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Optimization of Production Costs and Revenues for the Selected Confectionery Product

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Abstract: This article aims to demonstrate the usefulness of quantitative methods in production management, but also to point out the practical benefits that linear programming can bring in finding effective decisions in the specific conditions of a manufacturing company. Based on a detailed description of the production process in a selected company, mathematical models are developed to identify the optimal distribution of resources and determine effective production outputs. These models account for constraints such as production capacity, time availability, and raw material consumption. The primary goal is to find a solution that maximizes net revenue. The results indicate that the current pricing strategy is unsustainable, as production costs exceed revenues in the baseline scenario, necessitating a strategic adjustment of sales prices.

Keywords: quantitative methods; linear programming; production management; mathematical model; optimisation

JEL Classification: D81; C61; M11

1. Introduction

In an environment of increasing competition and dynamic market conditions, emphasis is placed on effective management of business processes, especially in the production sphere. Companies that want to survive in the long term must focus on continuous improvement of productivity, cost reduction and quality of production. A key tool that is increasingly being used in this direction is the optimization of the production process. (Cadkova, 2025).

Manufacturing process optimization involves the systematic analysis and adjustment of manufacturing systems with the aim of improving efficiency, reducing operational costs, and increasing overall output. This is typically achieved by identifying critical stages within the production process, eliminating non-value-adding activities, and implementing measures that enhance productivity (Slack, Brandon-Jones, & Johnston, 2022).

In practice, manufacturing process optimization is frequently supported by quantitative approaches, including material flow analysis, lean manufacturing principles, and the adoption of advanced production management information systems (Heizer, Render, & Munson, 2020). Lean manufacturing emphasizes waste reduction through methods such as

Just-in-Time (JIT), which limits excess inventory levels and improves material flow throughout the organization (Womack & Jones, 2003).

An alternative approach is the theory of constraints, which focuses on identifying and addressing the primary bottlenecks within a production system. This methodology is particularly effective in environments where production capacities across individual processes are uneven and where maintaining the continuity of the entire production chain is essential (Goldratt & Cox, 2016).

One widely used method for production process optimization is linear programming. This technique enables the modeling of production systems using systems of equations and inequalities, allowing key performance indicators—such as profit or production volume—to be maximized while respecting constraints related to raw material availability, machine capacity, or storage limitations (Bazaraa, Jarvis, & Sherali, 2010). In practical applications, linear programming is commonly employed for production planning optimization, waste minimization, and the efficient allocation of manufacturing resources (Winston, 2004).

Linear programming as an operations research tool has been very popular in recent years and is used in many scientific articles in various scientific fields, from computer science (Olivieri, Mangini & Fanti, 2026) and (Khezrimotlagh, 2026), through economics (Moatsos, de Zwart, 2025) or (Djeumou Fomeni, 2026) to energy (Wu, Li, 2026).

2. Methodology

Economic formulation focuses on the practical application and interpretation of the model in the context of economic problems. Objectives, such as maximizing profit or minimizing costs, are identified, and constraints based on real economic conditions, such as available resources, production capacity, or demand, are defined. The mathematical formulation of linear programming is the process of converting a real problem into a mathematical form, which allows its analysis and solution using mathematical methods. The first step in creating a mathematical model is to determine the decision variables. These variables represent the quantities or levels of various activities or resources that are to be optimized. Another key part is defining an objective function that expresses the optimization goal - for example, maximizing profit or minimizing costs. This function is written as a linear combination of the decision variables with corresponding coefficients that represent the benefits or costs of the individual variables. The formulation of the limiting conditions is another essential step. These constraints can include the availability of raw materials, production capacity, labor, and other factors. They are expressed using equations or inequalities that reflect resource constraints or other requirements that must be met.

The simplex method is one of the most commonly used algorithms for solving linear programming problems. This method was developed by George Dantzig and its principle is to search a finite number of basic solutions in order to find the optimal result (Dantzig and Thapa, 2003). The method is widely used in areas such as production, logistics or finance, where the emphasis is on efficient use of resources and cost minimization.

The mathematical function Solver is intended as a key tool for finding the optimal solution within a given mathematical model. This function is used primarily in optimization problems, where it is necessary to maximize or minimize a given target parameter while meeting all defined constraints.

3. Application

The aim of the application part of the contribution is to optimize the costs and revenues of a selected company for the production of the chosen confectionery. Company XYZ is manufacturing confectionery and for reasons of privacy, neither its exact name nor the exact composition of the product is given. More details about the production can be found in the thesis (Cadkova, 2025).

A questionnaire was created to obtain input data on the production of the chosen confectionery. This questionnaire was subsequently distributed to the company XYZ that specializes in the production of these products. The results of the questionnaire provide an overview of various aspects of production, distribution and costs associated with this product. Additional production data were provided by the company based on questions asked regarding a specific issue.

3.1. Basic Data for Building Mathematical Models

Based on the input data obtained from the questionnaire survey, the key parameters required for building of the mathematical models are summarized here. This data is used to define the input variables, constraints and optimization criteria that will be used in the design of the model. Due to the company's request, the attachments regarding the exact recipe and the amount of raw materials needed were hidden.

The cost of raw materials for the production of one piece of confectionery is carefully calculated. The cost of a waffle ingredience is 0.64 CZK, tube filling 2.42 CZK and tube packaging 5.32 CZK. All mentioned prices are with excluding VAT. The availability of raw materials is ensured by monthly deliveries, which include 5800 kg of flour, 4000 kg of sugar, 3200 kg of milk, 10500 kg of fat, 300 kg of egg yolks, 40 kg of flavoring and 2000 kg of starch. There are 2 shifts per day and the workforce consists of 53 employees working a 7.5-hour shift, of which 40 are production workers and the rest are warehouse workers. Working hours are from 6:00 to 14:00 and from 14:00 to 22:00, without restrictions, with the possibility of maintenance during operation or on Saturdays. The company's daily production capacity is 74000 waffles, 50000 rolled tubes, 60000 filled tubes and 56000 packages. The time required for one piece of confectionery is 1 minute per waffle, 50 seconds for rolling and 20 seconds to 1 minute for filling.

4. Models and Results

4.1 Revenue Maximization Model with Production Linkage (Model 1)

The first model is designed to maximize production yields while maintaining continuity (waffles, rolling, filling, and packaging). The price per package of confectionery is 6.9 CZK, and each package contains two pieces of confectionery. The time required is calculated in seconds as a ratio of the length of the shift and production capacity. The economic model is summarized in Table 1 below, and the mathematical model follows in formula (1).

Table 1. Economical model 1

Production	Time Consumption (in seconds)	Production capacity (in pieces)
x_1 - waffles	0.73	74,000
x_2 - rolling	0.90	60,000
x_3 - filling	1.08	50,000
x_4 - packaging	0.90	56,000
Time availability	54,000	
Price per package	6.90 CZK	

objective function:

$$f(x): 6.9x_4 \rightarrow max \qquad (1)$$

subject to:

time availability	$0.73x_1 + 0.9x_2 + 1.08x_3 + 0.9x_4$	$\leq 54,000$
production capacity – waffles	x_1	$\leq 74,000$
production capacity – rolling	x_2	$\leq 60,000$
production capacity – filling	x_3	$\leq 50,000$
production capacity – packaging	x_4	$\leq 56,000$
production linkage – rolling	$x_1 - x_2$	≥ 0
production linkage – filling	$x_2 - x_3$	≥ 0
production linkage – packaging	$x_3 - 2x_4$	≥ 0
non-negativity condition	$x_1,..., x_4$	≥ 0
integer condition	$x_1,..., x_4$	ϵZ

We convert the model to canonical form and enter it into the Solver. The output and settings of the solver are shown in the following figures.

	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	f(x)	
Solution objective function constrains	0	0	0	0	0	0	0	0	0	0	0	0		
	0	0	0	6.9	0	0	0	0	0	0	0	0	0	
	0.73	0.90	1.08	0.90	1	0	0	0	0	0	0	0	0	54,000
	1	0	0	0	0	1	0	0	0	0	0	0	0	74,000
	0	1	0	0	0	0	1	0	0	0	0	0	0	60,000
	0	0	1	0	0	0	0	1	0	0	0	0	0	50,000
	0	0	0	1	0	0	0	0	1	0	0	0	0	56,000
	1	-1	0	0	0	0	0	0	0	-1	0	0	0	0
	0	1	-1	0	0	0	0	0	0	0	-1	0	0	0
	0	0	1	-2	0	0	0	0	0	0	0	-1	0	0

Figure 1. Canonical form

	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	f(x)	
Solution objective function constrains	17,088	17,088	17,088	8,544	1.92	56,912	42,912	32,912	47,456	0	0	0		
	0	0	0	6,9	0	0	0	0	0	0	0	0	58,953.6	
	0,73	0,9	1,08	0,9	1	0	0	0	0	0	0	0	54,000	54,000
	1	0	0	0	0	1	0	0	0	0	0	0	74,000	74,000
	0	1	0	0	0	0	1	0	0	0	0	0	60,000	60,000
	0	0	1	0	0	0	0	1	0	0	0	0	50,000	50,000
	0	0	0	1	0	0	0	0	1	0	0	0	56,000	56,000
	1	-1	0	0	0	0	0	0	0	-1	0	0	0	0
	0	1	-1	0	0	0	0	0	0	0	-1	0	0	0
	0	0	1	-2	0	0	0	0	0	0	0	-1	0	0

Figure 2. Solver settings

We obtain the following optimal solution:

$$x_{opt} = (17088; 17088; 17088; 8544; 1.92; 56912; 42912; 32912; 47456; 0; 0; 0) \quad (2)$$

with corresponding objective function:

$$f(x_{opt}) = 5853.6 \text{ CZK} \quad (3)$$

Economical interpretation of solution (model 1)

To achieve the maximum revenue of 58,953.6 CZK per day, 8,544 packages of confectionery must be produced. Production capacity is mainly limited by the available time; the remaining time is less than 2 seconds in the entire production day. Individual production lines have sufficient capacity ranging from 33,000 to 57,000 seconds. Production continuity is ensured; all waffles are rolled, then filled, and finally packaged in pairs. This implies a 99.9% utilization of the defined 54,000-second production window.

4.2 Revenue Maximization Model with Production Linkage and Ingredients Capacity (Model 2)

The second model maximizing revenue is an extension of the previous model 1. We add constraints related to the storage capacity of ingredients needed to produce the chosen confectionery. When calculating daily capacities, 22 working days in a month were considered. Table 2 summarizes the quantities of ingredients for one waffle and one filling, including the daily available quantity in stock.

Table 2. Confectionery ingredients and their daily capacities

Production	Flour (in kg)	Sugar (in kg)	Milk (in kg)	Fat (in kg)	Egg yolk (in kg)	Flavouring (in kg)	Starch (in kg)
waffle	0.005	0.0002	0.0004	0.00	0.0002	0.00	0.00
filling	0.00	0.0042	0.0016	0.08	0.00	0.0002	0.0011
Daily capacity	263.64	181.82	145.45	477.27	13.64	1.82	90.91

Resulting mathematical model follows in formula (4):

objective function:

$$f(x): 6.9x_4 \rightarrow max \tag{4}$$

subject to:

time availability	$0.73x_1 + 0.9x_2 + 1.08x_3 + 0.9x_4$	$\leq 54{,}000$
production capacity	x_1	$\leq 74{,}000$
	x_2	$\leq 60{,}000$
	x_3	$\leq 50{,}000$
	x_4	$\leq 56{,}000$
production linkage	$x_1 - x_2$	≥ 0
	$x_2 - x_3$	≥ 0
	$x_3 - 2x_4$	≥ 0
storage capacity - flour	$0.005x_1$	≤ 263.64
storage capacity - sugar	$0.0002x_1 + 0.0042x_3$	≤ 181.82
storage capacity - milk	$0.0004x_1 + 0.0016x_3$	≤ 145.45
storage capacity - fat	$0.08x_3$	≤ 477.27
storage capacity – egg yolk	$0.0002x_1$	≤ 13.64
storage capacity - flavouring	$0.0002x_3$	≤ 1.82
storage capacity - starch	$0.0011x_3$	≤ 90.91
non-negativity condition	$x_1,\dots, x_4$	≥ 0
integer condition	$x_1,\dots, x_4$	ϵZ

We convert the model to canonical form and enter it into the Solver, the output can be seen in the following image.

	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12
Solution	27,528	27,528	5,965	2,982	3.36	46,472	32,472	44,035	53,018	0	21,563	1
objective function	0	0	0	6.9	0	0	0	0	0	0	0	0
constrains:	0.73	0.9	1.08	0.9	1	0	0	0	0	0	0	0
	1	0	0	0	0	1	0	0	0	0	0	0
	0	1	0	0	0	0	1	0	0	0	0	0
	0	0	1	0	0	0	0	1	0	0	0	0
	0	0	0	1	0	0	0	0	1	0	0	0
	1	-1	0	0	0	0	0	0	0	-1	0	0
	0	1	-1	0	0	0	0	0	0	0	-1	0
	0	0	1	-2	0	0	0	0	0	0	0	-1
	0.005	0	0	0	0	0	0	0	0	0	0	0
	0.0002	0	0.0042	0	0	0	0	0	0	0	0	0
	0.0004	0	0.0016	0	0	0	0	0	0	0	0	0
	0	0	0.08	0	0	0	0	0	0	0	0	0
	0.0002	0	0	0	0	0	0	0	0	0	0	0
	0	0	0.0002	0	0	0	0	0	0	0	0	0
	0	0	0.0011	0	0	0	0	0	0	0	0	0

x13	x14	x15	x16	x17	x18	x19	f(x)	
126	151.2614	124.8948	0.07	8.1344	0.627	84.3485		
0	0	0	0	0	0	0	20,575.8	
0	0	0	0	0	0	0	54,000	54,000
0	0	0	0	0	0	0	74,000	74,000
0	0	0	0	0	0	0	60,000	60,000
0	0	0	0	0	0	0	50,000	50,000
0	0	0	0	0	0	0	56,000	56,000
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1.1102E-16	0
1	0	0	0	0	0	0	263.64	263.64
0	1	0	0	0	0	0	181.82	181.82
0	0	1	0	0	0	0	145.45	145.45
0	0	0	1	0	0	0	477.27	477.27
0	0	0	0	1	0	0	13.64	13.64
0	0	0	0	0	1	0	1.82	1.82
0	0	0	0	0	0	1	90.91	90.91

Figure 3. Solver settings

We obtain the following optimal solution:

$$x_{opt} = (27528; 27528; 5965; 2982; 3.4; 46472; 32472; 44035; 53018; 0; 21563; 1; 126; 151; 125; 0.07; 8.13; 0.627; 84.35) \quad (5)$$

with corresponding objective function:

$$f(x_{opt}) = 20575.8 \text{ CZK} \quad (6)$$

Economical interpretation of solution (model 2)

Instead of 8,544 packages sold based on model 1, only 2,982 were produced when ingredients capacities were added. This reduced the revenue to 20,575.8CZK. The main reason is the insufficient capacity of fat, which remains in stock after production is 0.07 kg. If we were to double its stock, we would run out of stock of flavoring. To achieve the daily maximum production limited by time capacity, it would be necessary to have at least 226.5kg of sugar, 159.1kg of milk, 1,367.2kg of fat, 4.1kg of flavouring and 103.2kg of starch in stock to produce 8544 tube packages (i.e. 17088 pieces of tubes).

4.3. Cost Minimization Model with Production Linkage (Model 3)

Finally, let us design the model by minimizing the production costs of the selected confectionery. The basic constraints are again the available time and production continuity. In addition, the minimum production quantity must be considered; without this condition, the model would suggest not producing anything, resulting in zero costs. The minimum production value is set at 8,544 packages of confectionery, which results from model (1) maximizing revenue. to ensure comparability with the revenue maximization model. From the questionnaire, we know the costs of the semi-finished products, but we must convert them into individual costs. We can subtract the waffles and filling from the packaging to get the packaging costs, and we can subtract the cost of the waffles from the filling to get the filling costs. There is no cost of tube rolling as only production time is required and no ingrediencies are involved. The economic model is summarized in Table 3 below, and the mathematical model follows in formula (7).

Table 3. Economical model 3

Production	Time Consumption (in seconds)	Production cost (in CZK)
x_1 - waffles	0.73	0.64
x_2 - rolling	0.90	0
x_3 - filling	1.08	1.79
x_4 - packaging	0.90	2.26
Time availability	54,000	
Minimal amount	8,544 (pc)	

objective function:

$$f(x): 0.64x_1 + 1.79\,x_3 + 2.26x_4 \rightarrow min \quad (7)$$

subject to:

time availability	$0.73x_1 + 0.9x_2 + 1.08x_3 + 0.9x_4$	≤ 54000
production linkage – rolling	$x_1 - x_2$	≥ 0
production linkage – filling	$x_2 - x_3$	≥ 0
production linkage – packaging	$x_3 - 2x_4$	≥ 0
minimal production	x_4	≥ 8544
non-negativity condition	$x_1,\ldots, x_4$	≥ 0
integer condition	$x_1,\ldots, x_4$	$\in Z$

We convert the model to canonical form and enter it into the Solver, the output can be seen in the following image.

x1	x2	x3	x4	x5	x6	x7	x8	x9	f(x)	
0	0	0	0	0	0	0	0	0		
0.64	0	1.79	2.26	0	0	0	0	0	0	
0.73	0.9	1.08	0.9	1	0	0	0	0	0	54,000
1	-1	0	0	0	-1	0	0	0	0	0
0	1	-1	0	0	0	-1	0	0	0	0
0	0	1	-2	0	0	0	-1	0	0	0
0	0	0	1	0	0	0	0	-1	0	8,544

Figure 4. Canonical form

	x1	x2	x3	x4	x5	x6	x7	x8	x9	f(x)	
	17,088	17,088	17,088	8,544	1.92	0	0	0	0		
	0.64	0	1.79	2.26	0	0	0	0	0	60,833.28	
Solution objective function constrains:	0.73	0.9	1.08	0.9	1	0	0	0	0	54,000	54,000
	1	-1	0	0	0	-1	0	0	0	0	0
	0	1	-1	0	0	0	-1	0	0	0	0
	0	0	1	-2	0	0	0	-1	0	0	0
	0	0	0	1	0	0	0	0	-1	8,544	8,544

Figure 5. Solver settings

We obtain the following optimal solution:

$$x_{opt} = (17088;\ 17088;\ 17088;\ 8544;\ 1.92;\ 0;\ 0;\ 0;\ 0)\ \text{CZK} \quad (8)$$

with corresponding objective function:

$$f\left(x_{opt}\right) = 60833.3\ \text{CZK} \quad (9)$$

Economical interpretation of solution (model 2)

Producing at least 8544 packages of confectionery leads to the minimal daily cost of 60833,28CZK. Production capacity is mainly limited by the required production amount and available time; the remaining time is less than 2 seconds in the entire production day. Production continuity is ensured; all waffles are rolled, then filled, and finally packaged in pairs.

5. Discussion

The outputs of models (1) and (3) do not differ in terms of production volume and time consumption. However, there is a significant difference in their objective function values. The maximum daily profit is 58,953.6 CZK, and the minimum daily costs for the same production are 60,833.28 CZK. With the current sales price set at 6.9 CZK per package, there is a daily loss of 1,879.68 CZK. These findings align with the principles of Heizer, Render, and Munson (2020), who emphasize that operational efficiency is not merely about volume, but about the balance between sustainability and cost management. The production process set up is inefficient and unprofitable. We recommend that Company XYZ should increase the sales price to at least 7.12 CZK to balance costs and revenues. If Company XYZ wants to generate at least a 15 percent profit, the minimum selling price would need to be set at CZK 8.19 CZK per one package of confectionery.

6. Conclusion

Based on the three developed models, the following conclusions and recommendations are proposed:

- Pricing Strategy Realignment: The most significant finding is that at the current selling price of 6.90 CZK per package, the company generates a daily loss of approximately 1,880

CZK. The break-even price was identified at 7.12 CZK. To achieve a sustainable profit margin of 15%, the company must increase the selling price to at least 8.19 CZK per package.

- Supply Chain Optimization: Model 2 demonstrated that raw material constraints, specifically fat (shortening) reserves, significantly limit the potential revenue. The current stock levels allow for only 35% of the total production capacity to be utilized. It is recommended to renegotiate delivery frequencies or increase storage capacity for key ingredients to prevent production idling.
- Resource Allocation: The models show a near-perfect utilization of the 54,000-second production shift. However, such high utilization leaves no room for unexpected machine downtime or maintenance. A strategic buffer of at least 5-10% in time capacity should be integrated into future planning to increase operational resilience.

In conclusion, the use of quantitative optimization methods allowed the identification of "invisible" losses caused by an incorrectly set price-to-cost ratio. By implementing the proposed price adjustment and addressing material bottlenecks, Company XYZ can transform its production from a loss-making operation into a highly efficient and profitable business.

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