
A METHODOLOGY FOR ANALYSIS OF MATERIAL CONSUMPTION OF PRODUCTION

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Abstract: The issue of efficient use of material resources in the operations of industrial enterprises is especially topical in particular under the conditions of circular economy, which is based on the principle of keeping the value of materials, resources and production in the economic cycle as long as possible, i.e. during the product's life cycle. Material resources are an element within the structure of production resources, which are the main drivers for the achievement of the business objectives and the implementation of the business plan of every enterprise. Production resources are analyzed and evaluated in three interrelated directions – provision, use and efficiency of use of these means of the enterprise.

The indicators for analysis and evaluation of efficiency of use of material resources in production are material productivity and material consumption. Material productivity is calculated as a ratio of production value at net sales prices to value of materials used for production and sale of industrial products. It expresses the value of production per expenses for materials of BGN 1. Material consumption is calculated as a ratio of value of used materials to value of production at net sales prices. It expresses the expenses for materials incurred by the enterprises for the production of products of BGN 1.

This publication studies the material consumption of products manufactured by industrial enterprises, and the methodology for its analysis is the subject matter of the publication. Since expenses for materials input in the enterprise's principal activity have the biggest relative share in the cost of industrial production, we will present the methodology for analysis of material consumption with regard to such expenses only.

Production material consumption is analyzed and evaluated from two perspectives. This is based on the objectively existing causal relations between resultative and factor indicators characterizing the economic activity of enterprises. Firstly, production material consumption is analyzed and evaluated as a resultative indicator. Four direct factors influence the dynamics of direct material cost in the cost of production: 1) changes of the physical volume of production; 2) changes of the product range structure of production; 3) changes of expenses for materials per unit of good (consumption rates), and 4) changes of the prices of unit of material of each type. At the same time, changes that occur in the value amount of production are determined by the influence of the following factors: 1) changes of the physical volume of production; 2) changes of the product range structure of production, and 3) changes of net sales prices of production. The above factors affecting the dynamics of direct material cost and the value amount of production substantially affect the changes occurred in the material consumption of industrial production.

Secondly, production material consumption is analyzed as a factor indicator affecting the dynamics of volume of manufactured, respectively sold production.

With this publication we aim at presenting an improved methodology for analysis of material consumption of industrial production.

Keywords: analysis, methodology, material productivity, material consumption, industrial production

1. INTRODUCTION

Material consumption of industrial production is an important business indicator for the efficiency of use of material resources in every enterprise which mainly carries out industrial activity. Such fact requires detailed analysis of production material consumption as a resultative indicator and identification of the power and direction of direct factors affecting its dynamics.

2. MODEL FOR ANALYSIS OF PRODUCTION MATERIAL CONSUMPTION

Production material consumption (ME) may be calculated with the following formula:

$$ME = \frac{M}{P}, \quad (1)$$

where:

M is the value of used materials, and

P – is the value of production at net sales prices.

Analysis of industrial production material consumption may be further deepened with view of the factors affecting both the value of materials input in production and the value of production at net sales prices.

In this particular case, we should consider the direct material cost, which takes the biggest relative share in the cost of production. Taking into account this objective fact, we need to analyzed and evaluate production material consumption calculated on the basis of direct material cost.

The amount of direct material cost (M^{dmc}) may be calculated with the following formula:

$$M^{dmc} = \sum q_i (d_i) \times m_i \times p_i , \quad (2)$$

where:

q_i are the quantities of different types of goods;

d_i – product range of production;

m_i – consumption of different types of materials for the production of unit of different types of goods, and

p_i – price per unit of different types of materials.

The sales value of production (NS) may be presented with the following formula:

$$NS = \sum q_i (d_i) \times c_i \quad (3)$$

where:

c_i is the price of unit of different types of goods.

Therefore, production material consumption calculated on the basis of the major direct expense cost only may be calculated with the following formula:⁷

$$ME = \frac{M^{dmc}}{NS} = \frac{\sum q_i (d_i) \times m_i \times p_i}{\sum q_i (d_i) \times c_i} \quad (4)$$

This formula shows that the following direct factors have affected the changes of the production material consumption:

- 1) Changes of the physical volume of different types of goods.
- 2) Changes of the product range structure of production.
- 3) Changes of consumption of different types of materials for the production of a unit of different types of goods.
- 4) Changes of the price of a unit of different types of materials.
- 5) Changes of the price of a unit of different types of goods.

3. METHODOLOGY FOR ANALYSIS OF PRODUCTION MATERIAL CONSUMPTION

We will present the methodology for analysis of material consumption with the help of the suggested model – formula (4), based on the details for the business of an industrial enterprise. The information necessary for the analysis of production material consumption is presented as follows: production in table 1, and direct material cost – in table 2.

Table 1. Input data for production

Types of articles	Previous period				Current period			
	number	relative share, %	unit price, BGN	sale value, BGN	number	relative share, %	unit price, BGN	sale value, BGN
	(q_0)	(d_0)	(c_0)	$q_0(d_0) \times c_0$	(q_1)	(d_1)	(c_1)	$q_1(d_1) \times c_1$
Product A	300	24,00	22,70	6810	360	27,91	23,75	8550
Product B	500	40,00	18,16	9080	500	38,76	18,05	9025
Product C	400	32,00	11,35	4540	380	29,46	10,00	3800
Product D	50	4,00	45,40	2270	50	3,88	47,50	2375
Total	1250	100,00	-	22700	1290	100,00	-	23750

⁷ Refer to Chukov, K., Ivanova, R. (2017). Financial and Economic Analysis. C., IK UNWE, page 163

Table 2. Input data for materials

Types of materials	Material consumption per unit of product, kg								Price per unit of material, BGN	
	Product A		Product B		Product C		Product D		previous period	current period
	previous period	current period	previous period	current period	previous period	current period	previous period	current period		
m_0	m_1	m_0	m_1	m_0	m_1	m_0	m_1	p_0	p_1	
Mat. M1	0,2	0,3	0,8	0,7	0,3	0,2	0,4	0,4	4,0	4,5
Mat. M2	0,9	0,8	0,8	0,9	0,8	0,6	0,4	0,5	3,0	3,0
Mat. M3	0,8	0,9	0,7	0,9	0,4	0,3	0,4	0,4	3,0	3,5
Mat. M4	0,6	0,7	0,5	0,3	0,6	0,3	1,04	0,4878	5,0	5,1

Using the data in tables 1 and 2, we can calculate the main direct material cost with the help of formula (2) – by types of materials and for the overall production in aggregate.

For example, the cost for material M1 type by types of goods and for the overall production in aggregate for the previous period is in the amount of BGN 2400, which is calculated as follows:

- for product A: 300 numb. x 0,2 kg/numb. x 4,0 BGN = 240 BGN
- for product B: 500 numb. x 0,8 kg/numb. x 4,0 BGN = 1600 BGN
- for product C: 400 numb. x 0,3 kg/numb. x 4,0 BGN = 480 BGN
- for product D: 50 numb. x 0,4 kg/numb. x 4,0 BGN = 80 BGN

Total cost of material M1 = 2400 BGN

The cost for the same type of material M1 for the current period is in the amount of BGN 2493:

- for product A: 360 numb. x 0,3 kg/numb. x 4,5 BGN = 486 BGN
- for product B: 500 numb. x 0,7 kg/numb. x 4,5 BGN = 1575 BGN
- for product C: 380 numb. x 0,2 kg/numb. x 4,5 BGN = 342 BGN
- for product D: 50 numb. x 0,4 kg/numb. x 4,5 BGN = 90 BGN

Total cost of material M1 = 2493 BGN

Analogically, we can calculate the amounts of direct material cost incurred for the other types of materials input in the production of industrial products both for the previous and the current period. The information obtained for direct material cost by types of materials, by types of goods and for the overall production in aggregate is summarized in table 3.

Table 3. Main direct material cost for industrial production

Types of products	Cost of materials, BGN									
	material M1		material M2		material M3		material M4		Total cost	
	previous period	current period	previous period	current period	previous period	current period	previous period	current period	previous period	current period
	$q_0 m_0 p_0$	$q_1 m_1 p_1$	$q_0 m_0 p_0$	$q_1 m_1 p_1$	$q_0 m_0 p_0$	$q_1 m_1 p_1$	$q_0 m_0 p_0$	$q_1 m_1 p_1$		
Product A	240	486	810	864	720	1134	900	1285,20	2670	3769,20
Product B	1600	1575	1200	1350	1050	1575	1250	765,00	5100	5265,00
Product C	480	342	960	684	480	399	1200	581,40	3120	2006,40
Product D	80	90	60	75	60	70	260	124,40	460	359,40
Total	2400	2493	3030	2973	2310	3178	3610	2756	11350	11400

According to the data in table 3, we can identify the differences between the main direct material cost for the current and the previous period both by types of materials and by types of goods, and for the overall industrial production in general.

Calculations show that the cost for M1 and M3 type materials has increased by BGN 93 (2493 – 2400) and BGN 868 (3178 – 2310), respectively. At the same time, the cost for M2 and M4 type materials has decreased by BGN 57 (2973 – 3030) and BGN 854 (2756 – 3610), respectively. The decreases, respectively the increases of costs by types of materials have resulted in decrease, respectively increase of the aggregate main direct material cost with the same amounts.

If we follow-up the changes of material cost by types of goods, we can identify the differences between the factual (current period) and the reference (previous period) cost for each type of material for each type of good individually and for the overall industrial production in general. For example, the difference of the total material cost for good “A” is absolute over-expenditure in the amount of BGN 1099,20 (3769,20 – 2670). Such difference is due to the absolute over-expenditures of every type of material for the production of good “A” as follows: material M1 – over-expenditure of BGN 246 (486 – 240); material M2 – over-expenditure of BGN 54 (864 – 810); material M3 – over-expenditure of BGN 414 (1134 – 720), and material M4 – over-expenditure of BGN 385,20 (1285,20 – 900). Analogically, we can identify the differences of material cost of every type of material for the production of individual goods within the industrial product range.

Such approach for analysis and evaluation of the main direct material cost enables the financial management of the industrial enterprise to make decisions for the optimization of these costs by means of decommissioning or replacement of goods, which are more material-consuming with items that have less material consumption and therefore higher individual profitability.

In accordance with the data from table 1 for the sales cost of production and from table 3 for the main direct material cost of production, we can calculate the material consumption of overall production by using formula (4). We obtain the following results about the material consumption of production of the enterprise under review:

$$\text{- for the previous period: } ME_0 = \frac{M_0^{dmc}}{NS_0} = \frac{11350}{22700} = 0,50 \text{ BGN}$$

$$\text{- for the current period: } ME_1 = \frac{M_1^{dmc}}{NS_1} = \frac{11400}{23750} = 0,48 \text{ BGN}$$

These results show that material consumption of production has decreased by BGN 0,02 (0,48 – 0,50) for the current period in comparison to the previous year, i.e. the main direct material cost for manufacturing production of BGN 1 has decreased by BGN 0,02. This means that the efficiency of use of material resources in the enterprise has increased.

The decrease of production material consumption is affected by the direct factors mentioned above. The power and direction of influence of such factors may be identified by the method of successive substitution.

To this end, we should calculate in advance three conditional values of the main direct material cost. The first of them is the value of direct material cost at physical volume of production for the current period and the same product range structure of production, consumption rates and prices of unit of each type of material for the previous period - $\sum q_1 (d_0) \times m_0 \times p_0$.⁸ The results about material cost by types of materials, by types of goods and for overall production in aggregate are presented in table 4.

Table 4. Material cost for $\sum q_1 (d_0) \times m_0 \times p_0$

Types of products	Material M1	Material M2	Material M3	Material M4	Total cost of materials, BGN
Product A	247,68	835,92	743,04	928,80	2755,44
Product B	1651,20	1238,40	1083,60	1290,00	5263,20
Product C	495,36	990,72	495,36	1238,40	3219,84
Product D	82,56	61,92	61,92	268,32	474,72
Total	2476,80	3126,96	2383,92	3725,52	11713,20

⁸ The value $\sum q_1 (d_0)$ is calculated by adjusting the volume of the overall production for the current period by the relative share of each of the goods for the previous period. Thus, we obtain information about the physical volume of separate goods that would be produced by keeping the same product range structure of production from the previous period

The second conditional value shows the amount of direct material costs at physical volume and product range structure of production for the current period, and the same consumption rates and prices of unit of each type of material for the previous period - $\sum q_1 (d_1) \times m_0 \times p_0$. The results about material cost by types of materials, by types of goods and for overall production in aggregate are presented in table 5.

Table 5. Material cost for $\sum q_1 (d_1) \times m_0 \times p_0$

Types of products	Material M1	Material M2	Material M3	Material M4	Total cost of materials, BGN
Product A	288,00	972,00	864,00	1080,00	3204,00
Product B	1600,00	1200,00	1050,00	1250,00	5100,00
Product C	456,00	912,00	456,00	1140,00	2964,00
Product D	80,00	60,00	60,00	260,00	460,00
Total	2424,00	3144,00	2430,00	3730,00	11728,00

The third conditional value shows the direct material costs at physical volume and product range structure of production for the current period, consumption rates of materials for the current period, and the same prices of unit of each type of material for the previous period - $\sum q_1 (d_1) \times m_1 \times p_0$. The results about material cost by types of materials, by types of goods and for overall production in aggregate are presented in table 6.

Table 6. Material cost for $\sum q_1 (d_1) \times m_1 \times p_0$

Types of products	Material M1	Material M2	Material M3	Material M4	Total cost of materials, BGN
Product A	432,00	864,00	972,00	1260,00	3528,00
Product B	1400,00	1350,00	1350,00	750,00	4850,00
Product C	304,00	684,00	342,00	570,00	1900,00
Product D	80,00	75,00	60,00	121,95	336,95
Total	2216,00	2973,00	2724,00	2701,95	10614,95

On the basis of the information from tables 3, 4, 5 and 6, we can see the main direct material cost for manufacturing of industrial production:

- previous period = $\sum q_0 (d_0) \times m_0 \times p_0 = 11350,00$ BGN (table 3);
- the first conditional value = $\sum q_1 (d_0) \times m_0 \times p_0 = 11713,20$ BGN (table 4);
- the second conditional value = $\sum q_1 (d_1) \times m_0 \times p_0 = 11728,00$ BGN (table 5);
- the third conditional value = $\sum q_1 (d_1) \times m_1 \times p_0 = 10614,95$ BGN (table 6);
- current period = $\sum q_1 (d_1) \times m_1 \times p_1 = 11400,00$ BGN (table 3).

At the same time, we should also calculate two conditional values of the sales cost of production (net sales of production). The first one of them is at physical volume of production for the current period and the same product range structure and net sales prices of production for the previous period - $\sum q_1 (d_0) \times c_0$. The second conditional value is at physical volume and product range structure of production for the current period and the same net sales prices of production from the previous period. Information for the sales cost of production is presented in table 7.

Table 7. Sales cost of production at:

Types of products	$\sum q_0 (d_0) \times c_0$	$\sum q_1 (d_0) \times c_0$	$\sum q_1 (d_1) \times c_0$	$\sum q_1 (d_1) \times c_1$
Product A	6810,00	7027,92	8172,00	8550,00
Product B	9080,00	9370,56	9080,00	9025,00
Product C	4540,00	4685,28	4313,00	3800,00
Product D	2270,00	2342,64	2270,00	2375,00
Total	22700,00	23426,40	23835,00	23750,00

Based on the above calculations and the data in table 7, we can establish a system of values of production material consumption calculated with formula (4), as follows:

- from the previous period: $ME_0 = \frac{\sum q_0(d_0) \times m_0 \times p_0}{\sum q_0(d_0) \times c_0} = \frac{11350,00}{22700,00} = 0,50 \text{ BGN}$
- first conditional value: $ME' = \frac{\sum q_1(d_0) \times m_0 \times p_0}{\sum q_1(d_0) \times c_0} = \frac{11713,20}{23426,40} = 0,50 \text{ BGN}$
- the second conditional value: $ME'' = \frac{\sum q_1(d_1) \times m_0 \times p_0}{\sum q_1(d_1) \times c_0} = \frac{11728,00}{23835,00} = 0,49 \text{ BGN}$
- the third conditional value: $ME''' = \frac{\sum q_1(d_1) \times m_1 \times p_0}{\sum q_1(d_1) \times c_0} = \frac{10614,95}{23835,00} = 0,45 \text{ BGN}$
- fourth conditional value: $ME'''' = \frac{\sum q_1(d_1) \times m_1 \times p_1}{\sum q_1(d_1) \times c_0} = \frac{11400,00}{23835,00} = 0,49 \text{ BGN}$
- from the current period: $ME_1 = \frac{\sum q_1(d_1) \times m_1 \times p_1}{\sum q_1(d_1) \times c_1} = \frac{11400,00}{23750,00} = 0,48 \text{ BGN}$

Changes of the physical volume of manufactured industrial production do not affect the change of production material consumption. This is further confirmed by the difference between the first conditional value (ME') and production material consumption from the previous period (ME_0), which is BGN 0,00. The common factor of structural changes is expressed through the impact of changes of product range structure of production for the current period towards the previous period.

Under the effect of the changes in the product range structure, production material consumption has decreased by BGN 0,01 ($ME'' - ME' = \text{BGN } 0,49 - \text{BGN } 0,50$).

Changes of consumption rates of materials have resulted in decrease of production material consumption by BGN 0,04 ($ME''' - ME'' = \text{BGN } 0,45 - \text{BGN } 0,49$).

As a result of changes of prices of materials, production material consumption has increased by BGN 0,04 ($ME'''' - ME''' = \text{BGN } 0,49 - \text{BGN } 0,45$).

The changes of net sales prices of production have resulted in decrease of its material consumption by BGN 0,01 ($ME_1 - ME'''' = \text{BGN } 0,48 - \text{BGN } 0,49$).

We can see that the positive impact of changes of consumption rates – material cost for production of a unit of each type of good, which is due to the achieved relative savings of materials, is offset by the negative impact of changes of supplier's material prices.

Alternatively, as a result of the overall impact of direct factors, production material consumption has decreased by BGN 0,02 [$(-0,01) + (-0,04) + (+0,04) + (-0,01)$], i.e. with its change as calculated above.

4. CONCLUSION

The suggested methodology for analysis and evaluation of production material consumption is useful information for the financial management of industrial enterprises. It enables the analysis of material costs by types of materials, by types of goods and for the overall production in aggregate. Furthermore, we can calculate both the individual material consumption of goods and the cost product range structure of production. On this basis, we can analyze the production material consumption under the effect of two direct factors: changes of individual material consumption of goods and changes of the cost structure of manufactured industrial production. Based on the obtained analytical information, the financial management is able to develop and make reasonable, well-founded and proper decisions for optimization of enterprise's material cost.

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