Indicators for Measuring Outputs of Innovative Initiatives in the Czech Republic

Indikátory měření výstupů inovačních iniciativ v České republice

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Abstract

This paper focuses on the identification of a set of KPIs that are used in Czech companies to evaluate the outputs of innovative initiatives to maintain and improve organizational performance as a goal of implementation of innovations. The empirical evidence is based on a quantitative data, gathered through an email by structured self-assessment tool (check-list) which yielded 194 qualified responses. For the analysis of gained data there was used factor analysis within evaluation by factorial loadings. Results of the factor analysis provide possible groups according their similarity of variability and create new variables. Observed indexes were verified by coefficient Cronbach's alpha. Findings of the paper serve up suggestions, that especially financial performance indicators are statistical significant in market area and operation management.

Keywords

innovation, key performance indicators, innovation success, output, industrial companies, Czech Republic, factor analysis

Abstrakt

Tento příspěvek je zaměřen na identifikaci sady indikátorů KPI, které jsou v českých podnicích využívány k hodnocení výstupů inovačních iniciativ na udržování a zlepšování organizační výkonnosti jako cíle implementace inovací. Empirické zkoumání je založeno na kvantitativních datech, která byla sbíraná prostřednictvím e-mailů v podobě strukturovaného sebehodnotícího nástroje (tzv. check-list), což přineslo 194 kvalifikovaných odpovědí. Pro analýzu získaných dat byla použita faktorová analýza společně s hodnocením faktorové zátěže. Získané výsledky z faktorové analýzy poskytují možné skupiny na základě jejich vzájemné podobnosti variability a vytvoření nové proměnné. Zjištěné indexy byly ověřeny koeficientem Cronbachovo alfa. Výsledky příspěvku ukazují, že obzvláště finanční ukazatele jsou statisticky významné v oblasti trhu a řízení provozu podniku.

Klíčová slova

inovace, klíčové výkonnostní indikátory, inovační úspěch, výstup, průmyslové podniky, Česká republika, faktorová analýza

JEL Codes

L21, L25, O31

Introduction

Public policy is increasingly concerned about promoting innovation in order to stimulate economic growth, employment and ecological sustainability (Kleinknecht et al., 2002; Ambrozová et al., 2015). The innovation efforts of companies are viewed as the most important factor in developing and sustaining competitive advantage (Tidd et al., 2011). The ability of firms to adapt in their external environment and to remain competitive is closely related to their capacity to innovate and continuously upgrade and renew their knowledge bases, products and structures (Varis, Littunen, 2010). Innovation is extensive and diverse, and therefore there are currently a large number of definitions. In this paper, the term innovation is defined according to OECD/Eurostat (2005) definition as "the implementation of a new or significantly improved product, process, organizational or marketing method".

There is a need for enterprises to measure the performance of their innovation initiatives to ensure effectiveness of their investment (Kleinknecht et al., 2002; Tidd et al., 2011; Dewangan, Godse, 2014). Innovation management itself is evolving and presents enterprises with tough challenges in performance measurement. The use and interest in performance measurement systems by enterprises has got increased importance over the years because the effectiveness and efficiency of these activities not only determine a firm´s competitive advantage, but its very survival. According to Dewangan and Godse (2014, p. 537) to make innovation sustainable within the enterprise, it is important to have a well-defined innovation performance system that comprises the performance measurement scheme that defines and optimally clusters the key performance indicators (KPI) across appropriate dimensions i.e. optimally groups tangible and intangible KPIs so that enterprises can derive maximum benefits from the innovation program.

If we focus to the Czech companies, they have insufficient knowledge in the field of measuring the outputs of the implemented innovations and therefore it is important to know by which indicators and/or methods are possible to measure innovation effectiveness and success (Koudelková, Milichovský, 2014). So, the central research question of this paper is what kinds of KPIs are used by Czech enterprises to measure output of innovation employed? Main goal of the contribution is to find key indicators for measuring output of innovation and identify, which one of these indicators reflects the success from implemented innovation in the Czech companies.

The research paper is divided into three parts: (1) designing of innovation background with the focus on innovation and organizational performance literature (2) statistical analysis of data acquired from the survey carried out by a reliability test and factor analysis as statistical tool and (3) discussion of the gained results.

1 Theoretical Background

In general, innovation research can be approached from the perspectives of an individual, an organization, project-oriented and a nation or economic, focusing on personal traits, innovation management, customers as important source of innovation and a nation's source of

competitiveness, respectively. A review of the relevant literature reveals that organizational level innovation studies can be grouped into four research streams (Lin, Chen, 2007; Soderquist et al., 1997) concerned with:

1) types of innovation or innovation typology;
2) antecedents, determinants or critical success factors of organizational innovation;
3) developing conceptual models that deal with technology and innovation and finally;
4) assesses of successful implementation of technology and innovation practices adopting a consequence or result approach and explores the relationship between innovation efforts and firm performance.

This research focuses on the fourth stream stated above. The rationale is that organizational performance tends to be the ultimate goal of implementing innovation. Empirical research suggests that innovation is positively related to firm performance, although in some studies direct effects have not been found (Mavondo et al., 2005; Lin, Chen, 2007; Marques, Ferreira, 2009). From an organizational perspective, real innovation success resides in the marketplace. Devising innovative marketing measures is essential to help organizations transform good ideas and good products into sales revenue and profit (Lin, Chen, 2007). Measurement of performance helps the companies to organize day-to-day activities to reach strategic objectives.

However, correct division of used metrics is important. Industrial companies have different needs what and how to measure innovation performance and effectiveness and do not tend to display results mainly in the financial units (in comparison with companies in consumer market). As Dewangan and Godse (2014) pointed out, traditional financial performance measures worked well for the industrial era, but they are out of step with the skills and competencies companies are trying to master today. These metrics should be included into the group of Key Performance Indicators (KPI), which are used in the most crucial fields in present and future development of the company. Therefore, KPI represent a tool, by which measurement of performance, finding of relevant results and their interpretation in correct way shall be possible (Zaherawati et al., 2011; Kerzner, 2011; Ratnayake, 2009). Individual metrics of corporate performance and its results are included in one of the four groups of indicators (Parmenter, 2010; Hornungová, 2014):

- Key Result Indicators (KRI) tells how we fared in a particular area or in terms of critical success factors. They are usually confused with KPI. They provide clear view of the right direction organization is going to. If not, tell what is necessary to do.
- Result Indicators (RI) provide what have been done. RI provides summarization of activities in connection with financial activities in company.
- Performance Indicators (PI) gives information what we do. All of these indicators help to the company to achieve own strategies.
- Key Performance Indicators (KPI) describe instruction what we should do to significant improving corporate performance. This group has become set of metrics, which are focused on those aspects of organizational performance that are most important to its current and future success.

Traditionally, researches used objective data such as sales, return on equity, assets, investments (ROE, ROA, ROI), and profit to reflect organizational performance (Lin, Chen, 2007,

Kmieciak et al., 2012; Žižlavský, 2014) based on predominantly on financial criteria. To the late 20th century witnessed the emergence of several multi-dimensional IPM systems designed to address this need providing some means of integrating a combination of financial and non-financial measure to measure the tangible and intangible value created by the enterprises such as customer based (e.g. customer satisfaction, number of visitors, loyalty level), process based success or learning perspective in the context of performance measurement.

In innovation performance measurement literature are generally two approaches in this area (Dewangan, Godse, 2014, p. 538):

1) The first approach discusses the relative metrics and demerits of performance indicators (e.g. patent counts, R&D inputs and new products launched).
2) The second approach focuses on optimally clustering innovation performance metrics (IPM) and may discuss related indicators as well.

All used KPI metrics depend on industry and clear defined innovation strategy, which is the main driver of firm performance and should be developed and executed as an integral part of the business strategy (Dewangan and Godse, 2014). According to Tidd et al., (2011) none the less it is possible to develop a number of indicators which give some underpinning to what will otherwise be rather subjective judgments about the innovation management capability of a company.

2 Methodology

The primary research originally is focused on the performance evaluation of enterprises was conducted in the end of year 2015 in the Czech Republic. From the population, 527 companies were randomly selected to participate in this survey. Totally 157 checklists were returned (relative amount 29.79 %). As the largest group of companies, which gave back checklists, was companies from manufacturing industry (14.04 % of companies). The second group was group of services (10.06 % of companies).

Following logic of Tidd et al. (2011), we constructed a simple checklist of indicators and assigned a score to each of them so as to develop a profile of measurement system of innovations and their outputs. This simple self-assessment tool focuses attention on some of the important areas of innovation performance identified from the literature review (e.g. investment in motivation programs of employee, R&D, operation management and overall measurement indicators of innovation in sales, market share and profit).

Respondents were offered a list of indicators, from which they could select indicators used in evaluating of their innovation. The check-list was open with possibility of adding another indicators they used in own company. For each item it was simply put a score between 1 (considerably lower values), 2 (lower values), 3 (indicators comparable level), 4 (a higher value) to 5 (considerably a higher value). The next issue relating to the overall assessment of the situation in the company in terms of successfully realized (implemented) innovations with regard to numerical data (not in scale) as approximate share (%) successfully implemented develop-

ment projects (in financial terms). For inter-item analysis is further use to check the scales for internal consistency or reliability. Cronbach´s coefficient alpha is calculated for each scale.

To process the results of the check-list survey there were used both of descriptive statistics and correspond analysis. These methods were applied on the selected data set, which are involved on realization of innovation projects in Czech companies. The data were processed by using the statistical program IBM SPSS Statistics 24. The provide characteristics of the limitations of our research and its potential further direction.

The factor analysis is based on the selection of correlation and partial correlation coefficients. The correlation coefficient represents the closeness of linear dependence of individual variables and partial correlation coefficients. The partial correlation coefficient shows a similarity of two variables in such a situation that the other variables are assumed constant. If it is possible to explain the dependence of variables using common factors, the partial correlation coefficients are very small, close to zero.

To assess the suitability of the factor analysis, two tests can be used as evaluation of factor analysis (Řehák, Brom, 2015; Tarnanidis et al., 2015; Conti et al., 2014): (1) Kaiser-Meier-Olkin (KMO) is a coefficient which could reach values between 0 and 1. Its value consists of the rate of squares sum of the correlation coefficients and squares sum of the correlation and partial coefficients. (2) The usage of Bartlet's sphericity test lies in testing the null hypothesis that the correlation matrix of variables is unit (on diagonal, there are only ones, others are zeros). If the null hypothesis is rejected, the factor analysis may be used for the defined variables.

For the purposes of verifying the factor analysis, Cronbach's alpha indicator must be used. This indicator is seen as a reliability coefficient, which is used as kind of analogue of the correlation coefficient. Usually, it is possible to reach values in the interval <0.1>. Zero as extreme value describes the situation in which individual variables are uncorrelated. On the other hand, the value of 1 describes the correlated variables. When the value is closer to 1, there is a reported higher degree of conformity (Hrach, Mihola, 2006).

However, a high Cronbach's alpha does not imply that the measure is one-dimensional. If, in addition to measuring internal consistency, you wish to provide evidence that the scale in question is one-dimensional, additional analyses can be performed. Exploratory factor analysis is one method of checking dimensionality. Cronbach's alpha is not a statistical test; it is a coefficient of reliability (or consistency). It could be written as a function of the number of test items and the average inter-correlation among the items. Below, for conceptual purposes, we show the formula for the standardized Cronbach's alpha:

$$\alpha = \frac{N \times \bar{c}}{\bar{v} + (N + 1) \times \bar{c}} \tag{1}$$

- where
    - o N is equal to the number of items,
    - o c-bar is the average inter-item covariance among the items,
    - o v-bar equals the average variance.

If the values were to increase the number of items (N), it is possible to increase Cronbach's alpha. Moreover, if the average inter-item correlation is low, the alpha will be low. As the average inter-item correlation increases, Cronbach's alpha increases as well. The values of Cronbach's alpha could be from 0 to 1. If the values were close to 0.5, it signifies a bad level of internal consistency. Over 0.7 means that the value is acceptable and values close to 1 are excellent (Hinton et al., 2004).

3 Results

Based on the statistical characteristics of the examined group, it could be presented conclusions as an approximate result, limited by the resulting reliability. In the results of the paper there are characteristics of research barriers and future research possibilities.

For purpose of factor analysis there is necessary to reach value of Kaiser-Meier-Olkin test at least 0.5. For indicators in factor analysis, KMO is 0.793 which has become in high level of acceptance. Factor analysis reveals the reduction of surveyed corporate performance indicators which companies use in their own measurement processes.

Factor analysis reveals the reduction of surveyed corporate performance indicators which companies use in their own measurement processes of implemented innovations. The main input into factor analysis was a correlation matrix which shows the individual correlation values of the chosen indicators.

The total variance of the performance indicators is explained by means of eigenvalues, which represent the total variance explained by each factor. The eigenvalues show that only five items reached the minimum value of 1. From this point of view, Extraction Sums of Squared Loadings with cumulative percentage is important. Factor analysis extracted four factors, which explains 61.45 % of the variance. This result confirms the good factor result of the interpreted variance.

In order to assess whether it is possible to use the factor analysis, Kaiser-Meyer-Olkin method (KMO) and Bartlett's test of sphericity were used. The KMO method is based on selective correlation and partial correlation coefficients. The KMO value range is between 0 and 1. Each variable correlates perfectly to itself (approximate to 1), but has no correlation to the other variables (approximate to 0). In our case, the KMO reached value is almost 0.8 (exact value is 0.793), which means that the performed level of usefulness of the factor analysis reaches high value. Bartlett's test of sphericity is a statistic test used to examine the hypothesis that the variables are correlated or uncorrelated. According to the KMO, no correlation was found with other variables (Sig = 0.000). Nevertheless, Bartlett's test of sphericity is significant because of the value, which is lower than 0.05.

Table 1: Rotated Matrix within Indicators for Innovation Measurement in Company

	I1	I2	I3	I4
Turnover	0.828	0.260	0.141	0.117
Net profit	0.813	0.159	0.072	- 0.042
Income of new products	0.766	0.111	0.091	0.038
Market share	0.703	0.102	0.167	0.144
Warehouse stock of inputs	0.231	0.801	0.065	- 0.008
Warehouse stock of final products	0.175	0.827	0.127	0.088
Motivate program's costs	0.297	- 0.011	0.743	- 0.095
Operative costs	- 0.050	0.409	0.695	0.209
Active debts	0.256	0.177	- 0.166	0.723
Delivery time changes	- 0.087	- 0.093	0.232	0.765
Customer satisfaction with new products	0.460	- 0.297	0.415	0.057
Price level	0.262	0.219	0.365	0.312
Number of employees	0.448	0.319	0.354	0.105
Cronbach's alpha	0.837	0.784	0.485	0.304

Source: own work

4 Discussion

For the correctness of the factor analysis and acceptance of the results, it is important to get a Cronbach's alpha value of over 0.5. Otherwise, there are requirements to improve the sample, or the check-list. Cronbach's alpha is a measure of internal consistency that is closely related to a set of items as a group. A "high" value of alpha is often used (along with substantive arguments and possibly other statistical measures) as evidence that the items measure an underlying (or latent) construct.

Titles of indexes were designed according to similar characteristic of individual indicators in index. According to observed results, acceptable values of Cronbach's alpha were found only for two indexes of four gained: (1) Market results factor (0.837), and (2) Warehouse stock factor (0.784). Other two factors were under minimal value of Cronbach's alpha. Final values calculating of acceptable factors need the transformation of individual coefficients. These coefficients have become the significance of used elements. Their sum total must be equal to 1. The index of the factor of production was defined by this procedure:

$$\textit{index of market results } (I1) = 0.2851 \times T + 0.2455 \times NP + 0.2347 \times I + 0.2347 \times M \quad (2)$$

- where
  - T – Turnover
  - NP – Net profit
  - I – Income of new products
  - M – Market share

index of warehouse stock (*I*2)= 0.453 7× *WI* + 0.5463 × *WF* (3)

- where
  - WI – Warehouse stock of inputs
  - WF – Warehouse stock of final products

On the basis of the calculation indexes, the mean values were found. These values represent the average factor for each set of data recorded. We can say that these indexes reflect average bonds within a factor. This is due to the range of possible answers listed in the check-list.

To modify the indexes, it is necessary to use a rating scale for companies, which determines whether the tool is used. For the calculation of the total index, it is necessary to put the answers of individual respondents into the appropriate index formula.

Table 2: Descriptive Statistics of Observed Indexes

	Mean	**Variance**	**Std. deviation**
Index of market results	3.4581	0.596	0.77219
Index of warehouse stock	3.0321	0.665	0.81527

Source: own work

Indicators in index of market results (turnover, market share, net profit and income from new products) report the highest score in terms of successful implemented innovation up to 75 % among respondents. Similarly, warehouse indicators reached values of inputs and of final products at almost same level. By using the acquired indexes there have been identified which indicators should be used when measuring success of implemented innovations in industrial environments.

On the basis of the calculation index of the market results and index of warehouse stock, the mean value of these indexes were found. These values represent the average value for each company in data set. This value reflects low bonds within factor. They are due to the range of possible answers listed in the check-list. To modify the indexes, it is necessary to use a rating scale for companies, which determines whether the tool is used. For the calculation of the total index, it is necessary to put the answers of individual respondents into the appropriate index formula.

Conclusions

Nowadays, lots of companies use performance measurement system, which is important not only for the actual management and other interested stakeholders, but also for overall sustainable corporate development. The reason is that KPI´s indicators help organizations derive maximum benefits from the innovation programs.

The paper is focused on the area of innovation outputs in relation to performance management, especially to KPIs. The main goal of the research was to find out set of the KPIs indicators (whether are tangible or intangible), which are used by Czech enterprises to

measure the outputs of innovation and especially those, which the best reflects the success from implemented innovation.

Empirical research deals with factor analysis that gives up reduction of surveyed corporate performance indicators for realized innovations by individual company as main input of own measurement process. Main input into factor analysis was correlation matrix. Results of the factor analysis are four component groups. All of these groups had to be evaluated by Cronbach's alpha (with value over 0.5), which provide applicability of individual factors. Therefore, there were accepted only two indexes of four, which fulfil conditions of Cronbach's alpha. They are (1) Market results and (2) Warehouse stock. These indexes confirm that companies focus their attention on market area and operation management.

The reasons for usage indexes are turbulent environments in market, which put requirements on new approaches in day-to-day activities. Companies use mainly financial metrics for measurement innovation performance than non-financial. Financial results in companies don't support complex view on innovation process, which reflect products and artefacts rather than ideas and processes (Milbergs and Vonortas, 2005).

To make sustainable innovation, company must have well-defined corporate performance system, which is focused on appropriate dimensions of optimally groups tangible and intangible KPIs that companies can derive maximum benefits from the innovation program (Dewangan, Godse, 2014).

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