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A Model for Optimizing Operating Profit Considering the Suboptimal Distribution of Production Resources with Emphasis on Accrual Items

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Abstract

Accrual items, as accounting entries recorded by company accountants before actual realization, are considered a type of accounting registration that can have a positive effect on profits, increase transparency, and ultimately attract the attention and trust of stakeholders. Therefore, significant emphasis has been placed on this subject in the accounting literature. However, the reality is that there is no model in the research literature that uses operations research methods to examine the effect of accrual items on operating profit. Given the benefits and usefulness of accrual items, this gap in research can be considered a research gap. The present study, addressing this gap, proposes a model for optimizing operating profit considering the suboptimal distribution of production resources and based on accrual items. The proposed model indicates that accrual items have a positive effect on operating profit, and as their ratio to cash items increases, this effect becomes more pronounced. Specifically, it is expected that accrual sales will have an effect of approximately 18%, and accrual expenses will have an effect of approximately 20% on operating profit.

Keywords: *Optimization, Operating Profit, Resource Distribution, Accrual Items.*

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1. Introduction

Accrual items in accounting refer to costs or revenues that are recorded by companies but have not yet been realized. The use of accrual accounting arises from the accurate and fair representation of a company at each stage, which is made possible by accrual accounting [1]. Through accrual accounting, stakeholders are able to understand the stage a company is at, thus ensuring the accuracy of ongoing activities. Common examples of accrual accounting include credit sales, credit purchases, prepaid rent, electricity costs, depreciation, audit fees, and so on [2].

Research in the field of accounting suggests a positive impact of both discretionary and non-discretionary accrual items, as well as their quality. In other words, most studies indicate that accrual items positively affect profit increases or, conversely, reduce losses [3]. Moreover, they contribute to greater transparency and higher investor trust in the company. Accrual accounting, by recording events regardless of cash inflows or outflows, provides many benefits for stakeholders and companies [4].

Vali-Zadeh Larijani et al. (2020) focused on the interactive effect of accrual item quality and corporate governance quality on performance volatility [4]. Haji Reza and colleagues (2023) investigated the impact of accrual items and free cash flow on financial stability using genetic algorithms [5]. Salimi-Qaleh and colleagues (2023) analyzed the role of accrual items in mitigating timing issues and cash flow alignment [6]. Nguyen Thi Thanh (2020) explored the factors influencing accrual accounting reforms and performance transparency in Vietnam's public sector [7]. Edwards (2021) assessed cash-based and accrual accounting in the central government of the United Kingdom [8]. Mikhalikov (2021) studied the impact of revenue quality and accrual items on the corporate life cycle [9]. Breuer and Schütt (2023) applied Bayesian methods to accrual models, focusing on uncertainty management [4]. Salato et al. (2024) examined accrual accounting in the public sector in emerging economies using bibliographic analysis [2]. Alghizzawi and Masruki (2024) explored the effect of information technology on the adoption of accrual accounting. Amal et al. (2024) reviewed the implementation of accrual-based accounting in the public sector in Indonesia through a literature review [1].

Despite the considerable research in this area, the relationship between accrual items and profit has been a focus in accounting studies, while the optimization of profit based on accrual items has been neglected. In other words, the literature has not explored how the difference between accrual items and cash items—essentially the distinction between cash and accrual accounting—leads to higher profits and lower losses. This is significant because part of the accounts in company ledgers are recorded on an accrual basis, while others are recorded on a cash basis, and this distinction can explain the resulting profit or loss. The current study aims to examine whether accrual items influence profit improvement, with sensitivity analysis used to address this question. Additionally, the proposed model is based on the suboptimal distribution of production resources, assuming that manufacturing companies face resource constraints in terms of labor, energy, raw materials, and intermediate goods. Therefore, resource optimization must also be considered from a financial perspective. The structure of the paper is as follows: the next section reviews the existing literature, followed by the identification of research gaps. Then, the mathematical model is presented, and finally, analysis and conclusions are provided.

2. Methodology

Given the identified research gap and the lack of studies in the area of profit optimization based on accruals, this research aims to maximize operational profit in manufacturing companies while considering resource constraints and focusing on accrual items. The researcher, through implementing the model and performing sensitivity analysis, seeks to discover whether the use of accrual accounting and accrual items has a greater impact on profit levels. Moreover, resource constraints are also taken into account, and this profit optimization occurs in conditions of resource scarcity. As previously mentioned, resources include intermediate goods, raw materials, labor, and energy. A product for production may only require raw materials or intermediate goods, both of which are considered in this study. In fact, for each of the resources, constraints are established according to the research objective. The assumptions of the model are as follows:

- Resources include intermediate goods, raw materials, labor, and energy.
- Resources have restricted access and inefficient distribution.
- Multiple production units exist.
- Multiple products exist.
- The model is multi-period.
- Overhead, energy, and maintenance costs differ for each production unit.

- Raw materials and intermediate goods costs differ for each product.
- The labor required for each product unit is specified.
- The number of intermediate goods required for each product unit is specified.
- The amount of raw materials required for each product unit is specified.
- The selling price of each product can vary across periods.
- The cost of maintaining the product in each production unit differs.
- Revenue from sales is recorded in both accrual and cash methods.
- Costs, except for maintenance and labor wages, are recorded separately for cash and accrual methods.

Table 1. Notations explained

Notation	Description	Mathematical Expression
Product i	Product index	i
Production unit j	Production unit index	j
Time period t	Time period index	t
Raw material source r	Raw material source index	r
Intermediate goods source rr	Intermediate goods source index	rr
Accrual sales of product i in company j during time period t	Accrual sales	AS_ijt
Cash sales of product i in company j during time period t	Cash sales	CS_ijt
Maintenance cost of company j during time period t	Maintenance cost	CH_jt
Labor cost of company j for product i during time period t	Labor cost	CLBR_ijt
Accrual raw materials cost for producing product i in company j during time period t	Accrual raw materials cost	ARW_ijrt
Cash raw materials cost for producing product i in company j during time period t	Cash raw materials cost	CRW_ijrt
Accrual intermediate goods cost rr for producing product i in company j during time period t	Accrual intermediate goods cost	ACMediate_ijrrt
Cash intermediate goods cost rr for producing product i in company j during time period t	Cash intermediate goods cost	CCMediate_ijrrt
Accrual energy consumption cost for producing product i in company j during time period t	Accrual energy consumption cost	ACENR_itj
Cash energy consumption cost for producing product i in company j during time period t	Cash energy consumption cost	CCENR_itj
Accrual maintenance unit cost for producing product i in company j during time period t	Accrual maintenance cost	ACNET_itj
Cash maintenance unit cost for producing product i in company j during time period t	Cash maintenance cost	CCNET_itj
Accrual overhead cost for producing product i in company j during time period t	Accrual overhead cost	AOVRHD_itj
Cash overhead cost for producing product i in company j during time period t	Cash overhead cost	COVRHD_itj
Large number M	Large number used for constraints	M
If product i is produced in production unit j during time period t, then X_ijt = 1, otherwise X_ijt = 0	Binary variable indicating if product is produced	X_ijt
Amount of product i produced in production unit j during time period t	Production amount	Y_ijt
Total operational revenue	Total revenue	P
Total operational costs	Total cost	V
Amount of raw material r required for producing product i during time period t	Raw material requirement	RAW_itr
Number of intermediate goods rr required for producing product i during time period t	Intermediate goods requirement	Mediate_itrr
Amount of labor required for producing product i during time period t	Labor requirement	LBR_it
Amount of energy consumption for producing product i in production unit j during time period t	Energy consumption requirement	ENR_itj

$$\text{MAX}\, Z = P - V$$

The above relation seeks to maximize operational profit by subtracting costs from revenue.

$$P = \sum_i \sum_j \sum_t AS_{ijt} \,.\, Y_{ijt} + \sum_i \sum_j \sum_t CS_{ijt} \,.\, Y_{ijt}$$

Revenue calculation: The relation calculates the operational revenue of the manufacturing company, differentiating between accrual and cash revenues.

$$V = \sum_i \sum_j \sum_t CH_j . Y_{ijt} + \sum_i \sum_t CLBR_{it}\, LBR_{it} + \sum_i \sum_j \sum_t \sum_r ARW_{ijt} \, . \, RAW_{ijt} + \sum_i \sum_j \sum_t \sum_r CRW_{ijt} \, . \, RAW_{ijt}$$
$$+ \sum_i \sum_{rr} \sum_t \sum_j ACMediate_{ijrrt} \, . \, Mediate_{itrr} + \sum_i \sum_{rr} \sum_t \sum_j CCMediate_{ijrrt} \, . \, Mediate_{itrr}$$
$$+ \sum_i \sum_j \sum_t ACENR_{itj}\, X_{itj} + \sum_i \sum_j \sum_t CCENR_{itj}\, X_{itj} + \sum_i \sum_j \sum_t ACNET_{itj} . Y_{ijt}$$
$$+ \sum_i \sum_j \sum_t CCNET_{itj} . Y_{ijt} + \sum_i \sum_t \sum_j AOVRHD_{itj}\, X_{itj} + \sum_i \sum_t \sum_j COVRHD_{itj}\, X_{itj}$$

Cost calculation: The relation calculates operational costs, differentiating between accrual and cash costs.

$$\sum_j X_{itj} = 1$$

Constraint equations: This relation indicates that in each time period, only one production unit is chosen.

$$Y_{ijt} \leq MX_{itj}$$

This relation shows that if a product is not selected, the production volume for that product will not exist.

$$LBR_{it} \leq MX_{itj}$$

This relation indicates that if a product is not selected, labor will not be required for it.

$$RAW_{itr} \leq MX_{itj}$$

This relation shows that if a product is not selected, raw materials will not be required for it.

$$Mediate_{itrr} \leq MX_{itj}$$

This relation shows that if a product is not selected, intermediate goods will not be required for it.

$$LBR_{it} = \frac{Y_{ijt}}{PRO_{it}}$$

This relation determines the production capacity limit.

$$RAW_{itr} = \frac{Y_{ijt}}{RW_i}$$

This relation determines the amount of labor required.

$$Mediate_{itrr} = \frac{Y_{ijt}}{MDT_i}$$

This relation determines the amount of raw materials required.

$$ENR_{itj} = \frac{Y_{ijt}}{UNTENR_i}$$

This relation determines the amount of intermediate goods required.

$$RAW_{itr} \leq CAPRAW_{itr}$$

This relation determines the amount of energy required.

$$Mediate_{itrr} \leq CAPMediate_{itrr}$$

This relation determines the raw materials capacity, considering the capacity limitation.

$$X_{ijt} \in \{0.1\}$$

This relation determines the intermediate goods capacity, considering the capacity limitation.

$$Y_{ijt} \geq 0$$
$$U \geq 0$$
$$V \geq 0$$
$$RAW_{itr} \geq 0$$
$$Mediate_{itrr} \geq 0$$
$$LBR_{it} \geq 0$$

$$ENR_{itj} \geq 0$$

The above relations determine the energy capacity, considering the capacity limitation.

3. Findings

This section focuses on the analysis of the findings and model solution. Initially, the model is solved in various dimensions, followed by an examination of the differences and impact of accruals on profit. The dimensions of the model are introduced first.

Table 2. Dimensions of the Model

Example	Products	Production Units	Time Periods	Raw Material Sources	Intermediate Goods Sources
1	1	2	3	1	1
2	2	4	4	1	1
3	3	6	5	2	2
4	4	8	6	2	2
5	5	10	7	3	3
6	6	12	8	3	4
7	7	14	9	4	5
8	8	16	10	4	6
9	9	18	11	5	7
10	10	20	12	5	8
11	11	22	13	6	9
12	12	24	14	6	10
13	13	26	15	7	10
14	14	28	16	7	11
15	15	30	17	8	11
16	16	32	18	8	12
17	17	34	19	9	12
18	18	36	20	9	13
19	19	38	21	10	13
20	20	40	22	10	14

In Table 2, 20 examples are presented, where for each problem, the volume of products, number of production units, time periods, and sources of raw materials and intermediate goods have increased compared to the previous example. This results in the formation of different problems. The results of the model solution using a genetic algorithm are presented in the chart below.

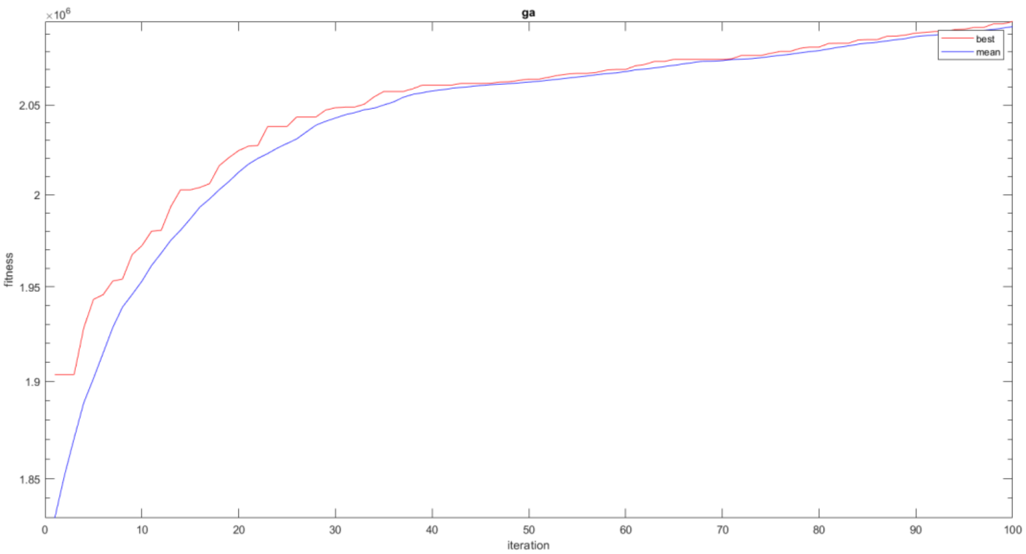

Figure 1. Results from Model Solution (Problem 20)

In the above chart, the horizontal axis represents the iterations, while the vertical axis shows the resulting profit. As can be observed, the proposed algorithm successfully solves the model, and profit is maximized using this algorithm. Therefore, the model has achieved the desired result, as shown by the convergence chart. The maximization problem results in an ascending chart, which is observed in the figure. The objective function values and computation times for each example are provided below.

Table 3. Model Solution in Different Dimensions

Example	Profit	Computation Time (Seconds)
1	1,789,571	10
2	1,807,052	16
3	1,817,561	23
4	1,833,868	37
5	1,848,134	51
6	1,860,751	64
7	1,879,776	78
8	1,897,078	83
9	1,915,938	90
10	1,932,870	101
11	1,946,538	110
12	1,963,267	119
13	1,982,902	129
14	1,998,493	137
15	2,017,311	147
16	2,031,077	162
17	2,046,913	170
18	2,065,088	177
19	2,081,377	182
20	2,097,441	189

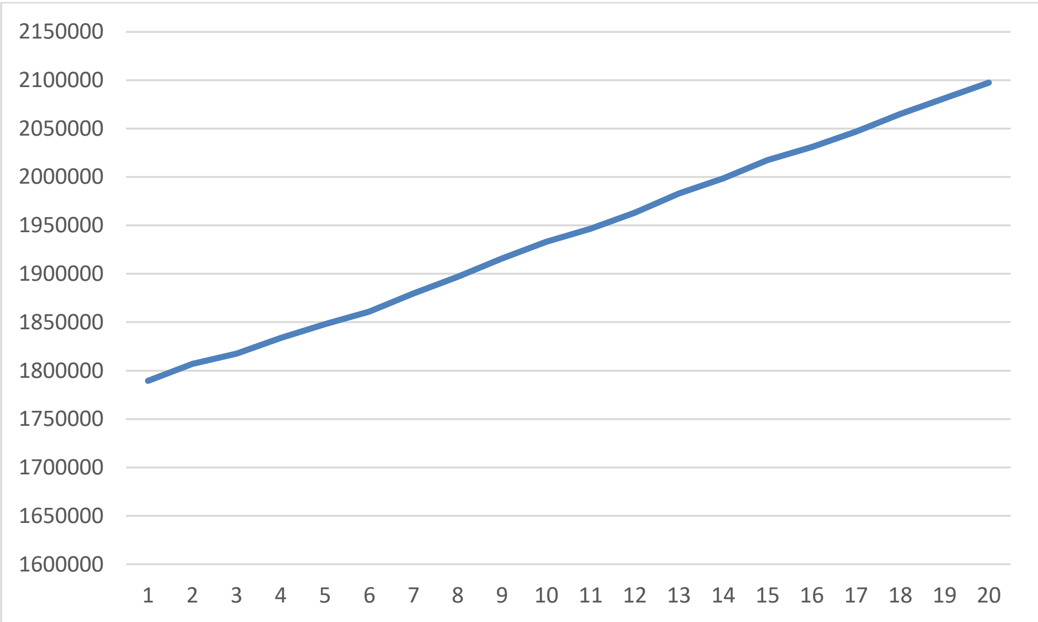

Figure 2. Profit Obtained from Model Solution in Different Dimensions

In the above chart, the horizontal axis represents the dimensions, and the vertical axis represents profit. As can be observed, with the increase in the dimensions of the problem, the resulting profit also increases, indicating the accuracy of the model's performance. Therefore, the model has the necessary validity.

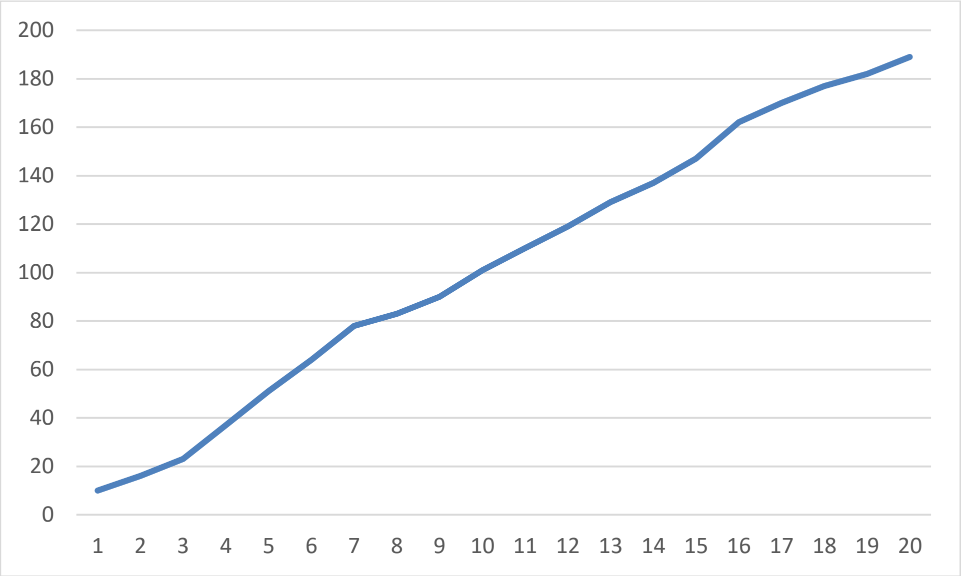

Figure 3. Solution Time for the Model in Different Dimensions

In the above chart, the computation time for solving the model is plotted, which also increases as the dimensions of the problem increase. Therefore, at this stage, the validity of the model is confirmed, and it can be concluded that with the increase in dimensions, both profit and solution time increase.

Next, the sensitivity analysis of accrual items is presented. In this stage, the researcher aims to discover whether the accrual items and their increased values can improve profit and achieve optimal profit. To this end, the accrual sales and accrual cost values are analyzed.

Table 4. Sensitivity Analysis of Accrual Sales

Increase in Accrual Sales to Cash Sales Ratio	Profit	Change in Profit (%)
0%	2,097,441	
10%	2,223,241	5.9978
20%	2,524,489	13.5499
30%	2,935,799	16.2928
40%	3,463,544	17.9762
50%	4,095,879	18.2569

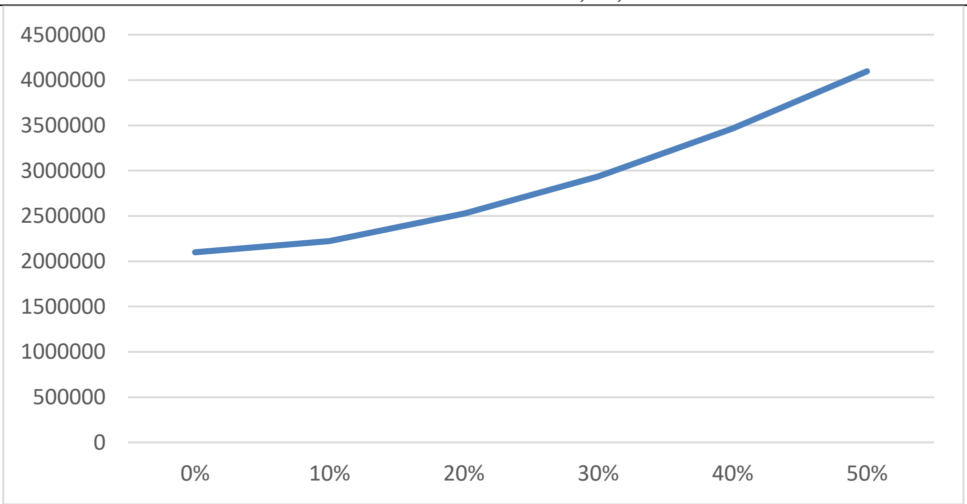

Figure 4. Sensitivity Analysis of Accrual Sales

In the above chart, the horizontal axis represents the increase in the ratio of accrual sales to cash sales, and the vertical axis represents profit. As observed, with the increase in accrual sales, and specifically the accrual sales items considered as a ratio to cash sales, the total profit of the companies is expected to increase. Therefore, it can be expected that increasing accrual sales will lead to optimal profit.

Table 5. Sensitivity Analysis of Accrual Costs

Increase in Accrual Costs to Cash Costs Ratio	Profit	Change in Profit (%)
0%	2,097,441	
10%	2,251,030	7.3227
20%	2,550,596	13.3080
30%	2,972,054	16.5239
40%	3,547,633	19.3664
50%	4,257,489	20.0093

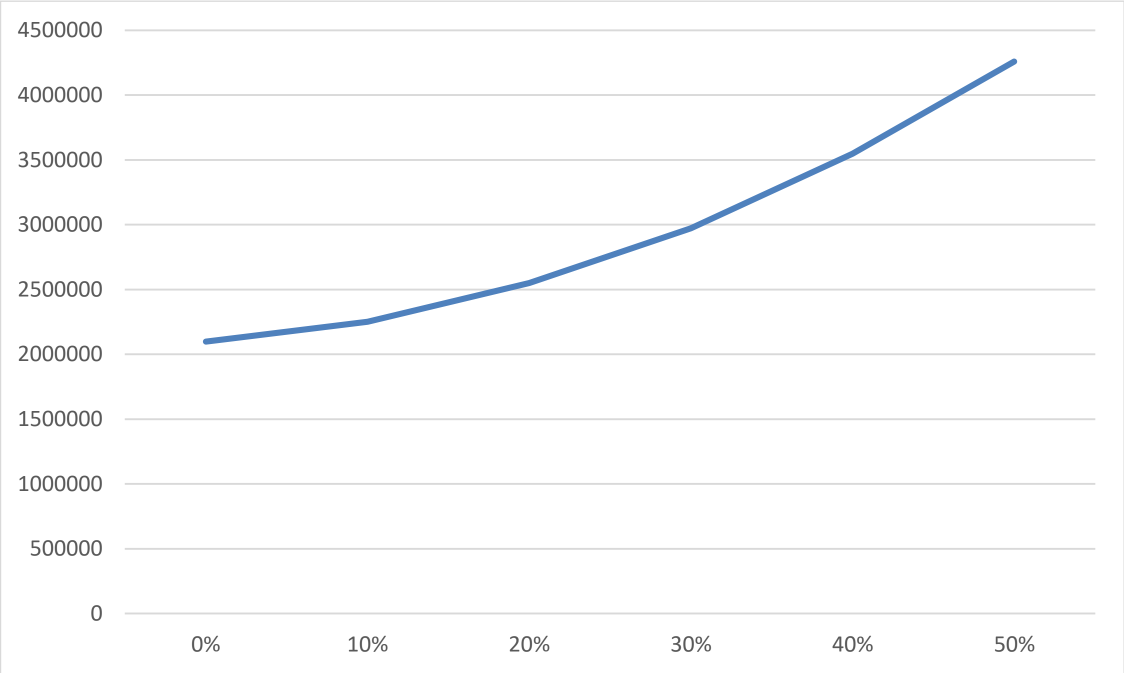

Figure 5. Sensitivity Analysis of Accrual Costs

In the above chart, the horizontal axis represents the increase in the ratio of accrual costs to cash costs, and the vertical axis represents profit. Based on the chart, the sensitivity analysis of total costs is performed, assuming that accrual costs increase relative to cash costs. The result of the above chart, like the sales chart, indicates that profit increases and becomes optimized through the increase in the accrual-to-cash cost ratio. Therefore, it can be expected that accrual cost items will also improve profit.

Table 6. Sensitivity Analysis of Accrued Purchase Costs for Materials and Intermediate Goods

Accrued Purchase Costs for Materials and Intermediate Goods	Profit	Change in Profit
0%	2,097,441	
10%	2,268,094	0.081362
20%	2,634,455	0.161528
30%	3,131,749	0.188765
40%	3,760,005	0.200609

50%	4,531,839	0.205275

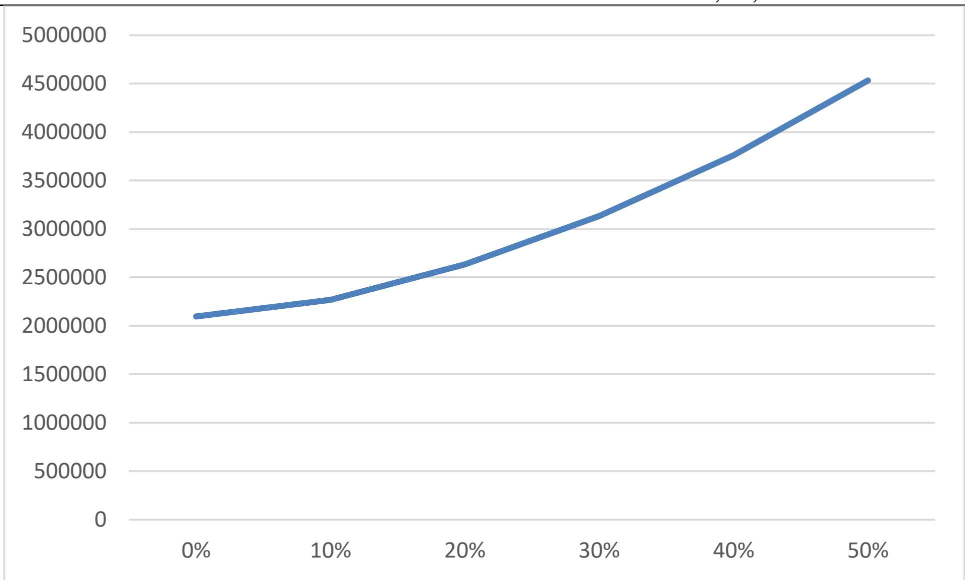

Figure 6. Sensitivity Analysis of Accrued Purchase Costs for Materials and Intermediate Goods

This section examines the details of costs, and the goal of the researcher is to discover whether specific cost items, such as the purchase of materials and intermediate goods, can improve profitability and result in optimal profits. The results in the figure above indicate that as the accrued costs for purchasing materials and intermediate goods increase, there is an expected improvement in profit. In fact, with a 50% increase in this ratio, the total profit is expected to improve by up to 20%.

Table 7. Sensitivity Analysis of Accrued Energy Consumption Costs

Accrued Energy Consumption Costs	Profit	Change in Profit
0%	2,097,441	
10%	2,238,504	0.067255
20%	2,553,520	0.140726
30%	2,990,245	0.171029
40%	3,554,967	0.188855
50%	4,274,912	0.202518

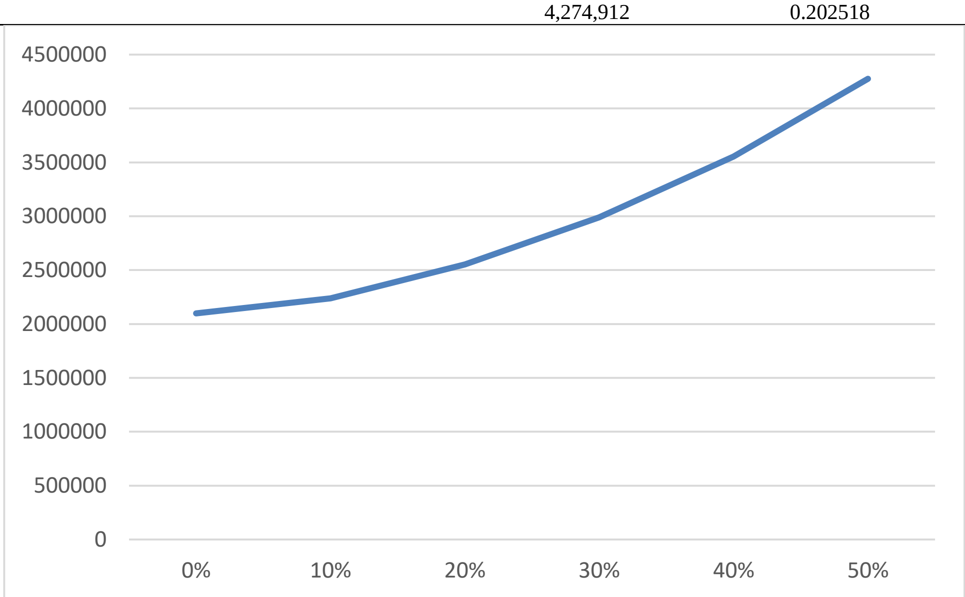

Figure 7. Sensitivity Analysis of Accrued Energy Consumption Costs

In the above chart, energy is considered an important resource in production, and it is assumed that costs are recorded as accrued. Therefore, the effect of accrued energy consumption costs on profit is examined, and the results indicate an increase in profitability and optimal profits due to the increase in accrued energy consumption costs. Moreover, it is expected that a 50% increase in the ratio of accrued costs to cash costs will lead to a 20% increase in profit.

4. Discussion and Conclusion

This research presented a model for optimizing operating profit, considering the suboptimal distribution of production resources, with an emphasis on accrued profit items. The proposed model takes into account the limitations of the suboptimal distribution of production resources and focuses on the effect of accrued cost and sales items on profit. The results of the model show that both accrued costs and revenues have a positive effect on profit. Specifically, as the ratio of accrued items to cash items increases, an increase in profit and its optimization can be expected. For example, regarding accrued sales, it can be observed that increasing the ratio of accrued sales to cash sales by up to 50% can result in an 18% increase in profit. Similarly, increasing the ratio of accrued costs to cash costs by up to 20% also leads to an increase in profit.

This suggests that the effect of both accrued costs and revenues on profit is positive. In addition to providing transparency and gaining stakeholder support and trust—important qualitative factors—it can also positively influence profit from a quantitative perspective. Considering that no similar model based on operational research has been explored in previous studies, it can be stated that this research is among the first to measure the effect of accrued items on profit based on operational research models, rather than econometric models. Econometric models typically examine relationships and do not focus on profit optimization, whereas the present study aimed to consider the reduction of cash items and the increase of accrued items, both in revenue and cost, and measure their impact on operating profit.

Future research building upon this study could delve into more detailed analysis and consider accrued items in a more granular way. This study has paved the way for future research in the field, particularly concerning accrued items and their impact on profit.

Authors' Contributions

Authors equally contributed to this article.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

All procedures performed in this study were under the ethical standards.

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