SHAPING A PRODUCT STRATEGY FOR A DIVERSIFIED MANUFACTURING CORPORATION

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Abstract: The article is dedicated to the improvement of the strategic planning method for diversified manufacturing corporations based on I. Ansoff’s strategic management zone theory. These zones are the key tool of a corporation’s entry into a multi-industry market. The conditions of such entry include sufficiently effective life cycles of the products offered for sale in these zones and sufficient required capacity for their manufacturing. Furthermore, in view of the market laws gradually reducing the profits and profitability of the sales of products in strategic zones, many variants of locating product life cycles on the time axis in the forecast period have to be considered. The best variant is selected from them using the development and solution of an optimization problem with the criterion of increasing the corporation’s annual profits.

Keywords: product strategy, diversified manufacturing corporation, strategic management zone, required product manufacturing capacity, actual capacity of corporation, profitability of sales, forecast period duration, product life cycle, strategic management center, interactive planning.

Introduction

The strategic management zone theory (Ansoff, 1981) is usually applied in practice in the form of the interactive planning of the manufacturing and sale of each new product (Petrov, 2005, pp. 236-247). The first phase of this planning is carried out by the corporate administration body constantly occupied with shaping, implementing and adjusting the corporation’s development strategy. The main task of this body is turning diversification into a constant process of searching for the need of the multi-industry market for new products that could be manufactured with the existing, modified or newly created equipment in the corporation. However, this is merely the first task of the diversification process. Its second task is selling the products manufactured effectively in the market segments where a need for these products have arisen or may arise under the influence of advertising. Solving these tasks represents the first phase of interactive planning. During this phase, the strategic management zone (SMZ) is created – a structural unit of a corporation actively collecting search information in the segment of the multi-industry market chosen by the corporation. If the search yields a positive result, the SMZ switches to solving the second task, gaining information for the active marketing study of the new product and participating in the development of the corresponding marketing strategy.

The second phase of interactive planning is represented by the numerous discussions of the new product’s concept on the corporate management level in the following areas: the manufacturing process of the new product, the characteristic of the market segment where it will sell (the level of the number of potential customers, the level of competition, the possible prices for the product), marketing strategy and required financial investments.

The third phase of planning is represented by the development of the predicted product life cycle (PLC) by marketing experts. There are many methods of PLC modeling in strategic management, but using them while shaping a predicted PLC for each SMZ formed is difficult due to the significant uncertainty of the influence of environmental factors, the environment always being quite new for a diversified corporation compared with a specialized corporation. This uncertainty has been somewhat decreased by the discussions of the new product conducted in the second phase, but the need for getting stable expert ratings while obtaining the most important characteristics of the predicted PLC makes marketing experts also resort to numerous expert reviews. As a result, three main dependences of the PLC on the forecast period time are formed: the required capacity for the manufacturing of the quantity of the products necessary for sale in each year; the annual profit of product sale and the annual profitability of product sale.

The final phase of the planning is represented by the integration of all the SMZs created into a unified complex of the search for their needs for new products, their development, their manufacturing and sale.
In progressively organized diversified corporations, this phase is implemented with the creation of one or multiple strategic management centers (SMCs). While the corporation functions under the influence of many internal and external environmental factors, they develop projects of solutions for the corporation’s top personnel concerning the priority funding of some zones, the dissolution of others, concerning the start of studies and the development of new products, concerning the development or creation of new capabilities for product manufacturing. It is beyond doubt that the constant work of the SMCs on such solution projects is the crucial information support of the management process of the functioning of a diversified corporation. However, these projects must have a certain systemic quality. They must include several alternatives of the decision being made, each of them having a quantitative rating. Otherwise, interactive planning remains an expert method with all its qualitative drawbacks. This article proposes increasing the quality of interactive planning in a diversified corporation by using an analytical mathematical model taking into account the key characteristics of diversification – the existence of strategic management zones different in their predicted PLCs, the placement of PLCs on the time axis of the forecast period, its duration, the annual profit and profitability of sales by years of the forecast period – to assess plan decisions.

Method
1. Problem statement.

While developing a strategic plan for a diversified manufacturing corporation, a certain product strategy that represents not only a form of business organization on the basis of the strategic management zone theory but also a description of the theory of the economic mechanism providing for the effective functioning of a system of these zones in view of the constant formation of new ones and the cessation of the functioning of those zones whose products are declining is necessary. At the same time, taking into account the great diversity of PLC characteristics in various strategic zones is also necessary. In practice, it means that the key elements of the strategic management zone management system are represented by the PLCs for the corresponding zones, and their management consists in the search for the optimal placement of these elements relative to each other on the time axis of the forecast period. First of all, an optimization criterion has to be selected. As a rule, the profit criterion is used for the analysis of diversified corporations. Yet there are various types of profit. It is reasonable to select time-consolidated profit as the criterion for short time periods (a year or two). However, consolidated profit is inappropriate for large, long-time forecast periods. Annually rising profit is more relevant for the covering of the growing costs. The significant fluctuations of the annual profit create great difficulties for the diversified company in innovation management. Thus, this article proposes a method of managing the functioning of an SMZ complex using the criterion of the gradual increase in the annual corporate profit by forecast period years.


In general terms, the problem of the optimal placement of all the PLCs included in strategic management zones on the time axis is formulated as follows.

The sequence of zone-consolidated annual corporate profits must be ascending, i.e.

\[
\pi_\theta = \sum_{k=1}^{i} \pi_{k,i} (k_i, k_{1_i}) \rightarrow \max; \quad \theta = 1, 2, \ldots, T/\pi_T < \pi_{T+1}
\]

(1)

if

1) \( \pi_\theta > \pi_{\theta-1} \)

2) \( \sum_{k=1}^{i} M_{i,k} (k_i, k_{1_i}) \leq M_\theta \)

3) \( \pi_{T+1} \geq \pi^0 \)

4) \( \max \phi^{(cp)} \cdot \phi^{(cp)} \leq \frac{\Delta}{100} \)

Controlled variables in case of such formulation of the problem include the following values:

- \( k_i \) is the number of the quarter when the product is introduced to the market in SMZ i.
- \( k_{1_i} \) is the number of the quarter of removal of the product from sale in SMZ i.

The change in \( k_i \) gives an opportunity to move PLC i along the time axis, and the increase in \( k_{1_i} \) allows prolonging the commercial availability of product i if necessary, when the profit is still rather high at its decline stage.

The sequence \( \{\pi_\theta\} \) allows determining the duration of the forecast period \( T \) equal to such year \( \theta \) that its ascending property is contravened in the year \( (\theta+1) \) following it, i.e., in fact, \( \pi_T > \pi_{T+1} \). However, in this case, condition 3) that requires the profit in the year \( (T+1) \) to be not less than the minimum annual profit \( \pi^{(0)} \) set by the corporation’s key personnel should be checked. If this condition is not met, the duration \( T \) must be decreased by 1; otherwise, a profit of \( \pi_{T+1} < \pi^{(0)} \) will be obtained in...
the first year of the following forecast period and it will not be successfully raised, as setting any PLC from the product portfolio for the next forecast period for the start of the first year will never yield a significant profit gain, as this will be the first stage of the PLC – the market entry. Thus, condition 3) ensures the economic tie between forecast periods following each other. However, there is also the influence of the previous forecast period actually ending on the forecast period under consideration. It is the influence of the rolling sales plan when not all of the PLCs included in this plan are removed from sale before the end of the period when they are introduced into the market. Some of them go over to the forecast period under consideration and occupy several years or quarters in it. The profit and other characteristics of the parts of these PLCs to have gone over are summed up by year with the corresponding characteristics of the PLCs introduced for sale in the forecast period under consideration. However, the PLCs to have gone over have one peculiarity – they cannot be shifted either to the right or to the left, as they are only half-forecast ones. Their left half is real and already implemented in the pre-forecast period.

Condition 4) in problem (1) controls the evenness of the average profitability of sales achieved \( \bar{\pi}^{(\text{avg})} \) in all the strategic management zones of the corporation by forecast period years. If this evenness is contravened, the directions of adjustment of some \( k_i \) and \( \pi_i \) may be found. The value of \( \bar{\pi}^{(\text{avg})} \) is calculated with the following formula

\[
\bar{\pi}^{(\text{avg})} = \frac{1}{n_0} \sum_{i=1}^{n_0} \pi_i^{(0)},
\]

where \( n_0 \) is the multitude of the PLC types corresponding to the corporation’s strategic zones going to year \( \theta \) of the forecast period completely or partially (see fig. 2), and \( n_0 \) is the number of these types.

Condition 4) checks whether the acceptable deviation \( \Delta \) of average profitability of sales \( \bar{\pi}^{(\text{avg})} \) from its maximum \( \max \bar{\pi}^{(\text{avg})} \) is met. This deviation \( \Delta \) is set as a percentage.

Alongside with the statement of the method of solving problem (1), the example of forming a product strategy of a diversified corporation is considered to explain it.

Background information for solving the example:

\[
\| M_{1,01} \| = \begin{bmatrix}
300 & 1000 & 1000 & 950 & 800 & 640 & 250 \\
100 & 800 & 800 & 800 & 700 & 500 & - \\
200 & 750 & 700 & 600 & 400 & 400 & - \\
250 & 700 & 700 & 700 & 600 & 500 & - \\
100 & 500 & 500 & 350 & 150 & - & -
\end{bmatrix}
\]

Matrix \( \| M_{1,01} \| \) is represented in Fig. 1 in the form of the graphs of function \( M_{1,i} \).

\[
\| B_{1,01} \| = \begin{bmatrix}
350 & 2000 & 2000 & 1900 & 1700 & 875 & 612 \\
114 & 1440 & 1440 & 1440 & 1120 & 900 & - \\
228 & 1500 & 1400 & 1200 & 800 & 300 & - \\
278 & 1283 & 1283 & 1283 & 1100 & 583 & - \\
114 & 1000 & 1000 & 700 & 300 & - & -
\end{bmatrix}
\]

\[
\| \pi_{1,01} \| = \begin{bmatrix}
24 & 856 & 892 & 844 & 748 & 408 & 128 \\
0 & 464 & 536 & 536 & 436 & 136 & - \\
52 & 572 & 604 & 512 & 328 & 80 & - \\
16 & 468 & 496 & 496 & 388 & 164 & - \\
6 & 388 & 412 & 292 & 68 & - & -
\end{bmatrix}
\]

\( M = 2,200 \text{ in } 10^6 \); \( \Delta = 5\% \); \( l^{(0)} = (i=3,i=4) \) are the types of products going over;

\( l = (i=1,i=2,i=3,i=4,i=5) \) is the multitude of all the product types consideration; \( k_3 = -12; k_4 = -12; k_1 = 9; k_1 = 9; \pi^{(0)} = 700 \text{ in } 10^6 \$ \)
Fig. 1. The capacities required for the manufacturing of all the product types set as a function of the time of the product life cycles

The bold elements of matrixes $\|B_{i,\theta_1}\|$ and $\|\pi_{i,\theta_1}\|$ correspond to the last year of the maturity stage in PLC $i$. While shifting various PLCs, it is supposed that as a first approximation, products are removed from sale at the end of the last year of the corresponding maturity stage. However, if it turns out that the profit growth by forecast period year is contravened in case of the shift strategy chosen, a certain decline in the products sold of all or some of the strategic management zones may help to even out the unevenness to have arisen.

The key information for the calculation of $\pi_{\theta}$ is matrix $\|\pi_{i,\theta_1}\|$, which represents the predicted profit of PLC $i$ calculated by years $\theta_1$ of this PLC ($i \in I$). Other important information is represented by matrix $\|M_{1,\theta_1}\|$ – the capacity required for the manufacturing of the predicted number of units product $N_{i,\theta_1}$ of type $i$ of in year $\theta_1$ in terms of value. It is calculated according to the following formula

$$M_{1,\theta_1} = C_{i,\theta_1} N_{i,\theta_1} \quad (3)$$

It is supposed in this case that one product unit may be manufactured and sold within one quarter, i.e. the diversified corporation under consideration is part of mass-serial production. The expression of the capacity required in value terms is chosen due to the fact that the types of the products manufactured for various SMZs may differ greatly, but the equipment with which they are manufactured is often the same. Thus, the required capacity by PLC type must be summed up. The total required capacity must never be greater than the actual capacity $M$ of the corporation in value terms.

The actual manufacturing capacity of a firm is conventionally understood as the maximum average annual volume of the products released by it in value terms on the manufacturing process and organization level achieved or set. The actual capacity of the corporation may be calculated using the labor productivity existing or predicted in its various manufacturing units (Gorev, 2014, p.88):

$$M = \frac{\Pi}{\sum_{j=1}^{m} \beta_j \lambda_j} \quad (4)$$

where $\Pi$ is the total number of workers in the corporation’s manufacturing units;
$\beta_j$ is the labor productivity of one worker in corporate unit $j$;
$m$ is the number of the corporation’s manufacturing units determining its actual capacity;
$\lambda_j$ is the share of the firm’s actual capacity created by the firm’s unit $j$. 
In Fig. 2, the placement of required capacity $M_{1,1}, M_{1,2}, M_{1,5}$ curves ensuring the non-exceedance of the actual corporate capacity $M$ for 8 years is shown. To this end, the curve of $M_{1,2}$ was shifted to the right by 4 quarters ($k_2 = 5$), and the curve of $M_{1,1}$ by 9 quarters ($k_1 = 10$). The quarterly ordinates of required capacities on these curves also shifted accordingly. Upon summing up these ordinates on year borders and on breakpoint abscissas within each year and comparing these totals with the value of $M$, one sees that the actual corporate capacity is not contravened anywhere. However, the results of the two shifts are accompanied by changes in $\|B_{i,01}\|$ and $\|\pi_{i,01}\|$ matrixes, as not only the forecast period duration but also the annual values of these characteristics change. The matrixes themselves are also transformed: $\|B_{i,01}\| = \begin{pmatrix} - & - & 262 & 1565 & 1565 & 1900 & 1700 & 875 \\ - & 114 & 1440 & 1440 & 1440 & 1120 & 900 & - \\ 1200 & 800 & 900 & - & - & - & - & - \\ 1283 & 1100 & 583 & - & - & - & - & - \\ 114 & 1000 & 1000 & 700 & 300 & - & - & - \end{pmatrix}$, $\|\pi_{i,01}\| = \begin{pmatrix} - & - & 18 & 648 & 883 & 892 & 844 & 748 \\ - & 0 & 464 & 536 & 536 & 436 & 136 & - \\ 512 & 328 & 80 & - & - & - & - & - \\ 496 & 388 & 164 & - & - & - & - & - \\ 6 & 388 & 412 & 292 & 68 & - & - & - \end{pmatrix}$.

Let us consider the procedure of changing these matrixes. We will pay special attention to the shift of curve $M_{1,1}$ (Fig. 2) carried out. This shift carried out, curve $M_{1,1}$ occupied a position on the forecast period year axis corresponding to $k_1 = 10$ (quarters are numbered by quarter end, thus curve $M_{1,1}$ starts from the point with $\tau = 9$). The following formula is used to change the first lines of matrixes $\|\pi_{i,01}\|$ and $\|B_{i,01}\|$:

$$\pi_{1,0} = \begin{cases} \rho \pi_{1,01} \text{ if } \theta_1 = 1.2 \\ \max (\pi_{1,01}; \pi_{1,01-1}) \text{ if } \theta_1 = 3,4,\ldots,T_{11}, \end{cases}$$

(4)

where $\theta_1$ is the year number of PLC61 from Fig. 1; $\pi_{1,\theta}$ is the annual profit on the sale of product 1 in the year $\theta$ of the forecast period; $\rho$ is the share of the number of quarters included in the penultimate year of the shift of PLC1 (in Fig. 2, these are the 3 quarters 10, 11 and 12 assigned to the 4 quarters 10, 11, 12 and 13 which make up the first year of PLC1. This share will repeat for each year of the PLC1 being shifted):

$$\rho = \frac{k_2}{4} \cdot E\left(\frac{k_2}{4}\right),$$

(5)

where $E\left(\frac{k_2}{4}\right)$ is the whole part of number $\left(\frac{k_2}{4}\right)$ – the shift of PLC1 to the right along the time axis of the forecast period.

The background information for the calculation of $\pi_{1,\theta}$ is represented by the values of $k_1$ and $\{\pi_{1,01}\}$, and that for the calculation of $B_{1,0}$ – the values of $k_1$ and $\{B_{1,01}\}$. In this case, $\pi_{1,01}$ is substituted with $B_{1,01}$ in formula (4).

Now let us sum up the profits in each column of matrix $\|\pi_{i,01}\|$. In general terms, one will get the following expression:

$$\pi_{0}^{\theta} = \sum_{\theta_{1,\theta} \in \pi_{i,01}} \pi_{i,0} \quad \theta = 1,2,\ldots, \max\left(E\left(\frac{k_2}{4}\right) + T_{11}\right)$$

(6)

One will obtain the following sequence of annual profits for the example under consideration:

$$\pi_{0}^{\theta} = (1014 \ 1104 \ 894 \ 1476 \ 1419 \ 1328 \ 844 \ 748).$$

This sequence has two drawbacks:

- the profit dropped rapidly in year 3;
- the profit in year 5 became less than that in year 4, which forces one to decrease the duration of the forecast period to 4 years due to the formulation of the optimization problem.
Both drawbacks can be corrected by changing the variable $k_1$. If the moments of the removal of goods from sale 3, 4 and 5 are shifted by 4 quarters to the right (see fig. 2), i.e. the variables $k_1$ will take on the following values: $k_3 = 13$; $k_4 = 13$; $k_5 = 21$, then the profit from the sale of goods 3 and 4 in year $\theta = 3$ from matrix $\pi_{3,6}$ is added to the value $\pi_{5,6} = 80$ and $\pi_{4,6} = 164$. One will obtain

$$\pi_3 = \pi_{3,6} + \pi_{3,5} + \pi_{4,6} = 894 + 80 + 164 = 1138.$$  

As for the value $\pi_{5,6}$, the profit on the sale of product 5 in year $\theta = 5$ is added to it from matrix $\pi_{5,6}$:

$$\pi_5 = \pi_{5,6} + \pi_{5,5} = 1419 + 68 = 1487.$$  

One will obtain

$$\pi_5 = \pi_{5,6} + \pi_{5,5} = 1419 + 68 = 1487.$$  

As a result, an ascending sequence arises

$$\{\pi_\theta\} = (1014 \ 1104 \ 1138 \ 1476 \ 1487)$$  

with the forecast period duration $T = 5$ years.

It remains to check the fulfillment of condition 4) in problem (1). Let us calculate the average profitability values for each year of the new forecast period with $T = 5$ years according to formula (2):

$$\theta = 1. \ 0_1^{(a)} = \frac{1}{n_1} \left( \pi_{3,1} + \pi_{4,1} \right) = \frac{1}{2} \left( \frac{312}{1200} + \frac{426}{1283} \right) = 0.41;$$

$$\theta = 2. \ 0_2^{(a)} = \frac{1}{n_2} \left( \pi_{3,2} + \pi_{4,2} + \pi_{5,2} \right) = \frac{1}{3} \left( \frac{328}{1000} + \frac{388}{1200} + \frac{388}{1000} \right) = 0.38;$$

$$\theta = 3. \ 0_3^{(a)} = \frac{1}{n_3} \left( \pi_{3,3} + \pi_{4,3} + \pi_{5,3} + \pi_{6,3} \right) = \frac{1}{4} \left( \frac{564}{1440} + \frac{80}{800} + \frac{164}{800} + \frac{412}{1000} \right) = 0.33;$$

$$\theta = 4. \ 0_4^{(a)} = \frac{1}{n_4} \left( \pi_{3,4} + \pi_{4,4} + \pi_{5,4} + \pi_{6,4} \right) = \frac{1}{5} \left( \frac{669}{1565} + \frac{586}{1565} + \frac{292}{700} \right) = 0.4;$$

$$\theta = 5. \ 0_5^{(a)} = \frac{1}{n_5} \left( \pi_{3,5} + \pi_{4,5} + \pi_{5,5} \right) = \frac{1}{6} \left( \frac{883}{1865} + \frac{586}{1440} + \frac{68}{300} \right) = 0.4.$$  

Note: The profitability of sales at the PLC stages of the market entry of the products is not taken into account due to its insignificant value.
The check of condition 4) in problem (1) shows that it is contravened only in the third year of the forecast period:

$$\max \left( B^{(av)} - B^{(av)} \right) = 0.41 - 0.33 = 0.08 > \frac{\Delta}{100} = 0.05,$$

as $\Delta = 5\%$ is set in the background information.

This contravention can be removed if the quarters of removal from sales of PLC 3 and 4 are dispersed, i.e. one has to make $k_3 = 9$ once again. And then, profit $\pi_{2,3} = 464$ and $\pi_{5,3} = 412$ from matrix $[\pi_{1,9}]$ has to be increased by 10%, which is absolutely acceptable during forecast calculations and decreases the cumulative profit $\pi_3$ by as little as $11\%$, which does not change the annual profit increase for the forecast period. Then, let us calculate the average profitability of sales in year 3 again:

$$B^{(av)} = \frac{1}{10} \left( \frac{\pi_{2,3}}{10} + \frac{\pi_{4,3}}{10} + \frac{\pi_{5,3}}{10} \right) = \frac{1}{3} \left( \frac{510}{100} + \frac{164}{100} + \frac{432}{100} \right) = 0.36.$$

Let us check condition 4) from problem (1) again:

$$\max \left( B^{(av)} - B^{(av)} \right) = 0.41 - 0.36 = 0.05 = \frac{\Delta}{100}.$$

Thus, the condition is fulfilled. Problem (1) is solved. The graph in Fig. 2 reflects the solution of this problem in the example considered. Its form is convenient for showing all the characteristics of the product strategy of a diversified manufacturing corporation. The graph’s zone between the actual capacity $M$ and required capacity $M_1$ shows the degree of capacity use in case of rational placement of $M_1$, curves on the time axis in view of the factor of profit, which must grow annually, albeit not strictly evenly. This relaxed evenness allows increasing not only the profit of but also the profitability of the corporation’s sales by year, minimizing its fluctuating nature. A crucial result of this optimization is represented by determining the maximum duration of the forecast period $T$. Its value is pegged to the growth speed of the annual profit. The less the profit grows annually, the greater the value of $T$.

**Conclusion**

The quantitative method of product strategy formation for a diversified manufacturing corporation proposed in the article can be used in several focus areas. The first one of these focus areas is the rational use of the corporation’s production capacity for the set scope of strategic management zones and future demand for the products sold by them. It can also be used to increase the economic effectiveness of the corporation’s development. The third focus area is the extension of the corporation’s level of diversification not only owing to an ever greater coverage of the multi-industry market, but also owing to the simultaneous consideration for such organizational internal factors of corporate management as combining product sales with various growth levels of profitability of sales.

**References:**

