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Economic Production Quantity Model under Back Order, Rework, Imperfect Quality, Electricity Tariff, and Emission Tax

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ABSTRACT

This study aims to develop a novel Economic Production Quantity (EPQ) model that integrates important sustainability and operational factors reorders, rework, imperfect quality, emission taxes, and variable electricity tariffs- by minimizing the total inventory cost while considering environmental and energy-related constraints. The model is formulated as an Integer Non-Linear Programming (INLP) problem, with two main decision variables: the total number of products produced in a cycle (y) and the maximum allowable reorder level (w). To solve this complex optimization problem, the Genetic Algorithm (GA) is used for its efficiency in handling non-linear and combinatorial problems. In addition, a sensitivity analysis is performed to assess the impact of various parameters on the total cost. Numerical experiments show that increasing emission taxes, electricity tariffs, and installation costs significantly increase the total inventory and production costs. In particular, higher emission taxes and electricity tariffs amplify the financial burden on manufacturers, underscoring the economic implications of environmental regulations and energy use. These findings emphasize integrating operational and ecological considerations into production planning. This study contributes to the field by offering a comprehensive framework that supports sustainable manufacturing practices through cost-effective inventory management. The proposed EPQ model enables manufacturers to balance economic performance and ecological responsibility, aligning operational strategies with sustainability goals and regulatory compliance.

1. Introduction

Inventory is important role for a company because it can affect operational efficiency (Evita et al., 2019; Giorgi Doborjginidze et al., 2021; Utama et al., 2022). Inventory also affects the product supply chain due to its ability to fulfill consumer demand (Maulana et al., 2019; Shabna et al., 2024). Inventory and production are strongly related to energy consumption efficiency (Siagian, 2018). Inefficiency in managing inventory and production affects energy consumption and increases emissions, leading to high operating costs (Afriyanti et al., 2020; Mishra et al., 2019; Utama et al., 2019). This encourages decision-makers to change to more efficient production and inventory decisions, improving energy and emission efficiency and support sustainability (Hamdhani et al., 2022; Setiawan & Haramaini, 2020). The Economic Production Quantity (EPQ) concept is a production and inventory decision-making concept that helps companies optimize production batch sizes to minimize total inventory costs, including storage costs and set-up costs (Nobil et al., 2023; Taleizadeh et al., 2024; Yee et al., 2023). Furthermore, EPQ integration involving back orders, rework, imperfect quality, energy efficiency, and sustainability is increasingly urgent to investigate (Kumar et al., 2021; Priyan et al., 2022).

In recent years, growing research interest in sustainability has focused on production and supply decisions related to energy and emissions (Kumar et al., 2021; Priyan et al., 2022). The increased global focus on sustainability, energy efficiency, and emissions is recognized as one of the efforts to achieve sustainable production in enterprises (Dellnitz et al., 2020; Utama et al., 2024) This can be achieved by increasing output or reducing energy consumption or energy costs. Many researchers have proposed several approaches to solve inventory problems, including using the EPQ approach with a heuristic algorithm (Dixon et al., 1983; Karaoglu et al., 2023; Xie et al., 2023), Apriori Algorithm (Dongga et al., 2023), and an Agglomerative Hierarchical Clustering algorithm (AHC) (Priambodo & Jananto, 2022). This shows the recognition of the impact of operations on the environment and the importance of managing carbon emissions in the context of sustainability (Ahmad et al., 2024; Tan et al., 2019). This is reflected in the assumptions made in the study (Alamri et al., 2022) that CO2 directly emitted from fuel in product storage is considered an important factor contributing to emissions. Therefore, research on the EPQ model is relevant because it considers aspects of production efficiency and sustainability aspects, such as emission reduction and energy management.

Based on several previous studies, EPQ is one of the classic methods to achieve efficiency goals in inventory management and production. The EPQ model helps determine the optimal order quantity that minimizes total inventory costs, including production set-up and storage costs (Turkensteen, 2019; Yang, 2023). In inventory management, factors such as set-up cost, storage cost, and cost of lack of inventory need to be considered to determine an effective strategy (Utama et al., 2023). Several studies have been conducted on the EPQ model that considers current issues. Research Anggita et al., 2023 developed an inventory model for distributors and retailers by including aspects of transportation, loading and unloading, and carbon emission taxes. Meanwhile, research in Aldhaheri, 2020 investigated an inventory model that considers stochastic demand, limited storage space, and sustainability to optimize inventory decisions and reduce storage costs. In addition, research Chiu et al., 2014 examined an EPQ model that considers aspects of scrap, rework, and multiple deliveries. In addition, the journal Mashud et al., 2020 proposed an inventory model by considering imperfect products, deterioration, and controllable emissions. From these studies, models that consider aspects of sustainability and real operational conditions are becoming increasingly important in facing the challenges of efficient inventory management.

Previous studies on the EPQ model have significant areas for improvement in its application to more modern industries. One of the most prominent areas for improvement is the neglect of electricity costs in all processes that occur in product manufacturing. At the same time, electricity costs are the key to a factory's operation. In addition, previous research often overlooks emission taxes, which are increasingly relevant to environmental regulations and awareness of the importance of sustainability. Although EPQ research has grown, very few studies involving electricity tariffs and emission taxes are included in the model. To the best of our knowledge, there needs to be EPQ research that integrates rework, imperfect quality goods, electricity tariffs, and emission taxes into one continuous EPQ model. One of the recent EPQ studies as presented by Utama & Lubis (2024) which focus on two shops by considering repair factors, waste disposal, electricity rates, and emission taxes. This research which focuses on EPQ models under integrates rework, imperfect quality goods, electricity tariffs, and emission taxes on single shop is different from Utama & Lubis (2024) research. This prompted the investigation of the EPQ model with rework, imperfect quality goods, emissions, and electricity demand incurred. This study aims to develop a new EPQ model that considers rework, imperfect quality goods, emission taxes, and electricity tariffs incurred on production and inventory activities to optimize costs. This approach is expected to provide a more comprehensive insight into efficient and sustainable inventory management in the manufacturing industry sector.

2. Method

2.1. Proposed Model

This section describes some assumptions, notations, and mathematical models used in the study. The objective of this EPQ modeling problem is to minimize the total cost. This proposed model was developed from research by Pascale and Moueen in Hayek & Salameh (2001) using some assumptions. The following are the assumptions in this study:

1. It is assumed that the level of demand is constant. This assumes that the market's demand remains stable without significant fluctuations.
2. It is assumed that the production rate is constant. This suggests the factory or production facility can maintain a consistent output level over time without major changes.
3. The number of defective items will affect the production policy as only perfect items are produced to fulfill demand.
4. Since not all goods produced are of perfect quality, we assume that imperfect goods occur randomly during production. This reflects the reality that not all production units will be the same quality, and some goods may not meet the desired quality standards.
5. The production rate of imperfect goods is multiplied by the percentage of defective goods produced. This implies that the production rate of defective goods will vary depending on the total production rate and the estimated percentage of defective goods.
6. Imperfect goods are then repaired at a certain constant rate of production after the production cycle stops and are added to the inventory of perfect goods continuously after being repaired. This assumes that defective goods will be repaired at a fixed production rate to ensure that the inventory of perfect goods continues to be met.

Based on the assumptions and notations contained in the previous paragraph, we consider several costs in the EPQ model created. This model includes the cost of electricity tariffs and emission taxes incurred in the production process. The cost of electricity tariffs and emission taxes is very relevant in the context of the company's sustainability and operational efficiency. We consider the electricity tariff cost to be a variable cost that depends on the production level and the emission tax cost to be an additional cost that must be incurred to comply with environmental regulations. This is explained in Eq. (1).

$$T_C = C + (\lambda_c . L) + (\varepsilon_c . E_T) \tag{1}$$

Based on Eq. (1) above, T_C is represents total production cost, C denotes the production cost, λ_c indicates the electricity needs for production, L refers to the electricity tariff, ε_c signifies the emissions released for production, and E_T stands for the emission tax.

We also consider the electricity tariff and emission tax incurred in the repair process. The total repair cost (T_R) is the repair cost plus the electricity cost incurred during the repair process and the emission tax that must be paid due to the emissions generated during the repair process. All these costs are multiplied by the percentage of defective goods produced. This is modeled in Eq. (2):

$$T_R = (C_r + (\lambda_{cr} . L) + (\varepsilon_{cr} . E_T)) . E1 \tag{2}$$

According to Eq. (2), T_R signifies the total repair cost, C_r defines the repair cost, λ_{cr} describes the electricity requirement for repairs, L designates the electricity tariff, ε_{cr} expresses the emissions incurred for repairs, E_T denotes the emission tax, and $E1$ represents the percentage of imperfect quality items produced.

In the formulation of the mathematical model, we consider the machine set-up cost, which consists of the standard set-up cost plus costs related to electricity tariffs and emission taxes incurred. The total set-up cost is calculated with direct costs and additional costs related to electricity usage and emissions' environmental impact. It is important to obtain a more accurate cost estimate and consider the environmental impact of the production process. The set-up cost is formulated in Eq. (3):

$$T_K = K + (\lambda_k . L) + (\varepsilon_k . E_T) \tag{3}$$

Referring to Eq. (3), T_K represents the total set up cost, K is set up fee, λ_k indicates electricity requirement for set up, L designates the electricity tariff, ε_k refers to the emissions incurred for set up, and E_T denotes the emission tax.

This study factors electricity tariffs and emission taxes in storing perfect quality goods. This is represented in Eq. (4). The total storage cost of a perfect quality product consists of the storage cost plus the electricity cost and emission cost, all of which are divided by 2 to get the average cost.

$$T_H = \frac{h+(\lambda_h.L)+(\varepsilon_h.E_T)}{2} \tag{4}$$

As indicate in Eq. (4), T_H is total cost of storing perfect quality products, h refers to the storage cost of perfect quality products, λ_h indicates electricity requirement for the storage of perfect quality products, L designates the electricity tariff, ε_h refers to the emissions released for storage of perfect quality products, and E_T denotes the emission tax.

In addition, in storing goods with imperfect quality, researchers also consider electricity tariffs (L) and emission tax (E_T). The total storage cost for imperfect quality products is calculated using Eq. (5). This equation shows that the total storage cost of imperfect quality goods is the sum of the storage cost, electricity cost, and emission tax cost divided by two because it is assumed that the cost is shared equally between the imperfect quality goods produced during the production cycle.

$$T_{H1} = \frac{h_1+(\lambda_{h1}.L)+(\varepsilon_{h1}.E_T)}{2} \tag{5}$$

As shown in Eq. (5), T_{H1} is total cost of storing imperfect quality products, h_1 refers to the storage cost of imperfect quality products, λ_{h1} indicates electricity requirement for the storage of imperfect quality products, L designates the electricity tariff, ε_{h1} refers to the emissions released for storage of imperfect quality products, and E_T denotes the emission tax.

In shortage cost, this research models the total shortage cost presented in Eq. (6):

$$T_P = P + (\lambda_p . L) + (\varepsilon_p . E_T) \tag{6}$$

In reference to Eq. (6), T_P represents the total shortage cost, P denotes the shortage cost, λ_p indicates the electricity demand for shortage, L designates the electricity tariff, ε_p refers to the emissions released for shortage, and E_T reflects the emission tax.

From the above equations, the total inventory cost can be calculated by summing up the total production, repair, set-up, storage, and shortage costs. The optimal total inventory cost is formulated in Eq. (7). In this modeling, factors such as production costs, repair costs, set-up costs, storage costs of perfect quality products, storage costs of imperfect quality products, and shortage costs are the main considerations. This study aims to find a combination of variables that results in the lowest total inventory cost by the desired operating conditions.

$$TCU = \beta[T_C + T_R] + [\frac{T_K}{y}] + [\frac{T_H}{2}(y(1-\frac{\beta}{\alpha}) - 2w)] + [\frac{T_{H1} - T_H}{2}.y.\frac{\beta}{\alpha_1}E_2] + [(T_P + T_{H)}.\frac{w^2}{2y}.E_3] \tag{7}$$

As derived from Eq. (7) above, β denotes demand, T_C stands for total production cost, T_R reflects total repair cost, T_K signifies total set up cost, y represents total goods produced during the production cycle, T_H describes the total cost of storing perfect quality products, α shows the production rate of perfect quality products, w defines the maximum backorder rate allowed in the production cycle, T_{H1} outlines the total cost of storing imperfect quality products, α_1 quantifies the production rate of imperfect quality products, E_2 and E_3 depict the percentage of imperfect quality items produced, and T_P is total shortage cost.

Based on the mathematical model that has been presented, the inventory system can be formulated using the Integer Non-Linear Programming (INLP) model based on Eq. (8). The equation shows that the main objective of this model is to minimize the total cost of inventory (TCU), which is the sum of production costs, repair costs, set-up costs, perfect quality product storage costs, imperfect quality product storage costs, and stock shortage costs.

$$Min\ TCU = T_C + T_{Cr} + T_K + T_H + T_{H1} + T_P \tag{8}$$

With constraint function:

$$0 \leq w \leq \beta \tag{9}$$

$$0 \leq y \leq \beta \tag{10}$$

$$w, y \text{ integer} \tag{11}$$

Based on formulas, notations used in the proposed model above include:

β : Demand
C : Production cost
C_r : Repair cost
K : Set up fee
P : Shortage cost
h : Storage cost of perfect quality products
h_1 : Cost of storing imperfect quality products
α : Production rate of perfect quality products
α_1 : Production rate of imperfect quality products
λ_c : Electricity needs for production
λ_{cr} : Electricity requirements for repairs
λ_k : Electricity requirement for set up
λ_h : Electricity requirement for the storage of perfect quality products
λ_{h1} : Electricity requirements for the storage of imperfect quality products
λ_p : Electricity demand for shortage
ε_c : Emissions released for production
ε_{cr} : Emissions incurred for repairs
ε_k : Emissions incurred for set up
ε_h : Emissions released for storage of perfect quality products
ε_{h1} : Emissions released for storage of imperfect quality products
ε_p : Emissions released for shortage
L : Electricity tariff
E_T : Emission tax
$E1$: Percentage of imperfect quality items produced
$E2$: Percentage of imperfect quality items produced
$E3$: Percentage of imperfect quality items produced
w : Maximum backorder rate allowed in the production cycle
y : Total goods produced during the production cycle
T_C : Total production cost
T_R : Total repair cost
T_K : Total set-up cost
T_H : Total cost of storing perfect quality products
T_{H1} : Total cost of storing imperfect quality products
T_P : Total shortage cost
TCU : Total inventory cost

In the mathematical model formulation, Eq. (8) shows the objective function of the total inventory cost of the model discussed in this study that must be minimized. This optimization process must meet several constraints, such as the backorder level (w) must be greater than 0 and not exceed the demand (β) shown in Eq. (9). The total product produced (y) must also be greater than 0 and not exceed the demand (β) shown in Eq. (10). In addition, the backorder rate (w) and total products produced (y) must also be an integer, as shown in Eq. (11). Determining the decision variables, namely the backorder level (w) and total products produced (y) optimized simultaneously, can help reduce the total inventory cost. Thus, the model is formulated to find a solution that satisfies these restrictions and simultaneously optimizes the total inventory cost.

2.2. Numerical Experiment Data and Procedures

In this section, the data used in the experiments of the proposed EPQ model will be presented. The experimental data is contained in Table 1, this table contains the parameters used in the mathematical model.

Table 1. Experiment Data

Variables	Unit	Value
β	Unit/year	1200
C	\$/year	\$50
C_r	\$/year	\$8
h	\$/year	\$20
h_1	\$/year	\$22
P	\$/year	\$10
K	\$/year	\$100
α	Unit/year	1600
α_1	Unit/year	100
λ_c	kWh	2
λ_{cr}	kWh	1
λ_k	kWh	50
λ_h	kWh	1
λ_{h1}	kWh	1
λ_p	kWh	2
ε_c	Kg	0.5
ε_{cr}	Kg	0.4
ε_k	Kg	1
ε_h	Kg	0.2
ε_{h1}	Kg	0.01
ε_p	Kg	0.3
L	\$/kWh	\$0.14
E_T	\$/kg	\$0.002
$E1$		0.05
$E2$		0.00333
$E3$		4.831192

Meanwhile, sensitivity analysis was conducted on three key variables: electricity tariff, emission tax, and set-up cost. This study used 5 variations of data for each of these variables. This experiment was conducted to determine the effect of electricity tariffs, emission taxes, and set-up costs on total inventory costs. For the electricity tariff sensitivity analysis, the variation data increased from \$0.14 per kWh to \$4.14 per kWh. Concurrently, variations were made from \$0.002 to \$20.002 per kg for the emission tax parameter. However, in the set-up cost sensitivity analysis, the parameter variation starts from \$100 to \$300 per year. Once the variation data was determined, numerical experiments were conducted by inputting the values into the previously formulated mathematical model. This aims to observe how changes in the values of the key variables will affect the total inventory cost generated by the model. Thus, this sensitivity analysis provides insight into how sensitive the total inventory cost is to changes in the values of these key variables.

The numerical experiment procedure is done by optimizing the model using the Genetic Algorithm procedure, run with Microsoft Excel in the Solver feature. Several genetic algorithm parameters were used in the Solver settings, as presented in Table 2, Using the Genetic Algorithm method to solve the problem with solver feature in Microsoft Excel aims to obtain the minimum total cost value according to the objective function. In addition, the estimated value of emissions and electrical energy released from all activities carried out is also calculated. Moreover, this research also determined the optimal values of the decision variables, namely the backorder level and the total goods produced. Therefore, this experiment aims to find an optimal solution that satisfies all restrictions and minimizes the total inventory cost while considering the environmental impact and energy requirements.

Table 2. Genetic Algorithm Parameters

Data	Value
Convergence	0.0001
Mutation Rate	0.075
Population Size	100

3. Results and Discussion

3.1. Optimization Results

The optimization results using a genetic algorithm resulted in a minimum total inventory cost of \$61,971,762 with emissions of 634.106028 Kg and electricity usage of 2755.86 kWh. In this solution, the total number of products produced (y) is 224 units, while the backorder rate (w) is 0 units. This indicates that using a genetic algorithm results in an optimal solution with no backorders, preventing stock shortages. This result indicates that using a genetic algorithm can produce an efficient solution for optimizing inventory costs. Although the minimal inventory cost has been achieved, it is important to note that the estimated emissions and electricity consumption also need to be taken into account, indicating the environmental impact of the inventory operation.

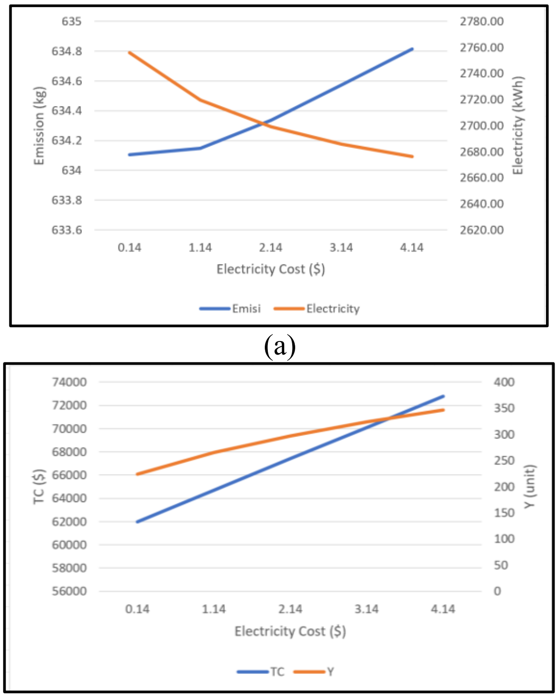
These results can be used as a basis for better decision-making in inventory management, where companies can consider reducing or eliminating backorders to optimize inventory costs. In addition, estimating emissions and energy consumption can also help companies direct their sustainability efforts by minimizing the environmental impact of their operational activities.

3.2. Sensitivity Analysis

The sensitivity analysis to changes in electricity tariffs is presented in Fig. 1, the figure illustrates the impact on the total inventory cost, the amount of electrical energy spent, the total emissions released, and the number of goods produced. The results showed that increased electricity tariffs result in higher total inventory costs. Electricity costs are a significant component in calculating total production costs. In addition, the increase in electricity tariffs also resulted in higher total emissions due to higher electricity usage. However, it is interesting that the rise in electricity tariffs is also associated with an increase in total products produced.

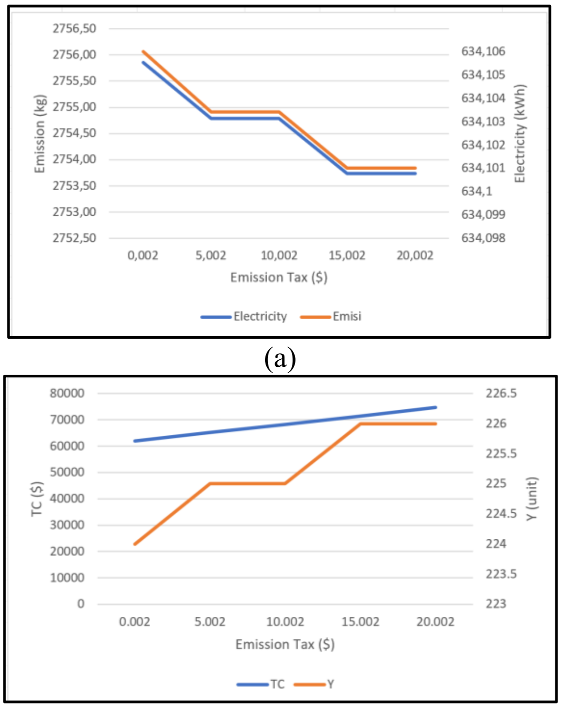
This occurs because the company aims to maximize production output to offset the additional costs incurred due to increased electricity tariffs. Conversely, the increase in Electricity tariffs impacts on the smaller amount of electrical energy released (Zaki & Hamdy, 2022). This suggests that adjustments to electricity tariffs incentivize firms to reduce energy consumption and explore more efficient alternatives. This analysis shows the importance of considering electricity tariffs in inventory management decision-making to achieve a balance between production costs, energy use, and environmental impact.

The sensitivity analysis results to changes in emission tax in Fig. 2, show the impact on total inventory costs, the amount of electrical energy spent, total emissions released, and the number of goods produced. The results show that an increase in emission tax causes the total inventory cost and the number of goods produced to increase. The increased cost per unit can explain this due to the additional emission tax. Meanwhile, the value of emissions and electrical energy consumption incurred tends to decrease. This means that the increase in emission tax encourages companies to increase production volume to reduce the impact of higher per-unit costs. By producing more goods in one batch, companies can spread fixed costs, including emission taxes, over more product units, reducing per-unit costs.



(b)

Fig. 1. Sensitivity Analysis of Electricity Tariff Changes to TC and Y (a) and Emission and Electricity (b)



(b)

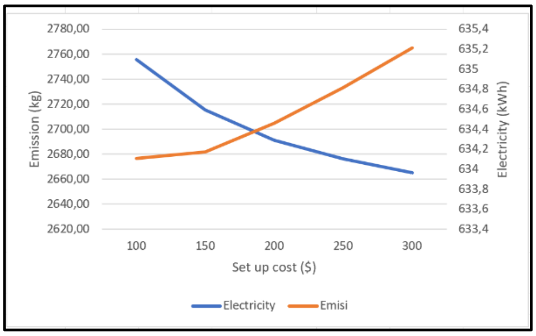
Fig. 2. Sensitivity Analysis of Emission Tax Changes to TC and Y (a) and Emission and Electricity (b)

At the same time, the increase in emission tax also encourages companies to adopt more energy efficient technologies and practices to reduce their emissions and electrical energy consumption. This can be seen from the decrease in the value of emissions and electrical energy released, which shows that companies pay more attention to energy efficiency to adjust to stricter tax regulations. As a result, the increase in emission tax not only impacts the financial aspects of the company but also drives changes in technology and operational practices to achieve more efficient and sustainable production.

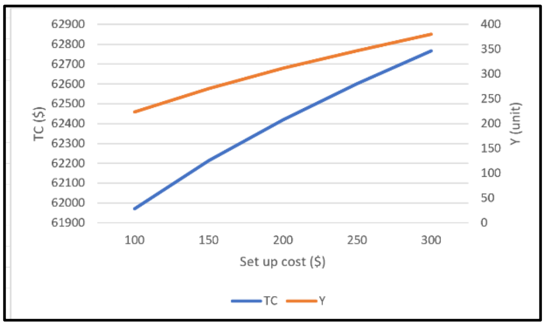
The results of the sensitivity analysis to changes in set-up costs that impact total inventory costs, electrical energy expended, total emissions generated, and the number of goods produced are shown in Fig. 3. The findings show that an increase in set-up cost leads to an increase in total inventory cost, emissions generated, and total goods produced. However, interestingly, the opposite is true for the electrical energy expended, which tends to decrease as the set-up cost increases. As the set-up cost increases, the costs incurred each time production starts become more significant, increasing the total inventory cost, as these additional costs have to be covered by the cost of producing and storing goods.

Companies may choose to produce in larger batch quantities to reduce set-up frequency and the impact of higher per-unit costs. However, production in larger batches may require more fuel and continuous engine use over a longer production period, which may increase emissions. On the other hand, the increase in set-up costs encourages companies to reduce set-up frequency so that electrical energy consumption decreases (Das, 2022). This suggests a trade-off between production costs, energy use, and emissions in decision-making regarding set-up costs in the production process. By understanding this relationship, companies can make wiser decisions in managing their production activities' costs and environmental impacts (Guchhait et al., 2020).

The sensitivity analysis results show that all values for the number of backorder products (w) result in a value of 0. This indicates that the proposed EPQ model does not allow the value of backorders or inventory shortages because, in this study, the demand value is constant at 1200 units per year. This means that new orders can be made on time before the stock runs out, so there is no need for backorders. These results show that the proposed model effectively manages inventory without any stock shortages, which can significantly reduce storage costs and stock shortage costs. The main objective of the EPQ model is to optimize the inventory policy and reduce the company's overall cost. Thus, the proposed model can be an effective solution for managing inventory in an environment that has constant demand.



(a)



(b)

Fig. 3. Sensitivity Analysis of Set Up Cost Changes to TC and Y (a) and Emission and Electricity (b)

3.3. Research Implication

This research has several important theoretical implications in inventory management and production process optimization. The proposed EPQ models can assist companies in managing inventory more efficiently by integrating factors such as electrical energy costs and emission taxes. Thus, the proposed EPQ models can be effectively used in inventory management decision-making and sustainable production. This leads to greater awareness of the environmental impact of company operations and the importance of minimizing emissions and using energy efficiently.

In addition, the results of this study also contribute to the understanding of how efficient inventory management can be achieved by considering external factors such as energy costs and emissions. These theoretical implications can help the development of more holistic and sustainable inventory management models in the future. Therefore, this research not only makes a practical contribution to inventory management but also enriches theoretical understanding in the field of operations and environmental management.

Sensitivity analysis of electricity tariffs, emission taxes, and setup costs shows the importance of managers in managing production costs. From the results of this analysis, managers can understand how changes in electricity tariffs or emission taxes will affect total production costs and how sensitive production decisions are to these changes. This suggests the need for more strategic management in planning resource use and considering external factors that could impact operating costs.

In addition, sensitivity analysis also gives managers insight into which factors have the greatest impact on production decisions. By understanding the sensitivity to electricity rates, emission taxes, and setup costs, managers can identify areas that need more attention in strategic planning. This allows managers to make better decisions to optimize production costs, improve efficiency, and minimize the risk of negative impacts on company performance.

4. Conclusion

This research has successfully developed an EPQ that integrates various production and inventory costs, including repair, set-up, and storage costs of perfect and imperfect quality products. In addition, this study also included the cost of electricity tariffs and emission taxes in the model. Sensitivity analysis shows that increases in emission taxes, electricity rates, and set-up costs significantly impact total inventory, emission, and production costs. Numerical experiment results support the model's effectiveness in optimizing production costs and improving energy efficiency and emission reduction in the manufacturing industry. Nonetheless, this study has some limitations. One of them is that the developed model may only partially represent complex conditions in the field. In addition, using more extensive empirical data and additional variables can improve the validity and generalizability of the model. For future research, developing a more complex model that considers more complex production dynamics, such as uncertain demand variations and uncertainty in cost parameters, is recommended. In addition, further research can explore using more advanced optimization techniques and algorithmic solutions to address these issues. In addition, future research can also expand the scope of sensitivity analysis to understand the impact of other variables on production decisions and inventory costs.

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