The Impact of the Technological Development Level of Ukrainian Enterprises on the Competitiveness of Their Products

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Abstract

Indicators of the technological development level of enterprises have been proposed in accordance to the type of its output and competitiveness level. We have explained the role of the main factors that influence competitive advantages of the output. The method of the evaluation of the product's competitiveness level with the use of its manufacture parameters is also presented. The criterion for selecting among possible alternatives such technological process that results in the most competitive type of products has been shown.

Keywords: output, competitiveness factors, technology level, competitive advantages, selection criteria.

Introduction

Nowadays there is a big competition among companies for product markets. In these conditions each company must develop a reasonable strategy for this fight. This strategy should be based on the evaluation of existing competitive advantages and development of the ideas for their *increase*. Thus, it is important to elucidate an optimal algorithm of enterprise behavior in the process of formulation and implementation of its competitive potential. Specificity of competitive advantages lies in the fact that their presence (or absence) is fully manifested in those times when external conditions of enterprise functioning significantly deteriorate. This situation has arisen in recent years in Ukraine. This happened due to a decrease of the demand for a range of industrial products on the global and domestic markets. Also growing number of competitors (primarily foreign) and increase of their production capacity made negative influence.

In these circumstances, many enterprises of Ukraine, primarily exporters, were not prepared for negative changes in their external environment. This naturally caused a reduction of their manufactured products. One of the reasons for the poor competitiveness of many Ukrainian enterprises is the low extent of their technical upgrading. During the last decade the owners of Ukrainian enterprises invested little money in the implementation of new techniques and technologies. Therefore, in last years in several sectors of Ukrainian economy the level of physical and moral deterioration of assets tends to increase. Slow updating of technical and technological base of many Ukrainian enterprises is due to the lack of financial resources, low demand for their products and other objective factors.

Also negative impact is made by disadvantages of the political system of Ukraine, where it is more perspective for owners of large enterprises to invest in the financing of political projects rather than in the technological renovation of manufacture. Therewith, one of the reasons for the slow implementation of new advanced techniques and technologies in Ukraine is insufficient knowledge of the owners and managers of Ukrainian enterprises in the planning of their technological development.

At the moment, there are many publications about issues of technological development of enterprises. In particular, the work (Glazyev, 2009; Kotarbiński, 1965) presents patterns of technological changes happening in the economy. Scientific papers (Abrahamson, 1991; Castelacci, 2006; Da Silveira, 2001; Faderberg, Vespagen, 2002) describe a detailed analysis of the process of diffusion of technological innovations. Also, a number of research papers, in particular (Stadnitskii et al, 2006; 2009), explain rational choice for the best technology of product manufacture.

However, the development of methodological principles of planning the technological update of the manufacture process has been not studied sufficiently. This leads to the need of additional research that examines patterns of technological development of enterprises.

It is very important to consider technological development of enterprises as a tool for improving the competitiveness of their products. Presently there are many research papers that describe factors of the competitive advantages of enterprises, in particular (Nikookar et al, 2010; Barney, 1991). However, the authors of these works don't pay enough attention to the relationship between the level of product competitiveness and efficiency of used technologies.

Methodological Principles of Assessment of the Technological Development Level of Enterprises

Formation of enterprise's competitive advantages through the use of progressive types of equipment and technology is based on the ability to manufacture products with lower costs and with higher quality compared to competitors. Cost reduction of products manufacture and improvement of their consumer properties should be considered as the main objective of the technological development of enterprises. In this case technological development can be seen as a form of economic development of enterprises, which is reflected in the growth of their economic potential and financial results because of the implementation of better technological processes.
So, the better technology is used in the enterprise, the higher is the level of its technological development.
Therefore, in order to evaluate this level one must first define selection criteria of the best alternate of the manufacturing technology.

Let's suppose that there are several variants of the manufacturing technology of the same type of the product. These variants differ in two main ways: cost per unit and its capital intensity (the amount of investments in the manufacture of this product per unit in a given period, e.g. in a year).
Let's also assume that the market for these products is competitive, which means there are (or will be) a sufficiently large number of manufacturers to quickly establish products price at the level at which these producers will not get too high profits (excess profits). So, if there is only one product's manufacturing technology, price of a unit at equilibrium will be determined by the following formula:

$$Z = c + k \times r, \qquad (1)$$

Z – the equilibrium price per unit of output; c – unit cost; k – capital intensity of output; r – the return on investment (its minimum acceptable level at which investors agree to invest in the manufacture of these products).

Then, in the case of few several alternative product's manufacturing technologies the best would be the one in which the value of (1) is the smallest.
It should be noted, that the expression (1) as the criteria for selecting the best manufacturing technology is well known (Hryshko, 2010; Koleshchuk, 2010). However, the limits and possibilities of its usage are not completely considered. In particular, it is important to prove possibilities of index (1) usage as criteria for selecting the best manufacturing technology in the case of competitive and noncompetitive markets.

If the product market is competitive and the technology that does not meet the minimum equilibrium price is selected, then new producers, that will choose optimal variant of technology according to this criterion, will enter the market. Under these conditions, new producers will increase the total volume of supply of these products, thereby reducing the price of it to the minimum equilibrium price. Consequently, the return on investment in the products manufacturing for those investors, who chose not the best choice of technology according to the criterion of minimum equilibrium price, will be lower than normative. Thus, the index (1) indeed is the criterion for selecting the best technology in conditions of the competitive market.

However, the criterion of minimum equilibrium price is also fair in conditions of the non-competitive market.

In order to substantiate this claim, let's consider the situation from the point of view of potential manufacturer that solves two problems at once: to choose the best version of the technology, and to estimate optimal natural volume of the products to manufacture. Then the value of the excess profits of the manufacturer (the difference between the actual profit from the production and the profit from investments multiplied by standard ROI value) will be determined by the following formula:

$$H(\Delta Q, c, k) = \left(P(Q_0 + \Delta Q) - c\right) \times \Delta Q - k \times \Delta Q \times r, \quad (2)$$

or

$$H(\Delta Q, c, k) = \left(P(Q_0 + \Delta Q) - c - k \times r\right) \times \Delta Q = \left(P(Q_0 + \Delta Q) - Z\right) \times \Delta Q, \quad (3)$$

$H(\Delta Q, c, k)$ – value of excess profits of the enterprise as a function of ΔQ, c and k; ΔQ – natural volume of production and sales of this product, which the company plans to carry out; Q_0 – current natural volume of production and sales of this product, which is carried out by industries of already existing areas of industrial market; $P(Q)$ – function that describes dependency of the product unit price (excluding indirect taxes) from its natural scope of market supply Q ($Q = Q_0 + \Delta Q$); c, k – cost and capital intensity per unit of output, that correspond to a particular variant of the product technology; Z – the equilibrium price in accordance to this variant of technology ($Z = c + k \times r$).

When ΔQ are constant, function (3) increases with decreasing of Z. Therefore, to maximize the excess profits the company must choose the technology for which the equilibrium price is the lowest. Moreover, this choice does not depend on the magnitude of the natural volume of products manufacture and sales and, consequently, does not depend on the number of companies that produce it. As follows, the criterion of the minimum equilibrium price can be used for selection of the best technology for any number of producers (i.e. it can be used regardless of the level of market competition).

Given the above, it is expedient to determine the level of technological development of the company for a certain type of product by the following formula:

$$L = Z / Z_{\min}, \quad (4)$$

L – indicator of the technological development level of the company for a certain type of product; Z – equilibrium price of the product that meets the technology used by that company; $Z_{\min}$ – minimum equilibrium price that meets the best technology of the product manufacture.

As it follows from equation (4), the value of this parameter can't be less than one. In this case, the nearer it approaches to the one, the higher is the level of technological development of the company for a certain type of product.

Competitiveness Factors of Enterprise's Products

The level of technological development of the enterprise affects the competitiveness of its products through a certain set of factors. In order to establish a list of the main factors that determine the level of competitive advantages of products, it is advisable to perform the following steps:

1. to set general index of product competitiveness. Such an index can be result of comparing the actual profitability in the manufacture of certain products to maximum on this market profitability in the manufacture of the same products (or its certain kind that differs with a level of consumer properties);
2. to identify previous list of indicators-factors that affect the value of selected above general index of product competitiveness;
3. to select indicator-factors, combined values of which, are determining the full value of the general index of product competitiveness;
4. to perform screening of indicator-factors, that have duplicate character in relation to each other. Under such circumstances the single factor can determine necessary and sufficient list of product competitiveness factors;
5. to determine a possible mutual influence of some product competitiveness factors.

If there are several types of certain output on the market that are characterized by different types of consumer characteristics, the unit price of this output will be a function of two parameters – unit price of the output with basic level of quality and consumer properties of these products relative to the basic production quality. In this case as the output with basic level of quality can be chosen any of its kind that is presented on the current market.

Further we will choose the kind of the output that has maximum return on investment from its manufacture and sales as a basic level. Then the relative competitiveness level of a certain type of the output is advisable to determine with the following formula:

$$F = V : V_{\max}, \qquad (5)$$

F – relative competitiveness level of a certain type of the output, fraction units; V – the level of the return on investment from product's manufacture and sales, fraction units; $V_{\max}$ – the level of the return on investment from manufacture and sales of that product for which this level is maximum among all kinds of similar products on the commodity market, fraction units.

Therefore, the level of the return on investment from manufacture and sales of this product unit can be calculated with the following formula:

$$V = (p - c) / k, \qquad (6)$$

p – unit price of this product without indirect taxes.

Thus, under these conditions the following parameters can be used as the indicator-factors of competitiveness level of certain kind of the output:

- unit price of the output with basic level of quality when its return on investment from manufacture and sales is the maximum among all kinds of the output on the commodity market;
- unit cost of the output kind when its return on investment from manufacture and sales is the maximum among all kinds of the output on the commodity market;
- capital intensity of the output kind when its return on investment from manufacture and sales is the maximum among all kinds of the output on the commodity market;
- quality level of the output with current return on investment.

The given list of indicator-factors of competitiveness level of certain output should be considered as completed and not containing duplicate parameters. Since the knowledge of information about the quantitative characteristics of these indicators-factors is necessary and sufficient in order to compute the relative competitiveness level of a certain kind of the output, that can be calculated with the following formula (5).

Implementation of the proposed approach for the evaluation of the relative competitiveness level of the output leads to the following conclusions:

1. When the list of factors of the product's competitiveness includes the level of its quality (according to the given version of the product and its basic version), only price of the basic version of product's quality works as an indicator-factor of the competitiveness. In other words, under these conditions index of price for the given version of the product will be needless in the list of competitiveness factors;

2. Capital intensity has a big influence on the relative level of product's competitiveness. It should be noted that this fact is unreasonably out of the researcher's sight who evaluate competitiveness level of enterprises and their output;

3. Indices of unit cost and capital intensity have double influence on the relative level of product's competitiveness: direct and relative (due to the level of their consumer properties).

Justification of the Selection Criteria of the Most Competitive Type of the Output Based on its Technological Parameters

All of these indicator-factors of product's competitiveness named above, especially unit cost, capital intensity and consumer properties are directly dependent on the technologies used for their production. However, the above mentioned criterion of the minimum equilibrium price does not include such an important factor of competitive advantage as a quality of the output. Therefore, usage of this criterion is not proper if different versions of the technology lead to a different product quality.

Also, it should be mentioned that the increase of the product quality in most cases increases its attractiveness for consumers and, therefore, leads to the growth of prices.

Let's suppose that the function $P(Q)$ that was introduced to construct expressions (2) and (3) describes dependency of the price from natural volume of supply of the type of the output, which is characterized by the lowest (basic) level of the quality.

Improvement of the output quality leads to the transformation of this function, first of all, to the increase of its value for each Q. The form of this transformation can be different (depending on the behavior of product's consumers). For example, the transformation can occur through: adding to each value of the function a constant value; multiplying of the function values on a certain coefficient that exceeds one; combination of the two previous methods and etc.

Let's mark operation $W_i\left(P(Q)\right)$ that involves the transformation of function $P(Q)$ during the transition from sales of the output with basic level of quality ($i = 1$ and, therefore, $W_1\left(P(Q)\right) = P(Q)$) to the sales of the output that is manufactured by using the i^{th} version of technologies (in this case with the increase of the quality level value of i also increases).

Let's implement an operation G_i that is the inverse to the operation W_i, i.e. $G_i(W_i\left(P(Q)\right)) = P(Q)$. Therefore, if there will be enough competitors, the most competitive will be the type of product (and, respectively, – the technology of its production) for which the following condition is fulfilled:

$$G_i(c_i + k_i \times r) \to \min, \qquad (7)$$

c_i, k_i – unit cost and capital intensity of the product that correspond to the i^{th} version of the production technologies.

Indeed, the technology for which the value of indicator (7) is the smallest in terms of market equilibrium (when its price is an equilibrium price) promises the maximum natural volume of the output production and sales (as for most types of the output when natural volumes of their proposition increase the price tends to decrease). Accordingly, if the producers will choose suboptimal variant of the technology according to the criterion (7) and the product price will become equilibrium, then new producers will enter the competitive market choosing the best technology and, therefore, the natural production volumes of this product will be increased. Consequently, the unit product price of producers, which use suboptimal variant of the technology according to the criterion (7), will fall decreasing their return on investment to the values lower than normal return.

In particular, if the transformation of the function $P(Q)$ during the transition to the production and sales of the higher quality output is performed by adding to each value of this function a constant value, then the criterion (7) takes the following form:

$$c_i + k_i \times r - \Delta P_i \to \min, \qquad (8)$$

ΔP_i – increase of the unit price of the output with basic level of quality during the transition to the production and sales of the output with higher level of quality using the i^{th} version of technologies.

If the transformation of the function $P(Q)$ during the transition to production and sales of the output with higher level of quality is performed by multiplying each value of this function on a constant value, the criterion (7) takes the following form:

$$(c_i + k_i \times r) : I_{Pi} \to \min, \qquad (9)$$

I_{Pi} – growth rate of the unit price of the output with basic level of the quality during the transition to production and sales of the output with higher level of quality using the i^{th} version of technologies.

It should be noted that the criterion (8) is true in the case of any level of the competition on the product market. To prove this statement it is enough to substitute the equilibrium price index in the equation (3) with the analytical expression of this criterion and repeat the analysis of the obtained result.

Implementation Patterns of New Competitive Technologies of the Product Manufacture

The assessment procedure of importance of the new technologies implementation for the product manufacture process depends on whether it produces some sort of this output at the moment.

If the company does not manufacture these products, then it should choose the best option for the technology according to criteria (7) and determine the best natural volume of the production corresponding to this choice of the variety of products for which the value of excess gets maximum (see equation (3)).

If at the current point time the company produces such products, it has to follow next steps of the procedure:

1. According to the criterion (7) the best variant of the technology must be chosen (and, therefore, the most competitive type of products). If the company uses this option of the technological process, then the possibility of expanding of natural manufacture volume and amount of sales will be considered in order to maximize the value of excess profit;

2. If the company does not use the best technology option, then it is important to consider cost of replacing current technology with new one. For this purpose the sum of the profit and depreciation (in the part of the fixed assets that will be replaced) per product unit with the old (current) version of the technology should be less than the profit with the best variant of the technology, chosen on the previous stage;

3. If the replacement of old technology to the new one will be useful, then the optimal natural volume of the production using the best technology option will be calculated according to the criterion of the maximum excess profit. If the replacement of the technology will be insufficient, then the optimal natural value of additional production using the best technology option will be calculated by using the same criteria (i.e., the possibility of simultaneous use of two technologies for production of these products is considered).

For example, let's consider the case, when the transformation of the function $P(Q)$ during the transition to manufacture and sales of the output with the higher quality is performed by adding to each value of this function a constant value. Then the condition, under which the company raises the competitiveness level of its products by replacing one technology to another, can be formalized as the following inequality:

$$P - c_n - k_n \times r + \Delta P > P - c_a, \qquad (10)$$

or

$$\frac{c_a - c_n + \Delta P}{k_n} > r, \qquad (11)$$

P – unit price of products which are manufactured with the use of the old technology; c_n, k_n – cost per unit and capital intensity which correspond to the new (the most competitive) technology; ΔP – increase in the unit price of the product during the transition to its production using the new technology; c_a – unit cost of the product using current technology.

As it follows from the above mentioned criterion of sufficiency of the substitution of one technology to another, the efficiency of the technology replacement is relative: the lower the technological development level of enterprises, the more effective is implement the implementation of new advanced technologies. Accordingly, the time of this implementation for the company with a low level of the technological development comes earlier than for companies with higher level of the technological development in the same sector of the economy. Therefore, the objective pattern of the technological development of enterprises in the context of competition appears to be a periodic change of those enterprises which belong to the technological leaders in the industry.

It is also very important to mention that there is a possibility of extrapolation of the obtained results in the case of the competition between enterprises of the same industry, located in different countries. This extrapolation usually has some limitations related to the action of the factors, which characterize the conditions of the manufacture in different countries. These factors include the cost of purchase and exploitation of the manufacturing resources, natural and climate features, etc. Despite all of this, there is a real possibility the countries with the low technological development would overcome this gap and could become a member of the world's technological leaders. In particular, Ukraine is one of these countries, and has significant scientific and technical potential.

However, this requires considerable enhancement of technical cooperation between Ukraine and the leader nations of the world, primarily with the United States and countries of the European Union.

Conclusions

Technological development level of the company that manufactures a certain type of products is easy to determine by comparing its equilibrium price that meets the technology that is used by the company, with minimal equilibrium price that meets the best technology of the product manufacture.

The indicator-factors of the competitiveness level of products include: unit price of the output with basic level of quality by which the return on investment in its manufacture and sales is the highest among all types of the products on a particular commodity market; cost per unit of the output of the given and its basic types; relative capital intensity of the output of the given and its basic types; the level of the output's quality of the given and its basic types. The assessment of the competitiveness level of the enterprise's output should take into account the factors of its technological development, especially, the level of quality, cost per unit and relative capital intensity of the production.

The suggested approach of the implementation of this assessment allows to improve the process of selecting the most competitive variant of the technology under the condition that these options differ according to the three named parameters. The company with a high technological development level can be not interested in the urgent replacement of its technology for the more advanced one, while for the technologically poor enterprises such a replacement can be quite effective. In this case technologically poor enterprises could overtake more developed companies in the terms of technical equipment. Consequently, the periodic change of the technological leaders of the industry should be considered as an objective pattern of the technological development.

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