

Econometric Approach to Company's Production Potential Assessing Taking into Account Human Capital

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Abstract: In furtherance of the production potential model of the company in which the notion of stochastic frontier is used the authors have developed an econometric model for assessing human capital (a major component of intellectual capital).

Keywords: Production Potential, Stochastic Frontier, Human Capital of Company, Econometric Modeling.

1 Introduction

The relative value of production factors is one of the important characteristics of the economic development level. This problem generates a set of research publications based on *Stochastic Frontier Analysis* (Kumbhakar and Lovell, 2004). The era of post-industrial development, related with the concepts of “information economy” and “knowledge economy”, is characterized by the increasing role of intangible resources, possessing the features of capital, the total of which is now referred as intellectual capital. As a research tool for innovation companies the authors developed the econometric model of production capacity (see Aivazian and Afanasiev, 2009), which includes, along with the physical capital, the components of intellectual capital.

Model for the productive capacity of the “intellectual” company can be represented as follows:

$$P_i = \exp\{\beta_0\} \cdot \left(x_i^{(1)}\right)^{\beta_1} \cdots \left(x_i^{(n)}\right)^{\beta_n} \exp\{V_i - U_i\},$$

where i is the index of the company; P_i is the production volume; $x_i^{(1)}, \dots, x_i^{(n)}$ are the values of the primary production factors (the costs of labor, physical capital, human capital, structural capital and other factors)¹ for the company i ; $\beta = (\beta_0, \beta_1, \dots, \beta_n)$ is a vector-line of the model parameters; $V_i \in N(0, \sigma_V^2)$ is a normally distributed random variable, which represents the combined random effects on the production of the company i ; $U_i \in N^+(\delta z_i, \sigma_U^2)$ is a nonnegative truncated in zero normally distributed random variable, which does not depend on the random variable V_i and reflects the effectiveness of the primary production factors utilization by the company i ; z_i is a vector-column of the valued production efficiency factors for the company i whose components are $1, z_i^{(1)}, \dots, z_i^{(p)}$, δ is a vector-line of parameters with components $\delta_0, \delta_1, \dots, \delta_p$.

Examples of the production efficiency factors, for which are needed additional substantiation, are the following: $z_i^{(1)}$ is a share of the revenues from new contracts; $z_i^{(2)}$ is a rate of the employees income (the ratio of the total income for the 10% of the most highly

¹The definition and role of structural capital as part of the production potential of the company remain outside the framework of this study.

Table 1: Assessment of the advertising company (in dollars).

Regional office	Expected volume of the auto loans after advertising activities	Expected volume of the auto loans without advertising activities	Expected increase in the volume of the auto loans	Actual volume of the auto loans after advertising activities	Expected economic effect of the advertising activities
Kemerovo	1865629	1051982	813647.2	1582234	44412.48
Nijnii Novgorod	1759858	1005457	754400.9	1537179	43103.79
Murmansk	830160.7	730527.8	99632.89	630920.7	5032.291
Sankt-Peterburg	924884.3	817019.3	107865	1029768	205.9181
Yoshkar-Ola	2117721	1103577	1005554	2274815	55253.67

paid employees to the total income for the 10% of the least paid employees); $z_i^{(3)}$ is a status for the internet resources; $z_i^{(4)}$ is a share of the new products in the total production volume; $z_i^{(5)}$ is a level of company's quality certification.

Technical efficiency of the i th company determined by the formula $TE_i = \exp\{-U_i\}$. The developed method for evaluating the factors of production effectiveness is based on the methodology of the stochastic frontier. The estimates of measures, aimed at improving the production efficiency, are obtained. The approach was tested on the evaluation of activities aimed at improving the labor efficiency in the production of products for household purposes (see Aivazian, Afanasiev, and Makarov, 2008). Based on 1093 observations for the productive facility, we have obtained the estimators of the labor efficiency and efficiency, which are predicted as a consequence of relevant measures.

The method of the measures efficiency evaluating, which are aimed at improving the efficiency of production, has been tested also in the service sector. Predicted values of increase in the volume of car loans from the planned promotional activities in the five regional offices of a major Russian bank are presented in the Table 1 (see Aivazian, Afanasiev, and Afanasiev, 2009).

Based on the methodology of project analysis, the economic efficiency of promotional activities is evaluated. Using simulation modeling method, the distribution of activities economic effect is evaluated that allows us to estimate the risks associated with implementation of that activities. The following Figure 1 shows a histogram of the economic effects from advertising events for the regional office in Yoshkar-Ola.

2 Human Capital of the Company as a Major Component of its Intellectual Capital

Till now the unique definition of category "Intellectual Capital" does not exist. Economists offer its different treatments and ways of measurement. We will use following definition of this category.

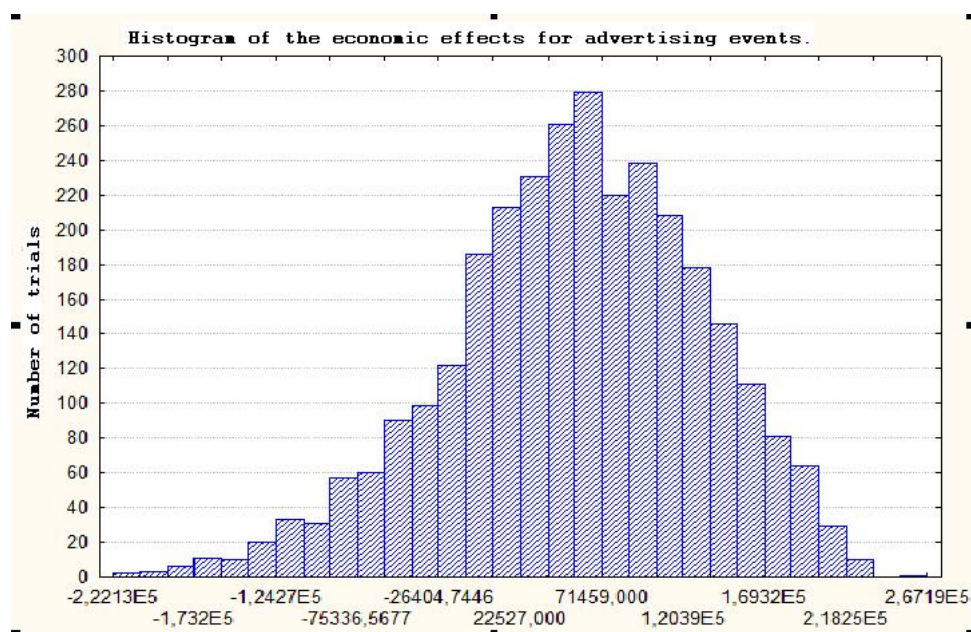


Figure 1: Histogram of the economic effects for advertising events.

Intellectual capital is the set of non-material actives of the company, knowledge, acquired skills and qualities of its employees, which provides the possibility of receiving incomes and competitive advantages.

Many authors adhere to structurization offered by L. Edvinsson, according to his theory intellectual capital consists of three elements: human capital, organizational capital and client capital. There are different approaches to definition of components of intellectual capital (Edvinsson, 2000; Stewart, 1997; Sveiby, 1997). We will accept definitions which seem to be constructive for procedure of formalization. The basis of intellectual capital, in other words, the whole set of knowledge belonging to company, is the **human capital**. Apparently, this term is used since 1960 (Schultz, 1960).

Formation of the definition of "Human Capital" accepted by us is based on papers by Schultz (1960), Becker (1964), Bourdieu (1986), Coleman (1988), and Makarov (2009).

The Nobel Prize-winner 1979 T. Schultz wrote: "All human resources and abilities are either congenital or acquired. Every person is born with individual set of genes, defining congenital human potential. Under human capital we mean valuable qualities got by person that can be strengthened by corresponding investments". T. Schultz has brought the considerable contribution to the theory of human capital formation at the beginning of its development, to its acceptance by scientific community and popularization. He was one of the first who has entered the conception of human capital as the factor of productivity and has made much for understanding of a role of human capital as main engine and base of postindustrial innovational economics. T. Schultz considered accumulation of abilities of people to work, effective conscious activities in society, health maintenance, etc. as the main results of investments into a person. He proved that human capital possesses necessary signs of productive character: it is capable to accumulate and to be reproduced.

According to G. Becker (also the Nobel Prize-winner, 1999) "Human capital is the set of skills, knowledge and abilities of the person" (Becker, 1964). G. Becker considered

Table 2: Components of the human capital.

Categories	Description
Skills	The set of skills, dexterity, which requires physical work or applied activity
Knowledge	The knowledge gained during training, the amount or range of what that has been realized, assimilated or learned by the individual
Experience (skills)	Knowledge and skills which are obtained through active participation in the developments that have occurred, activities, events.
Abilities	Acquired abilities of the target changing of the physical and moral condition of the individual, his character, temperament and behavior
Social relationships	Available for the individual social institutions, social opportunities, culture, public information, informal relationships.

that expenses for education and training are the main investments into human capital. The special contribution by G. Becker was made to the theory of competition, strategy and development of the firm. He has entered the distinction between special and common investments into a person and particularly allocated the significance of special education, special knowledge and skills. Special training of workers forms competitive advantages of firm, characteristic and significant features of its production, market behavior and, finally, its know-how, image, brand. It is considered that for human capital management approximately such set of parameters should be traced: education; professional qualification; knowledge connected with work; professional propensities; psychometric characteristics; skills connected with work.

Social capital carries out special role in the structure of company's intellectual capital. Category "Social Capital" entered Bourdieu (1986) for designation of social connections that can act as a resource for deriving benefits. P. Bourdieu defined social capital as "resources based on family relations and relations in membership group". According to P. Bourdieu social capital is a display of social-economic conditions and circumstances; it is a group resource and can not be measured on the individual level. More strict conceptualization of social capital has been proposed by J. Coleman, who defined social capital as the interconnection network that can be used as the instruments for production of goods and services. Social capital is characterized by the sum of individual relations and it is also the catalyst for mobilization of another's resources. Social capital - the "social glue" that helps to mobilize extra resources of relations on the base of confidence between actors.

In the framework of the economy of knowledge social relations are not only the factor of income reception, but also promote creation and spreading of new knowledge. Social capital of company is the base for assistance and coordination.

Further taking it into account we will use definition of individual human capital enlarged by evident inclusion of social relation. So **human capital** is the set of skills, knowledge, abilities, acquired abilities and social relations of a person. The main components of human capital are presented in Table 2.

When constructing the model, basic and related factors of human capital, as well as the factors of its efficiency, are discriminating. A set of human capital factors can be quite extensive. This set traditionally includes the level of education, professional expe-

rience, level of competence. For example, in Coleman (1988), there is a description of the different factors of human capital, characterizing mainly human capital management. Among the factors of human capital efficiency there are the degree of demand for knowledge of the staff, the level of motivation in productive activity and training, the quality of institutional support. Among the efficiency factors innate ability of the employee can be considered.

3 Assessing of a Company Human Capital and of Efficiency of its Utilization

It is assumed that the company has a set of factors which allow to characterize the human capital of any employee. We also assume that the values of these factors can be measured for each employee. Measure of employee's human capital, used by the company, is his salary. When determining the amount of salaries, not only the amount of human capital is taken into account, but also the efficiency of its use. Part of the employee's salary is determined by the company taking into account the established of its objective characteristics of human capital. These characteristics are the estimates of the main human capital factors. In setting up the salary subjective evaluation of associated human capital factors are taken into account. Also it takes into account the efficiency of its use. That is, determining the size of the employee's salary, the company objectively assesses its human capital and makes adjustments accounting for its efficiency utilization and subjective assessments associated factors of human capital. Then, as a measure of employee's human capital, the expected size of his salary corresponding to the maximum efficiency utilization of human capital, can be used.

Consider the following regression:

$$g_j = \gamma_0 + \sum_{k=1}^l \gamma_k w_j^{(k)} + v_j - u_j, \quad (1)$$

where j is the index of the company's employee, $j = 1, \dots, N$; k is the index of the primary human capital factor; g_j denotes the income of the employee j for the considered period of time; w_j is the vector with components $w_j^{(1)}, \dots, w_j^{(l)}$, which are the values of primary human capital factors of the employee j ; $\gamma_0, \dots, \gamma_l$ are parameters; $v_j \in N(0, \sigma_v^2)$ is a normally distributed random variable reflecting the sizes of the salary adjustments, with accounting for the subjective assessments of associated human capital factors; $u_j \in N^+(\lambda y_j, \sigma_u^2)$ is a nonnegative truncated in zero normally distributed random variable which does not depend on the random variable v_j , which reflecting the size of wage cuts as a result of inefficient human capital utilization for the employee j ; y_j is a vector-column $(1, y_j^{(1)}, \dots, y_j^{(m)})'$, components of which $y_j^{(1)}, \dots, y_j^{(m)}$ are the values of human capital efficiency factors for the employee j ; λ is a vector-line of the parameters with components $\lambda_0, \lambda_1, \dots, \lambda_m$.

For the evaluating of the model (1) it is required the following background information which characterizes each employee of the company: the value of income g_j for the considered period of time, vector w_j of the values for human capital factors, vector of his effi-

ciency factors y_j . The estimators of the parameters: $\gamma_0, \gamma_1, \dots, \gamma_p, \lambda_0, \lambda_1, \dots, \lambda_m, \sigma_v^2, \sigma_u^2$ can be obtained using the maximum likelihood method:

$$(\hat{\gamma}, \hat{\lambda}, \hat{\sigma}_v^2, \hat{\sigma}_u^2) = \arg \max_{\gamma, \lambda, \sigma_v^2, \sigma_u^2} L(\gamma, \lambda, \sigma_v^2, \sigma_u^2 | g_1, \dots, g_N, w_1, \dots, w_N, y_1, \dots, y_N),$$

where L denotes the likelihood function. Model (1) generalizes the well-known econometric Mincer's model (Mincer, 1975), which also uses the income of the individuals as an explanatory variable. Mincer's model as well as model (1) assumes the possibility of forming a set of human capital components and obtaining the estimates of their values for each employee. Traditionally it is accounted for the level of education, skills, psychometric characteristics and health. However, the evaluation of human capital, derived from the Mincer's model, is valid only under the assumption that human capital is used effectively. An important feature of the model (1) is that it allows you to evaluate the efficiency utilization of human capital for any employee, the efficiency utilization both by the employee and the company. In accordance with the methodology of the stochastic frontier, random variable $g_j^{pot} = \gamma_0 + \sum_{k=1}^l \gamma_k w_j^{(k)} + v_j$ characterizes the frontier potential of the employee's income. This level of income, when excluding u_j , corresponds to the maximum efficiency utilization by the company of the employee's j human capital.

The value g_j^{pot} is a random variable, due to inclusion of the random variable v_j , which reflects the impact of subjective evaluations of the associated human capital factors. Its expected value $E(g_j^{pot}) = \gamma_0 + \sum_{k=1}^l \gamma_k w_j^{(k)}$ can be regarded as an estimate of the employee's human capital. The value $E(g_j^{pot})$ defines the amount of salaries, which is determined by the values of the human capital primary factors under its effective utilization. Accordingly, the value $\sum_j E(g_j^{pot})$ is an estimate used by the company for the estimation of all its employees human capital. Given estimated $\varepsilon_j = v_j - u_j$, the expected value of the salary cuts $E(u_j | \varepsilon_j)$ due to the inefficient use of human capital is defined by the expression:

$$E(u_j | \varepsilon_j) = \tilde{\mu}_j + \frac{\sigma_*}{\sqrt{2\pi}\Phi(\tilde{\mu}_j/\sigma_*)} \exp \left\{ -\frac{\tilde{\mu}_j^2}{2\sigma_*^2} \right\},$$

where

$$\tilde{\mu}_j = (\mu_j \sigma_v^2 - \varepsilon_j \sigma_u^2) / \sigma^2, \quad \sigma_*^2 = \sigma_u^2 \sigma_v^2 / \sigma^2, \quad \sigma^2 = \sigma_u^2 + \sigma_v^2, \quad \mu_j = \lambda y_j,$$

with $\Phi(\cdot)$ the distribution function of the standard normal distribution.

A magnitude

$$\rho = \left(\sum_j E(g_j^{pot}) - \sum_j E(g_j) \right) / \sum_j E(g_j^{pot})$$

or, that is the same,

$$\rho = \left(\sum_j E(u_j) \right) / \left(N\gamma_0 + \sum_{j=1}^N \sum_{k=1}^l \gamma_k w_j^{(k)} \right),$$

can be considered as a measure of human capital efficiency utilization. When ρ is close to zero, the efficiency of human capital utilization is high. If used by the company system

of labor payments and incentives is based on mainstreaming human capital, then under high efficiency of its use by each of the employees, variance of the random variables $\varepsilon_j = v_j - u_j$ in the model (1) will be small.

That is, the income of any employee will be highly determined by the set of specific human capital key factors. In this case, the value $\sum_j E(g_j^{pot})$ will be close to the size of payroll. Consequently, when the payment system and labor incentives are based on human capital factors, payroll can be used as an estimate of the human capital of the company. Otherwise, as follows from the results presented in Afanasiev (2007), the difference between the assessment of human capital and assessment of its utilization in view of efficiency can be substantial.

The study of recruitment or dismissal of individual employees influence on the efficient utilization of human capital of the remaining staff is the task of human capital management, relevant in the context of the decision on full or partial merger of the human capital of various companies. To evaluate the activities, aimed at improving human capital, can be used developed by the authors (see Aivazian and Afanasiev, 2009) the concept of attainable capacity, which relies on the ability to manage efficiency factors. For the model (1) assessment of the achievable human potential of the company can be represented as:

$$g_j^{potS} = \gamma_0 + \sum_{k=1}^l \gamma_k w_j^{(k)} + v_j - s_j, \quad (2)$$

where $s_j \in N^+(\lambda \bar{y}_j, \sigma_u^2)$ is a nonnegative truncated in zero normally distributed random variable, which does not depend on random variable v_j , which reflects the impact of subjective evaluations on the employee's human capital factors, in which the values of these factors are characterized by a set of vectors $\{\bar{y}_j\}_{j=1}^N$ with the known value of total management costs. Expression (2) describes the income potential of the employee, attainable as a result of company's activities, aimed at improving human capital. The value $\sum_j E(g_j^{potS})$ is an estimate of human capital in the attainable efficiency of its use.

In accordance with Makarov (2009) some categories of employees can be varied. For example, employees who specialize in the production of knowledge, staff, distributing knowledge, which in this context is convenient to call the managers and employees who embody the knowledge, which can be attributed to the workers. The separation of employees into categories for modeling human capital should be based on additional substantiation caused by specificity of the company and the possibility of effective differentiation of the human capital of each of these categories.

4 Conclusions

Human capital has a special significance in the structure of intellectual capital because it is the base for development of intellectual capital and its components.

It is reasonable to distinguish human capital of three categories of workers in the structure of human capital: manual workers, workers of management and intellectuals. Division of workers into categories when designing human capital has to have additional substantiations due to specific character of the company and possibility of effective differentiation of human capital of each category of workers.

Value of frontier potential of wage determined by values of main factors of special human capital can be used as the estimate of human capital.

Presented model of human capital enables to determine expected value of wage decreasing for each employee as the result of unaffected use of human capital, and also expected value of correction of wage as the result of subjective assessment of factors of human capital.

If the system of remuneration and stimulating of labor used by company is based on accounting of factors of human capital, income of each worker is highly determined by set of main factors of special human capital and, cause of it, valuation of human capital is close to the wage fund. Otherwise difference between estimation of human capital of the company and wage fund can be significant.

Presented estimations can be the base for decision making in the sphere of personnel management with the view of development of human capital and higher efficiency of its usage. Proximity measure of expected values of frontier and attainable potentials of income of workers can be considered as the characteristic of efficiency of management of human capital.

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