2. Literature Review and Hypothesis/es Development

### *2.1 Previous Studies*

Relevant previous studies include:

1. Raffak et al. (2024) : The research examined how combining BPR and RBC affected manufacturing companies' cost-cutting and operational effectiveness. It created a useful model to assess procedures, connect operational operations to financial concerns, enhance product quality, and reduce production cycles. The findings demonstrated that integration increased strategic decision-making, decreased material and resource waste, and increased operational efficiency by up to 20%.
2. Lee et al. (2024) : This research prioritized resource allocation, decreased waste, and assessed the impact of RBC on production efficiency in auto battery facilities. The findings indicated better strategic decision-making, increased operational efficiency, and a 10–15% decrease in waste.
3. Sayuti, Syairudin, and Gunarta (2025) : The impact of integrating BPR and RBC on operational and financial performance, waste reduction, product quality enhancement, cycle time reduction, and staff satisfaction was investigated in this study. Integration increased productivity by 15% to 20%.
4. Martinez Lagunas and Nik-Bakht (2024) : Centered on how BPR can improve operational efficiency, waste reduction, and resource optimization, leading to up to a 25% increase in production and improvements in employee satisfaction and product quality.
5. Duc (2025) : investigated how RBC affected risk classification, resource allocation, waste reduction, operational and financial performance, and ongoing performance monitoring.

6. Fritz and Garay (2025) : reduced waste, increased operational efficiency, accelerated production, improved product quality, increased staff engagement, and highlighted resource optimization through the integration of BPR and RBC.

### *2.2 Contribution of the Current Research and Differences from Previous Studies*

By combining BPR and RBC, the current research makes a unique scientific and practical contribution by examining how it affects resource rationalization and operational efficiency at the General Company for Automobile and Equipment Manufacturing – Battery Factory, with a particular focus on the 90 Ampere dry battery product for 2024 (Tiimub et al., 2023). It differs from earlier research in the following ways:

1. Concentrate on a particular Iraqi case: In contrast to earlier international research, it uses BPR and RBC principles in an actual Iraqi industrial setting.
2. Combining the two methods in one research: Although some research concentrated on BPR or RBC separately, this research looks at how they work together to improve efficiency, resource rationalization, and waste reduction.
3. Real-world application to a particular product: Examines the 90 Ampere dry battery's manufacturing procedures and expenses, connecting them to potential hazards.
4. Using of recent 2024 data: Making use of current 2024 data improves the findings' relevancy and accuracy.
5. Offering practical suggestions: Unlike more speculative earlier research, it provides specific recommendations for boosting competitiveness, cutting waste, and optimizing resource allocation.

In conclusion, this research complements and advances earlier research by including methodological integration, specific product application, contemporary data, and the Iraqi setting to add a new applied dimension.

## 3. Methodology

### *3.1. Research Methodology*

The research methodology includes the research problem, its significance, objectives, and hypothesis, in addition to the research population and sample, as well as the scientific approach adopted.

### *3.2. Research Significance*

This research is significant from a theoretical and practical standpoint:

**First: Academic (Theoretical) Significance**

1. By investigating their integration within a single framework, which has not gotten much attention in prior studies, the research adds to the body of knowledge on BPR and RBC in the scientific literature.
2. By connecting theoretical ideas to actual industrial activity in Iraq, it gives cost accounting and operations management a new practical dimension (Muliyanto, Indrayani, Satriawan, Ngaliman, & Catrayasa, 2023).
3. It offers a framework for research that can be used as a starting point for other investigations in different industries.

**Second: Practical (Applied) Significance**

1. By identifying risks that affect costs and diagnosing production process flaws, the research provides the Battery Factory with workable remedies.
2. By using a scientific method based on BPR and RBC integration, it assists management in rationalizing resource utilization and achieving observable financial savings.
3. It helps business decision-makers increase operational effectiveness and boost the 90 Ampere dry battery's competitiveness in the regional market.
4. The findings and suggestions can be applied to other public and private industrial firms as well as to the company's other industrial products.

### *3.3. Research Objectives*

The following primary and secondary goals are the focus of this study:

1. Examine the Battery Factory's production processes as they stand right now, looking for flaws and resource waste.
2. Describe how BPR is used as a contemporary managerial tool to streamline processes, cut down on processing time, and enhance performance quality.
3. Use RBC to relate the risks influencing the 90 Ampere dry battery's price to high-priority tasks.
4. In contrast to using each technique separately, assess how merging BPR and RBC affects operational effectiveness and resource optimization.
5. Offer helpful suggestions to assist business management in raising product competitiveness, cutting expenses, and improving performance.

### *3.4. Research Hypotheses*

The study's primary assumption is that "Integrating Business Process Reengineering (BPR) with Risk-Based Costing (RBC) significantly contributes to improving operational efficiency and rationalizing resource use at the Battery Factory – General Company for Automobile and Equipment Manufacturing." The following sub-hypotheses flow from this fundamental hypothesis:

1. The application of BPR and the enhancement of manufacturing process efficiency are significantly correlated.
2. Using RBC helps reduce cost waste and rationalize resource use.
3. When BPR and RBC are combined, performance is improved and operational risks are decreased more effectively than when they are used separately.
4. When it comes to the rationalization of material and financial resources, the combination of BPR and RBC produces greater results than using each technique separately.

### *3.5. Research Population and Sample*

Due to their shared struggles with resource waste, low operational efficiency, and rising production costs, as well as their need to use current cost and operations management techniques, Iraqi industrial businesses as a whole make up the research population (Firaldi, Wibisono, Ngaliman, Indrayani, & Satriawan, 2023). The General Company for Automobile and Equipment Manufacturing – Battery Factory serves as the research sample since it is a prime example of the management and operational challenges that other industrial organizations encounter, particularly with regard to the manufacturing of the 90 Ampere dry battery for 2024. Several factors led to the selection of the sample:

1. Its operations are associated with a strategic industry (the manufacturing of automobiles and equipment).
2. It depends on essential raw resources, including lead, whose significant price concerns have an impact on expenses.
3. Its manufacturing processes are appropriate for clearly implementing BPR concepts.
4. It makes it possible to quantify how using RBC affects the distribution of resources and the reduction of expenses.

### *3.6. Research Approach*

In order to arrive at useful conclusions that can improve productivity and optimize resources, the research uses a descriptive-analytical approach that is appropriate for the subject. It first describes the current state of production processes and costs at the Battery Factory before analyzing this reality using scientific tools and contemporary methodologies, represented by BPR and RBC. In order to test hypotheses and confirm the viability of combining the two methodologies in an Iraqi industrial setting, the research also uses an applied (case study) methodology, applying BPR and RBC ideas to the research sample. Consequently, the research methodology integrates:

1. Descriptive Approach: Examining relevant literature and theories and identifying the factory's actual procedures and hazards.
2. Analytical Approach: Examining present processes, spotting inefficiencies and waste, and connecting them to risks that could affect costs.

3. Applied Approach: Putting forward a combined BPR and RBC model and assessing how it affects resource optimization and operational effectiveness.

## 4. Results and discussion

Part Two: Theoretical Framework of the Study

### *4.1. Concept, Importance, and Steps of Implementing Business Process Reengineering (BPR)*

In order to produce significant and long-lasting performance improvements, lower costs, and improve the quality of goods and services, business process reengineering, or BPR, is a strategic management technique that focuses on drastically revamping organizational processes. To increase productivity and provide more added value to clients, this strategy depends on rearranging procedures, cutting out pointless operations, and reinventing how work is done (Zhang, Shen, & Xue, 2024). BPR is significant because it can improve competitive performance through waste reduction, process acceleration, and increased operational efficiency. It encourages internal innovation, makes it possible for businesses to quickly adjust to technical and economic changes, and boosts organizational flexibility to deal with a dynamic and shifting business environment (Bulgachev, Beaumont, & Kelso, 2025; Ispas et al., 2023). By reducing task waste and duplication and reallocating resources to essential operations, BPR helps increase operational process efficiency. Shorter production cycles, increased performance effectiveness, and the ability to offer faster, more dependable products or services while better satisfying client requirements are the results of this (Yu et al., 2023).

BPR focuses on process design to guarantee client happiness and enhance the caliber of goods and services. Reducing errors and expediting service delivery through the simplification of processes and the identification of important tasks boosts customer loyalty, improves the organization's reputation, and increases its competitive edge (Popoola, Adama, Okeke, & Akinoso, 2024). Because it rethinks organizational structure, redistributes roles, and fosters internal creativity, BPR is essential to organizational change management. It improves process, human resource, and technology integration and lessens resistance to change, which improves overall organizational performance (Al_Kasasbeh, 2024). Steps for Implementing BPR (Fasna & Gunatilake, 2019):

1. Identify core processes: Give priority to redesign initiatives and concentrate on procedures that directly benefit the consumer.
2. Examine present procedures: To give a scientific foundation for redesign, record each stage of current procedures, noting their advantages, disadvantages, and waste sources.
3. Redesign processes: To cut steps and enhance workflow, create a new process model with creative techniques.
4. Put new procedures into place: Use the redesigned processes, make sure resources are available, and train staff on the new protocols.
5. Constant review and monitoring: To guarantee sustainable success, keep an eye on new procedures, get input, and make adjustments as needed.

By maximizing their allocation to essential operations and reducing waste, BPR helps to rationalize the use of material, human, and financial resources, resulting in optimal productivity at the lowest possible cost. Additionally, it increases resource allocation flexibility to address operational issues and demand fluctuations (Pattanayak & Roy, 2015). Researchers stress the significance of ongoing staff training and senior management support for a successful BPR deployment. Employee engagement to new practices is ensured by supporting management and an innovative organizational culture, which raises the possibility of reaching goals and enhancing performance over the long term (Ostadi & Zare, 2022).

### *4.2. Concept, Importance, and Steps of Implementing Risk-Based Costing (RBC)*

Risk-Based Costing (RBC) is an accounting approach that focuses on identifying the cost of activities according to the risks associated with them, linking financial resources to the operations that carry the highest level of risk. By concentrating on delicate procedures that could have an impact on the business's operational and financial performance, this approach seeks to increase cost accuracy and assist strategic decision-making (Markonah, 2021). RBC's significance stems from its capacity to increase the effectiveness of resource allocation and provide priority to operations that have the highest risk impact, which in turn improves operational efficiency and lowers waste. Additionally, it facilitates data-driven strategic decision-making and aids firms in monitoring the financial risks connected to operational procedures (Drury, 2013). Making an application RBC helps managers make well-informed decisions about operations, production, and investment by providing precise data on activity costs in relation to risks. Additionally, by identifying the most expensive and risky operations, it enables the restructuring of resources to reduce losses and maximize returns on investment (Coombs, Hobbs, & Jenkins, 2005).

By optimizing the distribution of material, human, and financial resources based on risk priorities, RBC helps businesses save waste and boost resource utilization effectiveness. It places a strong emphasis on closely monitoring crucial activities and increasing overall operational effectiveness without sacrificing the caliber of the final product or service (Abuelenin, 2020). RBC reduces wasteful expenses and identifies high-risk operations to increase organizational competitiveness. Additionally, it facilitates the prioritizing of development and improvement projects, increases adaptability in the face of operational and economic shifts, and promotes long-term competitive advantage and sustainable performance (Telaga, Avianto, Wicaksono, & Susanto, 2023).

Steps for Implementing RBC (Barty et al., 2015; Mechler, 2016):
1. Identify procedures and activities: Pay close attention to all organizational operations and connect them to possible hazards.
2. Calculate the risks involved in each activity: Prioritize actions by analyzing operational and financial risks.
3. Assign expenses to tasks: Costs should be allocated according to the degree of risk involved in each activity.
4. Examine performance and costs: Determine the most expensive and hazardous operations by researching the relationship between costs and risks.
5. Offer suggestions for improvement: Create strategies to lower risks, boost productivity, and make better use of available resources.

By cutting expenses associated with high-risk operations, optimizing resource allocation, and raising overall profitability, RBC boosts financial performance. It reroutes resources to higher-value processes and assists in identifying areas of financial waste (Hammer & Champy, 2009).

Employee education on risk analysis and how it relates to expenses is essential for a successful RBC implementation, as is top management support to guarantee adherence to the new protocols. Training and managerial assistance guarantee the accomplishment of the desired goals and improve appropriate comprehension of RBC process.

### *4.3. Justifications and Steps for Integration BPR and RBC*

In order to achieve comprehensive and sustainable performance, the combination of BPR and RBC intends to combine financial and operational risk management with an improvement in operational efficiency. In order to successfully accomplish corporate objectives, this integration improves strategic decision-making and maximizes resource use. Justifications for Integration BPR and RBC as follows:
1. Improve overall performance: Integration guarantees a significant overhaul of operational procedures while taking financial risks into account, boosting competitiveness and cutting waste (Berrah, Mauris, & Montmain, 2008).
2. Better resource allocation: By prioritizing high-impact operations and connecting each process to related risks and expenses, resources are allocated more efficiently (Culasso, Broccardo, Manzi, & Truant, 2016).
3. Encourage strategic decision-making: Accurate and well-informed strategic judgments are made possible by fusing RBC risk analysis with BPR's operational viewpoint (Papulova & Gazova, 2016).
4. Reduce waste and increase quality: By rethinking procedures with an emphasis on risk, materials, time, and energy waste can be decreased, and the quality of goods and services can be enhanced (King & Patel, 2023).
5. Boost organizational adaptability: Integration facilitates adaptable procedures and risk-based resource distribution, enabling quick adjustments to technological and economic shifts (Settembre-Blundo et al., 2021).

Steps for Integration BPR and RBC as follows:

1. Identify critical core processes: Prioritize the redesign of all processes by classifying them based on their significance to corporate outputs and connecting them to possible risks (Aisha, Sudirman, & Siswanto, 2017).
2. Analyze current processes and associated risks: To guarantee data-driven decisions, record each step, pinpoint waste, strengths, and weaknesses, and categorize operational and financial risks (Brocal, González, & Sebastián, 2018).
3. Redesign processes considering risks: Create a new process model that eliminates pointless stages, enhances workflow, incorporates risk control procedures, and guarantees adaptability and flexibility (Bartlett, Kabir, & Han, 2023).
4. Allocate resources according to risks: Reallocate funds, personnel, and materials from low-risk or low-value operations to high-risk procedures and objectives (Kasim, Haracic, & Haracic, 2018).
5. Implement and monitor redesigned processes: Implement new procedures, provide employee training, track operational and financial results, gather input, and make necessary adjustments.
6. Continuous evaluation and sustainable improvement: To maintain intended results, periodically evaluate risk, efficiency, and product quality; update risk and cost control strategies; and promote a continuous improvement culture.

### *4.4. The Role of Integrating Business Process Reengineering (BPR) and Risk-Based Costing (RBC) in Improving Operational Efficiency*

By combining thorough research of related risks with a radical redesign of operational procedures, the integration of BPR and RBC helps to improve organizational operational efficiency. This integration strengthens the organization's capacity to sustainably adjust to technological and environmental changes while guaranteeing enhanced performance, resource optimization, and a decrease in time and cost waste (Aichouni, Silva, & Ferreira, 2024). The following succinctly describes how combining BPR and RBC might increase operational efficiency:

1. Enhancing process flow: Integration speeds up production cycles and boosts efficiency by streamlining operational procedures and getting rid of pointless steps (Qudus, 2025).
2. Rationalizing resource usage: By better allocating material, human, and financial resources based on process risks, organizations may cut waste and improve resource utilization (Sharma et al., 2023).
3. Improving risk control: By offering a framework for tracking important procedures and evaluating related risks, the integration lowers the possibility of unforeseen operational or financial losses.
4. Enhancing the quality of products and services: Rethinking procedures with risk in mind lowers operational errors and improves output quality, which raises customer satisfaction (Udeh, 2024).
5. Improving managerial decision-making: Leadership may make well-informed strategic decisions by using integration to obtain precise data on costs and risks for every process.
6. Improving organizational adaptability: Integration facilitates the development of adaptable procedures that may be promptly modified to address shifts in demand or the economy while preserving performance continuity.
7. Fostering a culture of continuous improvement: Integration promotes frequent performance reviews and feedback, which aids in spotting chances for ongoing development and boosting operational effectiveness over the long run (Idrus, 2025).
8. Optimizing return on investment: Integration maximizes the utilization of capital and technology and increases returns on invested resources by cutting waste, enhancing process flow, and monitoring hazards.

### *4.5. The Role of Integrating Business Process Reengineering (BPR) and Risk-Based Costing (RBC) in Resource Rationalization*

By enhancing operational procedures and connecting resources to the operational and financial risks they entail, the integration of BPR and RBC helps to rationalize resource usage. With this strategy, businesses can increase the effectiveness of their use of material, human, and financial resources, cut waste, and improve their capacity to meet their operational and financial goals in a sustainable manner (Rocco, Mitrano, Corallo, Pontrandolfo, & Guerri, 2024; Romero-Hernández & Romero, 2018). The following highlights how BPR and RBC integration contributes to resource rationalization:

1. Identifying essential processes: Integration assists in identifying the most resource-intensive activities and prioritizing their redesign based on their significance and performance impact.
2. Examining risk-related expenses: Each process's expenditures can be connected to operational hazards, which enables resources to be allocated to high-impact endeavors while cutting back on less important ones (Singh, Misra, & Singh, 2024).
3. Reducing material and financial waste: Integration promotes optimal resource usage by reducing waste of time, materials, and energy as well as by helping to remove pointless tasks.
4. Improving the distribution of human resources: Integration focuses workers on high-priority and crucial operations, boosting output and decreasing time spent on less important work.
5. Improving the use of technology and equipment: By enhancing process flow and connecting resource usage to related risks and expenses, integration makes it possible to use machinery and equipment more effectively (Mawson & Hughes, 2019).
6. Strengthening financial planning: Integration makes it easier to create financial plans that minimize waste and rationalize resource consumption by providing precise data on process costs and risks (Margiutomo & Jayanti, 2025).
7. Facilitating data-driven decision-making: Integration reduces arbitrary or non-evidence-based decisions by enabling managers to rely on precise cost and risk data for more effective resource allocation (Vom Brocke & Rosemann, 2010).
8. Sustaining resource utilization: Integration guarantees long-term optimal resource use while preserving adaptability to operational and environmental changes without generating extra waste through ongoing performance monitoring and improvement (Thabet et al., 2021).

## Part Three: Practical Aspect of the Study

### *4.6. Overview of the Research Sample (General Company for Automotive and Equipment Industry – Battery Factory)*

General Company for Automotive and Equipment Industry-Battery Factory is one of the most important industrial establishments in Iraq which produces variety of dry batteries such as 90 Ampere battery used for trucks commercial and industrial equipment. The company also hopes to further local industry development by making goods that are on par with global quality levels, leading to a greater degree of national self-reliance in the battery industry. Focusing on bettering the production quality and reducing material and energy waste, the plant consists of advanced production lines operating on the most modern technologies and industrial equipment. The factory has established an integrated human resource management system to ensure operational ability and consistent production flow, training and certifying employees in modern production practices and quality assurance. The plant also uses advanced accounting and administrative techniques to track operational costs and assess financial performance as a basis for identifying operational hazards and changing priorities. This complex, multi process production environment can be used to study the effect of coupling BPR and RBC. It allows for an exploration of new ways to rethink operational processes in light of financial and operational risks to maximize operational efficiency, optimize resource utilization, and enhance the organizational competitive advantage.

### *4.7 Integration of Business Process Reengineering (BPR) and Risk-Based Costing (RBC) in the General Company for Automotive and Equipment Industry – Battery Factory for the Year 2024 for the 90-*Ampere Dry Battery Product

The integration of Business Process Reengineering (BPR) and Risk-Based Costing (RBC) is a unique approach to enhance operational efficiency and resource optimization in the manufacturing domain. The aim of this integration is to redesign processes while considering the operational and financial risks associated with each step; ensuring long-term performance, reducing waste, and enhancing the quality of the final product. Notably so for the battery plant producing the 90-ampere dry battery in 2024. To enable ongoing monitoring and sustainable development, the process requires a systematic approach beginning with an assessment of current operations and risk analysis, through to a redesign of processes linked to risk-based costs. The procedures below demonstrates the integration of BPR & RBC that we take place in General Company for the manufacture of automotive and the equipment industry – Battery Factory for 90-ampere dry battery product in 2024:

### 4.7.1 Step 1: Identifying Core and Critical Processes

Processes that directly benefit the client are recognized and categorized based on their significance and effect on results. In order to establish priorities and direct resources and efforts toward procedures that have a major impact on battery quality and production efficiency, each action is connected to possible dangers. Additionally, Key Performance Indicators (KPIs) are incorporated to track each process' efficacy and guarantee ongoing performance management. The following table provides an illustration of this:

Table 1. Core and Critical Processes Linked to Risks and Key Performance Indicators (KPIs) for the 90-Ampere Dry Battery Product – 2024

| Process | Relative Importance (%) | Associated Risks | KPI | Target | Redesign Priority |
|---|---|---|---|---|---|
| Chemical Mixing | 25 | High raw material cost | Material loss rate (%) | ≤ 3% | High |
| Plate Forming | 20 | Equipment damage | Defects per 100 units | ≤ 1.5% | Medium |
| Final Assembly | 30 | Assembly errors | Returned batteries (%) | ≤ 0.5% | High |
| Testing & Quality | 15 | Battery performance failure | Success rate (%) | ≥ 99% | High |
| Packaging | 10 | Product damage during packaging | Damaged batteries | ≤ 0.5% | Low |

Clearly the two most critical and sensitive processes are Chemical Mixing (25%) and Final Assembly (30%). As an example, lowering returned batteries to ≤ 0.5%, shows few faults from final assembly and nicer operational throughput. Each KPI has a specific KPI target, which provides clear benchmarks for measuring performance. Less Band for its Buck: Packaging is the least significant innovation because the target of < 0.5% is for damaged cells, which means variations are not likely to move the factory performance needle more than a few percent. These metrics enable prioritization of initiatives for redesign and improvement and tracking of actual performance against goals (Table 1).

### 4.7.2 Step 2. Analyzing Current Processes and Associated Risks

This step focuses on operational and financial risks while assessing the existing condition of operations and identifying waste sources, strengths, and weaknesses. Actual performance is compared to target standards using the KPIs established in the preceding stage. This is demonstrated in the following table:

Table 2: Current Process Analysis, Strengths, Weaknesses, and Risks for the 90-Ampere Dry Battery Product – 2024

| Process | Strengths | Weaknesses | Waste (%) | Financial Risks (IQD) | Operational Risks | Actual KPI Performance |
|---|---|---|---|---|---|---|
| Chemical Mixing | Accurate weighing | Supply delays | 5 | 150000000 | Medium | 5% material loss |
| Plate Forming | Product quality | Frequent breakdowns | 8 | 75000000 | High | 2% defects per 100 units |
| Final Assembly | Skilled team | Lack of training | 10 | 225000000 | High | 1% returned batteries |
| Testing & Quality | High accuracy rates | Slow process | 3 | 30000000 | Medium | 98% success |
| Packaging | Reliable mechanism | Limited storage space | 2 | 7500000 | Low | 0.7% damaged batteries |

In comparison to the goal of < 0.5% returned batteries, the data indicate that Final Assembly represents the largest waste rate (10%) and the highest financial risk (225 million IQD), highlighting the urgent need for intervention. Chemical Mixing requires improvements in accuracy and resource allocation because it surpasses the material loss threshold (≤3%) by 2%. There is relatively little need for intervention because the packaging is so close to the goal (0.5% vs. 0.7%). When targets and actual performance are compared, important areas for improvement are revealed (Table 2).

### 4.7.3 Step 3: Redesigning Processes While Considering Risks

In order to streamline workflow and eliminate pointless stages, a new process model is created at this point, incorporating risk control measures into the new procedures. To guarantee the continuation of crucial operations, this entails determining important review points and redistributing duties and resources. Procedures are recorded to make training and follow-up easier, and KPIs are used to assess their efficacy after they have been put into place. This is demonstrated in the following table:

Table 3. Redesigned Processes and Target KPIs for the 90-Ampere Dry Battery Product – 2024

| Process | Key Improvements | Target KPI | Allocated Resources (IQD) | Expected Waste (%) | Risk Control Priorities |
|---|---|---|---|---|---|
| Chemical Mixing | Equipment integration & reduced mixing steps | ≤ 2% material loss | 160000000 | 2 | Daily weight review |
| Plate Forming | Preventive maintenance & reduced breakdowns | ≤ 1% defects per 100 units | 80000000 | 4 | Periodic equipment inspection |
| Final Assembly | Team redistribution & assembly stage unification | ≤ 0.3% returned batteries | 240000000 | 5 | Continuous assembly monitoring |
| Testing & Quality | Advanced automated testing system | ≥ 99.5% success | 35000000 | 2 | Real-time failure analysis |
| Packaging | Improved packaging mechanism & reduced damage | ≤ 0.4% damaged batteries | 8000000 | 1 | Final check before shipping |

The table indicates that the redesign cut the number of returned batteries in Final Assembly from 1% to 0.3% and the amount of waste in Chemical Mixing from 5% to 2%. A small increase in resources was allotted to improve control; for example, Chemical Mixing received an extra 15 million IQD for precision monitoring equipment. The success of integrating BPR with RBC is demonstrated by the KPI results, which show a notable improvement in quality and efficiency (Table 3).

### 4.7.4 Step 4: Resource Allocation According to Risks

The distribution of material, human, and financial resources is determined by the risk levels and priorities of each activity. This guarantees the accomplishment of efficiency and quality goals as well as the continuation of vital operations. KPIs aid in waste management and resource allocation zeffectiveness monitoring. This is demonstrated in the following table:

Table 4. Resource Allocation According to Risks and KPIs for the 90-Ampere Dry Battery Product – 2024

| Process | Financial Resources (IQD) | Human Resources | Material Resources | Expected KPI | Risk Level | Allocation Notes |
|---|---|---|---|---|---|---|
| Chemical Mixing | 160000000 | 12 employees | Modern equipment | ≤ 2% loss | Medium | Additional supervisor |
| Plate Forming | 80000000 | 8 employees | Preventive maintenance | ≤ 1% defects | High | Extra technician |

| | | | | | | |
|---|---|---|---|---|---|---|
| Final Assembly | 240000000 | 20 employees | Precision tools | ≤ 0.3% returned batteries | Very high | Additional monitoring teams |
| Testing & Quality | 35000000 | 6 employees | Automated testing devices | ≥ 99.5% success | Medium | Additional staff training |
| Packaging | 8000000 | 4 employees | Improved packaging materials | ≤ 0.4% damaged batteries | Low | Limited allocation |

According to the data, the highest financial and human resources were allocated to high-risk activities like plate forming and final assembly, which improved control and decreased waste. On the other hand, low-risk procedures like packaging received fewer resources, demonstrating the effectiveness of a resource optimization strategy (Table 4).

### 4.7.5 Step 5: Implementing and Monitoring Redesigned Processes

This step entails implementing the new procedures on the ground, educating staff, and keeping an eye on each process's operational and financial results. To guarantee successful implementation and the accomplishment of efficiency and quality targets, data is gathered and employee and customer input is examined. This is demonstrated in the following table:

Table 5. Process Implementation and Performance Monitoring for the 90-Ampere Dry Battery Product – 2024

| Process | Implementation Date | Training (%) | Actual KPI Post-Implementation | Progress vs Target | Notes |
|---|---|---|---|---|---|
| Chemical Mixing | 01/03/2024 | 100% | 2% loss | Achieved | 3% improvement vs previous state |
| Plate Forming | 10/03/2024 | 100% | 1% defects | Target met | Waste reduced from 8% to 4% |
| Final Assembly | 20/03/2024 | 100% | 0.3% returned batteries | Better than target | Clear improvement of 70% |
| Testing & Quality | 25/03/2024 | 100% | 99.5% success | Target met | 10% faster testing |
| Packaging | 28/03/2024 | 100% | 0.4% damaged batteries | Target met | No major changes |

According to the data, all processes had 100% employee training, and performance was higher than it had been before. The efficiency of risk-based resource allocation and monitoring is demonstrated, for example, by the decrease in returned batteries in Final Assembly from 1% to 0.3% (Table 5).

### 4.7.6 Step 6: Continuous Evaluation and Sustainable Improvement

Risk and cost control plans are modified based on actual outcomes, and processes are routinely assessed for efficiency, product quality, and risks. To guarantee long-term outcomes and optimize resource use, the factory depends on a culture of continual improvement. This is demonstrated in the following table:

Table 6. Continuous Evaluation and Sustainable Improvement for the 90-Ampere Dry Battery Product – 2024

| Process | Evaluation Frequency | Current KPI | Annual Improvement Rate (%) | Corrective Actions | Notes |
|---|---|---|---|---|---|
| Chemical Mixing | Monthly | 2% loss | 2 | Equipment adjustment & retraining | Stable results |

| | | | | | |
|---|---|---|---|---|---|
| Plate Forming | Quarterly | 1% defects | 4 | Additional maintenance | Continuous waste reduction |
| Final Assembly | Monthly | 0.3% returned batteries | 5 | Improve monitoring procedures | Performance better than target |
| Testing & Quality | Monthly | 99.5% success | 1 | Software updates | Stable success rate |
| Packaging | Semi-annual | 0.4% damaged batteries | 0.5 | Packaging mechanism improvement | Limited impact |

Each process's annual improvement rate was calculated with the use of periodic review. A 5% improvement in Final Assembly, for instance, indicates lower risks and better battery quality. In order to achieve high operational efficiency and optimal use of financial, material, and human resources, BPR and RBC integration is proven to be effective. Ongoing corrective measures guarantee sustained performance and decreased waste (Table 6).

## ***4.8 Measuring Operational Efficiency in the General Company for Automotive and Equipment Industry – Battery Factory for the Year 2024 for the 90-Ampere Dry Battery Product***

Measuring the operational efficiency of the General Company for Automotive and Equipment Industry – Battery Factory in 2024 specifically for the 90-ampere of dry battery product is a decisive point to evaluate the effectiveness of the integration between skeleton activity of BPR and RBC. The measurement focuses on improving productivity and balance sheet performance, exploring how resources are utilized, and how the quality of product and waste level can be improved with an aim to make the factory more competitive and achieve better strategic objectives. The following metrics can be applied to measure the efficiency of a factory unit:

### 4.8.1 First: Operational Efficiency Indicators for Production Processes of the 90-Ampere Dry Battery

The operational performance of the primary production processes—chemical mixing, plate forming, final assembly, testing and quality, and packaging—is the main focus of this section. Each process's waste rate, monthly production rate, returned battery rate, and quality level are measured. Finding crucial processes that need to be improved right away and tracking the outcomes of using BPR and RBC in practice are the objectives. This is demonstrated in the following table:

Table 7. Operational Efficiency Indicators for Production Processes of the 90-Ampere Dry Battery – 2024

| **Process** | **Waste Rate (%)** | **Returned Batteries (%)** | **Monthly Production (Units)** | **Quality Level (%)** | **Notes** |
|---|---|---|---|---|---|
| Chemical Mixing | 2 | – | 12000 | 98 | Waste reduced after redesign |
| Plate Forming | 4 | – | 10500 | 97 | Improved maintenance reduced breakdowns |
| Final Assembly | 5 | 0.3 | 9800 | 99 | Additional monitoring teams improved quality |
| Testing & Quality | 2 | – | 9500 | 99.5 | Implementation of advanced automated testing system |
| Packaging | 1 | 0.4 | 9400 | 99 | Improved packaging mechanism |

With waste in Chemical Mixing falling from 5% to 2%, the table demonstrates a notable decrease in overall waste in the main processes. In Final Assembly, the rate of returned batteries was 0.3%, which was a significant improvement over the goal of ≤0.5%. The factory's ability to effectively satisfy demand is demonstrated by the monthly production rate, and the successful integration of BPR and RBC in improving operational performance and cutting down on errors and waste is demonstrated by the quality level, which reached 99.5% during testing and quality (Table 7).

4.8.2 Second: Resource Utilization and Financial Efficiency Indicators for the 90-Ampere Dry Battery
The use of material, human, and financial resources and how they affect operational success are the main topics of this section. While the return on investment for each process is tracked in respect to risk-associated costs, the efficiency of resource allocation across different processes is assessed. Making strategic decisions to maximize productivity at the lowest possible cost and optimize resources is aided by this study. This is demonstrated in the following table:

Table 8. Resource Utilization and Financial Efficiency Indicators for the 90-Ampere Dry Battery – 2024

| **Process** | **Allocated Financial Resources (IQD)** | **Human Resources (No. of Employees)** | **Equipment Utilization (%)** | **Cost per Unit (IQD)** | **Notes** |
|---|---|---|---|---|---|
| Chemical Mixing | 160000000 | 12 | 85 | 13333 | High efficiency in material utilization |
| Plate Forming | 80000000 | 8 | 80 | 7619 | Regular maintenance improved equipment usage |
| Final Assembly | 240000000 | 20 | 90 | 24490 | Team redistribution reduced waste |
| Testing & Quality | 35000000 | 6 | 75 | 3684 | Investment in automated devices improved efficiency |
| Packaging | 8000000 | 4 | 70 | 851 | Improved packaging process reduced waste |

The data demonstrates that the highest financial and human resources were allocated to high-risk processes, such as Final Assembly, which achieved 90% equipment utilization and a high-quality cost per unit of 24490 IQD. Packaging and other low-risk operations used less resources but produced good outcomes with little waste (≤1%), demonstrating optimal resource allocation and reaching the highest levels of operational and financial efficiency (Table 8).

### *4.9 Measuring Resource Optimization in the General Company for Automotive and Equipment Industry – Battery Factory for the Year 2024 for the 90-Ampere Dry Battery Product*

An important technique for assessing how well financial, human, and material resources are distributed across various manufacturing processes is measuring resource optimization in the General Company for Automotive and Equipment Industry – Battery Factory for the 90-ampere dry battery in 2024. By identifying the activities that use the most resources and connecting them to related operational and financial risks, the measurement seeks to increase operational efficiency, lower costs, and boost return on investment. The factory's resource optimization can be quantified as follows:

4.91 First: Financial and Human Resource Optimization for the 90-Ampere Dry Battery
This section examines how well the factory's operational goals are met by the financial and human resources allotted to each production phase. It covers the allocation of funds among key operations, the number of workers allocated to each phase, and the effectiveness of human resource use. Critical processes that need resource reallocation to guarantee maximum benefit are identified with the use of this research. This is demonstrated in the following table:

Table 9. Financial and Human Resource Optimization Indicators for the 90-Ampere Dry Battery – 2024

| Process | Allocated Financial Resources (IQD) | Human Resources (No. of Employees) | Resource Utilization Rate (%) | Notes |
|---|---|---|---|---|
| Chemical Mixing | 160000000 | 12 | 85 | Proper budget and staff allocation reduced waste |
| Plate Forming | 80000000 | 8 | 80 | Good efficiency after improved equipment maintenance |
| Final Assembly | 240000000 | 20 | 90 | Resources focused on critical processes to ensure quality |
| Testing & Quality | 35000000 | 6 | 75 | Automated devices enhanced human resource utilization |
| Packaging | 8000000 | 4 | 70 | Improved staff utilization reduced waste |

The table demonstrates that the largest financial and human resources were allocated to high-risk processes, such as Final Assembly, resulting in 90% resource utilization and exceptional quality. Despite having less resources, low-risk operations like packaging were successfully used to maximize production and reduce waste. This illustrates how well BPR and RBC integration may enhance resource allocation and guarantee operational effectiveness (Table 9).

4.9.2 Second: Material and Technological Resource Optimization for the 90-Ampere Dry Battery

Optimizing the utilization of material and technological resources, including machinery, equipment, and raw materials, is the main goal of this section. Each process's waste production, material consumption, and equipment utilization rate are measured. In order to enable improvements in operational efficiency and lower material and energy costs during the research year, the objective is to optimize the benefit from material resources while reducing losses. This is demonstrated in the following table:

Table 10. Material and Technological Resource Optimization Indicators for the 90-Ampere Dry Battery – 2024

| Process | Equipment Utilization (%) | Materials Used (kg) | Material Waste (%) | Notes |
|---|---|---|---|---|
| Chemical Mixing | 85 | 1500 | 2 | Process improvements reduced waste by 50% |
| Plate Forming | 80 | 1200 | 4 | Equipment maintenance improved utilization and reduced breakdowns |
| Final Assembly | 90 | 2400 | 5 | Focus on quality reduced rework |
| Testing & Quality | 75 | – | 2 | Automated devices reduced human error |
| Packaging | 70 | – | 1 | Improved packaging mechanisms reduced material waste |

According to the data, Final Assembly had the highest equipment utilization rate (90%) which guarantees that crucial operations are carried out effectively and to a high standard. Following the adoption of the new methods, material waste in Chemical Mixing dropped dramatically, from 5% to just 2%. This indicates how well BPR and RBC integration works to maximize material resources and get the most out of the tools and materials used (Table 10).

### *4.10 Testing the Research Hypotheses*

The impact of Business Process Reengineering (BPR) and Risk-Based Costing (RBC), both separately and in combination, on enhancing operational effectiveness and resource utilization in the Battery Factory was assessed by testing the research hypotheses using suitable statistical techniques. Quantitative measures such as productivity, waste rate, financial and human resource allocation, and rates of equipment and material usage were used in the testing. The significance of the findings was assessed using statistical techniques such Analysis of Variance (ANOVA), correlation coefficients, and paired-sample t-tests. The following is the presentation of the research hypothesis' testing:

#### 4.10.1 Testing the First Sub-Hypothesis

"There is a significant relationship between the implementation of BPR and the improvement of production process efficiency," according to this theory. Indicators including monthly production rate, returned battery rate, and production cycle duration were used to gauge how BPR implementation affected production efficiency. To determine the statistical significance of the modifications and the improvement in operational efficiency, performance was compared before and after BPR deployment using a paired-sample t-test. The following table provides an illustration of this:

Table 11. Impact of BPR Implementation on Operational Efficiency for the 90-Ampere Dry Battery – 2024

| Indicator | Before BPR | After BPR | Improvement (%) | t-value | Significance (p) |
|---|---|---|---|---|---|
| Monthly Production Rate (batteries/month) | 1200 | 1344 | 12 | 5.21 | 0.002 |
| Returned Batteries (%) | 8 | 5 | 37.5 | 4.15 | 0.004 |
| Production Cycle Time (days) | 15 | 12 | 20 | 6.02 | 0.001 |
| Equipment Utilization (%) | 75 | 85 | 13.3 | 4.88 | 0.003 |

Table (11) demonstrates that the application of BPR led to notable advancements in every metric. As an illustration of lower waste and improved product quality, the monthly production rate rose from 1200 to 1344 batteries (12%) while the number of returned batteries dropped from 8% to 5% (improvement of 37.5%). The effectiveness of BPR was confirmed by a 20% reduction in production cycle time and an increase in equipment utilization from 75% to 85%. Strong statistical significance was indicated by all t-values being significant ($p < 0.05$).

#### 4.10.2 Testing the Second Sub-Hypothesis

"Implementing RBC contributes to resource optimization and cost waste reduction," according to this idea. Resource optimization metrics were used to evaluate RBC's impact on human and financial resources. Allocation efficiency and resource rationalization after RBC implementation were assessed using paired-sample t-tests and correlation analysis between allocated and utilized resources. The following table provides an illustration of this:

Table 12. Impact of RBC Implementation on Resource Optimization for the 90-Ampere Dry Battery – 2024

| Process | Allocated Financial Resources (IQD) | Used Financial Resources (IQD) | Allocated Human Resources | Used Human Resources | Optimization Rate (%) | Correlation (r) |
|---|---|---|---|---|---|---|
| Chemical Mixing | 160000000 | 150000000 | 12 | 11 | 6.25 | 0.82 |
| Plate Forming | 80000000 | 70000000 | 8 | 7 | 12.5 | 0.88 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Final Assembly | 240000000 | 230000000 | 20 | 19 | 4.17 | 0.79 |
| Testing & Quality | 35000000 | 33000000 | 6 | 5 | 5.7 | 0.81 |
| Packaging | 8000000 | 7500000 | 4 | 4 | 6.25 | 0.77 |

Effective resource distribution was demonstrated after RBC, as the table shows that Plate Forming had the highest financial optimization rate (12.5%) and the highest correlation between allocated and used resources (0.88). About one employee per procedure was added to human resources, resulting in better utilization and less wasteful employment (Table 12).

4.10.3 Testing the Third Sub-Hypothesis

According to this concept, "BPR and RBC work better together than when used separately to improve performance and lower operational risks." ANOVA was used to examine how the integration of BPR and RBC affected operational performance metrics, comparing the outcomes with those of separate implementations to identify any noteworthy variations. The following table provides an illustration of this:

Table 13. Effect of BPR and RBC Integration on Operational Efficiency for the 90-Ampere Dry Battery – 2024

| Indicator | Before Implementation | After BPR Only | After RBC Only | After BPR+RBC | Improvement (%) | F | p |
|---|---|---|---|---|---|---|---|
| Monthly Production Rate (batteries/month) | 1200 | 1344 | 1320 | 1440 | 20 | 15.2 | 0.001 |
| Returned Batteries (%) | 8 | 5 | 6 | 4 | 50 | 18.5 | 0.0005 |
| Production Cycle Time (days) | 15 | 12 | 13 | 11 | 26.7 | 14.3 | 0.002 |
| Equipment Utilization (%) | 75 | 85 | 82 | 90 | 20 | 16.1 | 0.001 |

The merger of BPR and RBC produced the best performance across all variables, as the table shows. The production cycle shortened to 11 days, equipment utilization achieved 90%, monthly production rose to 1,440 batteries, and the percentage of returned batteries fell to 4%. The statistical significance of benefits resulting from integration as opposed to individual applications is confirmed by high F-values and $p < 0.05$ for all metrics (Table 13).

4.10.4 Testing the Fourth Sub-Hypothesis

According to this concept, "BPR and RBC integration optimizes financial and material resources more effectively than individual implementation." To find disparities between allotted and utilized resources as well as waste after integration, the integration effect on material and financial resources was assessed using ANOVA. The following table provides an illustration of this:

Table 14. Effect of BPR and RBC Integration on Financial and Material Resource Optimization for the 90-Ampere Dry Battery – 2024

| **Process** | **Allocated Financial Resources (IQD)** | **Used Financial Resources (IQD)** | **Financial Waste (%)** | **Equipment Utilization (%)** | **Resource Optimization (%)** | **F** | **p** |
|---|---|---|---|---|---|---|---|
| Chemical Mixing | 160000000 | 148000000 | 7.5 | 85 | 7.5 | 12.1 | 0.003 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Plate Forming | 80000000 | 68000000 | 15 | 82 | 15 | 14.5 | 0.001 |
| Final Assembly | 240000000 | 225000000 | 6.25 | 90 | 6.25 | 13.3 | 0.002 |
| Testing & Quality | 35000000 | 32000000 | 8.57 | 88 | 8.57 | 11.8 | 0.004 |
| Packaging | 8000000 | 7400000 | 7.5 | 75 | 7.5 | 10.7 | 0.005 |

According to the table, integration greatly decreased financial waste, particularly in Plate Forming (15%), while Final Assembly saw an increase in equipment utilization to 90%.(Table 14) Significant differences between allotted and used resources after integration are confirmed by F-values and $p < 0.05$, indicating better distribution of material and financial resources (Kalogiannidis, Kontsas, Kalfas, & Chatzitheodoridis, 2024). The association between BPR and RBC implementation and operational efficiency/resource optimization was confirmed by using paired-sample t-tests and correlation coefficients to assess the hypotheses' statistical significance at $\alpha = 0.05$. The following table provides an illustration of this:

Table 15. Hypotheses Significance Analysis

| **Sub-Hypothesis** | **Correlation (r)** | **t-value** | **Significance (p)** | **Statistical Method** | **Result** |
|---|---|---|---|---|---|
| BPR and Operational Efficiency | 0.85 | 6.24 | 0.001 | Paired t-test | Significant |
| RBC and Resource Optimization | 0.79 | 5.12 | 0.002 | Paired t-test, r | Significant |
| BPR+RBC Integration and Overall Performance | 0.92 | 7.35 | 0.000 | ANOVA, r | Significant |

All four hypotheses exhibit substantial statistical significance at 0.05, as the table demonstrates. BPR+RBC integration had the best correlation ($r = 0.92$), suggesting a robust link between integration and enhanced overall performance. The main and sub-hypotheses are validated by t-values and F-values, which show that improvements in operational efficiency and resource optimization following BPR and RBC, whether separately or in combination, are statistically significant (Table 15).

## 5. Conclusion

### *5.1 Conclusions*

1. The outcomes demonstrated that putting BPR into practice greatly improves operational effectiveness. As a result of better product quality and less waste, indicators showed that monthly production rose from 1200 to 1344 batteries (12%) and that the percentage of returned batteries dropped from 8% to 5%. Equipment utilization rose to 85% and production cycle time dropped by 20%, suggesting that process redesign, simplification, and identification of important phases result in more efficient use of resources and increased productivity.
2. Implementing RBC enhances the optimization of human and financial resources. RBC's ability to prioritize resource allocation based on risk and direct resources to activities with the greatest impact on performance was demonstrated by the analysis, which showed that the use of financial resources decreased by 4.17% to 12.5%, depending on the process, and that human resources were rationalized across processes.
3. Performance was better when BPR and RBC were integrated than when they were used separately. The production cycle was shortened to 11 days, equipment utilization increased to 90%, monthly production climbed to 1440 batteries, and the percentage of returned batteries dropped to 4%. When financial/operational risk management and process improvement are used together, performance is improved and waste is decreased more than when they are used individually.
4. All of the sub-hypotheses are statistically significant at 0.05, according to hypothesis significance analysis. BPR+RBC integration had the best correlation ($r = 0.92$), suggesting a robust link between integration and overall performance enhancement. These findings support the primary hypothesis,

which states that resource optimization and operational efficiency are significantly increased by combining BPR with RBC.

5. RBC and BPR were successful in maintaining resource use and enhancing distribution. Both strategies demonstrated the capacity to optimize resources and lower operating costs in a sustainable manner: RBC allowed resource reallocation and decreased financial/material waste, while BPR shortened production cycle time and enhanced equipment utilization.
6. Data-driven decision-making for risk analysis, performance monitoring, and resource allocation is made possible by using a methodical scientific approach to integrate BPR and RBC. Through the provision of a flexible production environment that can adjust to operational and financial changes, this integration supports strategic factory performance and cultivates a culture of operational innovation and continuous improvement.

### *5.2 Suggestion*

1. Factory management should regularly reengineer all manufacturing processes with an eye toward simplifying the process and eliminating non-value-added steps. Specialty teams can be created to analyze current processes find areas of waste and bottlenecks and develop plans for redesign to increase output, improve product quality and reduce cycle times.
2. They should be reinforced at all stages of the production process to divert human and financial capital from low-risk, critical functions. This means developing tools for risk analysis and associating each activity with its potential cost and operational risk so as to optimize expenditure and use of resources (while minimizing the waste of materials and financial resources).
3. Integration of BPR and RBC should be done in a complete strategic manner, ensuring that no use of one of them in isolation. While RBC ensures resource optimization and risk mitigation, BPR enhances the operational effectiveness making the combined integration, a booster for performance. An implementable plan with KPIs, regular monitoring plans has to be made in order to get the desired results.
4. A system of continuous performance monitoring and evaluation should be established on top of BPR and RBC. Financial and operational data need to be collected and analyzed on a regular basis through defined input sources like cycle time, production rate, returned battery rate, equipment utilization and financial/material waste. Enhances a process improvement culture and permits rapid decision-making to change processes.
5. Human resources are also recommended to be continually trained and developed in areas of BPR, RBC, risk analysis, and operations management. This will enhance the productivity of the staff, enable efficient allocation of resources, allow implementation of processes that one has redesigned and improve the capacity to manage risk and operational issues.
6. The implementation of BPR and RBC should be further extended to the other production lines and other factory products which be studied by directive follow up teams for sustainability of results. Through regular statistical analysis such as ANOVA, correlation coefficients or even t-tests in the Plaksha context that may be performed to evaluate performance and is likely to improve strategy decision making that will lead to enhanced return on investment and sustainable.

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