OFFICIAL TEMPLATE FOR THE SUBMISSION OF PAPERS
II INTERNATIONAL SCIENTIFIC CONVENTION
"II ICC UCLV 2019"

JUNE 23th – 30th, 2019
CAYOS DE VILLA CLARA. CUBA.

COMEC 2019

Logistic aspects of inventory optimization

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Abstract: *In case of a restaurant we reviewed the factors which are related to stocks and to their economic sizes.*
Matrices were used to describe data related to material output ratio in case of both elementary and composite components. With the help of these matrices we created the material output ratio matrix. Prices of components that can be bought from suppliers were arranged into matrices based on their size and variety. We also dealt with the effects of preferential options. Furthermore, we pointed out the terms of actual and planned waste. After that we defined cases in which we could calculate the quantity of unused raw materials.
Following these efforts we overviewed those costs that can occur during the order process and stock keeping. we created various formulas to identify costs. As constraint the storage capacities must have been taken into consideration.
During the optimization we searched for the combination of set inventory products which meet the requirements of defined stock levels, the available storage capacity and costs altogether – including purchasing price as well – in order to take the lowest value. Our model is validated with a case study.

Keywords: *inventory, optimization, restaurant, costs*

1. Introduction

Proper management of inventory and determination of optimal stock levels is a key task for production companies [1]. In order to provide trouble-free customer service, a set of required components should be kept, but larger stocks are not advantageous due to cost considerations. As an excessive reduction in inventories can lead to a drop in turnover , unjustifiably high stockholding has a negative impact on economy.

In order to ensure smooth material flow processes, it is important to determine the inventory levels required for efficient operation [2]. The task of inventory management is to implement inventory-related activities cost-effectively.

2. The decisive factors for inventory management in a restaurant

As with production, many aspects of a restaurant should be taken into account when designing an optimal stockholding system. In connection with purchases, account should be taken of potential suppliers, alternative purchasing options, alternative raw material options, purchase prices, available discounts, shipping costs, unit package sizes, cost of orders, lead time for orders, takeover costs , the cost of breaking up the units, the expected level of sales and the number and quantity of raw materials required [3, 4].

For perishable materials (e.g. meat), weekly shipping is not an option. Depending on the particular material, the time between deliveries is a minimum of two days, but may take several weeks or months.

The factors to be considered during storage, prior to use, are the storage capacity and its expandability, the storage conditions required by the raw material, the quantity of semi-finished products to be prepared, the shelf-life, the degradability, and the storage regulations. The purchased products , in accordance with the required/possible storage conditions , usually carry the expiration information themselves, if not, then they can be used for a regulated period.

Other influencing factors include inventory shortage disadvantages, supplier stock shortages , cost of scrap, cost of capital tying , safety stock level , stochastic parameters that affect sales (outside temperature, rain, wind), seasonal or cyclical fluctuations, actions, events, available IT background, time horizon for reviewing inventory levels [5]. Every enterprise wants to reduce the amount of scrap to zero, or at least keep it at an acceptable level. A ready-to-eat or semi-finished product may be discarded if it is still can be kept , but it is no longer of inadequate quality or deteriorated, or because it was not used by the deadline. One of the most important limiting conditions is the amount of capital ties. As a result of the calculation of the amount of fixed capital and the risk-free investment rate – taking into account the time horizon – the cost of the capital tie can be calculated. Having a safety reserve stock provides the opportunity to meet unexpectedly growing customer needs , of course, only to the extent of the stock.

Many external factors independent of the restaurant may affect daily traffic, such as weather, seasonality, or even when customers gets paid or the weekend or weekday, but school breaks can also have an impact.

3. The way to the optimal set

The following is an example of a fictitious restaurant showing how to determine the optimal stock size in the presence of specific factors, parameters, and constraints [6].

The products sold by the restaurant are composed of elementary and compound ingredients during cooking and preparation. Products available from suppliers are the elementary components, while composite products are called semi-finished products prepared in the restaurant. The terms used in the study are: $\boldsymbol{y} = [y_1; y_2; \dots; y_m]^T$ contains the m number of products in the restaurant's menu, $\boldsymbol{z} = [z_1; z_2; \dots; z_m]^T$ contains the average quantity of products sold in one day, $\boldsymbol{x}^* = [x_1; x_2; \dots; x_n; \cdots; x_{n+k}]^T$ contains the ingredients needed to prepare food, of which n are elementary ingredients, while k are semi-finished products ($n+1$ ... $n+k$). $\boldsymbol{x} = [x_1; x_2; \dots; x_n]^T$ contains only the elementary components.

The restaurant's standard book contains non-zero elements of the columns of the $\boldsymbol{F}$ and $\boldsymbol{A}^*$ matrices detailed below, as well as the recipes themselves, the standard of preparation, important information about serving, and a photograph of the finished food. $\boldsymbol{F}$ is the proportion of material in the semi-finished product matrix, where f_{ij^*} is the j^*-th is the amount of *i*-th ingredient in SI unit expressed per SI unit. $\boldsymbol{A}^*$ is a material fraction matrix where a^*_{ij} the amount of the *i*-th ingredient required for a portion of product *j*, expressed in SI units, if the elemental ingredient is otherwise in a portion and a^*_{ij} does not contain any amount of material added due to the semi-finished product component. Figures for elementary components in the first *n* row of the matrix, for compound components, are in the following *k* row (*n+1 ... n+k*). The $\boldsymbol{A}^*_{\boldsymbol{red1}}$ is calculated from the $\boldsymbol{A}^*$ matrix's first *n* row, while the $\boldsymbol{A}^*_{\boldsymbol{red2}}$ is a matrix calculated from the $\boldsymbol{A}^*$ matrix's last *k* row. The elements of the $\boldsymbol{F^*}$ matrix represent the amounts of elementary components resulting from the breakdown of the composite components specified in matrix $\boldsymbol{A^*}$, taking into account the material ratios given in the matrix $\boldsymbol{A^*}$. $\boldsymbol{F}^* = \boldsymbol{F} \cdot \boldsymbol{A}^*_{\boldsymbol{red2}}$, *where* $f^*_{ij} = \sum_{j^*=1}^{k} (f_{ij^*} \cdot a_{(n+j^*)j})$. Substance A matrix also contains elementary components required for semi-finished products, for which we have to sum up the matrices $\boldsymbol{A}^*_{\boldsymbol{red1}}$ and $\boldsymbol{F}^*$. $\boldsymbol{A} = \boldsymbol{A}^*_{\boldsymbol{red1}} + \boldsymbol{F}^*$, *where* $a_{ij} = a^*_{ij} + f^*_{ij}$. A $w_i = \boldsymbol{x}_{\boldsymbol{i}}^{\boldsymbol{T}} \cdot \boldsymbol{z} = \sum_{j=1}^{m} (a_{ij} \cdot z_j)$ is the total quantity required for the i th component, while $\boldsymbol{w} = [w_1; w_2; \dots; w_n]^T$ contains the required amounts for all ingredients. $\boldsymbol{x}_{\boldsymbol{i}} = [a_{i1}; a_{i2}; \dots; a_{im}]^T$ - the vector of the *i*-th row of matrix $\boldsymbol{A}$ - specifies the amount of *i*-th component required for each portion of products, $\boldsymbol{y}_{\boldsymbol{j}} = [a_{1j}; a_{2j}; \dots; a_{nj}]^T$ - the vector from the *j*-th column of matrix $\boldsymbol{A}$ - quantifies the material ratio for the product $\boldsymbol{y}_{\boldsymbol{j}}$.

In the case of semi-finished products and finished products, if it has a vegetable (or some kind of spice) component, you can start with earthy and cleaned ingredients. Depending on the type of starting vegetable (spice), the degree of cleaning loss and the cost of processing time can be determined. After all, you can determine if the cleaned vegetables should be purchased. For the sake of comparability, it is advisable to determine the price per kilogram of the cleaned product and to use it as a unit price, using the price of the ground vegetables and taking into account the losses.

Purchasing products, discounts and scraps

The specific products that represent the ingredients can be obtained as a variety of product types, in a variety of product sizes and generally from several suppliers. Product and product size combinations for each component are interchangeable products. To define this, we create the prices for the *g*-product type in the *g*-column of the $\boldsymbol{C_{il}}$ matrix, while in the *f*-th we find the prices for the *f*-product size by product type.

We should be able to compare the individual prices, so it is necessary to determine the prices expressed in the unit of mass ratio, which is indicated by k^1 and called unit price: $k^1_{ilfg} = c^{fg}_{il} \cdot \frac{1}{p^f_{il}}$. In addition to the prices, it is important to know whether the product can be ordered in pieces or in larger quantities. The number of products in unit loads is included in the $\boldsymbol{DB_{il}}$ matrix by product size and product type. We may choose a larger package size from a product type, even though we know that we will not be able to fully utilize it within the shelf life. h_{ilfg} indicates shelf-life in unopened packaging, expressed in days,, h^*_{ilfg} usability after opening, expressed in days. From x_i component w_i is consumed in 1 day, so in h^*_{ilfg} days $w_i \cdot h^*_{ilfg}$.

$$the\ amount\ of\ scrap = \begin{cases} 0, & \text{if } w_i \cdot h^*_{ilfg} \geq p^f_{il} \\ p^f_{il} - w_i \cdot h^*_{ilfg}, & \text{otherwise} \end{cases}$$

The price change effect of the planned scrap should be taken into account, as we should not refer to the original p^f_{il} but the actual amount used. It is worth choosing a larger package if the resulting k^{1*}_{ilfg} unit price is more favorable.

Determining Total Cost

When determining the total cost, mark K^1 the amount to be paid for the purchased products, K^{RN} the cost of the order, K^{SZ} the shipping cost, $K^{ÁV}$ the cost of taking over the goods, K^R the cost of stocking, K^A the cost of administration tasks, K^T is the cost of storage, K^F is the cost of processing, K^P is the cost of portions, K^{TL} is the cost of capital tying.

The total cost is summarized by summing up the different types of costs:

$$K = K^1 + K^{RN} + K^{SZ} + K^{ÁV} + K^R + K^A + K^T + K^F + K^P + K^{TL}$$

Cost per day:

$$K_{day} = K_{day}^1 + K_{day}^{RN} + K_{day}^{SZ} + K_{day}^{ÁV} + K_{day}^R + K_{day}^A + K_{day}^T + K_{day}^F + K_{day}^P + K_{day}^{TL}$$

When determining the total cost, account must be taken of the costs associated with the order and stockholding [8, 9] and the cost of modifying the purchase price.

When determining the price to be paid for the product, please indicate the quantity of the material in the product weight unit, and the number of products. For a given daily order, the number of items to be purchased from component *i* from supplier *i* is contained in the $\boldsymbol{U_{il}}$ matrix per product size (*1…s(il)*) and product type (*1…q(il)*).

Number of all products from all suppliers:

$$sz = \sum_{i=1}^{n} \sum_{l=1}^{t(i)} \sum_{g=1}^{q(il)} \sum_{f=1}^{s(il)} u_{il}^{fg}$$

Quantity of material purchased from all components from all suppliers::

$$me = \sum_{i=1}^{n} \sum_{l=1}^{t(i)} \sum_{g=1}^{q(il)} \sum_{f=1}^{s(il)} (u_{il}^{fg} \cdot p_{il}^{f})$$

Total orders daily:

$$K_{day}^1 = \sum_{l=1}^{t(i)} \sum_{i=1}^{n} \sum_{g=1}^{q(il)} \sum_{f=1}^{s(il)} (u_{il}^{fg} \cdot c_{il}^{fg})$$

When determining the cost of ordering, indicate $l_1; \dots; l_\alpha$ the suppliers involved in the given order, $time^{RN}$ the time spent on ordering the goods on a given day, $time^{\text{list}}$ census of the time spent on writing the order list, $time^{rf}$ he time used to send orders daily, $time_1^{email}$ the average time spent preparing a letter addressed to a supplier, $time_1^{itemrow}$ the average time of writing an item line, k^{RN} the hourly cost of the ordering employee, α the relevant suppliers number. The cost of ordering is the sum of the cost of ordering and the time spent on ordering.

Cost of ordering per day:

$$K_{day}^{RN} = k^{RN} \cdot time^{RN} = k^{RN} \cdot \left(time^{\text{list}} + time^{email} \cdot \alpha + time^{itemrow} \cdot \sum_{l=1}^{l_ö} \sum_{i=1}^{n} u_{il}^{\alpha} \right)$$

When determining the shipping cost, indicate k_l^{SZ} the shipping charge below the order limit, $\boldsymbol{R_l^{min}}$ the minimum order value for *l*-th supplier. The shipping cost above the minimum order value (R_l^{min}) is usually *0*, below which the supplier determines the delivery fee or does not deliver it. Total shipping costs for daily orders:

$$K_{day}^{SZ} = \sum_{l=1}^{l_\alpha} k_l^{SZ}$$

When determining the cost of receiving the goods, mark $time^{ÁV}$ on the day of the receipt of the goods, $time^{ell}$ the time spent on the inspection, $time_1^{ell}$ the average time spent on checking a product type, $time^{szp}$ the time spent on random spot checking daily, $time_1^{szp}$ average time required for random spot check, $time^{af}$ time spent with administrative tasks related to the receipt of goods, $time_1^{af}$ average time spent by the administrative tasks related to the receipt of goods by supplier, $k^{ÁV}$ the hourly cost of the goods handling staff member.

The task of taking over the goods is to check the quantity and quality of the ordered goods (*ell*); random check of the temperature and cleanliness of the transport vehicle (*szp*) and the signature of the delivery note, receipt of the invoice, payment if necessary (*af*). The cost of receiving the goods per day:

$$K_{day}^{ÁV} = k^{ÁV} \cdot time^{ÁV} = k^{ÁV} \cdot \left(time_1^{ell} \cdot \sum_{l=1}^{l_\alpha} \sum_{i=1}^{n} u_{il}^{\alpha} + time_1^{szp} \cdot \frac{\alpha}{10} + time_1^{af} \cdot \alpha \right)$$

When determining the cost of stocking, mark $time^{szr}$ time spent on shipping to warehouse per day, $time_1^{szr}$ shipment time of goods shipped from one supplier, $time^{poz}$ time spent on positioning, $time_1^{poz}$ for positioning time for a component, $time^{rak}$ takes the time spent on loading, $time_1^{rak}$ the time spent on loading a product/unit load, k^R the hourly cost of the warehouse employee.

The steps of placing the goods in the warehouse are: moving the goods to the warehouse, positioning, loading. Let $ER\{x\}$ denote the integer x. Total number of items not included in unit loads per supplier:

$$\sum_{i=1}^{n}\sum_{g=1}^{q(il)}\sum_{f=1}^{s(il)}(u_{il}^{fg} - ER\left\{\frac{u_{il}^{fg}}{db_{il}^{fg}}\right\} \cdot db_{il}^{fg})$$

The time spent on loading is primarily determined by the number of unit loads (bulk packaging, multipacks) and the number of separate products, while positioning is determined by the number of components involved. The number of affected components is equal to the number of non-zero $\boldsymbol{U_{il}}$ matrices, denote this value by supplier $\boldsymbol{NN_l}$. The time of delivery to the warehouse depends on the number of suppliers involved. Cost of stocking per day:

$$K_{day}^{R} = k^R \cdot time^R =$$

$$= k^R \cdot \left\{ time_1^{szr} \cdot \alpha + time^{poz} \cdot \sum_{l=1}^{l_\alpha} NN_l + time_1^{rak} \cdot \right.$$

$$\left. \cdot \left[\sum_{i=1}^{n}\sum_{g=1}^{q(il)}\sum_{f=1}^{s(il)} ER\left\{\frac{u_{il}^{fg}}{db_{il}^{fg}}\right\} + \sum_{i=1}^{n}\sum_{g=1}^{q(il)}\sum_{f=1}^{s(il)}(u_{il}^{fg} - ER\left\{\frac{u_{il}^{fg}}{db_{il}^{fg}}\right\} \cdot db_{il}^{fg}) \right] \right\}$$

When defining administrative tasks, mark $time^A$ time required for administrative tasks per day, $time_1^A$ time required for administrative tasks related to a product, k^A the hourly cost of an administrative staff member. Cost of administration tasks per day:

$$K_{day}^{A} = k^A \cdot time^A = k^A \cdot time_1^A \cdot \sum_{l}^{l_{ö}}\sum_{i}^{n} u_{il}^{\alpha}$$

Storage costs may be due to the following major factors: K_{day}^{rent} the warehouse's rent per day, $K_{day}^{amortization}$ amortization is 1/365 part of the annual depreciation of the equipment,

$K_{day}^{\text{electricity}}$ current is the average daily consumption of electricity. The daily storage cost is the sum of the cost factors: $K_{day}^{T} = K_{day}^{rent} + K_{day}^{amorization} + K_{day}^{\text{electricity}}$.

Due to the small increase in the stock, it may be necessary, e.g. to buy an additional refrigerator, then the rent does not change but the other two factors increase.

When determining the processing cost, specify ve_i^{fg} as % of the cleaning loss, $time_{1ilg}^{F}$ for processing of 1kg product, k^F the hourly cost of the processing worker. Cost of processing per day:

$$K_{day}^{F} = k^F \cdot \sum_{i=1}^{n}\sum_{l=1}^{t}\sum_{g=1}^{q(il)}\sum_{f=1}^{s(il)}(u_{il}^{fg} \cdot p_{il}^{f} \cdot time_{1ilg}^{F})$$

When determining the dispense cost, indicate $idő_{1ilfg}^{P}$ the time required to convert the product to smaller portions, k^P he hourly cost of the worker dispensing the product. If you buy a larger package of product, it may be necessary to convert it into smaller units, so you should also count on the cost of portions at the expected price. If the product is opened then it will no longer be the shelf life but the useful life that matters. If these two periods differ from each other, then we must also calculate the possibility of scrap formation. In this case, the modified unit price should be taken into account instead of the purchase price. Cost of converting products into smaller portions per day:

$$K_{day}^{P} = k^P \cdot \sum_{i=1}^{n}\sum_{l=1}^{t}\sum_{g=1}^{q(il)}\sum_{f=1}^{s(il)}\left(u_{il}^{fg} \cdot time_{1iflg}^{P}\right)$$

When we buy stocks, we tie our free funds. Calculations can be based on the risk-free interest rate or the average profitability of a company operating in a similar business. The expected annual interest rate of interest should be $interest_{expected}$, VALUE_{day} is the total value of the inventory per day. The daily cost of the capital bond: $K_{day}^{TL} = \text{VALUE}_{day} \cdot interest_{expected}/365$.

Stored foods, depending on whether they require refrigeration or freezing, are basically divided into three groups according to storage location: dry warehouse, refrigerator, freezer. These aspects should also be taken into account during the examination. The amount of space that can be utilized in the φ-th storage space is given by $kap^{\varphi 1} \cdot kap^{\varphi 2}$.

Limit: For all storage locations, it should be true that the total stock of products stored there is less than or equal to the size of the space that can be used there:

$$kap^{\varphi 1} \cdot kap^{\varphi 2} \geq \boldsymbol{TH}_{\varphi} = \sum_{i=1}^{n} \sum_{g=1}^{q(i)1} (rpt_i^g \cdot r_i^{g\varphi}) = \sum_{i=1}^{n} \sum_{g=1}^{q(i)1} \sum_{f=1}^{s(i)} \left(rp_i^{fg} \cdot \mathrm{re}_i^{fg} \cdot r_i^{g\varphi}\right) =$$

$$= \sum_{i=1}^{n} \sum_{g=1}^{q(i)1} \sum_{f=1}^{s(i)} \left(rp_i^{fg} \cdot rh_i^{fg} \cdot db_i^{fg} \cdot r_i^{g\varphi}\right) =$$

$$= \begin{cases} \displaystyle\sum_{i=1}^{n} \sum_{g=1}^{q(i)1} \sum_{f=1}^{s(i)} \left(\frac{ru_i^{fg} \cdot rh_i^{fg} \cdot r_i^{g\varphi}}{reh_i^{fg}}\right), & \text{if ER}\left\{\dfrac{ru_i^{fg}}{db_i^{fg} \cdot reh_i^{fg}}\right\} = \dfrac{ru_i^{fg}}{db_i^{fg} \cdot reh_i^{fg}} \\ \displaystyle\sum_{i=1}^{n} \sum_{g=1}^{q(i)1} \sum_{f=1}^{s(i)} \left[\left(\text{ER}\left\{\frac{ru_i^{fg}}{db_i^{fg} \cdot reh_i^{fg}}\right\} + 1\right) \cdot rh_i^{fg} \cdot db_i^{fg} \cdot r_i^{g\varphi}\right], & \text{otherwise} \end{cases}$$

where $kap^{\varphi 1}$ is all areas of φ-th storage space, $kap^{\varphi 2}$ is capacity utilization, $\boldsymbol{TH_{\varphi}}$ is the total usable area, rpt_i^g is the total area occupied by g-th product type, the storage location is identified by $r_i^{g\varphi}$ (1 if the g-th product type is in the φ-th storage location, otherwise 0), the area reservation for specific products is rh_i^{fg}, the number of products in unit loads db_i^{fg}, the number of stored items ru_i^{fg}, the maximum number of unit loads that can be stacked at one warehouse position reh_i^{fg}, ER is the whole part.

Usage, stock level markers, checks, conditions

Due to fluctuations in use, it is advisable to use a safety reserve stock. Taking into account all m pieces of y_j products, the quantities of ingredients needed to produce the products sold in one day for the past period (e.g. 1 year) should be calculated and then the average and standard deviation for each component. Depending on the likelihood of allowing a stock shortage, you can determine the safety stock level by multiplying the value z by the standard deviation and the service level expectation. The z is a standard normal distribution value that can be retrieved from a table. If a stock shortage is not allowed, then the value of $z = 3.8$ for the 99.99% service level should be multiplied by the standard deviation. $SafetyReserve_i = Bk_i = z \cdot \sigma_i$.

The commodity products are divided into 5 groups according to their shelf life: very perishable products: $h_{ilfg} \leq 3\ days$; degradable products: $3\ days < h_{ilfg} \leq 7\ days$; products with shelf life minimum 1, maximum 2 weeks: $7\ days < h_{ilfg} \leq 14\ days$; Products for 2-4 weeks: $14\ days < h_{ilfg} \leq 28\ days$; Products that can be stored for more than 1 month: $28\ days < h_{ilfg}$.

Table 1: The evolution of the maximum inventory and order launch inventory level

Shelf life	**Maximum stock ($\boldsymbol{Maxk_i}$)**	**Order launch inventory level ($\boldsymbol{Rk_i}$)**
$h_{ilfg} \leq 3$ days	$h_{ilfg} \cdot w_i + Bk_i$	stock $\leq (2+T) \cdot w_i + Bk_i$
3 days $< h_{ilfg} \leq 7$ days	$0{,}9 \cdot h_{ilfg} \cdot w_i + Bk_i$	stock $\leq (2+T) \cdot w_i + Bk_i$
7 days $< h_{ilfg} \leq 14$ days	$0{,}85 \cdot h_{ilfg} \cdot w_i + Bk_i$	$(4+T) \cdot w_i + Bk_i \leq stock \leq (2+T) \cdot w_i + Bk_i$
14 days $< h_{ilfg} \leq 28$ days	$0{,}8 \cdot h_{ilfg} \cdot w_i + Bk_i$	$(7+T) \cdot w_i + Bk_i \leq stock \leq (2+T) \cdot w_i + Bk_i$
28 days $< h_{ilfg}$	$0{,}75 \cdot h_{ilfg} \cdot w_i + Bk_i$	$(7+T) \cdot w_i + Bk_i \leq stock \leq (2+T) \cdot w_i + Bk_i$

Source: created by the authors

Table 1 summarizes the recommended values for the maximum stock and order launch stock level. T is the number of days after the day of delivery when there is no delivery. For products with longer shelf life, order launching is more flexible to allow for consolidation to reduce the number of orders. The listed inventory levels are meant to be without a planned scrap. The maximum quantity of ordered products is $Maxk_i - Rk_i$.

According to the model used for optimization, various equations, inequalities, target values, and quantities to be minimized can be described. If the goal is to achieve the lowest total cost, then we have to choose the products that are ordered and suppliers, so that the sum of the cost factors is as small as possible, taking into account the maximum stock level of the products, the prices, the available quantity discounts, and the space requirements.

4. Determining the optimal solution in an example of a fictitious restaurant

During the optimization we will deal with food products. As a first step, we have to consider the products sold and their quantities. Given the products from the restaurant menu and the quantities sold each day between 1 Jan 2017 and 31 March 2018. For each food, we need to know the ingredients and the amount of ingredients needed to make it, which makes it possible to make a material proportion matrix. The material ratio matrix was prepared in three steps as described in the previous chapter. The matrix ***A**** (expanded material ratio matrix) contains the composite ingredients and the semi-finished products (marked in yellow), as well as the prepared vegetables (marked in green) as ingredients, in the example, the ingredients are sorted alphabetically by the quantities in terms of the number of units and the unit of measurement of the ingredient in question (kg, l).

Table 2: Expanded material ratio matrix (snippet)

	Gulash soup	Chicken soup	Vegetable soup	Spaghetti carbonara	Spaghetti Bolognese
Argentin grill spice	0	0	0	0	0
Dried tomatoes	0	0	0	0	0
Bay Leaf, Whole	0	0	0,000125	0	0
Basil, fresh	0	0	0	0	0
Basil, purified	0	0	0	0,0001	0,0001
Bolognese ragout	0	0	0	0	1
Potatoes, earthy	0	0	0	0	0
Potatoes, cleaned	0,15	0	0,025	0	0

Source: created by the authors

In the next step, the composite components and semi-finished products must be further broken down into elementary components. The unit price of the cleaned vegetables should be determined taking into account the losses. On the basis of the quantities of cleaned vegetables used, the amount of earthy vegetables required should be determined.

In the third step, the non-elementary components in matrix ***A**** should be replaced by the amount of elementary components needed to produce them, it creates the matrix ***A***, the material ratio matrix (Table 2).

The amount of food sold per day and the material ratio matrix can be used to determine which elementary component is needed on a given day. Then, based on daily data, we determined the average use and dispersion of the components for the whole period and the first quarter of 2018.

Since the dispersion of values were fairly high, we examined whether the average and scatter values calculated using weekly or monthly moving averages do provide a more reliable estimation basis for further calculations.

In the following, we will calculate the daily uses and scatter values determined on the basis of weekly moving averages.

The daily use based on quantities and shelf life can be used to determine whether an opened product can be fully utilized within a given period or will be scrapped. The possible discard quantities thus determined have been corrected for the unit price of a given product, as it is certain that a portion of it will be wasted without recovery.

The next task is to determine the different inventory levels: security set, token set on $T = 0$ day, set of tokens on $T = 1$ day, set of tokens on $T = 2$ day, maximum set. The maximum set takes into account shelf-life, when the set of orders can be re-ordered in the days following the order, the safety kit can help to meet the increased usage demands resulting from the dispersion of traffic. Subsequently, the unit prices adjusted for the planned scrap were determined. We need to know the capacity and usability of each storage site for the calculations. By multiplying the previous two volumes, the maximum area of the dry goods warehouse (R), and the milk cooler (TH) in cm^2, the maximum volume of the freezer (F) expressed in cm^3 (Table 3).

Table 3: Storage capacity by storage locations (cm^2, cm^2, cm^3) and utilization

	Capacity	Utilization
R (cm^2)	90000	0,6
TH (cm^2)	14400	0,7
F (cm^3)	290000	0,9

Source: created by the authors

An additional definition of the time required or the cost of the staff involved in the task (wages, contributions, etc.) (Table 4). The new cost should be 2000 HUF.

Table 4: Times used

Order	Time (hours)	Receiving	Time (hours)	Shipping to warehouse	Time (hours)	Admin	Time (hours)	Storage	Cost (HUF/day)	Capital tie	% (yearly)
Time list	1	Time ell	0,00278	Time szr	0,1	time	0,01667	Rent fee	0	interest	10
Time email	0,1	Time szp	0,1	Time poz	0,00278			amortization	548		
Time itemrow	0,00833	Time af	0,1	Time rak	0,00139			electricity	720		

Source: created by the authors

Dry goods, dairy products, frozen goods

We determined the optimal solution, the specific calculation, using the MS Excel Solver application. Since the number of unknowns can be up to 100 and the limiting conditions can be 200, it is not possible to treat all the raw materials together. We divided the components into three parts. The first group includes the products that are placed in the dry goods warehouse, the milk fridge or the freezer, the second is the vegetables, and the third is the meat products. Most of the types of raw materials to be procured are made up of elements of the first group, so optimization was done for them. The method for the other two groups can be applied along similar lines.

The number of suppliers was determined in three. Prices of specific products (HUF), dimensions (in the given unit of measure), unit prices (HUF), warehouse dimensions (cm), area or volume occupied by one product (cm^2, cm^3), at the same time number of items in unit loads (pieces), area or volume occupied by the unit load, number of units to be stacked from the unit loads and storage location were added (*R, TH, F*) in a matrix.

Table 5: Delivery limits, shipping charges

	sz1	sz2	sz3	total
Shipping min limit (HUF)	10000	10000	8000	0
Fee below min order (HUF)	3000	3200	2400	0

Source: created by the authors

Table 5 summarizes the free shipping limit per supplier and the shipping charges below. The results obtained in the solution were placed in the column marked gray (Assigned ER volume, Table 6). It is assumed that they are positive integers or zero. As a limiting condition, I used the maximum stock and storage capacity. We determined the minimum value for the starter inventory as follows:

- if the *shelf life* is < 7 days, then the *minimum stock = shelf life * average daily use,*
- if the *shelf life* is > = 7 days, then the *minimum stock = 7 * daily average usage*

In the calculation of the costs, the possible delivery charges had to be taken into account for each supplier.

Table 6: Optimal order quantity (snippet)

Product	Ordered ER (pieces)	Value (Ft)	Quantity (kg, l)	Space (cm^2, cm^3)
Cream 10% Cooking UHT 250ml Tatras	0,00	0	0	0
Cream Meggle 1l	14,00	9170	14	96
Spicy paprika sweet ground I.gr. 1kg Paprikamolnár	1,00	1437,1	1	300
Spicy sweet peppers 250gr CM	0,00	0	0	0
Grana padano 1kg italian	5,00	15781,5	5	400
Grana padano 1kg polish	0,00	0	0	0
Fries 2kg	0,00	0	0	0
Fries 2kg B	2,00	3024	16	12000
Fries 2kg C	0,00	0	0	0
Steak 2kg	0,00	0	0	0
Steak 2kg B	2,00	3472	16	12000
Steak 2kg C	0,00	0	0	0

Source: created by the authors

Table 7: Inventory used and maximum areas / volumes

	Space	**Max**
R (cm^2)	15025	54000
TH (cm^2)	1284	10080
F (cm^3)	34900	261000

Source: created by the authors

The target value to be minimized was cost, calculated together with the cost of the acquisition (Total2, Table 8).Fields marked with orange contain values calculated using the result (Table 6). The area or volumetric space data in combination with the maximum option is shown in Table 7. Table 8 shows the extent of each cost factor, its amount (Total1), and the total cost of the purchase price (Total2).

Table 8: Cost (HUF)

Costs	Product order	Shipping fee	Delivery reception	Place to warehouse	Admin	Storing	Capital tie	Total1	Total2
	4975	0	1707	2325	2150	1268	64	12498	245134

Source: created by the authors

5. Summary

Most models that look for the best solution contain serious simplifications compared to real life, often counting on only one product and using neglect to determine costs.

In connection with a restaurant, we took into account the factors related to the stocks, their economical size. We have matrixed data on material proportions, both for elementary and compound components, and we have created the material proportion matrix. The prices of specific products that represent components that can be purchased from suppliers are arranged in matrices based on their size and product type.

After all, we reviewed the various costs that might arise during ordering and stock keeping. Formulas were created to quantify costs. Opportunities, specifications, and storage capacity of the purchased components can be a constraint that must be taken into account. Finally, we determined which inventory levels are essential for finding the optimal solution, limiting the inventory from minimal and maximum sides.

In the last chapter of our thesis, we searched for a combination of products in the optimum stock that match the specified inventory levels, the available storage capacity, and the lowest cost, including the purchase price, through an example of a fictitious restaurant.

6. Acknowledgements

This project has received funding from the EFOP-3.6.1-16-00011 "Younger and Renewing University – Innovative Knowledge City – institutional development of the University of Miskolc aiming at intelligent specialization" project implemented in the framework of the Szechenyi 2020 program.

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