MANAGING THE IMPACT OF THE INVENTORY LEVEL ON THE FINANCIAL RATIOS THROUGH DUAL SIMPLEX ALGORITHM IN THE CORONAVIRUS CRISIS

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Abstract: *This paper presents the impact of inventory level on the financial ratios, namely Return on assets and Debt to assets ratio. This study is designed to help managers to establish an efficient inventory level to obtain a high ROA and a low D/A, which indicates that the company is doing well in managing its resources, can attract more investors and can meet financial obligations with its resources. Determining the inventory level that generates a high ROA and a low D/A is possible using the Primal or Dual Simplex Algorithm. Primal Simplex Algorithm has some limits in determining the inventory level, so the Dual is preferable. Using Dual, the company can simulate more production plans until the optimal stock level is obtained. Also, the Dual Algorithm can help managers to identify the initial optimal solution in the shortest time possible and to re-optimize this solution until the ROA and D/A have the expected value. This possibility of re-optimization is important nowadays due to the impact of the coronavirus crisis on the sales: the company can model the production plan whenever the demand is changing and can simulate the production process which generates the best ROA and D/A that can be obtained even if the revenues decrease or the liabilities increase. This paper presents the initial production plan created by the managers, a worst-case scenario (most common in crisis), where the turnover decreases, the ROA is low and D/A is high, and a best-case scenario (the ideal one), where the turnover increases and ROA and D/A have optimal values. Forecasting inventory level, and therefore ROA and D/A has also the advantage that it could avoid a potential conflict of interest between shareholders and managers. Despite these advantages, there are some limits: firstly, using Dual Simplex Algorithm on determining the inventory level that generates a high ROA or a low D/A makes managers simulate several times until the optimal solution is obtained and secondly there are some short them debts that are not considered. The first limit would be removed in further research, by using fuzzy numbers.*

Keywords: *simplex algorithm; return; debt; assets; liabilities; optimal solution.*

JEL Classification: *C61; G17; G31.*

1. Introduction

All companies, either large or small companies, hold stocks. A shop buys stocks from suppliers and holds them until they meet the demand. A factory buys raw materials and uses them in the production process; even non-manufacturing or service companies need to hold stocks to provide their services to customers.

Holding stocks and determining the stock level are important issues in the decision process. There are three types of decisions, depending on the time horizon: strategic decisions (long term), tactical decisions (medium-term), and operational decisions (short term). The stock level is a:
- strategic issue for the decision of building a new warehouse for stocks or shipping them directly to the consumers;
- a tactical issue for the decision of how much to invest in stocks;
- an operational issue for decisions about the number of raw materials needed for the production process or about the quantity of the finished goods that should be produced in the next period. (Waters, 2009).

There are some traditional inventory methods: EOQ (Economic Order Quantity), JIT (Just-in-time), ABC (Activity-based Costing) that measure and determine the stock level. Moreover, some mathematical algorithms provide the possibility to identify an optimal inventory stock in the next period. These are the Simplex Methods, and compared to inventory methods, they have more advantages: firstly, they relate the stock level not only to the holding cost and reorder cost as EOQ does, but to the time, space, budget, or demand constraints, and secondly, they help managers not only to make the right operational decisions, but also tactical, or strategic decisions.

2. Short Literature Review

Establishing the inventory level is an important issue, due to the impact that it may have on the company's financial performance. There are two different perspectives in the literature: some researchers sustain that there is no relationship between the inventory level and financial performance, while others demonstrate the impact of the stock level on the ROA and Debt to Asset Ratio. Table 1 classifies the publications according to these different views.

Table 1: Different perspectives in literature review

Existing relationship between stock level and ROA, D/A	Non- existing relationship between stock level and ROA, D/A
- Blinder, A. S., & Maccini, L. J. (1991) - Lieberman, M. B., Helper, S., & Demeester, L. (1999) - Chen, et. al (2005) - Waters, C. D. (2009) - Koumanakos, D. P. (2008) - Modi, S. B., & Mishra, S. (2011) - Jayaram, J., & Xu, K. (2016)	- Rumyantsev, S., & Netessine, S. (2007) - Basu, N., & Wang, X. (2011)

Chen et al. (2005) formulated the idea that a low inventory level does not mean a profitable company, but the highest inventory level makes companies perform poorly. It is relevant to determine a stock level that is "low, but not too low."

Waters (2009) demonstrated that level stock has an impact on ROA, considering the formula: Net Profit/Total Assets, where Total Assets means: Current Assets + Non-current (Fixed) Assets. Current Assets are accounts receivable, cash, inventories: raw materials, work-in-progress, and finished goods; and non-current assets are warehouses, plants, equipment, information systems. Current assets will be low when reducing the stock level, while the investment in non-current assets will decrease, and the value of ROA will be high.
Blinder & Maccini (1991) showed that maintaining low inventory would improve production planning, would minimize the cost of shortage and the reorder cost. They also mentioned that it is crucial to establish the inventory level not too high but not too low either.
On the other side, Rumyantsev & Netessine (2007) considered that the absolute inventory level does not influence financial performance. They compared the inventory and sale movements as follows. If the inventory moves faster or more slowly than sales, the company will be less profitable.
Basu, N., & Wang, X. (2011) proved that for the wholesale and retail industry, the relation between stock level and financial indicators is attenuated by the fact that the companies from these industries generally carry a low level of inventory. Also, they showed that the relation between stock and financial performance is sensitive to the choice of the analyzed period.
Reviewing the literature, the question, "what levels of inventory maximize financial performance?” remains, mainly because there is no exact answer to this question.
This paper would offer an answer by using the Simplex Algorithm. The companies would be allowed to find the inventory level adapted to their activity and forecast this level considering both financial performance and operational restrictions (space, time, budget, reorder level, safety stock). Moreover, if the company has a lower ROA and a higher Debt to Asset Ratio after optimizing stock level, this paper provides the possibility for the management to re-optimize the stock level until the expected ROA or D/A has the best value.

3. Optimizing Inventory Level Using Simplex Dual Algorithm

3.1. Definition and Methodology
The inventory level depends on production planning and market demand. The market demand is a variable that can be rarely influenced by the company. The only way to deal with this factor is to adapt the company strategies to the movements of the market in the quickest way. Therefore, it is vital to use methods that collect data and process them in the shortest time. The production planning is at the hand of each company. Using mathematical methods, companies can determine the production level considering the beginning stock, safety stock, and space, time, financial constraints. The most popular method for optimizing production is Primal Simplex Algorithm. The quickest way for re-optimization production is the Dual Simplex Method.
The Simplex Algorithm is "a step by step arithmetic method of solving linear programming problems, whereby one moves progressively from say a position of zero production and therefore zero contribution until no further contribution can be

made. Each step produces a feasible solution and each step is an answer better than one before it, either greater contribution in maximizing problems or smaller costs in minimizing problems" (Okoye,1998).
In using the Simplex Algorithm, it is necessary to formulate the linear program as a mathematical model.

Table 2: The Elements of Linear Program

Components	Mathematical Model	Explanations
1. Objective function	$f(x) = c_1x_1 + c_2x_2 + c_3x_3 + \ldots + c_nx_n$	c_n – the coefficients of the objective function x_i , i $=\overline{1,n}$ - the variables of the problem
2. Restrictions	$\begin{cases} a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n \leq b_1 \\ a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n \leq b_2 \\ a_{31}x_1 + a_{32}x_2 + \ldots + a_{3n}x_n \geq b_3 \\ \vdots \\ a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n \leq b_m \end{cases}$	a_{ij} , i $=\overline{1,n}$ - the coefficients of restrictions b_i , i $=\overline{1,m}$ - right hand side value of the constraint
3. Nonnegativity conditions	$x_1 \geq 0$, $x_2 \geq 0$, ... , $x_n \geq 0$	

After the formulation of the linear program, some steps should be followed to obtain an optimal solution for the linear program. The next step after modeling the linear program is: transforming the linear program from canonical form to standard form (Table 3). There are three possibilities:
- Adding slack variables for every inequality from the linear program. For ≤ inequality, it is necessary a slack variable with a positive coefficient, and for ≥ inequality, a slack variable with a negative coefficient. In the first case, it is recommended to apply the Primal Simplex Algorithm. In the second case, there are two different options: Big M Penalty Method and Dual Simplex Method.
- Adding artificial variables if the slack variable coefficients are negative. Then it is necessary to use the Big M Penalty Method.
- Multiplying the constraints with negative coefficients for slack variables by -1. This form of the linear program can be solved by using the Dual Simplex Algorithm.

Table 3: Converting linear program from canonical form to standard form

Converting canonical form to standard form	Mathematical description
- Adding slack variables (s_i) – Primal Simplex Method, if their coefficients a_{ij} are positive;	$\begin{cases} a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n + s_1 = b_1 \\ a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n + s_2 = b_2 \\ a_{31}x_1 + a_{32}x_2 + \ldots + a_{3n}x_n + s_3 = b_3 \\ \vdots \\ a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n + s_n = b_m \end{cases}$
- Adding artificial variables (A_n) - Big M Penalty Method, if slack variable coefficients a_{ij} are negative;	$\begin{cases} a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n + s_1 = b_1 \\ a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n + s_2 = b_2 \\ a_{31}x_1 + a_{32}x_2 + \ldots + a_{3n}x_n + s_3 = b_3 \\ \vdots \\ a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n - s_n + A_n = b_m \end{cases}$
- Multiplying by -1 the constraints with negative coefficient for slack variable – Dual Simplex Metod	$\begin{cases} a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n + s_1 = b_1 \\ a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n + s_2 = b_2 \\ a_{31}x_1 + a_{32}x_2 + \ldots + a_{3n}x_n + s_3 = b_3 \\ \vdots \\ a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n - s_n = b_m(-1) \end{cases}$

According Keough Gerard and Thie Paul (2011), the next steps are:

- Creating the Initial Simplex Table:
    - If all $b_i \geq 0$ and the differences from the last row of the table are positive for maximizing problem and negative for minimization program, then stop. The solution is primal and dual feasible, so it is optimal.

- If there is a row on the table such that $b_r \leq 0$, and $a_{rj} \geq 0$ for all j, there is no feasible solution.
- Otherwise, determine the pivot by selecting leaving and entering variable.

- Selecting of the leaving variable – the most negative b_i.
- Selecting of the entering variable – the non basic variable that accomplish this condition: Max $\{c_j/a_{rj} : a_{rj} < 0\}$
- Updating the Simplex Table and solving the iteration until the solution meet the optimality criterion.

Theorem 1 (Fundamental Theorem of Duality): Suppose the problems (Eiselt & Sandblom, 2007):

P (primal): maximizing z= c • x subject to A • x ≤ b
D (dual): minimizing v = b • y subject to y • A ≥ c

1. If the P program has an finite optimal solution, the D program has finite optimal solution too, and their objective function value are equal: max z= min v.
2. If the P program has an unbounded optimal solution, the D program is infeasible.
3. If the P program is infeasible, the D program is infeasible.

Theorem 2 (Complementary Slackness) : Suppose the same programs for Theorem 1 . Then x^* and y^* are optimal solution for P and D program if and only if the following equations are satisfied:

$$\begin{cases} (yA - c)x = 0 \\ y(b - Ax) = 0 \end{cases}$$

Linear programming problems use theorem 1 that formulates a dual problem for a primal problem. The Dual Simplex Method does not assess the formulation of the dual problem. It solves the primal problems that do not have a standard form.
Theorem 2 defines the optimality criterion for the dual program. The optimality criterion for the solution means that the P or D program has an optimal solution if and only if the solution for each program is at the same time primal and dual feasible as well. A basic solution is a primal feasible solution if its elements are non-negative and it is a dual feasible solution if it accomplishes the optimality criterion of the Simplex Method.
The Dual Simplex Method is also used in the re-optimization problem:

- When the right-hand side values of the constraints are modified;
- When the constraints system needs a new restriction.

3.2. Example

Suppose a manufacturing company X, that produce 3 products A_1, A_2 and A_3 and should optimize its production process so that to determine the inventory level for the next period. The company collects data about its resources and constraints in the Tabel 4, relates them to the objective (minimizing cost) and formulates the mathematical model for the production planning in order to obtain the minimum value of the objective function and to establish the optimal production quantity and inventory level.

Table 4: The Coefficient's Values of the objective function and constraints

Elements	Criteria	Not.	A_1	A_2	A_3
Objective function	Number of products Unit cost	x_i c_i	x_1 20€	x_2 30€	x_3 15€
Restriction 1	Production time/product	h_i	20'	60'	45'
	Total production time	H	28.760' *		
Restriction 2	The surface/product	s_i	30cm	16cm	20cm
	Total surface	S	10.000 cm**		
Restriction 3	The demand ratio/ product (complementary goods)	q_i	1	2	0
	Total demand	D****	300		
Restriction 4	Price/product	p_i	30€	55€	40€
	Total Sales	T	25.000 €		

*28.720 hours – the company has the working time in three shifts (3 shifts x 8 hours/shift x 20 working days x 60 minutes/hour – 2 hours for maintenance/day x 20 working days)
**10.000 cm – the company has a storage space of 1000 m
**** Total Demand = Expected Demand – Initial Stock + Safety Stock (the initial stock for A_1 and A_2 is equal to 200; the initial stock for A_3 is 0 and safety stock is equal to 100)

The mathematical model for the linear program is as follows:
Objective function:

$$f(x) = 20x_1 + 30x_2 + 15x_3 \text{ - minimize}$$

Constraints:

$$\begin{cases} 20x_1 + 60x_2 + 45x_3 \leq 28.760 \\ 30x_1 + 16x_2 + 20x_3 \leq 10.000 \\ 1x_1 + 2x_2 \geq 300 \\ 30x_1 + 55x_2 + 40x_3 \geq 25.000 \end{cases}$$

Non-negativity conditions

$x_1, x_2, x_3 \geq 0$

Due to the last constraints with ≥ inequalities and due to the coefficients of objective function, the production program needs to be solved with the Dual Simplex Algorithm. Using this algorithm, the problem has the following optimal solution: x_1=0, x_2=150, x_3=419. This means that the company should produce only the product A_2 and A_3 in order to achieve the minimum cost (=10.781€). This optimal solution indicates the stock level, considering the holding cost (space), the production time and the demand. So, the company should have the following inventory level: 150 pieces of product A_2 and 419 pieces of product A_3.

4. The impact of ROA and D/A on inventory level

4.1. Definition of ROA

The return on asset (ROA) is one of the most popular of the financial ratios. It measures how well available resources of the company are used to achieve the highest financial performance.
Jewell and Mankin (2012) summarized the formulas of the ROA in the following table:

Table 5: The ROA formulas adapted from Jewell and Mankin (2012):

Version	Formula
1	Net Income/Total assets
2	Net Income/Average Total assets
3	Earnings Available to Common Shareholders/Total Assets
4	Operating profit/Total Assets
5	Earnings Before Tax/Total Assets

All these formulas have as denominators “Total assets.” Total Assets is the sum of current assets (accounts receivable, inventories, cash) and fixed assets (equipment, plants, lands). There are two possibilities for any company to reduce or increase total assets:

- to increase or reduce current assets through optimizing stocks, contracting or reimbursing credits to influence cash, investing in short term bonds, treasury bills, or other money market funds;
- to increase or reduce fixed assets through buying or selling them, depending on the management decision and optimizing inventories.

Optimizing stocks influence both possibilities. Low inventory level frees up cash for other uses (reimbursing credits, short-term or long-term investments), so the current assets will decrease. Low inventory level will also bring reductions in IT systems, storage space, materials handling equipment, so the fixed assets will decrease.
If the denominator “Total Assets” is low, ROA will be high, if “Total Assets” will be high, ROA will get low. A high value of ROA means that the company uses efficiently available resources to generate income. A low value of ROA means that inventory management was bad. The relationship between ROA and inventory level optimization was described by Waters (2009) through the following figure:

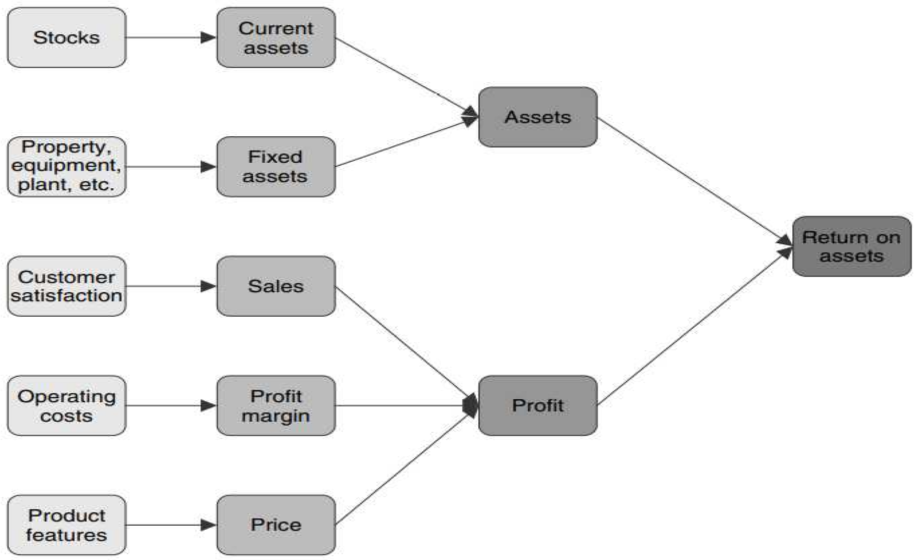

Figure 1 Effects of stock on the ROA
Source: Waters, C. D. (2009). *Inventory control and management*.

4.2. Definition D/A

Debt to asset ratio is a solvency ratio that indicates the participation of debt in financing assets. (Hidayat & Yahya, 2020). It is used to measure the capacity of a company to meet its long-term liabilities (Zelgalve, E., & Berzkalne, I., 2015).
The formulas for these ratios in the previous papers are summarized in the next Table:

Table 6: The D/A formulas

Author	Formulas
R. A. Brealey et al. (2001)	Total Liabilities/Total Assets
E. F. Brigham, J. F. Houston (2009)	Net Debt/ Total Assets
A. Cekrezi and A. Kukeli (2013)	Financial Debt/Total Assets

D/A formulas, as ROA ratios, have as denominator “Total Assets”. A high “Total Assets” generates a low D/A ratio, a low “Total Assets” generates a high D/A ratio. A high D/A ratio means that a significant proportion of assets are financed from debt and show a high risk of investing in a company. A low D/A means that the company can meet its financial obligations.
Inventory level, through D/A denominator, can influence debt to asset ratio this way:
- a high inventory level generates high total assets and a low D/A ratio;
- a low inventory level generates low total assets and a high D/A ratio.

D/A does not refer to long or short-term debts. That means the inventory level cannot impact the debt level if the company is contracting loans for non-current assets. Thus, the numerator of the formula will be approximately the same, but the denominator will be low or high, depending on the stock level.
Short-term debts, such as accounts payable, can be influenced by the stock level. This relationship between short-term debts and inventories can be directly proportional if more acquisitions draw up more debts and inversely proportional if buying more materials can bring discounts, so the debt will decrease. Considering this relation, short-term debts as accounts payable, in this paper are equal to 0 (company buys and pays for the materials at the same time.)
Compared to the impact of inventory level on ROA, there are some differences:

Table 7: Differences of the stock level on ROA and D/A

Impact on ROA	Impact on D/A
Bad impact: - a high inventory level generates a high total assets and low ROA – which means that the company does not use efficiently available resources to generate profits Good impact: - a low inventory level generates low total assets and high ROA	Good impact: - a high inventory level generates a high total assets and a low D/A – which means that company has capacity to meet its obligations Bad impact: - a low inventory level generates a low total assets and high D/A

4.3. Example

Considering the same company X, its ROA and D/A ratios after the production planning, from the previous example, are:

Table 8: ROA and D/A for company X

ROA	D/A
Net Income = 25.000 € (Turnover) - 10.781€ (Optimal Solution) + 3.000 € (Other income)	Total Debts = 20.000 €
Total Assets = 10.781 € (Optimal Solution) + 40.000 € (Fixed + Cash)	Total Assets = 10.781 € (Optimal Solution) + 40.000 € (Fixed + Cash)
ROA = 17.219 € / 50.781 € = 33%	D/A = 20.000 € / 50.781 € = 39%

If the company expects another value for the turnover in the next period due to the impact of the COVID crisis on the market and wants to evaluate the impact of the modified turnover on the inventory level and then on the ROA and D/A, the managers should simulate another production plans with fourth constraint or turnover constraint adjusted. There is a worst-case scenario when the managers expect a decreased turnover due to the regulations in the logistics systems or the consumers' behavior oriented to save money at that time. In the best-case scenario, where the turnover increase, the companies try to offer price reductions during the crisis and thus, to sell more items.

A. The new ROA < first ROA, the new D/A > the first D/A (worst case scenario)

The company wants to obtain a production plan that achieves the minimum cost and the highest turnover than the turnover from the first model (< 25.000 €). Thus, the new production model, with modified turnover constraint, will be:

Objective function:

$$f(x) = 20x_1 + 30x_2 + 15x_3$$

Constraints:

$$\begin{cases} 20x_1 + 60x_2 + 45x_3 \le 28.760 \\ 30x_1 + 16x_2 + 20x_3 \le 10.000 \\ 1x_1 + 2x_2 \ge 300 \\ 30x_1 + 55x_2 + 40x_3 \ge 20.000 \end{cases}$$

Non-negativity conditions

x_1 , x_2 , $x_3 \geq 0$

Using the dual algorithm, the new model has a different optimal solution: x_1=0, x_2=150, x_3=294. Compared to the first optimal solution, which shows that the company should produce only A_2 and A_3, this solution shows that the company should produce A_1 and A_2 to obtain a lower ROA and a lower D/A. The objective function of the new model is $f(x) = 8.906$€. It can be observed that the minimum production cost from the new model is lower than the first minimum production cost (10.781 €). Therefore, the decrease on the turnover generates an optimal solution with decreased cost.

The impact of the new inventory level on the ROA and D/A can be evaluated in the following table:

Table 9: ROA and D/A for company X according to the A case model

ROA	D/A
Net Income = 20.000 € (Turnover) – 8.906€ (Optimal Solution) + 3.000 € (Other income)	Total Debts = 20.000 €
Total Assets = 8.906 € (Optimal Solution) + 40.000 € (Fixed + Cash)	Total Assets = 8.906 € (Optimal Solution) + 40.000 € (Fixed +

	Cash)
ROA = 14.094€ / 48.906 € = 28%	D/A = 20.000 € / 48.906 € = 40%

The results show that ROA has a lower value and D/A has a greater value.

B. The new ROA > first ROA, the new D/A < the first D/A (best case scenario)
Considering this case, the fourth constraint will have a right-hand side value equal to 28.000 €.

Objective function:

$$f(x) = 20x_1 + 30x_2 + 15x_3$$

Constraints:

$$\begin{cases} 20x_1 + 60x_2 + 45x_3 \leq 28.760 \\ 30x_1 + 16x_2 + 20x_3 \leq 10.000 \\ 1x_1 + 2x_2 \geq 300 \\ 30x_1 + 55x_2 + 40x_3 \geq 28.000 \end{cases}$$

Non-negativity conditions

$x_1, x_2, x_3 \geq 0$

The optimal solution for this production plan is: x_1=191, x_2=54, x_3=481. The company should have the following stock level: 191 pieces of product A_1, 54 pieces of product A_2 and 481 pieces of A_3, in order to obtain the objective function: $f(x) = 12.685$ €.
The production cost is higher than the first and second model.
The impact on ROA and D/A is illustrated by the following table:

Table 10: ROA and D/A for company X according to the B case model

ROA	D/A
Net Income = 28.000 € (Turnover) – 12.685 € (Optimal Solution) + 3.000 € (Other income)	Total Debts = 20.000 €
Total Assets = 12.685 € (Optimal Solution) + 40.000 € (Fixed + Cash)	Total Assets = 12.685 € (Optimal Solution) + 40.000 € (Fixed + Cash)
ROA = 18.315 € / 52.685 € = 35%	D/A = 20.000 € / 52.685 € = 37%

This case is an ideal one because both ratios have the expected movement: ROA increased from 33% to 35%, and D/A has decreased from 39% to 37%. These movements are determined by acting only on the turnover constraint. There are more opportunities to obtain expecting ROA and D/A even in crisis period by modifying the production planning problem:

- Adding a new debt constraint, holding cost constraint, or budget constraint;
- Modifying the right-hand side value of the space constraint or time constraint by scheduling efficiently.

Table 9 summarizes the impact of the analyzed production model on the ROA and D/A. Case B is preferable to Case A in terms of ROA, due to the increased ROA and decreased D/A, but if the company appreciates that it is more important to have a low D/A (needed for banks or investors), then case A is the best option.

Table 11: ROA and D/A for company X according to the initial and two cases production models

Elements	Initial production problem	Case A	Case B
Linear Model	Objective function: $f(x) = 20x_1 + 30x_2 + 15x$ Constraints: $\begin{cases} 20x_1 + 60x_2 + 45x_3 \le 2 \\ 30x_1 + 16x_2 + 20x_3 \le 1 \\ 1x_1 + 2x_2 \ge \\ 30x_1 + 55x_2 + 40x_3 \ge 2 \end{cases}$ Non-negativity conditions $x_1, x_2, x_3 \ge 0$,	Objective function: $f(x) = 20x_1 + 30x_2 + 15x_3$ Constraints: $\begin{cases} 20x_1 + 60x_2 + 45x_3 \le 2 \\ 30x_1 + 16x_2 + 20x_3 \le 1 \\ 1x_1 + 2x_2 \ge \\ 30x_1 + 55x_2 + 40x_3 \ge 2 \end{cases}$ Non-negativity conditions $x_1, x_2, x_3 \ge 0$	Objective function: $f(x) = 20x_1 + 30x_2 + 15x$ Constraints: $\begin{cases} 20x_1 + 60x_2 + 45x_3 \le \\ 30x_1 + 16x_2 + 20x_3 \le \\ 1x_1 + 2x_2 \ge \\ 30x_1 + 55x_2 + 40x_3 \ge \end{cases}$ Non-negativity conditions $x_1, x_2, x_3 \ge 0$
Optimal	x_1=0, x_2=150, x_3=419	x_1=1.182 , x_2=0, x_3=114	x_1=191 , x_2=54, x_3=481
ROA	33%	27%	35%
D/A	39%	31%	37%

5. Conclusions and Recommendations

In the nowadays pandemic crisis, the necessity of mathematical methods that can solve inventory problems quickly is more and more obvious. The changes in the logistics fields, consumer behavior, and the markets can hustle the decision-makers into problematic decisions. They have to adapt their supply to the changing demand in the shortest time possible. Using the Dual Simplex algorithm in this context has some advantages:
- Solves problems with the non-standard form of mathematical method so the company can solve even the most difficult decision problems;
- If the company wants to modify one element of the initial linear program, and therefore to simulate more production plans, to compare optimal solutions, Dual simplex has fewer steps and helps the managers to obtain the solution in the shortest time.
- If the company wants to evaluate the impact of modifying one element of the production program on the financial indicators (ROA, D/A, in this paper), Dual Simplex makes an easier way for obtaining the solution. From the initial program,

the company must take the last Simplex Table and go through all the Dual Simplex Steps. There will be fewer iterations, so the company will reduce the solving time and will manage the need for an adapted supply to the changing market.
Using linear programming in evaluating the impact of stock level on ROA and D/A has also some advantages:
- Estimating an efficient production plan, the stock level will be ”low, but not too low,” expected ROA will be high, and expected D/A gets low. These projections would help managers to evaluate the impact of the production level on the financial ratios and to find the optimal solution that will give good results for financial ratios. Then, investors, banks, and other stakeholders will invest with confidence due to the values of ROA and D/A that meet the investor’s requirements;
- Estimating an efficient production program, and therefore high ROA and low D/A can attract more investors, more funds that will increase the financing capacity. This is important for the company, especially when inventory level is a strategic issue (the company needs funds to build a new warehouse for storage).
The limits of this study are:
- Short-term debts on the D/A ratio, such as accounts payable, are not considered;
- ROA considers the inventories at the level of optimal solution from the linear program. It does not take into account the difference between the production level and sales, which is the ending inventory. That means that ROA can be determined using the inventory level with 0 sales;
- Managers should simulate more times until the expected value of ROA and D/A are attained. This paper simulated only three scenarios (initial, A and B), but in fact, the company can have more cases.
These limits could be removed by using a fuzzy number. These numbers will overcome the last limit, due to the possibility of expressing both linear program’s elements and financial ratios in interval numbers, triangular or trapezoidal fuzzy number. Thus, if the company uses fuzzy numbers in the linear program, the ROA and D/A will also be expressed in fuzzy numbers. This means that the company can select the low value from the fuzzy number if it meets the requirements or the high value from the fuzzy ROA and D/A if it is preferable.
Further research is needed to evaluate the impact of using the fuzzy number on the relationship between inventory level and financial indicators. Also, it would be interesting to analyze this relationship using the Multi-objective linear programming and the Multi-objective Simplex Method.

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