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Zarządzanie kosztami i dokonaniem

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**APPLICATION OF ORDINAL LOGIT MODELS IN THE
DIAGNOSIS OF PERFORMANCE MEASUREMENT
SYSTEM IN POLISH ENTERPRISES***

**WYKORZYSTANIE PORZĄDKOWYCH MODELI
LOGITOWYCH W DIAGNOZIE SYSTEMU POMIARU
DOKONAŃ PRZEDSIĘBIORSTW POLSKICH**

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Summary: Successful achievement of strategic goals requires the implementation of adequate instruments to assist in the management of enterprises. These instruments undoubtedly contain performance measurement system. This is confirmed by the results of presented research. It has been proved that enterprises having performance measurement systems perform better than those which do not have them. For this reason, there is a need for research of applicable solutions implemented in a particular company or separate groups of organizations. The purpose of the article was to identify elements of performance measurement systems in three groups of objects: large, medium and small, classified by the size of revenues. In the study ordinal logit models were applied. The source of information was survey carried out by CATI technique in 2012. The sample was drawn from REGON database and consisted of 300 companies from the non-financial sector.

Keywords: performance measurement system, ordinal logit models, SME.

Streszczenie: Skuteczne osiągnięcie celów strategicznych wymaga wdrożenia adekwatnych instrumentów wspierających zarządzanie przedsiębiorstwami. Do takich instrumentów niewątpliwie należą systemy pomiaru dokonań. Potwierdzeniem tego są wyniki przeprowadzonych badań. Wykazano, że przedsiębiorstwa posiadające systemy pomiaru dokonań osiągają lepsze wyniki finansowe niż te, które ich nie posiadają. Z tego też powodu istnieje potrzeba badania stosowanych w tym zakresie rozwiązań w przestrzeni konkretnego przedsiębiorstwa jak i wyodrębnionych grup podmiotów gospodarczych. Celem artykułu była identyfikacja

* Project N N115 436640 “Key performance indicators in company’s performance management”.

elementów systemów pomiaru dokonań w trzech grupach podmiotów: dużych, średnich oraz małych, sklasyfikowanych według wielkości osiągniętych przychodów. W badaniu wykorzystano porządkowe modele logitowe. Źródłem informacji były przeprowadzone w 2012 roku techniką CATI badania ilościowe. Próba do badania została dobrana w sposób nieproporcjonalny z bazy REGON i obejmowała 300 przedsiębiorstw sektora niefinansowego.

Słowa kluczowe: systemy pomiaru dokonań, porządkowe modele logitowe, małe i średnie przedsiębiorstwa.

1. Introduction

The results of the research conducted so far confirm that firms that use the performance measurement systems (PMS) perform better than those that do not [Batóg et al. in print]. For this reason, there is a need for the research of solutions applied in this field in case of a particular company and their generalization for groups of firms determined by given criteria. The identification of the characteristics of effective performance measurement systems can be the basis of their popularization and application, enabling thereby the maximization of the benefits for individual entities, which is transferring to competitiveness of the whole economy.

The assessment of the performance measurement system is not a simple problem. There is lack of key characteristics of performance measurement system in the literature. R. Haffer referring to the research conducted by M. Franco-Santos, M. Kennerley, P. Michali, V. Martinez, S. Mason, B. Marr, D. Gray and A. Neely presents the following aspects of performance measurement system identified on the basis of performance measurement system definition [Haffer 2011, Franco-Santos et al. 2007]:

- elements which are components primarily of strategic objectives – the foundation for designing the measures that allows monitoring the strategy, individual and sets of effectiveness and efficiency measures or infrastructure that allows collecting, sorting, analysing, interpreting and making the data popular,
- functions, and the foreground in it, which is performance measurement and evaluation, used as a result in improving the performance, and secondary, which identify the maturity of the system, including: refining the vision and strategy, planning, objectives setting and strategic decision making, current operating controlling, communication and motivating the employees,
- processes, understood as a series of activities, among which the leading ones are: methodology for determining the moment of measuring and designing the indicators, shaping the process of data collecting and chosen indicators measuring and the process of distribution of measurement results.

The purpose of the article was to identify the characteristics of performance measurement systems in three groups of Polish enterprises: large, medium and small, classified by the size of revenues.

In the process of identification of the solutions in the field of performance measurement a lot of methods with different cognitive value and practical usefulness can be used. In the first stage simple descriptive statistics are appropriate. Then searching for regularities could be conducted with the more advanced methods including ordinal logit models.

2. Ordinal logit models

Multinomial models are the extension of binominal models. In the binominal models qualitative variable has two categories. In case of more than two categories for qualitative variable there are possible two situations: nominal or ordinal variable. In this paper the ordinal logit models will be applied [Cramer 2003; Kleinbaum, Klien 2002].

In ordinal models the probability of an equal or smaller category (P_{ik}) is compared to the probability of a larger category ($1 - P_{ik}$) (see Formula 1).

$$\frac{P_{ik}}{1 - P_{ik}} = F(\alpha_k + x_i^T \beta), \quad (1)$$

where: k – number of category, $k = 1, \dots, K$; K – number of categories for variable Y ; i – number of observation ($i = 1, \dots, N$); N – number of observations; P_{ik} – probability of category k or smaller for i th observation – cumulative probability; F – cumulative density function of chosen distribution; x – vector of independent variables; β – vector of model parameters; α_k – intercepts.

The number of equations in this kind of model is less by 1 than the number of categories for dependent variable, because when k is equal K then P_{ik} is equal 1.

In model (1) parameters β of independent variables are the same for all categories of dependent variable whereas intercepts α_k differ according to the consecutive probabilities P_{ik} . Intercept α_k are increasing along k because P_{ik} are cumulative probabilities.

When F is the a cumulative density of logistic distribution then probabilities P_{ik} are given by formula (2).

$$P_{ik} = \frac{1}{1 + e^{-(\alpha_k + x_i^T \beta)}}. \quad (2)$$

Since P_{ik} is the probability of an equal or smaller category then probability of category k is calculated as a difference between two consecutive probabilities: $P_{ik} - P_{i,k-1}$ (except P_{i1}).

The ordinal logit model could be verified by means of many statistical tests. One of them is Wald test. In case when null hypothesis assumes lack of significance of one parameter then test statistic is equal to square of t statistic and has χ^2 distribution.

The second test uses deviance D [Cramer 2003]. Statistic D compares the estimated model with saturated model¹ and is presented by Formula (3).

$$D = 2(\ln L_p - \ln L), \quad (3)$$

where: L_p – maximum of likelihood function for a saturated model; L – maximum of likelihood function for an estimated model.

Deviance D has asymptotic χ^2 distribution. The null hypothesis states that estimated model is the same as saturated model. Then the estimated model is well fitted if we cannot reject the null hypothesis.

The third test is called likelihood ratio test [*Mikroekonometria...* 2010; Hosmer, Lemeshow 2000]. The null hypothesis assumes that the estimated model is the same as a model with intercepts only. The test statistic is given by Formula (4).

$$\chi^2 = 2(\ln L_0 - \ln L), \quad (4)$$

where: L_0 – maximum of likelihood function for a model with intercept only; L – maximum of likelihood function for an estimated model.

The test statistic has χ^2 distribution, but in case of likelihood ratio test the null hypothesis should be rejected.

3. Characteristics of the survey

The aim of the survey was to gather information on performance measurement systems in non-financial Polish enterprises. The representative survey was conducted in 2012 for the whole Poland by means of CATI (Computer Assisted Telephone Interviews). The sample size covered by the research was 300 enterprises – three groups of size (small, medium and big), every with 100 respondents. In order to keep the structure of the firm's population the weights were computed on the base of data of the Central Statistical Office of Poland. The research problems considered in the questionnaire has been presented in Table 1.

Table 1. Issues covered by the research questionnaire

The role and position of the respondent (members of management boards, middle-level managers, and management accounting specialists)
Identification of the present level of performance measurement (strategic, operational or just individual employees) and its solutions applied
Possession of the strategy and possible ways and solutions of objectives measuring
The usage of financial performance measures – level, evaluation of validity and importance

¹ The number of parameters in a saturated model is equal to the number of observations.

Table 1, cont.

Applied solutions in the field of non-financial measures – the perspectives considered (customers, broadly defined as internal processes, learning and development, environmental protection, and others mentioned by the respondents) and specific measurement solutions in each of them (with their validation)
The assessment of the importance of the measures to the whole Performance Measurement System (PMS)
The structure of the PMS and its origin – such questions as: how PMS was developed, linkage with the motivation system, software and computer support
An opinion of the respondents on the degree of their satisfaction of PMS and the ways of its improvement
Respondent's particulars: the size of the enterprise (size of employment and incomes), economic section, place of business, the ownership and profits of the business in the last three years.

Source: own work.

4. Empirical results

The ordinal logit models were a ground of analysis of relationship between the size of the firms measured by the means of total revenue and the fundamental features of their performance measurement systems.

The ordinal dependent variable was constructed on the base of question about total revenue in 2011. The categories of this variable were as follows:

- 1 – total revenue less than 45 million PLN,
- 2 – total revenue greater than 45 million PLN and less than 220 million PLN,
- 3 – total revenue greater than 220 million PLN.

Five ordinal logit models were estimated. In every model a dependent variable was the same and an independent variable represented the answer to one question from the questionnaire.

In the next part the results of estimation of all ordinal logit models are presented. Every model contains two intercepts because a dependent ordinal variable has three categories and in case of cumulative probabilities the last one is always equal 1. The number of parameters for independent variable is one less than the number of its categories.

Table 2 presents the results of estimation of logit model with question Q1 as the independent variable.

Question Q1: Does firm have the development strategy?

Answers: 1. Yes, 2. No.

Table 2. Results of estimation of logit model with Q1 as the independent variable

	Category	Parameter	Standard error	Wald statistic	p value
Intercept 1		0.730	0.148	24.240	0.000
Intercept 2		2.413	0.215	125.707	0.000
Q1	1	-0.872	0.147	35.208	0.000

Deviation D = 428.828, $p = 0.999$; Likelihood ratio test $\chi^2 = 41.094$, $p = 0.000$

Source: own calculations.

The obtained results show the good quality of estimation. The negative sign of parameter for variable Q1 means that possessing strategy is connected with revenue level higher than in case of not having the strategy. The respective probabilities are presented in Table 3.

Table 3. Probabilities of different revenue levels for independent variable Q1

	Firm has development strategy	Firm has not development strategy
Probability of small revenues	0.465	0.675
Probability of medium revenues	0.359	0.243
Probability of big revenues	0.176	0.082

Source: own calculations.

The probability of big revenues is twice higher on the condition of having strategy (0.176 in comparison to 0.082). The similar situation could be observed for firms with medium revenues (0.359 and 0.243). The situation for firms with small revenues is opposite. The probability of small revenues is much higher in case of not having strategy (0.675 in comparison to 0.465).

Table 4 presents the results of estimation of logit model with question Q2 as the independent variable.

Question Q2: Does the company's strategy include not only the descriptive part but also measurable objectives?

Answer: 1. Yes, it does, 2. No, the aims of the strategy are expressed only descriptively.

Table 4. Results of estimation of logit model with Q2 as the independent variable

	Category	Parameter	Standard error	Wald statistic	p value
Intercept 1		0.029	0.180	0.027	0.871
Intercept 2		1.749	0.234	55.882	0.000
Q2	1	-0.603	0.174	12.054	0.001

Deviation D = 290.853, $p = 0.491$; Likelihood ratio test $\chi^2 = 13.006$, $p = 0.000$

Source: own calculations.

As previously the obtained results show the good quality of estimation. Negative sign of parameter for variable Q2 means that possessing a strategy with not only descriptive part but also with measurable objectives is connected with the revenue level higher than in case of only a descriptive strategy. The respective probabilities are presented in Table 5.

Table 5. Probabilities of different revenues level for independent variable Q2

	Strategy, beside descriptive part, has also measurable objectives	Strategy has only descriptive part
Probability of small revenues	0.360	0.507
Probability of medium revenues	0.398	0.345
Probability of big revenues	0.241	0.148

Source: own calculations.

The probability of big revenues is almost twice higher on the condition of having strategy with measurable objectives (0.241 in comparison to 0.148). The probabilities are almost the same for medium revenues (0.398 and 0.345). The situation for firms with small revenues is different. The probability of small revenues is much higher in case of only descriptive strategy (0.507 in comparison to 0.360).

Table 6 presents the results of estimation of logit model with question Q3 as the independent variable.

Question Q3: In what way is the performance measurement in the company organized?

Answer: 1. A senior position was established for the performance measurement, 2. It was run only by the accounting department, 3. It was conducted by all units within their competence.

Table 6. Results of estimation of logit model with Q3 as the independent variable

	Category	Parameter	Standard error	Wald statistic	p value
Intercept 1		0.494	0.143	11.977	0.001
Intercept 2		2.142	0.205	109.649	0.000
Q3	1	-0.644	0.208	9.553	0.002
Q3	2	1.094	0.206	28.179	0.000

Deviation D = 436.611, p = 0.998; Likelihood ratio test $\chi^2 = 33.311$, p = 0.000

Source: own calculations.

The results of estimation proved the good quality of above model. Negative sign of parameter for variable Q3(1) means that performance measurement conducted by a senior position is connected with revenue level higher than in case of conducting the measurement by all units within their competence. Positive sign of parameter

for variable Q3(2) means that performance measurement run only by the accounting department is connected with revenue level smaller than in case of conducting the measurement by all units within their competence. The respective probabilities are presented in Table 7.

Table 7. Probabilities of different revenues level for independent variable Q3

	Distinguished senior position for performance measurement	Performance measurement is carried out only by the accounting department	Measuring performance is driven by all the units within their competence
Probability of small revenues	0.462	0.830	0.621
Probability of medium revenues	0.355	0.132	0.274
Probability of big revenues	0.183	0.038	0.105

Source: own calculations.

The probability of big revenues is the highest when a firm has distinguished the senior position for performance measurement (0.183 in comparison to 0.105 and 0.038). The similar situation is for medium revenues (0.355 in comparison to 0.274 and 0.132). In case of small revenues the situation is different. The probability of small revenues is the highest when performance measurement is carried out only by the accounting department (0.830 in comparison to 0.621 and 0.462).

Table 8 presents the results of estimation of logit model with question Q4 as the independent variable.

Question Q4: What is the origin of the company's capital?

Answer: 1. Polish private equity, 2. Polish national equity, 3. Foreign capital, 4. Mixed capital.

Table 8. Results of estimation of logit model with Q4 as the independent variable

	Category	Parameter	Standard error	Wald statistic	p value
Intercept 1		0.100	0.175	0.327	0.567
Intercept 2		1.840	0.222	68.608	0.000
Q4	1	0.729	0.206	12.508	0.000
Q4	2	0.981	0.300	10.695	0.001
Q4	3	-1.363	0.298	20.958	0.000

Deviation D = 434.140, p = 0.998; Likelihood ratio test $\chi^2 = 35.782$, p = 0.000

Source: own calculations.

As in case of all previous models the good quality of estimation is observed. The negative sign of parameter for variable Q4(3) means that foreign capital is connected

with revenue level higher than in case of mixed capital. Positive signs of parameters for variable Q4(1) and Q4(2) mean that Polish private equity and Polish national equity are connected with revenue level smaller than in case of mixed capital. The respective probabilities are presented in Table 9.

Table 9. Probabilities of different revenues level for independent variable Q4

	Polish private equity	Polish national equity	Foreign capital	Mixed capital
Probability of small revenues	0.696	0.747	0.221	0.525
Probability of medium revenues	0.233	0.197	0.397	0.338
Probability of big revenues	0.071	0.056	0.383	0.137

Source: own calculations.

The probability of big revenues is the highest for firms with foreign capital (0.383), then for firms with mixed capital (0.137) in comparison to 0.071 for firms with Polish private equity and 0.056 for firms with Polish national equity. The similar situation is for medium revenues (0.397 and 0.338 in comparison to 0.233 and 0.197). In case of small revenues the situation is opposite. The probability of small revenues is the highest for firms with Polish national equity (0.747), then for Polish private equity (0.697) in comparison to 0.525 for firms with mixed capital and 0.221 for firms with foreign capital.

Table 10 presents the results of estimation of logit model with question Q5 as the independent variable.

Question Q5: On which levels the performance measurement is done by the company?

Answer: 1. The company as a whole, 2. Organizational units, 3. Individual employees.

Table 10. Results of estimation of logit model with Q5 as the independent variable

	Category	Parameter	Standard error	Wald statistic	p value
Intercept 1		-0.252	0.228	1.214	0.271
Intercept 2		1.363	0.249	30.022	0.000
O5	1	1.004	0.238	17.786	0.000
O5	2	0.090	0.281	0.103	0.748

Deviation D = 453.683, p = 0.990; Likelihood ratio test $\chi^2 = 16.239$, p = 0.000

Source: own calculations.

The results of estimation process are satisfying. Positive signs of parameters for variables Q5(1) and Q5(2) mean that the company and organizational units level of measurement are connected with smaller revenues than in case of individual employees level of measurement. The respective probabilities are presented in Table 11.

Table 11. Probabilities of different revenues level for independent variable Q5

	Measure on overall corporation level	Measure on business unit level	Measure on employee level
Probability of small revenues	0.680	0.460	0.437
Probability of medium revenues	0.235	0.351	0.359
Probability of big revenues	0.086	0.190	0.204

Source: own calculations.

The probability of big revenues is the highest when performance measurement is carried out on employee level (0.204 in comparison to 0.190 and 0.086). The similar situation was observed for medium revenues (0.359 in comparison to 0.351 and 0.235). In case of small revenues the situation is quite opposite. The probability of small revenues is the highest when performance measurement is carried out on overall corporation level (0.680 in comparison to 0.460 and 0.437).

5. Conclusions

According to Globerson [1985]; Maskell [1989], Dixon et al. [1990], Lynch and Cross [1991], Neely et al. [1996] performance measurement system should be derived from strategy. A. Neely describes this system characteristics as based on quantities that can be influenced, or controlled by the user alone or in co-operation with others [Neely et al. 1996]. Searching for the differences in the characteristics of performance measurement system should start from the most important one. All performance measurement systems assume that strategic objectives are measurable. Since 1954 when P. Drucker published the idea of Management by Objectives – managers must measure.

The diagnosis of performance measurement systems of Polish companies was conducted by means of ordinal logit models with a dependent variable related to revenues. Independent variables described chosen characteristics of the performance measurement systems in large, medium and small enterprises.

The results of research helped distinguish two types of systems for performance measuring. The first occurring in large and medium-sized enterprises and the second used in small enterprises. The first type of performance measurement system is often formalized and has a well-structured form. This is expressed in the pos-

session of the strategy containing indicators. It is also often institutionalized with separate organizational structure for the performance measurement. In large and medium-sized enterprises the measurement is carried out at the level of the employees. It can be concluded that the strategy and the resulting targets are cascaded down the business structure and to particular employees. Employees, by obtaining daily targets, realize the strategy and contribute to the results of the company. It turned out that the ownership structure of the surveyed companies may have an impact on a performance measurement system structure. The flow of know-how is higher in the international capital enterprises.

According to the study the performance measurement system was different in small businesses. These entities usually have not developed the strategy. If they had some, it was often only descriptive. Performance measurement system in these firms is usually assigned to the responsibilities of accounting. Performance measurement range is the entire enterprise as a whole. The main reasons of such a phenomenon are the characteristics of small and medium enterprises, e.g., personalized management, lack of capital, resource limitations, high flexibility, horizontal structure, small number of customers, access to limited market, and lack of knowledge [Alshawi et al. 2011, Ciliberti et al. 2008]. The popularization of positive outcomes from the implementation of systems for measuring performance in large and medium-sized enterprises can be the basis for the elimination of the gap of knowledge in small businesses and improve their efficiency and effectiveness.

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