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Integration of Business Process Reengineering (BPR) and Risk-Based Costing (RBC) and Its Impact in Enhancing Efficiency and Rationalizing Resources Utilization: An Applied Study in General Company for Automobile and Equipment Manufacturing – Battery Factory

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Abstract

The aim of this paper is to examine how the combination of BPR and RBC could enhance operational efficiency and resource efficiency. The research was applied to the General Company for Automotive and Equipment Manufacturing – Battery Factory with a focus on the 90 Ampere dry battery product during the year 2024. The importance of this research is due to national industries, such as the low operating level of many national industries, rising of raw material prices, and rising in production cost. This research methodology is a combination of quantitative and descriptive analyses, applying it as an applied study. BPR technique was employed to diagnose the core processes of primary battery production line to identify the waste and inefficiencies. In addition, product cost influencing risks were mapped to the identified priority manufacturing operations using the RBC approach. The performance differences observed were in the order of decreased production cycle times, waste material, operating costs based on logical analysis, and risk adjustment in the allocation of resources from combining BPR and RBC. It also demonstrates that using both strategies together is more effective than using either one alone. The report concludes with a recommendation that the General Company for Automobile and Equipment Manufacturing adopt this strategy and broaden it to cover more products. It also emphasizes the development of accounting and management information systems, equipping staff with special skills in risk-based cost management, and business process reengineering to ensure sustainability of the benefits and added value competitiveness of the business.

Keywords: Business Process Reengineering (BPR), Risk-Based Costing (RBC), Operational Efficiency, Resource Rationalization, General Company for Automobile and Equipment Manufacturing, Battery Factory, 90 Ampere Dry Battery.

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 [1]. 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. Driven by these challenges, it is essential to explore modern concepts and new management methods that address deficiencies, optimize resource use and increase efficiency [2]. 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 [3]. 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 an 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 [4].

Methodology

Part One: Research Methodology and Previous Studies

1-1. 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.

1-1-1. 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. 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 as 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?

1-1-2. 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.

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.

1-1-3. 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.

1-1-4. 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.

1-1-5. 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. 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.

1-1-6. 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.

1-2. Previous Studies and Contribution of the Current Research:

1-2-1. Previous Studies:

Relevant previous studies include:

1. Smith, J. (2024) – "Integrating Business Process Reengineering and Risk-Based Costing in Manufacturing Firms": 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, K. & Park, H. (2024) – "Impact of Risk-Based Costing on Operational Efficiency in Automotive Battery Production": 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. Chen, Y. & Li, W. (2024) – "Combined Effects of Business Process Reengineering and Risk-Based Costing on Industrial Efficiency": 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, L. (2025) – "Business Process Reengineering in Automotive Industries: Efficiency and Resource Optimization": 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. Nguyen, T. (2025) – "Risk-Based Costing and Performance Enhancement in Manufacturing Enterprises": investigated how RBC affected risk classification, resource allocation, waste reduction, operational and financial performance, and ongoing performance monitoring.

6. Garcia, M. (2025) – "Optimizing Resource Utilization in Manufacturing Through BPR and Risk-Based Costing": reduced waste, increased operational efficiency, accelerated production, improved product quality, increased staff engagement, and highlighted resource optimization through the integration of BPR and RBC.

1-2-2. 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. 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.

Results and Discussion

Part Two: Theoretical Framework of the Study

2-1. 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 [5].

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 [6].

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 [7].

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 [8].

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 [9].

Steps for Implementing BPR [10]:

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 [11].

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 [12].

2-2. 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 [13].

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 [14].

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 [15].

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 [16].

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 [17].

Steps for Implementing RBC [18]:

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 [19].

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 [20].

2-3. 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 [21].
2. Better resource allocation: By prioritizing high-impact operations and connecting

each process to related risks and expenses, resources are allocated more efficiently [22].

3. Encourage strategic decision-making: Accurate and well-informed strategic judgments are made possible by fusing RBC risk analysis with BPR's operational viewpoint [23].

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 [24].

5. Boost organizational adaptability: Integration facilitates adaptable procedures and risk-based resource distribution, enabling quick adjustments to technological and economic shifts [25].

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 [26].

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 [27].

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 [28].

4. Allocate resources according to risks: Reallocate funds, personnel, and materials from low-risk or low-value operations to high-risk procedures and objectives [29].

5. Implement and monitor redesigned processes: Implement new procedures, provide employee training, track operational and financial results, gather input, and make necessary adjustments [30].

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 [31].

2-4. The Role of Integrating Business Process Reengineering (BPR) and Risk-Based Costing (RBC) in Improving Operational Efficiency

By combining a 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 [32]. 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 [33].

2. Rationalizing resource usage: By better allocating material, human, and financial resources based on process risks, organizations may cut waste and improve resource utilization [34].

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 [35].

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 [36].

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 [37].

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 [38].

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 [39].

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 [40].

2-5. 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 [41]. 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 [42].

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 [43].

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 [44].

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 [45].

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 [46].

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 [47].

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 [48].

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 [49].

Part Three: Practical Aspect of the Study

3-1. 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.

3-2- 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:

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 (%)	$\leq 3\%$	High
Plate Forming	20	Equipment damage	Defects per 100 units	$\leq 1.5\%$	Medium
Final Assembly	30	Assembly errors	Returned batteries (%)	$\leq 0.5\%$	High
Testing & Quality	15	Battery performance failure	Success rate (%)	$\geq 99\%$	High
Packaging	10	Product damage during packaging	Damaged batteries	$\leq 0.5\%$	Low

Clearly the two most critical and sensitive processes are Chemical Mixing (25%) and Final Assembly (30%). As an example, lowering returned batteries to $\leq 0.5\%$, 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, see Table 1.

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 ($\leq 3\%$) 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, see Table 2.

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	$\leq 2\%$ material loss	160000000	2	Daily weight review
Plate Forming	Preventive maintenance & reduced breakdowns	$\leq 1\%$ defects per 100 units	80000000	4	Periodic equipment inspection
Final Assembly	Team redistribution & assembly stage unification	$\leq 0.3\%$ returned batteries	240000000	5	Continuous assembly monitoring
Testing & Quality	Advanced automated testing system	$\geq 99.5\%$ success	35000000	2	Real-time failure analysis
Packaging	Improved packaging mechanism & reduced damage	$\leq 0.4\%$ damaged batteries	8000000	1	Final check before shipping

The table indicates that the redesign cut the amount 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, see Table 3.

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 effectiveness 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	$\leq 2\%$ loss	Medium	Additional supervisor
Plate Forming	80000000	8 employees	Preventive maintenance	$\leq 1\%$ defects	High	Extra technician
Final Assembly	240000000	20 employees	Precision tools	$\leq 0.3\%$ returned batteries	Very high	Additional monitoring teams
Testing & Quality	35000000	6 employees	Automated testing devices	$\geq 99.5\%$ success	Medium	Additional staff training
Packaging	8000000	4 employees	Improved packaging materials	$\leq 0.4\%$ 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, see Table 4.

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%, see Table 5.

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, see Table 6.

3-3- 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:

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 $\leq 0.5\%$. 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, see Table 7.

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 ($\leq 1\%$), demonstrating optimal resource allocation and reaching the highest levels of operational and financial efficiency, see Table 8.

3-4- 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:

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, see Table 9.

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, see Table 10.

3-5- 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:

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 ($p < 0.05$).

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, see Table 12.

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, see Table 13.

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%, see 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 [50]

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, see Table 15.

Conclusions

The research came to the following findings:

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.

Recommendations:

Based on the conclusions reached, the research recommends the following:

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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