ANALYSIS AND PROGNOSTICATION OF ECONOMIC EFFICIENCY OF BUSINESS ENTITY'S INTERNATIONAL TRADING UNDER UNCERTAIN ECONOMY BASED ON THE MODELLING OF A LEARNING CURVE

*O. Martyanova*¹

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Abstract

International trade under economic uncertainty requires enhanced prediction accuracy. In order to make it possible we suggest using the learning curve, since it allows calculating time and expenses necessary for the new types of products, which act as efficiency factors of the business entity's international trading. The paper presents the model of choosing the optimal pricing policy for the exporter introducing a new product on the market.

The model relies on the effect of the learning curve as the learning rate data are significant when determining the probable expenses, which will be incurred as a result of the international contract fulfillment. In order to increase the validity of the predictive estimate attained using a learning curve we suggest complementing its toolware with economic and mathematical modelling based on Markovian processes.

Keywords: learning curve, efficiency analysis, cumulative mean time, international trade, learning index, price, export contract, economic and mathematical modelling, Markovian process, final probabilities, normalizing condition.

Continuous demand of the business owners to increase profit in the context of depreciation of ruble, decrease of beer consumption, increase of excise duties and ever tightening regulation of the brewery sector on behalf of the state fosters the company management to have profound knowledge of the market as well as well-developed toolware necessary to make managerial decisions under economic uncertainty. Absence of structural changes in product category production are driven by consistent demand for the light beer which accounts for about 96% of the overall production, while non-alcoholic, non-filtered, special and dark beer account for only 4% [4]. This provides rationale for working out accurate prognoses when launching a new beer brand. The performance efficiency of a business entity on the national and global market is defined by an array of factors including capacity analysis and operating expenses underlying budget formation, its implementation control and international trading project evaluation. We assume that the theory of the learning curve may be used for making such prognoses.

The learning curve represents a mathematical model of a phenomenon which means constant reduction of time rate required to produce one product unit

¹Olga Martyanova, Candidate of Economic Sciences, doctoral candidate The Orel State University of Economics and Trade, Russia.

when the same labour intensive task is repeated in a series of trials. The learning curve may be represented as follows [1]:

$$Y = a \times x^b, \quad (1)$$

Where Y – the cumulative mean time per unit or batch,

a – time per first unit or batch,

x – cumulative quantity of units or batches,

$$b = \lg V / \lg 2 - \text{learning index}, \quad (2)$$

V – learn rate.

Production of the first unit is always more expensive than the 100th unit, which comes as a result of several types of improvements, such as salaries expenses, resources and other overhead costs. We believe that one of the essential factors of operating efficiency of a business entity, including international trade is the effect of the learning curve which is not sufficiently analyzed in literature. We assume this to be an unreasonable flaw as the application of its concept facilitates making the optimal decision when prognosticating worktime costs and payment aimed at cost saving. The learning curve is essential when evaluating strategic target indicators, since the effect of its application makes it possible to calculate variances relevant to budgetary control, thus releasing the business entity involved in international trade from labor intensive definition of fixed standard variances applied to resources, materials, labor and variable overhead costs on account of their inexpediency. If the learning curve is not defined, the efficiency deviation will be useless for monitoring purposes [3, p. 100].

However, the learning curve has certain disadvantages, because it doesn't simulate the long-term dynamics of the production processes for cases in which there is no economic efficiency enhancement as a result of experience gained. Therefore, the data on the learning rate may be inaccurate before the large-scale production is launched. The following factors exert a significant impact on the learning process: employee turnover, change in staff motivation, long term breaks, downtime in production of product batches which diminish the effect of learning. We believe that learning cannot be deemed as a hands-off process, as it may be successful, on condition that the attention is focused and there is willingness to increase workforce productivity. Therefore, the companies with the same or similar material and workforce recourses might eventually attain different learning level. It is explained by the fact that the environment facilitating education is formed by the top management of the business entity and its corporate culture. So, the traditions of a business entity may be established regardless of a certain employee, thus preserving in a company even under workforce turnover.

We argue that the rate of production processes with repeated series of manual operations may be increased by training personnel in the course of work. The actual learning rate may be defined by observation in which the units produced and the time consumed are carefully considered and subsequently constitute the

basis for the learning curve model.

When carrying out international trading the impact of the curve should be taken into consideration in budget preparation stage, setting the parameters of export-import operations. This is mainly because the normative expenses characterize the point of the learning curve in which the business entity doesn't feel this effect due to its inessentiality, which means that the party involved in international trade has attained its sustainable position on the global market with its inherent expenditure level which is a way below the value attained during personnel learning stage, characterized by a considerable value of occurring variances.

We believe that learning curve knowledge makes a business entity strategically competitive on the global market which "in many ways defines the efficiency of its operation" in the sphere of international trade. In order to establish "...the whole complex of financial, economic, organizational, managerial, production and technological business processes is aimed at ...sustainable manageable competitive advantages for the long-term development perspective" [5, p. 12]. The procedure of the optimal decision making related to the launch of a new brand is illustrated by the example to follow. It is based on the expenditure analysis taking into consideration the learning curve.

The managerial report data of the upmarket brewery company exporting its goods abroad were taken as the information background for our research. Due to the change in economic situation followed by the temporary reduction of the brewery business, the company decided to launch a new beer brand in order to extend the product line of upmarket brand profile. The expenses incurred by the company during the lifecycle of this particular brand are presented in Table 1. The decision maker had to evaluate the variable costs required to produce the first 12,400 liters of beer and the learning curve percent, enabling to attain the target flat cost in order to define the overall project efficiency.

Table 1

Life cycle parameters of a new beer brand

Parameter	Total value
Overall production, l	12, 400.00
Supply batch size, l	200.00
Production expenses within the product life cycle:	
– direct, material expenses, euro/l	14.10
– variable, operating expenses, euro/l	10.25
– direct labour expenses, euro/h	28.20
Time to produce the first batch, h/batch	48.60
Learning performance curve, %	80
Target indicator:	
– shared variable costs, euro	334, 534.42

In order to calculate the shared variable costs it is necessary to calculate direct labour costs. For this purpose let us define the cumulative meantime necessary to produce one batch using the following formula (1), as a result we gain the following:

$$48.6 \times 62^{-0.3219} = 12.87 \text{ h}$$

Thus, our labour expenses necessary to produce 12,400 l beer will amount to:
 $12.87 \times 62 \times 28.20 = 22,501.91 \text{ euro}$.

The calculation results of the standard manufacturing expenses are presented in Table 2.

Table 2

Evaluation of manufacturing expenses of a new beer brand

Parameter	Calculation	Total value
Direct expenses:		
– material expenses, euro	$12,400.00 \times 14.10$	174,840.00
– labour expenses, euro	-	22,501.91
Miscellaneous variable expenses, euro	$12,400.00 \times 10.25$	127,100.00
Manufacturing costs, euro	$174,840 + 22,501.91 + 127,100$	324,441.91

We will define the experience coefficient gained by the personnel, whereby the targeted flat cost is attained using the learning index, calculated as follows from Table 3.

Table 3

Learning index definition

Parameter	Calculation	Total value
Direct labour costs, euro	$334,534.42 - 301,940.00$	32,594.42
Overall working time, h	$325,94.42 \div 28.20$	1,155.83
Mean time per batch, h/batch	$1,155.83 \div 62$	18.64
Learning index	$\lg(18.64 \div 48.60) \div \lg(62)$	-0.2322

In accordance with the formula (2) the following equation is valid

$$\lg V = b \times \lg 2$$

Or

$$\lg V = -0.2322 \times \lg 2$$

from which the learning rate will equal

$$V = 10^{-0.0699} = 0.8514 \text{ or } 85.1\%.$$

Thus, the percent of the learning curve under which the company will attain the targeted flat value is 85.1%. The cumulative data graph for 85% learning curve is presented in Fig. 1.

Figure 1 – Graph of 85% learning curve

It is necessary to note that the learning rate dependence on the working time will be less important with the increase of output.

We believe the knowledge of the learn rate may enhance the efficiency of international trade of a business entity by exerting an influence on the product item price supplied in the framework of international trading agreements, as it represents a rationale for elaborating the pricing value and determining the probable expenses. As it is illustrated by the example to follow, the detailed mechanism of sales price determination of a new beer brand is provided based on both – its life cycle and the learning curve. The characteristics of the product exported are presented in Table 4.

Table 4

Production parameters of export beer brand

Parameter	Total value
Life-cycle of a new beer brand, l	11, 750.00
Selling price, euro/l	48.00
Expenses:	
– direct labour expenses, euro/h	6.00
– miscellaneous variable expenses, euro/l	16.80
– fixed costs, euro	50, 760.00
Manufacturing time per first batch, h	120.00
Batch size, l	125.00
Learning effect, %	80.00
Overall production, followed by the rate increase of the learning curve, l	7,625.00

Due to tough competition on the global market a decision maker should evaluate the cumulative time necessary to produce 61 batches and the time used to launch 61st batch before the new beer brand production start-up. The dynamic character of brewery industry and the short life cycle of a new beer brand determine the selling price for the produced 2,350 litres of beer in order to gain profit in the amount equal or higher 282,000 euro.

Using the formula (1), we will calculate the meantime per batch production for the 61st batch as follows:

$$120.00 \times 61^{-0.3219} = 31.95 \text{ h/batch} \quad (3)$$

Using the equation result (3), we will define the overall time necessary to produce 61st batch, which will equal

$$61 \times 31.95 = 1,948.95 \text{ h/batch}$$

Using the same reasoning as in equations (3) and (4), we will get the mean time used for a batch production is 32.12 h/batch, provided that the overall output is 60 batches.

$$120.00 \times 60^{-0.3219} = 32.12 \text{ h/batch}$$

In this case the overall time necessary to produce 60 batches equals

$$60 \times 32.12 = 1,927.20 \text{ h/batch}$$

Therefore, the 61st batch will require 21.75 h.

Every batch produced after the output of 7,625 litres of beer, will require the same amount of time as the 61st batch, then the overall time necessary for the output of 11,750 litres will be as follows:

$$1,948.95 + (33 \times 21.75) = 2,666.7 \text{ h}$$

Thus, the overall labour costs will be as follows:

$$6.00 \times 2,666.70 = 16,000.20 \text{ euro}$$

Using the result of equation (5), we will calculate the mean sales price of the produced 2,350 liters of beer which will ensure a company's profit in the amount 282,000 euro (Table 6).

Table 6

Beer sales price evaluation, ensuring the target indicator of profit

Parameter	Calculation	Total value
Revenue from sales, euro	$9,400.00 \times 48.00$	451,200.00
Expenses:		
– direct labour expenses, euro	-	16,000.20
– miscellaneous variable expences, euro	$11,750.00 \times 16.80$	197,400.00
– fixed costs, euro	-	50,760.00
Profit excluding revenue from sales, euro	$451,200 - 16,200.2 - 197,400 - 50,760$	187,039.80
Target profit, euro	-	282,000.00
Expected revenue from sales, euro	$282,000.00 - 187,039.80$	94,960.20
Mean selling price essential for attaining a target profit indicator, euro/l	$94,960.20 \div 2,350$	40.41

Thus, the conducted calculations show that the learning curve, even though illustrating the production time reduction per unit, doesn't indicate reduction in cost as such. However, if the employees are paid by hour, and the hourly wage is fixed, then the labour costs per unit will reduce due to the learning curve, which in turn will enable the business entity to enhance its performance efficiency on the global market.

In our reckoning, the final evaluation of international trade efficiency is defined by the criterion selected by a decision maker to facilitate operation. However, the merchandise transactions occurring in the international trade environment may be modelled, in order to obtain certain results by means of mathematical methods. One of probabilistic models are the Markovian processes, which can be used when analysing the efficiency of export and import transactions. As it is illustrated by the example to follow, the mechanism of the learning curve defined by an international trading entity in many ways depends on the global market condition.

Despite the dynamic character of the brewery business, this segment of international trade may find itself in one of mutually excluding conditions:

s_1 – the market with the buyers over will enable the exporter gain a competitive advantage on condition of a 90% learning curve;

s_2 – equilibrium market when the quantity demanded equals the quantity supplied, enables the exporter to apply an 80% learning curve;

s_3 – market with the sellers over will enable the exporter to carry out transactions on the level of a 70% learning curve.

The informational data obtained by a decision maker proved that the state of the brewery upmarket in the future will depend on its condition at present. Thus, it has been defined that the market may randomly transfer from one condition to another at any time moment. Variability of transition probability density is feeble within the period under study and can be defined as the following matrix:

$$\omega = \begin{pmatrix} 0 & 2 & 4 \\ 3 & 0 & 1 \\ 5 & 1 & 0 \end{pmatrix}.$$

In order to prepare a fee proposal on the new upmarket beer brand in order to make an export agreement the decision maker made a mid-term prognosis on the condition of the international beer market. This was aimed to define the time per batch which would facilitate the exporter gain a competitive advantage though the learning curve model.

From the conditions we see that in system S viewed by a decision maker as the international brewery upmarket, there is a discrete homogeneous random process with a continuous time variable, therefore, a random process occurring in system S may be considered a Markovian process characterized by the absence of aftereffect. The process is discrete due to the fact that a set of states of the analyzed system S is finite $\{s_1, s_2, s_3\}$. Since the transition of system S from one condition to another may occur at any random moment of time, then it can be qualified as continuous-time Markovian process.

The analysis of the discrete Markovian processes occurring in system S should be carried out using the state graph compiled based on the density matrix of transition probabilities (6), which is shown in Fig.2.

Figure 2 – Marked state graph of the international brewery market

The analysis of the graph shows that system S is ergodic, since any of its implementations features the same characteristic features and one implementation of sufficient duration, when processing may replace the numerous implementations featuring the same total duration [6, PP 458-459]. Thus, system S may pass from state s_1 to any other using the following path (Fig. 3).

Figure 3 – Ergodic system

Some researchers [2, P 115] provided evidence that there are final probabilities of the states, on condition that the number of system S states is finite, system S is ergodic and all the flows of events generating the transitions of system S from one state to another are elementary. Since system S meets all the above

mentioned conditions, there are final probabilities of its state p_1, p_2, p_3 , independent on the time or initial state of system S . These final probabilities contain information on mid-term prognosis of the condition of international brewery up-market.

We will make up $n=3$ algebraic linear equations relative of three variables: p_1, p_2, p_3 .

$$\begin{cases} -6p_1 + 3p_2 + 5p_3 = 0, \\ 2p_1 - 4p_2 + p_3 = 0, \\ 4p_1 + p_2 - 6p_3 = 0. \end{cases} \quad (7)$$

And carry out a number of transformations in the system (7). This way we will get the following:

$$\begin{cases} -6p_1 + 3p_2 + 5p_3 = 0, \\ 18p_1 - 23p_3 = 0, \\ p_2 = 6p_3 - 4p_1. \end{cases}$$

Where

$$\begin{cases} -6p_1 + 3p_2 + 5p_3 = 0, \\ p_1 = 1.2778p_3, \\ p_2 = 6p_3 - 4p_1. \end{cases} \quad (8)$$

If we place expression for p_1 into the third equation of a system (8), we will get p_2 :

$$\begin{cases} -6p_1 + 3p_2 + 5p_3 = 0, \\ p_1 = 1.2778p_3, \\ p_2 = 0.8888p_3. \end{cases}$$

Therefore, the general solution of the system (7), depending on one arbitrary parameter $p_3 \in [0.1]$ and representing a set of specific solutions has the following view:

$$(p_1 = 1.2778p_3; p_2 = 0.8888p_3; p_3) \quad (9)$$

With reference to specific solutions (9), it is necessary to find the one, which would meet the normalizing condition:

$$p_1 + p_2 + p_3 = 1. \quad (10)$$

By substituting into expression (10) values p_1, p_2 found above we will get the following equation:

$$1.2778p_3 + 0.8888p_3 + p_3 = 1.$$

where

$$p_3 = 0.3158.$$

then

$$p_1 = 1.2778p_3 = 1.2778 \times 0.3158 = 0.4035;$$

$$p_2 = 0.8888p_3 = 0.8888 \times 0.3158 = 0.2807.$$

Thus, the mid-term prognosis of the state of international brewery upmarket is that upon the expiry of the period of one to two years it is very likely that ($p_1=0.4035 > p_2, p_3$) the market will be in overproduction state, when the supply exceeds demand. Therefore in order to gain competitive advantages on the global market the exporter has to carry out transactions aimed at the production of a new beer brand with a 90% learning curve.

Upon systematization of research outcomes we may draw the following conclusions:

1. A learning curve makes it possible to establish optimal pricing proposals for foreign contracting parties. The analysis of this curve allows revealing losses that may be incurred by a company when implementing an international trading agreement under economic uncertainty.

2. A learning curve, inherently representing a rationale for expenditures monitoring, is an essential tool for new product pricing, which strengthens the competitive position of a business entity on the global market, and eventually enhances efficiency of its activity in the international trade.

3. In order to define probabilistic functions of the learning curve at a particular moment, it is recommended to use Kolmogorov's system of differential equations, compiled based on the marked graph of states or the density matrix of transition probabilities.

The effect of learning is necessary for attaining the expected production level, as it results in a decrease of direct work time costs and overheads, which vary depending on work hours. Eventually it enhances the efficiency of international trade of a business entity regardless of conditions under which the production level is defined exclusively by the work of automated systems.

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