„Zeszyty Teoretyczne Rachunkowości", tom 72 (128), SKwP, Warszawa 2013, pp. 49–62

Production function in the cost accounting approach and managerial applications

Mieczysław Dobija [*], *Marcin Jędrzejczyk* [**]

Introduction

The main aim of the paper is a presentation of the methods and the procedures of labor productivity management in the case of a business unit. This method allows compensations with periodic economic performance to be linked. The procedure uses accounting data and the natural concept of production function, which arises as a mathematical description of the relationships between the variables from the costing system. The labor productivity ratio emerges as an important issue of this consideration followed by the definition of the level of management. Having identified these categories, an essential problem of management accounting has been identified and solved. This is an agenda of consistency between compensation and a company's economic performance.

The methodology of the presented research employs the previously elaborated concept of capital and its application to human capital and fair wages determination. All economic variables are linked by the original concept of the production function. The function represents a generalization of the cost accounting process accumulating all outlays increased by cost profitability ratio. The function applied to accounting data discloses two variables: Q as labor productivity and F as the level of management. Both of them can serve in the construction of procedures determining compensations consistent with the business performance. The basic rule is that none of the variables can decline. The presented managerial procedures emerge as an issue of the elaborated concept of capital and derived notions joined by the original production function. Research can be found as a parallel to Total Factor Productivity considerations.

1. Concept of an econometric production function and total productivity factor

The Total Factor Productivity (TFP) level shows how efficiently and intensely the inputs are utilized in production. These inputs are in a conventional econometric ap-

[*] Prof. Dr. hab. Mieczysław Dobija, full professor, Department of Accounting, Cracow University of Economics, e-mail: accountd@uek.krakow.pl

[**] Dr. Marcin Jędrzejczyk, assistant professor, Department of Accounting, Cracow University of Economics, e-mail: jedrzejm@uek.krakow.pl

proach; physical capital (assets) and labor measured with natural units, so TFP embodies all other factors. Thus TFP explains how much of the growth in output per worker is associated with growth in physical and human capital per worker and how much is due to technology, institutional changes and other factor. It seems reasonable that the economy's output is a positive function of physical and human capital given the technology (Baier et al., 2002). It seems that TFP plays a critical role in economic fluctuations, economic growth and cross-country per capita income differences. However, as the referred authors have proved for all countries, only eight percent of average output growth per worker is associated with TFP growth.

As is discussed by Comin (2006), TFP growth is usually measured by the Solow residual. Let gY denote the growth rate of aggregate output, gK the growth rate of aggregate capital, gL the growth rate of aggregate labor and alpha (α) the capital share. The Solow residual is then defined as $gY - \alpha \times gK - (1 - \alpha) \times gL$. The Solow residual accurately measures TFP growth if (i) the production function is neoclassical, (ii) there is perfect competition in factor markets, and (iii) the growth rates of the inputs are measured accurately. In practice, TFP is a „measure of our ignorance" (Hulten, 2001) because it is a residual. This ignorance covers many components, some wanted (such as the effects of technical and organizational innovation), others unwanted (such as measurement error, omitted variables, aggregation bias, and model misspecification).

In recent years the category of capital has been better elaborated and the model of capital changes has been presented. Taking into consideration these papers, for example Dobija (2007, 2011) and discerning capital as the abstract category of *the ability to do work* we should use the term *assets* instead of capital. Capital is embodied in assets. In the context of the new understanding of capital, *labor* is the transfer of human capital to a product, and its concentration in the products creates *value*. Moreover the growth of capital is related to the natural interest rate (a kind of economic constant). Equipped with these interpretations one can approach the productivity factor research in an original way.

The standard departure point for deriving TFP growth is the neoclassical production function: $Y = G\ (TFP, L, K)$, where Y is the volume of output, K is the capital stock and L is the labor input. Solow (1957) showed that the Cobb-Douglas production function can be reshaped to the following formula:

$$Y(t) = A(t)F(K(t), H(t))$$

where: Y(t) denotes output, K(t) denotes capital, and H(t) denotes human capital. A(t) – represents TFP in time t.

Growiec (2009) introduces the evolution of growth theory underlying the lack of explanation of explicit reasons. Many authors, such as Brodzicki and Ciołek (2007) or Garbicz (2009) search for deeper reasons such as geography, integrations, quality of institution, and even the amount of the sun radiance. This seems to be a good idea since it is difficult to explain growth without the forces of Nature.

Years ago, Joan Robinson author of *The Production Function and the Theory of Capital* (1953–1954, p. 81) wrote this critical opinion: „(…) the production function has been a powerful instrument of miseducation. The student of economic theory is taught to write Q = f (L, K) where L is a quantity of labor, K a quantity of capital and Q a rate of output of commodities. He is instructed to assume all workers alike, and to measure L in man-hours of labor; he is told something about the index-number problem in choosing a unit of output; and then he is hurried on to the next question, in the hope that he will forget to ask in what units K is measured. Before he ever does ask, he has become a professor, and so sloppy habits of thought are handed on from one generation to the next".

This opinion underlines the weakness of the econometric production function so it is an impulse for seeking another approach to production process descriptions. In particular it is possible to apply a cost accounting approach (more generally, accounting) to the function describing the production process. It has been already done in many papers for example in Dobija (2004), Barburski and Dobija (2007), Dobija and Jędrzejczyk (2003) and Barburski (2010). It appears that the function formulated in the cost accounting approach allows for more applications that serve both in macroeconomic problems as well in solving some business agendas. In this paper, the authors present a procedure of determining the total pay in line with the economic performance of a given business. As for macroeconomic applications, the accounting production function and its main factor Q (labor productivity ratio) are useful, among tools, in the trend of exchange rate explanation (Dobija, 2008; Jędrzejczyk, 2009, 2012) and budget size determination (Dobija, 2009, 2011a).

2. Understanding of the growth and the income. What does it grow?

It is undeniable that the fundamental growth model is the compound interest formula. This formula is the basic natural model of initial capital growth where the time variable t acts as a grow factor. Let us note as well that it is the formula where initial capital has to appear; it had to exist earlier. It satisfies the fundamental principle that capital does not arise from nothing. The formula is $C_t = C_0e^{at,}$ where the rate (a) is the rate of growth. This formula works reliably, and everybody uses it in the course of the life. Albert Einstein is credited with the following statement referring to compound interest formula, often repeated in Business Schools: „(…) the greatest mathematical discovery of all time" (http://www.ruleof72.net/rule-of-72-einstein.asp). Although one can see some exaggeration in this statement it is not necessarily a myth opinion since Einstein himself introduced the Rule of 72, explaining that initial capital is doubled if the percent is equal to (a). It comes after 72/years. Let us see that both rate and time are capital generating variables. Supposedly, the author as a scientist thought about the mathematical expression of the foremost law of Nature; in business operations capital grows due to an exponential formula.

There are some rationales for high positive reception of the compound interest formula. But the true challenge is the theory of the rate of growth. Virtually an explanation of the structure of ratio „a" means creating the theory of capital growth. According to the present knowledge resulting from research done by Dobija (2011b), Kurek (2012), Cieślak (2008), and Kozioł (2011), the rate of growth has a three-factor structure. Namely a = p – s + m. It denotes that the initial capital C_0 is influenced by the three subsequent factors and the variable t as follows:

$$C_t = C_0 e^{pt} e^{-st} e^{mt} = C_0 e^{(p-s+m)t},$$

and

$$p = E(s),$$

where E is the symbol of the mean value.

The variables are defined:

- t – is the coordinating (calendar) time of the Sun System or other cyclical movements;
- e^{pt} – is the natural potential of growth existing in Nature, determined by the economic constant p = 0.08 [1/year];
- e^{-st} – is the thermodynamic arrow of time; s is the rate of spontaneous random diffusion of the initial capital. There is the relationship p = E(s);
- e^{mt} – is the input of human labor and management, which can offset the natural diffusion of capital and it can protect the potential of growth changing it into profit. Letter m denotes rate of capital inflow.

Let us note that the first thermodynamic principle is also present in the above formula. It is the initial capital C_0, which must previously have existed; it cannot be created. The variables: t, p, s, and m are essential for understanding matters of growth. They all are strongly reasoned by the fundamental laws of the thermodynamics. In addition, the above model involves the economic constant p, which is a key point for falsification efforts.

The ratio m represents the input of human labor, thus it can be depicted by the function f (A, H, Q), where the variables denote assets A, human capital H, and labor productivity Q. Therefore, the model of growth can be expressed as:

$$C_t = C_0 e^{[p-s+f(A, H, Q)]t} = C_0 e^{pt} e^{[-s+f(A, H, Q)]t}$$

The model shows that the constant p in the tandem with flow of time t is sources of growth. Thus the growth is a quality of Nature. Human labor is a factor that sets off the variable (-s), that is to say, it decreases the influence of the Second Principle. Physiocrats were, to some extent, correct thinkers about the forces of Nature and the role of the labor processes. In fact, growth appears as issue of the Sun's radiance, the phenomenon of photosynthesis, and last but not least, human capital - labor. Practically, through labor, capital is merely shifted to products. Therefore there is no growth of capital in the total balance since, in order to accomplish the job, an employee earlier had to absorb his/her human capital (the ability of doing work). The total balance grows chiefly by the growth of human resources. It is possible thanks to photosynthesis, farmers' work, and the food industry.

In general, labor accomplished by a worker sets off the diffusion (-s), so that the potential p is saved. It is a way by which labor has a positive effect on growth. For example, the medical services help to maintain human health so that employees are healthy and they are able to shift their human capital to products. Therefore, we should consider two sources of growth. The first is determined by factor e^{pt} and the second is factor e^{mt}.

Various research has been carried out in respect to the constant p, whose size is equal to 0.08 per year. The risk premium, known from capital market research, is a manifestation of the constant p as explained in Dobija (2000, 2007). Long-term research conducted in the USA has disclosed its size. The so-called *Ibbotson Standard* determines the size of the risk premium gained on the capital market as 8% per year (Goetzman and Ibbotson, 2005). Research done by Kurek (2007, 2008) proved that companies' incomes and ROA confirm the Ibbotson standard exactly.

Many astonishing economic facts can be explained by the existence of the constant p. Human capital as well as the computation of fair wages require the rate of capitalization equal to 8%. It also appearred as legal yearly interest in ancient Rome (Pikulska-Robaszkiewicz, 1999, p. 41) where fair size interest had been established as 1/12 of the initial capital. Therefore the interest rate was 8.3% per year (let us note that $e^{0.08}$=0.083). Generally speaking, the constant is a fundamental for caclulating fair values. The constant is a wider elaboration of the natural interest rate introduced by proponents of the Austrian School (Garrison, 2006).

Having defined the capital model, one can introduce the yearly income model. This income is the yearly increase of the initial capital so the formula is as follows (after application of the relation, e^a is close to 1 + a, if a is small):

$$\text{Income} = \Delta C = C_t - C_{t-1} = C_0 e^{at} - C_0 e^{a(t-1)} = C_0[1 + at - (1 + at - a)] = C_0(p\text{-}s\text{+}m).$$

Interpreting the above formula we immediately see that the explanation given by Knight (1921) in respect to the essence of income is correct (but not complete). It is true that uncertainty is related to income but not so directly. The yearly income is initiated by an action (initial capital times time $\Delta t = 1$). It arises mostly thanks to the constant p, that is to say the natural potential of growth being an indispensable trait of our world. This potential is decreased by the spontaneous random dispersion (random variable s) of capital, that is to say by the risk and induced costs of risk. Additionally, ultimate income is shaped by human labor transfers (work) and the wise management (variable m). Sometimes m is greater than s, so the income is greater than C_0p.

The uncertainty means, among other things, that the level of capital embodied in assets is different at each point of time. In fact, the level of capital concentration representing the value of the assets is undetermined and can be only estimated. It is circumstances, not risk, which is the source of income. Its randomness allows for its decrease through correct procedures of management, which prevent losses of value in the processes of labor. The fundamental source of income is the economic constant p (or the risk premium) and the positive influence of labor and correct management (m). The uncertainty as a result of natural diffusion (the second law of thermodynamics) is a source of costs of risk, the volume of random costs other than clearly determined costs of production and management. The free market price covers all indispensable costs; therefore, effective control procedures that decrease the costs of risk increase income as well.

3. The epitome of the accounting approach to production function

An economic connotation of the productivity factor can be also appropriated by the production function arising in the accounting approach as discussed in earlier papers, for instance Dobija (2008) and Barburski (2010). Thus, applying the natural approach based on the calculation of costs, we arrive at the production function with seven specified arguments. As a result, the structure of arguments specifies all significant variables, and the basic analytical formula of the function does not require an estimation of the parameters. The production function expressed analytically may be a tool of economic analysis using differential calculations; or it may provide numerous nonlinear models describing the behavior of a selected variable. The cost value of production in historical prices of outlays may be expressed as follows:

$$P = K(1 + r) = K\left(1 + \frac{Z}{K}\right)$$

where: K – denotes overall costs of production expressed in historical cost, r – cost profitability factor, Z – periodic income. Let us note that the fraction Z/K can be expressed as follows:

$$\frac{K}{A} = w, \text{ so } K = wA$$

where w is turnover ratio.

Then the fraction Z/K is arrived at by the formula:

$$\frac{Z}{K} = \frac{Z}{wA} = \frac{ROA}{w}$$

where ROA is return on assets ratio.

Now we divide total cost K into two parts W + R, where W denotes costs of labor (total compensations) and R denotes rest of costs.

$$P = (W + R)\left(1 + \frac{ROA}{w}\right)$$

After reformulating the above equation we obtain:

$$P = W\left(1 + \frac{R}{W}\right)\left(1 + \frac{ROA}{w}\right)$$

The turnover ratio of production costs R to assets is named as z:

$$\frac{R}{A} = z, \text{ so } R = zA$$

What is more, from the human capital theory we have a fundamental relationship concerning compensations and human capital H:

$$W = uH$$

where: u denotes compensation level, and H is the value of human capital. Taking into consideration all these formulas we can arrive at the final form of the production function:

$$P = W\left(1 + \frac{Az}{Hu}\right)\left(1 + \frac{ROA}{w}\right)$$

Here A/H denotes the variable of technical equipment of labor, and u is the level of compensating the employees.

Introducing labor productivity ratio Q the production function is as follows:

$$P = W \times Q = W\left(1 + \frac{Az}{Hu}\right)\left(1 + \frac{ROA}{w}\right)$$

and

$$Q = \frac{p}{w} = \left(1 + \frac{Az}{Hu}\right)\left(1 + \frac{ROA}{w}\right)$$

The above formula shows that on the one hand Q can be computed as a simple quotient (if there is relevant data), and on the other hand Q is a synthesis of many important factors contributing towards successful production. In the simplest interpretation, Q is the information how many units of production are generated by one money unit of wages.

The presented production function shows that each level of production and combination of other variables determines an adequate level of compensations. It results directly from the shape of the production function. We know that in line with human capital theory (Dobija, 2000, 2011) the human capital of employees is preserved if the present value of a future stream of pay is equal to the employee's capital. This rule holds when basic pay is determined as 8% of employee capital. Research carried out shows that capitalistic Western countries entirely apply this rule establishing legal minimum wages. The last is a benchmark for basic pay for others. This is not the case in, for example, Eastern European countries. Thus, the percentage of pay in respect to human capital should be equal to or greater than 8%, that is to say: u > p = 8%.

The denominator of ratio Q is the sum of employees' earnings. The shape of production function points out that an optimal pay level exists, because compensation payoff ratio (u) appears both in the nominator and denominator.

$$P = uH\left(1 + \frac{Az}{Hu}\right)\left(1 + \frac{ROA}{w}\right)$$

In the case of business units this equation has been solved by Kozioł (2011) applying the iteration process. It is possible since, in the case of a firm, the value of assets is determined in the balance sheet. This is not true of the whole economy, however. In fact, it is known that the bottom limit of the payoff ratio u is 8% of employee' human capital. Eight percent determines the basic constant correct payment but some bonus pay can increase it. As research (Kozioł, 2011) carried out in Poland points out, a typical payoff ratio (u) is about 10% on average of a prospering company. Eight percent determines the basic pay and 2%, which makes 25% in respect to basic pay, indicates the average size of premium pay. Thus the fundamental formulas involving Human capital H are as follows: W = u × H, and L = p × H, where L denotes basic constant pay.

4. Models for output and factor of management

The multi-variable function describing product P plus the basic relation derived from human capital theory presented above institutes a basic departure point for a more brief a nd useful model of production. The basic function is replaced by model (A) where all variables denoted formerly by small letters are replaced by one variable F, which can be called the management factor.

The management factor F is parallel to TFP in econometric approaches. Believing that F involves all influences others than made by assets (A), basic payments measured naturally in money units (L), and natural forces (p) we may use it for solving some management problems. Introducing the variable F we get a set of models as follows:

$$\textbf{(A) } P = We^{\frac{AF}{H}}, \textbf{ (B) } P = W \times Q, \textbf{ (C) } W = u \times H, \textbf{ (D) } W = L(1 + b)$$

$$\textbf{(E) } L = p \times H, \textbf{ (F) } Q = e^{\frac{AFp}{L}}, \textbf{ (G) } Q = e^{TF}$$

where **L** denotes basic constant pay, **b** denotes percent of premium pay, and **T = A/H** substitutes as a variable denoting technical equipment of labor (materials, tools, machines, roads, bridges, facilities, and all useful infrastructures).

Variables of model (A) are identified by the above reasoning although we have to admit some measurement errors, aggregation bias, and model misspecification related to use of the exponential function. Model (C) is an import outcome of human capital measurement. This relationship allows for the measurement of total human capital in money units using easier accessible basic wages L. From the theory of human capital it is known that pay equal to L = p × H ensures that the human capital of an employee does not depreciate, since this pay is equal to yearly depreciation.

Using historical data one can compute Q, T, and F for a country and analyze their changes. Taking as departure point model (F) we can determine factor F using the following equation.

$$\ln Q = \frac{AF}{H} = \frac{AFp}{L}$$

The variable Q depends on the value of assets while factor F is discharged from the influence of the assets and natural forces expressed by economic constant p. For example, the wood industry depends not only from productivity factor, labor and assets. It relies heavily on the sun and rain, that is to say natural forces.

5. Compensation consistent with business performance

For managerial purposes, especially for estimating an appropriate pay level according to business performance, the introduced model of production can be used since all data are directly available from the accounting system of an enterprise. The company that has been chosen to conduct empirical analysis belongs to the food sector and has been present on the Polish market since 1945. As the company invests a lot in technical development, theoretically it is expected to raise productivity factor Q and management factor F. First of all, some data from the income statement must be accessible. Sales revenue and salaries expense has been taken from the income statement of the years 2010 and 2011. Total assets needed to compute productivity Q and factor F have been acquired from the statement of its financial position in 2010 and 2011. Bonus pay percentages in the period have been estimated by the chairman of the executive board at the level of 15%. The acquired data are presented in table 1.

Table 1. Empirical data needed to compute wage productivity and F in years 2010 and 2011

Financial statement item	Year 2010	Year 2011
Production in sale prices (P) in zł	105 856 364.10	151 234 628.40
Labor costs (W) in zł	4 879 904.00	5 067 171.55
Basic salary (L) in zł	4 147 918.40	4 307 095.82
Total Assets (A) in zł	46 644 526.08	53 285 081.46
Bonus pay percentage	0.1500	0.1500

Source: data of the analyzed company.

Analyzing amounts from table 1, we can formulate several general motions concerning the financial standing of the examined enterprise. First of all, sales revenue (P expressed in sale prices) has risen from 105 million to more than 150 million which makes almost 50% more of production sold. Total assets (A) changed from 46.6 million to almost 53.3 million, which can be the result of investing activities performed by the enterprise. Overall costs of labor (W) also increased from 4.87 million to more than five million. One can say that in this case the company is performing very well and its results should indicate stable development in forthcoming periods.

Using the model previously described it is possible to use the acquired data and determine the level of productivity Q and management factor F. We have the formula:

$$F = \frac{L \ln Q}{pA}$$

The results of the described calculations are presented in table 2.

Table 2. Labor productivity Q and management factor F calculation for years 2010 and 2011

Financial statement item	Year 2010	Year 2011
Production in sale prices (P) in zł	105 856 364.10	151 234 628.40
Labor costs (W) in zł	4 879 904.00	5 067 171.55
Labor productivity (Q)	21.69	29.85
Basic salary (L) in zł	4 147 918.40	4 307 095.82
Total Assets (A) in zł	46 644 526.08	53 285 081.46
F factor (F)	3.4203	3.4313
Bonus pay percentage	0.1500	0.1500

Source: own computation.

Productivity Q has increased a lot which confirms earlier deductions. What is more, factor F has been very stable and indicates a slight change upwards from 3.42 to 3.43 which proves a stable way of managing the company based on maintaining management ratio F at a similar level. It shows that the company's management is doing well. Managing a company that is based on the F ratio is very reasonable, as management level F integrates all significant short-term coefficients needed to per-form business activities. Maintaining the F ratio at a stable level means a stable value of the cost profitability and rotation turnovers, which is desired from the managerial point of view.

Taking into consideration the abovementioned fact there is the possibility of using the production function to estimate the level of bonus pay based on budgeting the forthcoming years' financial figures. Let us prepare two different scenarios, first in which managers of the company prepare the budget at the same level of factor F that would equal 3.42 and the second in which they assume the increase of factor F to the level of 3.52. The results of the calculations would be based on the reshaped model:

$$W = \frac{P}{e^{\frac{AFp}{L}}}$$

The results of the first scenario are presented in Table 3 and second scenario in table 4.

Table 3. Application of the F to wages budgeting for the year 2011 at the level of 3.42

Scenario 1, assumed level of F=3,4203	2010	Budget for 2011
Production in sale prices (P) in zł	105 856 364.10	151 234 628.40
Labor costs (W) in zł	4 879 904.00	5 122 809.19
Labor productivity (WP)	21.69	29.52
Basic salary (L) in zł	4 147 918.40	4 307 095.82
Total Assets (A) in zł	46 644 526.08	53 285 081.46
Management variable (F)	3.4203	3.4203
Bonus pay percentage	0.1500	0.1592

Source: own estimation.

Maintaining a stable value of F factor brings the result of bonus pay close to 16%, which is in fact very similar to the real data presented in the Table 2. There is only a slight increase in bonus pay which results in the increase of total labor costs. Let us consider the second scenario, in which the governing bodies of the company decided to place most importance to the growth of F ratio to the level of 3.52. The necessary computations have been provided in table 4.

Table 4. Application of F to wages budgeting for the year 2011 at the level of 3.52

Scenario 2, assumed level of F=3,52	2010	Budget for 2011
Production in sale prices (P) in zł	105 856 364.10	151 234 628.40
Work costs (W) in zł	4 879 904.00	4 641 456.24
Labor productivity (WP)	21.69	32.58
Basic salary (L) in zł	4 147 918.40	4 307 095.82
Total Assets (A) in zł	46 644 526.08	53 285 081.46
Management variable (F)	3.4203	3.5200
Bonus pay percentage	0.1500	0.0720

Source: own estimation.

In scenario 1 where the same level of management factor was assumed as in the year 2010 the work costs were estimated at 5,122 thousands, which reflects about 16% of bonus pay percentage. For the second scenario, with F equal to 3.52, the productivity Q of the enterprise rose to 32.58 and, assuming the same level of sales revenue (P) and total assets, would give a bonus of only 7.2%. Assuming a high level of management ratio F resulted in a decrease of bonus pay in the budgeted year.

Conclusion

A cost approach to the production function leads to a new description of the manufacturing process, where labor productivity Q and management variable F have significant parts. In particular, we obtain a method of determining an adequate wage level consistent with business performance. Since constant basic pay is under the control of human capital theory the established method introduces the formal procedure of controlling the bonus pay creating simultaneously the right motivation. The concept of production function meets Robinson's expectations of expressing all economic variables in monetary terms. Ratios Q and F computed from accounting data allow for a new form of management integrating compensations with economic performance. This solution requires, however, stronger common bargaining attitudes between management and employees as well their real participation in the management process. Therefore, business compensations schemes must be more visible if the organization culture is to achieve an adequate level.

The main and the most important drawback of the natural concept of the production function is the same as in the case of Total Factor Productivity, which is a residual value of the factors present in the function formula. But unlike Total Factor Productivity, factor F is based on the fair estimation of assets taken from the accounting record of the enterprise.

References

Baier S., Dwyer G., Tamura R. (2002), *How Important Are Capital and Total Factor Productivity for Economic Growth*, Federal Reserve Bank of Atlanta.

Barburski J. (2010), *Wynagrodzenia premiowe jako funkcja produktywności pracy*, [in:] M. Dobija (ed.), *Teoria pomiaru kapitału i zysku*, Wydawnictwo Uniwersytetu Ekonomicznego w Krakowie, Kraków.

Barburski J., Dobija M. (2007), *Produktywność pracy w aspekcie makro i mikroekonomicznym*, [in:] Dudycz, Ł. Tomaszewicz (eds.), *Efektywność – rozważania nad istotą i pomiarem*, Wydawnictwo Uniwersytetu Ekonomicznego we Wrocławiu, Wrocław.

Brodzicki T., Ciołek D. (2007), *Głębokie determinanty wzrostu gospodarczego – weryfikacja empiryczna z wykorzystaniem metod estymacji panelowych*, „Analizy i opracowania KEIE" (Uniwersytet Gdański) nr 1.

Cieślak I. (2008), *Value of human capital and wage disparities*, [in:] I. Górowski (ed.), *General Accounting Theory. Evolution and Design for Efficiency*, Wydawnictwa Akademickie i Profesjonalne, Warszawa, pp. 289–303.

Comin D. (2006), *Total Factor Productivity*, New York University and NBER.

Dobija M. (2000), *Human resources costing and accounting as a determinant of minimum wage theory*, „Zeszyty Naukowe Akademii Ekonomicznej w Krakowie", nr 553.
Dobija M. (2004), *Analityczna funkcja produkcji*, „Ekonomika i Organizacja Przedsiębiorstwa", nr 9.
Dobija M. (2007), *Abstract nature of capital and money*, [in:] L.M. Cornwall (ed.), *New Developments in Banking and Finance*, Nova Science Publishers, New York, pp. 89–114.
Dobija M. (2008), *Labour productivity ratio and international comparison of economic performance – formalization of the PPP theory and preliminary examinations*, paper presented at IEA 15th World Congress, Istanbul, Turkey, June 25–29, 2008, „EMERGO", no. 1, pp. 3–19.
Dobija M. (2009), *Produktywność pracy a rozmiar sektora publicznego*, „Master of Business Administration", nr 1(96).
Dobija M. (2011a), *Abstract nature of money and the modern equation of exchange*, „Modern Economy", no. 2.
Dobija M. (2011b), *Labor productivity vs. minimum wage level*, „Modern Economy", vol. 2, no. 5, pp. 780–787.
Dobija M., Jędrzejczyk M. (2003) *Rachunkowość i sprawozdawczość a pomiar produktywności działalności gospodarczej*, [in:] B. Micherda (ed.), *Sprawozdawczość i rewizja finansowa w procesie podnoszenia kwalifikacji kadry menedżerskiej*, Wydawnictwo Akademii Ekonomicznej w Krakowie, Kraków.
Garbicz M. (2009), *Problemy rozwoju i niedorozwoju*, [in:] W. Pacho (ed.) *Szkice z dynamiki i stabilizacji gospodarki*, Oficyna Wydawnicza SGH, Warszawa.
Garrison R.W. (2006), *Natural and neutral rates of interest in theory and policy formulation*, „Quarterly Journal of Austrian Economics", vol. 9, no. 4 (Winter).
Growiec J. (2009), *Wzrost gospodarczy i postęp technologiczny*, [in:] W. Pacho (ed.) *Szkice z dynamiki i stabilizacji gospodarki*, Oficyna Wydawnicza SGH, Warszawa.
Hulten Ch. (2001), *Total Factor Productivity. A short biography*, [in:] Ch. Hulten, E. Dean. M. Harper (eds.), *New Developments in Productivity Analysis*, „NBER Studies in Income and Wealth", vol. 63.
Jędrzejczyk M. (2009) *Konwersja wartości w skonsolidowanych sprawozdaniach międzynarodowych grup kapitałowych*, PTE, Kraków.
Kozioł W. (2011), *Rozwój rachunku kapitału ludzkiego*, [in:] M. Dobija (ed.), *Kapitał ludzki w perspektywie ekonomicznej*, Wydawnictwo Uniwersytetu Ekonomicznego w Krakowie, Kraków.
Kurek B. (2008), *The risk premium estimation on the basis of adjusted ROA*, [in:] I. Górowski (ed.), *General Accounting Theory. Evolution and Design for Efficiency*, Wydawnictwa Akademickie i Profesjonalne, Warszawa, pp. 375–392.
Kurek B. (2010), *Hipoteza deterministycznej premii za ryzyko*, Wydawnictwo Uniwersytetu Ekonomicznego w Krakowie, Kraków.
Kurek B. (2012), *An Estimation of the capital growth rate in business activities*, „Modern Economy", vol. 3, no. 4, pp. 364–372.
Pikulska-Robaszkiewicz A. (1999), *Lichwa w państwie i prawie republikańskiego Rzymu*, Wydawnictwo Uniwersytetu Łódzkiego, Łódź.
Robinson J. (1953–1954), *The production function and the theory of capital*, „Review of Economic Studies", vol. 21, no. 2, pp. 81–106.
Solow R. (1957), *Technical Change and the Aggregate Production Function*, „Review of Economics and Statistics", no. 39 (August), pp. 312–320.

Internet sources

American Bureau of Labor Statistics, http://www.bls.gov/oes/current/oes_nat.htm
China's gross domestic product (GDP) growth, http://www.chinability.com/GDP.htm
EconStat, http://66.221.89.50/weo/V020.htm
Goetzmann W.N., Ibbotson R.G. (2005), *History and the Equity Risk Premium*, „Yale ICF Working Paper", no. 05–04 (http://ssrn.com/abstract=702341).

Goldstein M. (2004), *Adjusting China's Exchange Rate Policies,* Revised version of the paper presented at the International Monetary Fund's Seminar on China's Foreign Exchange System, Dalian, China, May 26–27, 2004.

http://www.oanda.com/products/bigmac/bigmac.shtml

Knight F.H. (1921), *Risk, Uncertainty, and Profit,* Library of Economics and Liberty, retrieved December 10, 2007 (http://www.econlib.org/library/Knight/knRUP7.html).

Total Economy Database, January 2007, Groningen Growth and Development Centre and the Conference Board, www.ggdc.net/dseries/

World Salaries, http://www.worldsalaries.org/uk.shtml

Summary

Cost accounting is among other things a quantitative description of the manufacturing processes. Using algebraic notations of variables appearing in cost accounting one can describe production by function of many arguments. Considerations lead to the finding of two important factors, namely labor productivity and variable of management. The last variable is parallel to the concept of total factor productivity (TFP) well known in econometrics research. These two factors serve for cognitive aims and are useful for solving some management problems. One of the significant problems is the determination of an adequate level of compensation in accordance with economic performance. This paper presents an accounting concept of the production function and methods of controlling compensation according to data presented in financial statements. The procedures are applied to real company data.

Keywords: wage productivity, production function, bonus pay, budgeting.

Streszczenie

Zastosowanie analitycznej funkcji produkcji w procesie zarządzania przedsiębiorstwem

Domenę rachunkowości zarządczej stanowi między innymi kwantytatywny opis procesów wytwórczych. Używając zmiennych charakterystycznych dla procesów produkcyjnych, można dokonać formalnego zapisu funkcji produkcji polegającego na kompozycji czynników w procesach wytwórczych. Podejście zaprezentowane w artykule prowadzi do dwóch istotnych zmiennych: produktywności pracy oraz zmiennej zarządzania. Zmienna zarządzania jest paralelą koncepcji całkowitej produktywności czynników produkcji (*Total Factor Productivity* – TFP). znanej w ekonometrii. Produktywność pracy oraz zmienna zarządzania mogą służyć do rozwiązywania niektórych problemów związanych z zarządzaniem przedsiębiorstwem. Jednym z najważniejszych problemów poruszanych w treści artykułu jest kształtowanie rozmiaru wynagrodzeń premiowych w zależności od sytuacji finansowej przedsiębiorstwa. Przedstawiono przede wszystkim addytywną postać funkcji produkcji opartej na zmiennych dostępnych w systemie rachunkowości przedsiębiorstwa i jej rolę w controllingu wynagrodzeń w kontekście sprawozdawczości finansowej podmiotu gospodarczego. Wyprowadzone procedury zostały zweryfikowane na przykładzie danych firmy produkcyjnej z branży spożywczej.

Słowa kluczowe: produktywność pracy, funkcja produkcji, wynagrodzenia premiowe, budżetowanie.