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CONCEPTUAL PERFORMANCE MEASUREMENT AND MANAGEMENT CONTROL FRAMEWORK FOR INNOVATIONS: THE BASIS FOR FURTHER DECISION MAKING

KONCEPČNÍ RÁMEC CONTROLLINGU INOVACÍ: MĚŘENÍ VÝKONNOSTI INOVACÍ JAKO ZÁKLAD PRO DALŠÍ ROZHODOVÁNÍ

HABILITATION THESIS

HABILITAČNÍ PRÁCE

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ABSTRACT

The subject of this study is innovation performance measurement and management control. Innovation is becoming an entrepreneurial buzzword. At the same time no matter how great the investment in innovation there is no guarantee that it is being spent efficiently. Therefore it is necessary to innovate wisely and with focus. Such an activity requires that the company is capable of the continuous evaluation of on-going innovation projects and using this data to make decisions on whether to continue or not. This refers to the main challenge. There are many indicators for assessing the success of a company in a broad sense but when we refer to innovations it can be difficult to choose the right ones.

The aim of the thesis is to present knowledge and findings in the field of innovation performance measurement and management control as these areas are currently being dealt with in Czech as well as foreign expert literature and in practice in Czech manufacturing industry.

This thesis takes as its starting point the current state of affairs and the specific conditions arising from today's business environment. The research framework is based on four research projects conducted in Czech manufacturing industry which became the basis for in-depth research carried out in 2013–2015 within the Czech Science Foundation post-doc research project in the field of innovation performance measurement and management control. Therefore, the thesis presents findings from this latest research project.

The research aim of the post-doc project was: (i) to amplify current research in the field of innovation performance measurement and management control, (ii) to define the basic criteria and to set the right metrics and (iii) to further propose a management control system approach to the assessment of innovation performance on a micro-level suitable for the Czech business environment.

Considering Czech manufacturing companies and the main research aim, the following research hypotheses are addressed:

Hypothesis 1: *Innovations have an influence on company performance.*

Hypothesis 2: *Innovations are mainly performed by companies controlled by a foreign owner (or with foreign participation).*

Hypothesis 3: *Innovations are mainly performed in the Czech business environment by medium and large-sized companies with sufficient resources.*

Hypothesis 4: *Large companies perform innovation regularly – it is part of their business.*

Hypothesis 5: *Large companies tend to invest greater sums of money into innovation (measured by percentage of annual budget).*

Hypothesis 6: *Large companies tend to evaluate their innovative activities more than SMEs.*

Hypothesis 7: *Large companies have implemented their innovation performance measurement system for a longer time than SMEs.*

Hypothesis 8: *Large companies implement "modern" techniques of innovation performance measurement.*

With regard to the identified objective of the research project, set hypotheses and the method of their fulfilment, the following scientific work methods were utilized: (i) systemic approach, (ii) triangulation, (iii) analysis, (iv) questionnaire survey, (v) comparison, (vi) inquiry, (vii) content analysis, (viii) synthesis, (ix) induction, (x) feedback method and (xi) statistical methods (chi-square test, Spearman's correlation, two sample t-test, Likert scaling, Cronbach's alpha).

First part of the study is devoted to the theory and the definition of essential terms. The theoretical part is followed by an analysis of secondary data to shed light on the issue of why innovation performance measurement matters. The next section investigates the current state of the issue in the Czech manufacturing industry. It has been shown with the help of questionnaire survey that many enterprises tend to neglect such an important area of their business as innovation. Only a very few organizations appear to have an effective system for measuring their overall innovation performance. On the basis of desk-based research and empirical study, a management control system approach to innovation performance measurement suitable for the Czech business environment called the Innovation Scorecard is being proposed.

ABSTRAKT

Předmětem habilitační práce je controlling a měření výkonnosti inovací. Inovace se staly podnikatelským tématem, jemuž je dlouhodobě věnována pozornost. Ovšem investice do inovací, byť jakkoliv vysoké, nezaručují, že takto vynaložené prostředky jsou investované efektivně. Proto je nezbytné inovovat s rozvahou a cíleně. Předpokladem pro takovou činnost je, aby podnik dokázal průběžně vyhodnocovat činnosti v inovačním procesu a na základě těchto údajů rozhodnout, zda v inovaci pokračovat, či nikoliv. Měřítka výkonnosti inovačního procesu představují jeden z klíčových nástrojů při jeho řízení a rozhodování s konečným dopadem na celkovou konkurenceschopnost podniku. Zde se však dotýkáme hlavního problému. Podíváme-li se na hodnocení konkurenceschopnosti podniku širším pohledem, objevíme celou řadu měřítek, která lze využít. Pokud se ale zaměříme čistě na inovace, může být, a velmi často i je, obtížné vybrat ta pravá.

Cílem habilitační práce je představit znalosti a zjištění z oblasti controllingu a měření inovační výkonnosti, tak jak jsou tyto oblasti řešeny v současné české i zahraniční odborné literatuře a českém zpracovatelském průmyslu. Habilitační práce vychází ze současného stavu a ze specifických podmínek, jež přináší dnešní podnikatelské prostředí. Výzkumný rámec je založen na čtyřech výzkumných projektech uskutečněných v českém zpracovatelském průmyslu, jež se staly základem pro hlubší výzkum uskutečněný pod záštitou Grantové agentury České republiky v letech 2013 až 2015. Habilitační práce využívá poznatků tohoto nejaktuálnějšího detailního výzkumného projektu. Projekt si kladl za cíl rozšířit výzkum controllingu a měření výkonnosti inovací, doplnit jej o základní kritéria a měřítka, a vypracovat systémový přístup k hodnocení inovační výkonnosti na mikroúrovni, jenž by byl vhodný pro české podnikatelské prostředí.

Základním metodickým přístupem k řešení je formulace hypotéz a jejich ověřování analýzou sekundárních dat a primárním výzkumem u výrobních podniků v České republice s odpovídajícími zkušenostmi. Pro řešení výzkumného cíle projektu v českém zpracovatelském průmyslu byly stanoveny níže uvedené hypotézy:

Hypotéza 1: *Inovace mají vliv na výkonnost podniku.*

Hypotéza 2: *Inovace jsou častěji uskutečňovány v podnicích se zahraničním vlastníkem (nebo se zahraniční účastí).*

Hypotéza 3: *Inovacím se věnují v českém podnikatelském prostředí převážně střední a velké podniky, které k tomu mají dostatek zdrojů.*

Hypotéza 4: *Velké podniky provádějí inovace pravidelně coby součást svého podnikání.*

Hypotéza 5: *Velké podniky investují do inovací větší částky (měřeno procentem ročního rozpočtu).*

Hypotéza 6: *Velké podniky vyhodnocují své inovační aktivity více než MSP.*

Hypotéza 7: *Velké podniky mají zavedený systém měření inovační výkonnosti po delší dobu než MSP.*

Hypotéza 8: *Velké podniky zavádějí „moderní" techniky měření inovační výkonnosti.*

S ohledem na vytyčený cíl výzkumného projektu, stanovené hypotézy a způsob jejich naplnění, byl při zpracování výzkumu použit systémový přístup a tyto metody vědecké práce: (i) systémový přístup, (ii) triangulace, (iii) analýza, (iv) dotazníkové šetření, (v) komparace, (vi) osobní rozhovory, (vii) obsahová analýza, (viii) syntéza, (ix) indukce, (x) zpětná vazba, (xi) statistické metody (chí-kvadrát test, koeficient korelace, dvouvýběrový t-test, Likertovo škálování, Cronbachova alfa).

Habilitační práce začíná částí, v níž autor vysvětluje podstatu inovací a uvádí základní definice. Na tuto teoretickou část navazuje analýza sekundárních dat za účelem osvětlení otázky, proč na měření inovační výkonnosti záleží. Následuje blok, který je zaměřen na prezentaci současného stavu řešené problematiky v českém zpracovatelském průmyslu. Tento oddíl zahrnuje rovněž statistické testování vyslovených výzkumných hypotéz a zhodnocení, ve kterém autor zjištěné poznatky uchopuje co možná nejkomplexněji. Za pomoci dotazníkového šetření bylo zjištěno, že spousta českých podniků stále podceňuje tak významnou část svého podnikání jakou inovace jsou. Pouze velmi málo podniků má zavedený efektivní systém hodnocení inovační výkonnosti. Na základě výsledků sekundárního i primárního výzkumu je v posledním oddílu navržen koncepční rámec controllingu inovací – Innovation Scorecard, který se jeví jako vhodný pro české podnikatelské prostředí.

KEYWORDS

Innovation, innovation process, effects of innovation, innovation performance, performance measurement, management control, Innovation Scorecard, questionnaire survey, manufacturing industry, Czech Republic.

KLÍČOVÁ SLOVA

Inovace, inovační proces, efekty inovací, inovační výkonnost, měření výkonnosti, controlling, Innovation Scorecard, dotazníkové šetření, zpracovatelský průmysl, Česká republika.

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AUTHOR STATEMENT

I hereby confirm that I have written this thesis *Conceptual Performance Measurement and Management Control Framework for Innovations: The Basis for Further Decision Making* independently and using the professional literature and other sources of information which are all quoted in the thesis and detailed in the list of references at the end of the thesis

Brno, 7h July 2016 Ing. Ondřej Žižlavský, Ph.D.

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CONTENTS

INTRODUCTION

The subject of this study is innovation performance measurement and management control. You will obviously want to ask whether it is at all possible to assess the innovation performance of a company, and if it is possible whether companies have a need for this today? I am convinced that the answer is yes.

Innovation is currently becoming an entrepreneurial phenomenon. On the other hand, no matter how great the investment in innovation might be there is no guarantee that it is being spent efficiently. Therefore it is necessary to innovate wisely and with focus. Such activity requires that the company is capable of the continuous evaluation of on-going innovation projects and of using this data to make decisions on whether to continue or not.

However, establishing effective forms of performance measurement and management control for innovation processes undertaken at either the industrial or academic level is a very challenging task. Moreover, Adams et al. (2006) stress the absence of frameworks for innovation management measurement indicators as well as “the relatively small number of empirical studies on measurement in practice”.

The aim of the thesis is to present knowledge and findings in the field of innovation performance and management control as these areas are currently being dealt with in Czech as well as foreign expert literature and in practice in Czech manufacturing industry.

This thesis takes as its starting point the current state of affairs and the specific conditions arising from today’s business environment. Based on findings from long-term empirical research carried out under the auspices of the Faculty of Business and Management Brno University of Technology (in 2009 to 2012) and Czech Scientific Foundation (in the years 2013 to 2015) it attempts to provide an overview of the issues of innovation performance measurement and management.

This study is based specifically on project management, Balanced Scorecard, input–process–output–outcomes model and Stage Gate approach. The aim is not to provide a detailed explanation of these methods, but attaches great importance to the logic of the explanation. In doing so, thesis has the following unique outcomes:

- A clear view of what innovation means from a business point of view.
- Conceptual framework of innovation process reflecting the key characteristics that are identical or similar in many other definitions.
- Key insights and tools derived from the latest academic research, consulting companies' publications and practitioners' experience.
- Case studies underlining the importance of innovation and its impact on corporate performance.
- Comprehensive results on how the Czech companies measure and control performance of their innovation processes.
- An extensive discussion about the current situation and possible development trends in innovation performance measurement and management control.
- A road map to developing a management control system called Innovation Scorecard.
- A list of concrete innovation metrics to be inspired from.

Thesis is divided into seven main chapters. Chapters 1 and 2 present the main aims of the research and take us through its background, the details of the methods used and how the results were processed.

In order to understand the attitude to innovation performance measurement and management control, it is first necessary to clarify the scope and purpose of innovation. Therefore, Chapter 3 reviews what innovation means and entails from a business perspective. The introduction to the issue is the definition of innovation and the classification of innovation by the degree of novelty. What follows is a section defining the innovative potential of a company. It also characterises the individual phases of the innovation process. The chapter concludes with a description of the basic types of innovation effects and presents methods for their measurement.

Chapter 4 presents two case studies to shed light on the issue of why innovation performance measurement and management matters. The first case study focuses on

European manufacturing industry in order to illustrate the link between R&D expenditure and performance through a statistical model. The second case study from the Czech manufacturing industry utilizes company-specific time-series data to study differences in R&D expenditure structure depending on company ownership.

Chapter 5 provides an overview of the data used for this study and the main characteristics of the research sample. This section investigates the correlation between the innovation management control system (R&D expenditure, approaches to innovation project evaluation, methods utilised, tools, period of innovation evaluation system implementation, etc.) and company size, since it is the most important contingency factor. It presents the comprehensive results of an empirical investigation into the Czech manufacturing industry. This section also summarises statistical tests of research hypotheses and there is a discussion in which the author tries to offer where possible a comprehensive interpretation of the findings.

Chapter 6 proposes, on the basis of this literature review, an original management control system approach to innovation performance measurement suitable for Czech business environment, called the Innovation Scorecard. The basic structure of the Innovation Scorecard is first presented before individual phases are discussed. In addition, the Innovation Scorecard framework provides a set of factors and for each factor a set of inspiration metrics to choose from or be inspired by.

Last chapter summarizes implication of gained findings for academics, practise as well as teaching. However, all benefits has to be assessed in a purely realistic manner. Therefore this chapter points out limitations of research and formulates proposals for future research.

–Ondřej Žižlavský

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1 ISSUE DEFINITION AND RESEARCH AIM

Innovation contributes to the winning of competitive advantages. Successfully launching innovation onto the market is one of the basic preconditions for the long-term survival of a company. In practice success goes to those companies that manage to mobilise their innovative potential in the form of knowledge, technological prowess and experience, to create something new. Innovations are normally the result of the creativity of the employees and draw on the results of scientific and technological development. They are the comprehensive reactions of a company to new business opportunities and must always be focused on customers – offering them higher value.

Innovations are very expensive and over time consume a significant part of the exploitable resources of the company. The efforts and means expended on innovation must show a return if the company is to have a chance of surviving in a tough competitive environment. Unfortunately it is a sad reality that a significant number of innovations either do not end with the launch of a new product into the market, or else result in a new product that is not a success (see Box 1). The majority of companies manage to achieve only partial success, and that with problems. However, if an innovation does not make it, it still provides valuable information on what to do differently next time (see Box 2).

In the interests of business success the management of the company has to regularly evaluate the performance of their current innovations. This evaluation must be carried out comprehensively. In each phase of the innovation process the question must be asked as to whether it makes sense to continue with the task and not just from a technical perspective but also in marketing terms. It is essential to ascertain whether the set of technical parameters can be achieved and whether the innovation will have any prospect of success on the market. If it does not take this approach then there is a risk that the company will repeat the same mistakes.

Box 1 Innovation success rate

In a cross-sector, empirical, long-term study of product innovations in 116 companies, only 0.6% of the 1,919 product innovation ideas survived, proving to be marketable and successful. Innovation ideas are put through a stringent selection process: Not even 10% of the initial ideas reached the market as products; of those that made it, some 70% were eliminated by the market as flops. Of the products remaining in the market, 46% made a loss, 33% returned no appreciable profit, and only 21% (ultimately 0.6%, or 11 of the 1,919) were successful (Berth, 1993, p. 217).

There is a failure rate of 65% for the food industry sector in Germany and 70–90% for the packaging industry in the United States. Kerka shows a success ratio of 6 per 100 ideas, and Stevens and Busley one of 1 per 3000.

Here are some more examples: Volkswagen needed to write off € 700 million due to insufficient sales of the luxury limousine Phaeton, Texas Instruments lost US$ 660 million before withdrawing from the home computer sector, DuPont made a loss of US$ 100 million with an artificial leather called "Corfam", the investments in the "Concord" were never regained, and finally Motorola and partner companies wasted US$ 6 billion on the satellite telephone system Iridium (Thomaschewski & Tarlatt, 2010, p. 130–131).

How do Czech companies actually measure their innovation performance? This was the subject of the original research, which is in the fields of innovation, performance measurement and management as well as management control systems.

The research framework is based on four primary research projects carried out in Czech innovative companies under the auspices of the Faculty of Business and Management of Brno University of Technology and one comprehensive research project supported by the Czech Science Foundation.

Within four consecutive research projects carried out from 2009 till 2012 under the sponsorship of the Internal Grant Agency of the Faculty of Business and Management Brno University of Technology various approaches to management of the innovation process and its performance measurement were examined.

A total of 53 mostly production companies participated in the first project called *Research into the Level of Development of Innovation Potential, Creation and Evaluation of the Innovation Strategy of Medium-Sized and Large Machine-Industry Companies in the South Moravian Region in the Czech Republic* (Reg. No. AD 179001M5) conducted in 2009. This project uncovered several unfavourable findings on the state of management of innovative activities.

Therefore this area was examined in detail in three subsequent research projects called *Development of Knowledge for Improvement of Information Support of the Economic Management of Company Development in Accordance with Development of the Business Environment* (Reg. No. FP-S-10-17) undertaken in 2010, *Development of Knowledge for Improvement of Information Support of the Economic Management of a Company* (Reg. No. FP-S- 11-1) in 2011 and *Efficient Management of Companies with Regard to Development in Global Markets* (Reg. No. FP-S-12-1) in 2012.

These projects became the bases for in-depth research carried out in 2013–2015 within the Czech Science Foundation post-doc research project in the field of innovation performance measurement and management control. The comprehensive research was advised to collect where possible objective quantitative and also semi-qualitative data on the current state of the investigated issue.

This thesis presents findings from the latest research project *Innovation Process Performance Assessment: a Management Control System Approach in Czech Small and Medium-sized Enterprises* (Reg. No. 13-20123P) supported by the Czech Science Foundation. The main aim of the research project was to amplify current research in the field of innovation performance measurement and management, then to define the basic criteria and to set the right metrics and to further propose a management control system approach to the assessment of innovation performance on a micro-level suitable for the Czech business environment.

This refers to the main problem. There are many indicators for assessing the success of a company in a wider sense but if we refer to innovations it can be difficult to choose the right ones. For a better understanding the main aim is broken down into two interconnected aims – cognitive and creative.

Cognitive Aim

To learn about and study the current state of the art of innovation process performance measurement and management control from the contemporary Czech and foreign professional literature and especially Czech corporate practice. To achieve this first aim it will be necessary to fulfil the following minor goals:

- To define the basic terms associated with innovation issues, performance measurement and management control, etc.
- To compile secondary research from the Czech and foreign literature on the issues of innovation and the innovation process, innovation critical success factors, effects of innovations, innovation metrics, performance measurement systems, etc.
- To analyse the current state of the art, and to assess the suitability of individual approaches (indicators).
- To conduct primary research into Czech business environment – to gather data using a questionnaire survey and one-to-one interviews with executive officers and individuals from middle and higher management, and to evaluate the data.

Creative Aim

To contribute to the study of innovation management with a proposal for a conceptual performance measurement and management framework for innovation processes suitable for Czech business environment. To achieve this second aim it will be necessary to fulfil the following minor goals:

- To identify the critical success factors of innovations.
- To present possible methodological procedures for the evaluation of the expected effectiveness of innovation activities that can be used in companies under our conditions.
- To formulate proposals for the improvement of methods for innovation performance measurement.

Considering Czech manufacturing companies and the main research aim, the following research hypotheses are addressed:

Hypothesis 9: *Innovations have an influence on company performance.*

Hypothesis 10: *Innovations are mainly performed by companies controlled by a foreign owner (or with foreign participation).*

Hypothesis 11: *Innovations are mainly performed in the Czech business environment by medium and large-sized companies with sufficient resources.*

Hypothesis 12: *Large companies perform innovation regularly – it is part of their business.*

Hypothesis 13: *Large companies tend to invest greater sums of money into innovation (measured by percentage of annual budget).*

Hypothesis 14: *Large companies tend to evaluate their innovative activities more than SMEs.*

Hypothesis 15: *Large companies have implemented their innovation performance measurement system for a longer time than SMEs.*

Hypothesis 16: *Large companies implement "modern" techniques of innovation performance measurement.*

Hypothesis 1 illustrates a link between R&D expenditure and performance through a statistical model. Consequently whether and how innovation influences performance is tested (see Section 4.1). For this purpose, R&D expenditure (the independent variable) and other financial indicators of the company's performance (the dependent variables) are considered. Companies from the manufacturing industries have been chosen as the examined sample. The data was obtained from the Amadeus database in the period 2007 to 2012. From a managerial point of view such a model should be useful in predicting how companies might invest in new R&D capabilities in the future.

Hypothesis 2 investigates and explores the role of company ownership in relation to R&D expenditure (see Section 4.2). For this purpose data from a survey conducted annually by the Czech Statistical Office are studied. The period from 2007 till 2013 is examined.

Hypotheses 3 to 8 investigate the correlation between innovation performance measurement and the management control system (tools and methods) and company size, since it is the most important contingency factor (see Chapter 5). Therefore, as its exploratory aim, this study investigates the role of company size in innovation performance measurement and management control. For this purpose data from original primary research conducted in Czech innovative manufacturing companies in 2014 are considered.

2 RESEARCH DESIGN

2.1 Methodological Background

The fundamental unit of research interest is the company. This thesis presents a shift from a macroeconomic level of exploration to the sector and especially the level of the individual business (see Sections 2.2, 2.5 and 5.3). This level of investigation requires in particular the application of qualitatively based methodological procedures and allows a deeper understanding of the analysed phenomena.

The concept of the innovation performance solutions in this study depends on the following premises:

- The company is the source of innovation (see Section 2.2).
- Innovation performance, that is the ability to carry out the desired innovation, can be seen as one of the most significant factors in the competitiveness and efficiency of a company (see Section 3.5).
- Innovations are, in the context of the subject of the research, in the economic/organisational (not technical) category (see Section 3.1).
- Innovative outputs from companies cannot be restricted to the innovation of products, as steadily greater significance is being ascribed to the remaining types of innovation (according to the Oslo Manual (OECD, 2005)) and that is true even in companies of a production character (see Section 3.1).
- Innovation is not just a matter of the company's outputs but also changes in the sources of the internal environment of the concern and relations between these and changes in relationships with relevant entities in the external environment (see Section 3.1).
- The condition for innovative outputs (products and services) is comprehensive innovation, which represents a purposeful chain of all the mentioned changes in the internal and external environments of the company (see Section 3.4).

The theoretical background for the solving of the issues in question is made up not only of innovation management but also financial management, performance measurement and management control. The methodological background and to a certain extent also the framework is made up of standard methods for the evaluation of the business environment, innovation performance and the quality of sources.

Within the research project a representative survey of a research sample of about 3 000 companies is assumed. A survey of this extent requires, aside from careful content/specialist preparation, also highly demanding organisational/technical preparation, including the choice of an appropriate structure of research sample, especially in the choice of companies, and last but not least the finding and implementing of means to motivate companies to provide the cooperation needed. Alongside the large-scale survey, attention will also be focussed on specific surveys of a smaller number of selected companies that will be analysed with respect to worthy cases of innovative activity by conducting semi-structured in-depth interviews.

In the context of the research the relationship between innovation, innovation performance and competitiveness is essential. In the concept of the research assignment there is an implicit assumption that there is a direct relationship between innovation performance (see "*Hypothesis 1: Innovations have an influence on company performance.*").

This however does not apply generally, and even where it does apply it is not as a rule a simple linear relationship. It can be said that in the actual conditions of the Czech economy many companies lose their competitiveness due to the backwardness of their innovation performance, while those which have much higher innovation performance are competitive. Of course this does not mean that in all circumstances we can infer that to achieve a high degree of competitiveness it is essential to innovate to the maximum extent.

Generally it can be said that a company reacts to dynamic development in the internal and external environment by innovating. It is a question of optimising innovation activity and not maximising it, where the criterion of optimality is the benefit derived from the activity, as reflected in the long-term efficiency of the company.

It is argued that the research presented in this study is valuable for several reasons. First, it is one of the few comprehensive studies to address the question of what methods of innovation performance measurement are implemented in innovative Czech manufacturing companies.

Second, the research takes into account the specifics of the investigated issue, such as measurement in soft systems, the core micro-level of measurement (see Sections 2.2 and 2.5), and the specifics of the Czech business environment after the financial crisis (see Sections 4.2 and 5.2).

Third, only a few recent studies provide an attempt to develop a BSC framework for innovations. Garcia-Valderrama et al. (2008a) developed a general BSC model that is designed and limited to innovations, and both Garcia-Valderrama et al. (2008b) and Eilat et al. (2008) proposed an integrated data envelopment analysis (DEA) and BSC approach to evaluating innovation projects.

2.2 Innovation Performance Measurement Levels

The use of different dimensions and levels is a precondition for the success of performance measurement systems (PMS). Correlations within performance levels as well as level spanning correlations can be visualized and used for steering (Gleich, 2001). Figure 1 demonstrates the above dimensions of innovation management complemented by innovation projects and innovation fields. The innovation strategy plays a particular role, as fundamental strategic decisions have a major influence not only on the other dimensions, but also on concrete innovation fields.

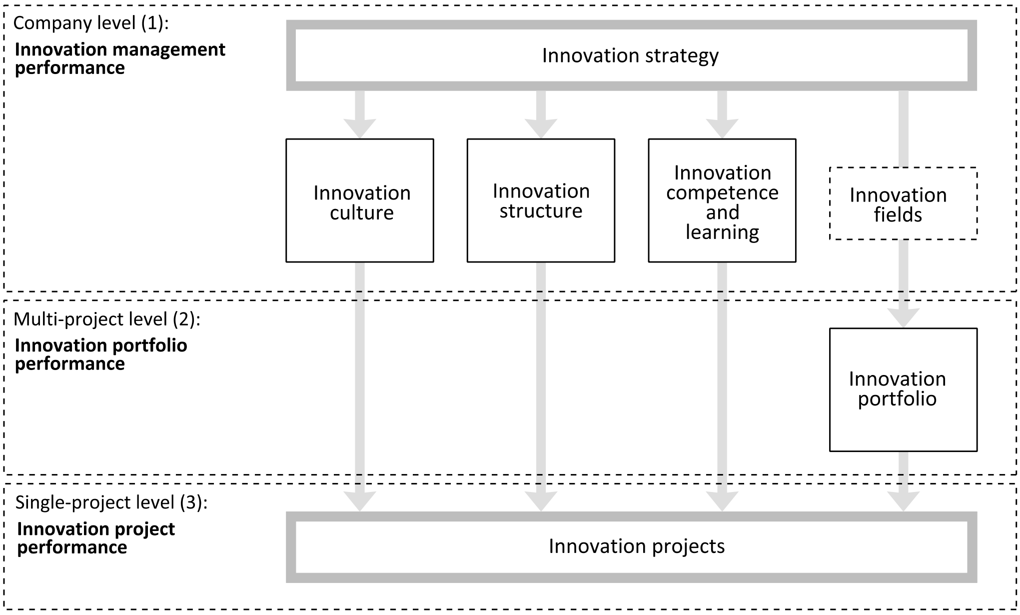

Figure 1 Levels and dimension of an IPMS (Schentler et al., 2010, p. 306)

As seen in Figure 1, innovation performance measurement can be classified into three different levels:

- **Company level** – innovation management performance. This includes innovation culture, innovation competences/learning, innovation structure and innovation strategy. The aspects on this level of the innovation performance measurement system are the basis for the innovation projects as well as for the innovation portfolio. Therefore, they are a prerequisite for putting innovation management into action.
- **Multi-project level** – innovation portfolio performance. Portfolio management is defined as a dynamic decision process in which a company's active innovation projects are constantly updated and revised. This level has a sandwich position between the project and company level. It should enable different projects in different innovation fields of a company to be linked with overall strategy.
- **Single-project level** – innovation project performance. A project represents a team--based approach to executing innovation processes. Practice shows that projects are the most common and important organisational form to put innovations into action. Each innovation project needs to be considered as a planning and management control

object. The aggregated project performance represents the input for the project portfolio level. Thus activities from early stages of the innovation process to the market launch of new products account for this level. Status reports of single projects are aggregated and used as input for the second performance level, multi-project level performance.

The measurement of performance on all three levels allows a detailed understanding of innovations and results as well as of innovation strategy implementation. It is of great significance to link the different levels and aspects to each other. Starting from the top down, the innovation strategy needs to be considered in the innovation culture, innovation competences/learning and innovation structure, as well as via the different innovation fields, in the innovation portfolio. The strategic decisions made on the first level need to be translated into specific goals and activities as input for the other dimensions and levels. The goals of the multi-project landscape need to be split into different projects. Thinking from the bottom up, the status reports of single projects are aggregated as an input for the portfolio management on the second performance level, and the portfolios themselves in the overall level.

The whole concept of the research and consequently this thesis, focuses on the **single--project level** for many reasons. First, as mentioned above, innovations are implemented in practice as a project; second, the single-project level represents the basis of overall innovation management; and third, there are not many suitable approaches to innovation performance measurement on this kind of level in the Czech scientific and business environments as well.

At this first level, academics have studied how metrics to measure innovation performance should be selected. Brown and Svenson (1988) suggest that companies should use a limited number of objectives and external indicators to measure innovation performance, focused on results and outcomes (e.g. Brown, 1996; Cardenas et al., 2011; Davila et al., 2013; Epstein & Westbrook, 2001) rather than behaviour. Nixon (1998) underlines the importance of ensuring strategic orientation in the selection of innovation indicators. These metrics should mirror the critical success factors (e.g. Balachandra &

Frias, 1997; Gruner & Homburg, 2000; Hauschildt & Salomo, 2007; Henard & Szymaski, 2001; Montoya-Weiss & Calantone, 1994; Thomaschewski & Tarlatt, 2010; Trommsdorff & Steinhoff, 2009; Van der Panne et al., 2003), they should be easy to understand and use and capable of encouraging changes in behaviour. Several authors (e.g. Bremser & Barsky, 2004; Driva & Pawar, 1999; Presley & Liles, 2000; Werner & Souder, 1997) state that the most effective measurement approaches to innovation are those that balance quantitative with qualitative (financial and non-financial) metrics.

Furthermore, given that economic-financial metrics are often questionable since it is very difficult to make a monetary evaluation of intangible and distant-in-time elements, as typically happens in the innovation process (Frattini et al., 2006), they are often integrated with non-financial metrics, which can more easily be estimated.

2.3 Applied Research Methods

With regard to the identified objective of research project and the method of its fulfilment, when processing the research the following scientific work methods were utilized.

Research work relies mainly on a systemic approach, which is normally applied for its ability to consider the situation in the context of external and internal circumstances. It employs a combination of different methods and techniques from various scientific disciplines – triangulation. In this study two types of triangulation are taken into account; (i) data – the use of varied data sources; and (ii) methodological – the use of a combination of data gained with the aid of questionnaires, analysis of available materials and semi-structured interviews.

Analysis is used as a method for obtaining new information and its interpretation. When processing secondary data, the method of secondary analysis is utilised. A source of secondary data was the professional literature, Czech and especially foreign – books, journals and articles from scientific and professional databases (Web of Science, Scopus, Emerald, EBSCO, etc.) with respect to their professional level and relevance.

In order to ascertain the real situation in innovation performance measurement in

Czech companies, a questionnaire survey was conducted in our manufacturing industry (see Chapter 5). This stage strove to contact as many companies as possible to obtain sufficient data.

Comparison is utilised for the results of the questionnaire inquiry of individual companies. This basic benchmarking approach selected more innovative companies for further personal interviews with the company's management.

An inquiry with the objective of acquiring particular data and the ensuing discussion about results acquired and verification of their implementation and realization in practice was carried out in the form of personal interviews with companies' management, i.e. especially with members of the top management, executive agents or owners of production facilities.

Content analysis is applied to the study of texts processed and acquired in the course of interviews with managers of selected companies (personal supporting documents acquired from respondents).

Synthesis is primarily used to announce the results (see Section 5.2), formulate conclusions (see Section 5.3), and produce a methodological proposal for the management control of innovation process performance (see Chapter 6).

Induction is utilised especially when generalizing all the findings achieved in the questionnaire survey, and it is also applied when general principles are defined for the methodological proposal for the assessment of innovation process performance based on specific data from individual companies. Verification of dependencies found was verified by the application of deduction.

The feedback method allows a reconsideration of every step in research to make sure the research does not deviate from its original aim and its starting points.

Statistical methods (see following Section 2.4) are utilised when analysing primary data and their results are presented in tables and charts in Chapters 4 and 5. In particular, Minitab® 15.1.1.0 statistical software is utilised for hypothesis testing and verification.

2.4 Data and Methods for Data Analysis

Three basic sources of information are used while carrying out the project:

- Information made available publicly.
- Information from questionnaire surveys.
- Information from interviews.

For the purposes of the empirical survey public information is taken; in particular data from the Amadeus database provided to the company Bureau Van Dijk and the Czech Statistical Office, which monitors the characteristics of R&D using a VTR 5-01 direct statistical survey. This survey has been carried out in the Czech Republic since 1995 and is a part of the Program of Statistical Surveys. The program is made public under Act No. 89/1995 Coll., On the State Statistical Service, as amended. Data from 2007 and 2013 serve as support and a basis for primary research in its publications.

In the primary analysis (see Chapter 5) the frequency of responses to individual questions on the questionnaire was evaluated. The results were processed in a unified manner in the form of standardised tables and graphs, including commentaries interpreting the presented numerical and graphical information. Evaluation is carried out on the research collection as a whole as well as on component files, broken down by size of company.

By this means a whole range of partial information is gained on the investigated companies. A basis is created for the interpretation of the data gained at the same time obtaining many suggestions for further processing. Concurrently businesses were suggested for the second stage of the primary research – the conducting of semi-structured interviews. An integral part of the primary analysis is data cleaning and its preparation for use in further steps in the process.

Statistical methods are used in the analysis of primary data and the results are presented in tables in the text. The statistical software Minitab® 15.1.1.0 was used for testing the proposed hypotheses (for a full test results log see Appendix 6). Specifically it involves the following methods.

The chi-square test for independence is applied when searching for statistical significance between respondents and non-respondents in primary research. It is also applied for testing hypotheses stated prior to the start of the research. In particular, hypotheses nos. 4, 5, 6 and 7 were tested.

Spearman's correlation coefficient and the generalized linear model are applied when testing hypothesis no. 1. The analysis of the relationship between performance (measured by ROA ratio) and R&D expenditure was carried out in two stages. First, the correlation between ROA values and the values of relative R&D expenditure in the years 2012-2007 is examined. To this end, Spearman's correlation coefficient was applied, particularly due to its non-parametric assumptions. In the second stage, a regression model was set up with only those variables that showed a statistically significant correlation to the ROA, at least at a 5% significance level. The purpose of the model is to determine to what degree current performance (ROA) is influenced by past R&D expenditure. To describe this dependence, a generalized model of linear regression is applied.

The two sample t-test with equal or rather unequal variances is used to evaluate hypothesis no. 2. Comparison of the share of non-investment R&D expenditure in companies controlled by a domestic owner versus companies with foreign participation proceeds with the help of the two sample t-test.

Likert scaling is used in this work to evaluate the significance of factors (i.e. implemented innovations, individual metrics and methods of measuring innovation performance). The following five-item Likert Scale is used: 1 – very important, 2 – important, 3 – neutral, 4 – not important and 5 – completely unimportant.

Cronbach's alpha is considered to be a measure of internal reliability, that is, how closely related a set of items are as a group. It is used in line with Likert scaling for measurement of consistency and reliability of scale. A reliability coefficient of 0.70 or higher is considered "acceptable" in most social science research situations.

2.5 Primary Research Procedure

As concerns the methodological approach, following recent examples (Baird et al., 2004; Carenzo & Turolla, 2010; CZSO, 2012; CZSO, 2014; OECD, 2009; Sulaiman & Mitchell, 2005; ZEW, 2013), a questionnaire-based survey was implemented to gather information and determine the real state of solved issues of performance measurement and management control of innovations. The survey method is often used to collect systematic data since it is time and cost-efficient and allows the carrying out of statistical analysis (Groves et al., 2009). In addition, the replication of questions is possible and thus allows a comparison of results and pattern analysis.

The first step was to define the research sample. Before the research commenced, the circle of respondents was duly considered. Research could have been limited based on company size, the field and the distribution of companies in the Czech Republic. After careful consideration, it was decided to carry out the research via a random selection of various-sized innovative companies from manufacturing industry in the Czech Republic.

This choice is related to the fact that managerial tools primarily originated and subsequently developed in manufacturing companies. The second feature was the fact that manufacturing industry is considered the most significant industry for the development of the Czech economy since it is the largest sector. This allows a sufficient number of companies to be contacted to participate in the study. It is estimated that the target population consists of over 11,000 manufacturing companies.

According to the Czech Statistical Office and its survey in 2012, 51% of 5,449 innovative companies belong to manufacturing industry. Moreover, these companies participated in total revenues by 45.4% in 2012 in the mentioned part of the Czech economy (CZSO, 2014, p. 15).

In order to establish innovation success it is first necessary to decide at what level the process will take place. Innovation effects can be measured at (i) the macro level (distinguishing national and sector levels), (ii) the meso level (the level of the company's product family), and (iii) the micro level (the level of innovation projects).

At the macro level, there is a wide range of known and sophisticated means of measuring innovation potential and performance such as the Innovation Union Scoreboard (EC, 2014a) and the Regional Innovation Scoreboard (EC, 2014b) in Europe. In the Czech Republic innovation surveys are regularly performed by the Czech Statistical Office as well as the Centre of Economic Studies at the University of Economics and Management (CES, 2013). The macro level has been the subject of abundant research and studies in past decades (e.g. Archibugi & Pianta, 1994; Brusoni et al., 2006; Casper & van Waarden, 2005; Cefis & Ciccarelli, 2005; Gourlay & Seaton, 2004; Malerba & Orsenigo, 1999; MEADOW, 2010; OECD 2007; OECD 2010a; OECD 2010b; Patel & Pavitt, 1994). Therefore the present work does not study this level and bases its considerations on the findings of the aforementioned studies.

There are several reasons for analysing the link between innovation and productivity at the company micro-level. First, it is companies that innovate, not countries or industries. Second, aggregate analysis hides a lot of heterogeneity. Companies' performance and characteristics differ both across countries and within industries; countries' innovation systems are characterised by mixed patterns of innovation strategies which have an impact on companies' behaviour; and companies may adopt multiple paths to innovation, including non-technological ones. The advantage of micro-level analysis is that it attempts to model the channels through which specific companies' knowledge assets or specific knowledge channels can have an impact on these companies' productivity and therefore sheds light on the role that innovation inputs, outputs and policies play in economic performance (OECD, 2009).

The key was to approach as many respondents as possible and so to acquire a sufficiently large data scale factor for evaluation of primary research. The inquiry itself provided quantitative as well as semi-qualitative data on the current state of the issue in question. Simplicity and the relative brevity of the questionnaire, influencing a respondent's willingness to fill it out, was an important factor when creating the questionnaire. There were the following types of question:

- With selectable answers and the option to select just one.
- With selectable answers and the option to select several.
- With pre-defined answers with an evaluation scale.
- Some questions had the option to fill in answers freely.

The questionnaire was web-based in order to facilitate access to a large number of respondents and was structured in two parts. The first part consists of general information about the company, whereas the second part focuses on innovation measurement and applied management control tools and methods. Regarding the structure of questionnaire, questions in the first part relate primarily to:

- Size of the company (defined by number of employees and turnover)
- Origin of the company (Czech, Czech with foreign participation or foreign).
- Geographical markets where the company sells its products or services (Czech regional market, Czech national market, EU market or Global market).
- Period in which the company implements innovations (irregularly and randomly, or regularly).
- Type of implemented innovations defined according to the Oslo Manual (product innovation, process innovation, organisational innovation or marketing innovation).
- Importance of implemented innovation (based on the Likert scale: 1 – very important, 2 – important, 3 – neutral, 4 – not important, 5 – completely unimportant).
- Total amount of expenditure for innovation by percentage of annual budget.

To reduce its size the questionnaire focuses almost exclusively only on information that cannot be obtained from publicly available sources or by other means. The purpose of the use of the questionnaire was above all to obtain the ideas and estimates of the qualified, strategically minded representatives of the business.

The second part of the questionnaire had a more analytical and less subjective character. Here, using scoring scales, numerical values, and in some cases other means, respondents evaluated the innovation process in the company and how it was measured and managed. The primary aim of the statistical evaluation that followed was to ascertain “what the businesses are like”, and the secondary aim was then to identify which of their characteristics and their values led the business to be or not to be economically successful and competitive in the long term. Questions in the second part relate to:

- Implementation of an innovation performance measurement system (PMS).
- Period, since when PMS has been implemented in the company.
- Reasons for PMS implementation and its importance for strategy management.
- Responsibility for innovation performance measurement.
- Tools and techniques of innovation performance measurement and management utilized in the company.

The structured questionnaire also enables additional comments. Thereby, respondents could express their opinion on given questions regardless of the degree of their own innovation. Data gained are presented in tables and graphs that are summarized in Section 5.2.

Once drawn up, the questionnaire should be tested on a sample population whether all items are understandable and clear. Therefore, the questionnaire was pre-tested by a number of academics and then sent to several practitioners for further review. Minor adjustments in wording and layout were made in order to further understanding of the questionnaire. None of these respondents considered the questionnaire difficult to complete. After several iterations of item editing refinement, the questionnaire was administered to the full research sample.

The survey was composed of 18 questions and was conducted by sending a fully standardized questionnaire (see Appendix 5) by e-mail to the company (a link to the electronic questionnaire was included in the e-mail). The e-mail supplied a brief introduction clarifying the purpose and objectives of the research project. It was sent exclusively to CEOs, top managers, executive officers, or in small companies, directly to the owners. The survey was anonymous, took approximately 10 to 15 minutes to complete, and was conducted from April to November 2014.

In addition, the survey's respondents were asked to indicate whether they would be willing to participate in a follow-up interview. The aim of the follow-up interviews was to analyse questionnaire responses in greater depth. The interviews were semi-structured and conducted with a degree of flexibility. A list of the main questions was sent in advance to facilitate the interviews. Although the questionnaire was semi-structured, individual questions were understood rather as topics for discussion. Numerous incentives revealed during meeting with businessmen and take the form of extended comments in Sections 5.2 and 5.3.

2.6 Methodology of the Innovation Scorecard Design

Neely et al., (1996, p. 424) propose definitions of performance measurement, a performance measure and a performance measurement system:

- Performance measurement can be defined as the process of quantifying the efficiency and effectiveness of action.
- A performance measure can be defined as a metric used to quantify the efficiency and/or effectiveness of action.
- A performance measurement system can be defined as the set of metrics used to quantify both the efficiency and effectiveness of actions.

Their study shows how a set of performance measures, a performance measurement system, can be examined at three different levels; (i) the individual performance measures, (ii) the PMS as an entity, and (iii) the relationship between the PMS and the environment within which it operates.

The starting point is an analysis of the state of the art of performance measurement and management control techniques in order to devise the framework proposed for the innovation process (see Chapter 3). This has been done by means of a review of the bibliography and by discussion with academics experienced in innovation management. With this approach obtaining a very high degree of consensus on the best way to measure each of the variables included in each dimension of proposed Innovation Scorecard is expected.

Table 1 Principles for PMS design

Globerson (1985)	Maskell (1991)	Bourne et al. (2003)
Performance criteria must be chosen from the company's goals.	The measures should be directly related to the company's manufacturing strategy.	Performance measurement refers to the use of a multi-dimensional set of performance measures.
Performance criteria must make possible the comparison of companies that are in the same business.	Non-financial measures should be adopted.	Performance measurement should include both financial and non-financial measures, internal and external measures of performance and often both measures which quantify what has been achieved as well as measures which are used to help predict the future.
The purpose of each performance criterion must be clear.	It should be recognised that measures vary between locations – one measure is not suitable for all departments or sites.	Performance measurement cannot be done in isolation.
Data collection and methods of calculating the performance criterion must be clearly defined.	It should be acknowledged that measures change as circumstances do.	Performance measurement is only relevant within a reference framework against which the efficiency and effectiveness of action can be judged.
Ratio based performance criteria are preferred to absolute numbers.	The measures should be simple and easy to use.	Performance measures should be developed from strategy.
Performance criteria should be under the control of the evaluated organisational unit.	The measures should provide fast feedback.	Performance measurement has an impact on the environment in which it operates.
Performance criteria should be selected through discussions with the people involved (customers, employees, managers, etc.).	The measures should be designed so that they stimulate continuous improvement rather than simply monitor.	Starting to measure, deciding what to measure, how to measure and what the targets will be, are all acts which influence individuals and groups within the company.
Objective performance criteria are preferable to subjective ones.		Once measurement has started, the performance review will have consequences, as will the actions agreed upon as a result of that review.
		Performance measurement, is an integral part of the management planning and control system of the company being measured.
		Performance measurement is being used to assess the impact of actions on the stakeholders of the company whose performance is being measured.

In empirical research on innovation performance measurement and management control, as in other disciplines, the relationships between the relevant variables are examined. However an initial problem may be encountered. How to measure these variables as accurately and reliably as possible? Often, the conclusions obtained in research studies on the behaviour of innovative companies and its consequences are measured by the empirical observations of the researchers, and therefore errors of measurement are likely to occur. Research in this field is characterised by the scarcity of studies on the innovation management.

It is worth reviewing one other relevant stream of writing in the literature, namely that concerned with rules and guidelines for PMS design, rather than the actual process. Authors such as Globerson (1985), Maskell (1991) or latter Bourne et al. (2003) offer the following principles of PMS design (see Table 1).

Therefore the concept of performance measurement used in this thesis refers to the use of a multi-dimensional set of performance measures for the planning and management of a business.

PMS Design Process

In the performance measurement literature, a wide range of performance measurement design processes is described (Keegan et al., 1989; Wisner & Fawcett, 1991; Azzone et al., 1991; Kaplan & Norton, 1993; Neely et al., 2000). These processes have been developed both jointly and severally, from theory and practice, by both academics and practitioners. Some have remained as theoretical models whereas others have been extensively tried and tested through application in commerce and industry. To develop a PMS, Neely et al., (1996, p. 425) suggest the following procedure:

1. Decide what should be measured.
2. Decide how it is going to be measured.
3. Collect the appropriate data.
4. Eliminate conflicts in the measurement system.

Points 1 and 2 are considered in this thesis. Points 3 and 4 are not included in the following explanations because these steps are specific for each company. To be able to conceptualize a performance measurement system for innovation and to decide what needs to be measured, a common understanding of innovation is necessary (see Chapter 3).

Categorising PMS design processes

However, there have been very few attempts to compare and contrast the different performance measurement design processes. Bititci et al. (2000) attempted to compare the characteristics of different frameworks, processes and systems using practitioner requirements as the criteria but this approach did not fully distinguish between frameworks, systems and processes, nor did it attempt to create a categorisation.

Categorising the performance measurement design processes described in the literature is not an easy task. Some are no more than a brief description of a series of tasks (e.g. Sink, 1986); others are descriptions of single tools (e.g. Eccles & Pyburn, 1992) whilst a few are complete processes (e.g. Bititci et al., 1998; Neely et al., 1996). In addition some are consultancy techniques that are only partially published (e.g. Davies & O 'Donnell, 1997; Kaplan & Norton, 1996b). However the literature does provide sufficient information to attempt a categorisation.

The first theme that is immediately apparent from the literature is that the procedures are not the same. In fact the underlying bases for developing the PMSs are very different.

However, as Platts (1994) demonstrated, procedure is not the only important criteria. From a change management or implementation perspective how it is done (Duck, 1993), the process consultation (Schein, 1969), facilitation (Hunter, 2009) and the structuring of the debate (Martin, 1993) are all important aspects that cannot be ignored. These softer aspects of the process are less explicitly addressed in the literature and have to be gleaned from careful reading. Given that developing a new PMS is a learning process (Bourne, 1999) and that participation and engagement is critical for a successful outcome (Kim & Mauborgne, 1998), this creates a second source of categorisation.

In summary, the literature suggests that two distinct dimensions can be used:

- The underlying procedure, which could be considered to be the hard issues.
- The underlying approach, in terms of the role of the process leader, change agent or consultant, which could be considered to be the soft issues.

The procedures

From the literature three distinctive procedures can be discerned. These are described here and labelled as (i) needs led, (ii) audit led and (iii) model led.

The needs led procedure is a top down procedure for developing performance measures where the customer, business and stakeholder needs are severally or jointly identified and used as a basis for the development of performance measures. In this approach the measures are designed to monitor the companies' progress towards achievement of these needs. Examples of this approach include the different processes for designing the BSC (Kaplan, 1994; Kaplan & Norton, 1993; Kaplan & Norton, 1996b; Neely et al., 1996; Neely et al., 2000).

The audit led procedure can be considered more of a bottom up approach to the design of a PMS, starting with an audit of the existing performance measures. The information collected is then used to challenge the status quo and as a basis for amending the existing performance measures. Examples of this approach include the Performance Measurement Questionnaire (Dixon et al., 1990).

The model led procedure uses a prescribed theoretical model of the organisation as a rationale for designing the performance measures that should be deployed.

The approach

In considering the soft issues, all the published processes are what might be considered partial processes (Bourne et al., 2002) in that they focus primarily on Lewin's (1951) phase of unfreezing with little consideration to moving and refreezing. Given this there are still two distinct types of approach that can be identified in the literature. These have been labelled here (i) consultant led and (ii) facilitator led approaches.

The consultant led approach is where the majority of the work is undertaken by an individual (or group of individuals, usually consultants – hence the term used here) almost in isolation from the rest of the management team. The approach is typified by a small number of workshops, well-spaced in time, where the work of the consultant is reviewed. Between the workshops the consultant undertakes his or her work. Data collection is undertaken, usually through interviews with individual managers. The consultant then does the analysis and the results are presented back to the management team at the next workshop in the form of a report with recommended actions. Although it is at the senior management workshops that the main decisions are made the majority of the work is done outside these meetings. An example of this is the approach of Kaplan and Norton (1993).

The facilitator led approach is different in that the majority of the work is undertaken by the management team together in facilitated workshops. Consequently the management team's role is not restricted to critiquing work done by others. In these workshops they are intimately involved in the discovery and analysis phases of the work. The role of the facilitator now revolves around eliciting information from the assembled group, structuring the debate, probing the assumptions and if necessary, challenging the decisions made. An example of this is the later approach to developing balanced scorecards (Kaplan & Norton, 1996a; Neely et al., 1996; Niven, 2006; Norton, 1997).

3 THE INNOVATION IMPERATIVE: STATE OF THE ART

3.1 Understanding Innovation

The significance of innovation was highlighted as early as the beginning of the 20th century by Schumpeter (1912). His concept of innovation became the basis for numerous studies and modern concepts in the sphere of innovation (e.g. Drucker, 1985; EC, 1995; Kline & Rosenberg, 1986; OECD 2005; Porter, 1990; Rothwell, 1992; Valenta, 1969).

However, the language of innovation and how people understand the term is vague and fuzzy at best and dangerous at worst. Moreover the term innovation is subject to countless classifications, typologies and categorisations in the professional literature. While named similarly these categories can differ significantly in their meaning and vice versa. Thus the term innovation carries broad shades of meaning (e.g. Birkinshaw et al., 2008; Boer & During, 2001; Fagerberg et al., 2004; Maital & Seshadri, 2007; Meeus & Edquist, 2006; Shavinina, 2003) and a huge amount of disorder and chaos is revealed (Bisbe & Otley, 2004; Damanpour & Aravind, 2006; Davila, 2000; Davila et al., 2009; Fritsch & Meschede, 2001; Gailly, 2011; Kaufman & Woodhead, 2006; Kleinknecht & Mohnen, 2002; Kumar & Phrommathed, 2005; Sylver, 2006, Yusof et al., 2010).

Historically research on the classification of innovations concentrated on the technological imperative of innovation, assuming that companies carry out innovative activities through research and development (R&D). As a result several studies on and definitions of innovation have been produced, pertaining directly to R&D (e.g. Gallouj & Weinstein, 1997; Mairesse & Mohnen, 2004; Miles, 2001). Many people, including managers, still understand innovation as something absolutely revolutionary, stemming from years of (laboratory) research. As a result innovation is often confused with R&D in common parlance, although top innovative companies (such as 3M, Apple, BMW, Google, Hilti, Procter&Gamble or Toyota) do not combine these two terms (Sommerlatte, 2010).

Thus according to some definitions the main characteristics of innovations are change and considerable novelty (e.g. Barnett, 1963; Drucker, 2009; Hauschildt & Salomo, 2007; Kotler & de Bes, 2003; Littkemann & Holtrup, 2008; Knight, 1967; Mohr, 1969, Porter, 1990; Rogers, 2003; Schumpeter, 1912; Valenta, 1969; or Whitfield, 1975). The novelty element can also be found in the OECD and European Commission definitions of innovations which are currently considered essential (e.g. EC, 1995; Gault, 2013; OECD 2002; OECD, 2005).

In contrast, it has been recognised by a number of scientists that the criterion "novelty" cannot be the only criterion of innovation but inventions or ideas become innovations in the course of their transformation into an application that is used in practice (e.g. Gailly, 2011; Robertson, 1967; Tidd et al., 2005; Walker, 1969). We can understand innovation as a way of transforming the resources of a company through the creativity of people into new resources and wealth.

Given the chaos in the definitions and typology of the term innovation in the professional literature, this key term is understood in line with the Oslo Manual (OECD, 2005), which is the foremost international source of guidelines for the collection and use of data on innovation activities in industry (Gault, 2013).

The third edition of the Manual takes account of progress in the understanding of the innovation process and its economic impacts. For the first time it attributes the same innovation importance to nearly all operations taking place in a company and includes links between various types of innovation. The Oslo Manual defines four types of innovation that encompass a wide range of changes in companies' activities:

- Product innovations involve significant changes in the capabilities of goods or services. Both entirely new goods and services and significant improvements to existing products are included.
- Process innovations represent significant changes in production and delivery methods.
- Organisational innovations refer to the implementation of new organisational methods. These can be changes in business practices, in workplace organisation or in the firm's external relations.

- Marketing innovations involve the implementation of new marketing methods. These can include changes in product design and packaging, in product promotion and placement, and in methods for pricing goods and services (OECD, 2005).

Thus, innovation is the culmination of a whole series of scientific, research, technical, organisational, financial and commercial activities that collectively constitute the innovation process (see Section 3.4).

3.2 Degree of Innovation

Another distinguishing element is the degree of innovation. In Schumpeter's (1912) definition of innovation, novelty for the relevant sector is repeatedly emphasised and radical innovations play a key role in economic development in his theory. This view is related to the classification of innovations by degree of novelty into:

- **Radical**, which represent the introduction of revolutionary new technologies, but also considerable uncertainty for the business model and the whole company (e.g. Kock, 2007). This type of innovations has risks. You may not be able to determine when the breakthrough will be made and the accompanying costs (Kerzner, 2013).
- **Incremental**, i.e. gradual improvements to existing technology, which have generally quantifiable impacts on business (e.g. Garcia & Calantone, 2002). This type of innovation may be able to be accomplished quickly and with the existing resources in the company. The intent is to solve a problem and add incremental value to the end result.
- **Rationalisation**, which involves the prevention and elimination of production losses while using existing business elements optimally (Tidd et al., 2005).
- **Disruptive**, which disrupt the existing market or create entirely new markets (e.g. Christensen, 1997).

The Oslo Manual (OECD, 2005) distinguishes three relevant concepts: (i) new to the company, (ii) new to the market and (iii) new to the world. The first concept covers the diffusion of an existing innovation to a company (the innovation may already have been implemented by other companies). Companies that first developed innovations (new to the market or new to the world) can be considered as drivers of the process of innovation. Many new ideas and knowledge originate from these companies, but the economic impact of the innovations will depend on their adoption by other companies. Information on the degree of novelty can be used to identify the developers and adopters of innovation, to examine patterns of diffusion and to identify market leaders and followers.

Valenta (2001) defines novelty levels as dimensions characterising innovation, or different distances travelled by new products, or other factors of production or some other activity, from the original condition preceding innovation. In total Valenta (2001) distinguishes eleven innovation levels of which one is negative (degeneration) and ten are positive.

3.3 Innovative Potential: An Internal Look at a Company

Innovation potential is basically an internal characteristic of a company. For its development, it is necessary to identify and utilize one‘s competitive advantage (Gebauer et al., 2011). It can be expressed as the company‘s ability to effectively use its own internal resources under the existing conditions in order to improve the quality, economy or efficiency of a specific product or process (e.g. Heřman, 2008; Veber, 2006; Technology Centre of the Academy of Sciences CR, 2008). It represents the overall ability of the company (including its divisions and sections) to successfully and permanently implements a vision, and it makes it possible for the company to flexibly respond to incentives, and generate and develop activities with an increased added value (Pittner & Švejda, 2004).

It is currently considered the key condition of companies' competitiveness (Andergassen et al., 2009; Epstein et al., 2004) and performance. Companies with limited innovation potential must direct their attention and efforts to the first part of the innovation process (see Figure 2), especially the phase in which the internal and external environments of the company are analysed and ideas come into being (Flynn & Chatman, 2004; Hansen & Birkinshaw, 2007). On the other hand companies with developed innovation potential concentrate on the economic and financial results of innovations and the possibility of launching a radical or disruptive innovation (Aaker, 2001; Andrew & Sirkin, 2006).

The innovative potential, from an internal perspective, combines all aspects that enable a company to initiate, foster, support and complete an innovation process successfully. Generating permanent innovations and growth from innovations needs to be accepted as an imperative in the company. The structures and processes of the organisation, and the behaviour and the motivation of the employees must be aligned with this guideline. Innovation is driven by a collective and collaborative attitude of all functions involved (Thomaschewski & Tarlatt, 2010).

3.4 Innovation: A Key Process of the Company

It is not about whether to innovate or not, but how to innovate successfully!
(Hauschildt & Salomo, 2007)

Innovations are not separate activities in the company, but they proceed in the form of processes that encourage change and have to be successfully terminated (Cooper, 1998; Gopalakrishnan & Damanpour, 1997; Greve, 2003; Whitfield, 1975). Successful innovations are the result of a series of management, marketing, scientific, technological, organisational, financial, business and other types of activity (Synek, 2011). Market participants act together with employees, technologies and environmental influences, all of them acting dynamically and independently. This characterizes a complex system. In order to manage this complexity, researchers suggest understanding innovation, including all activities around it, as one process (Tidd et al., 2005).

It is expected that companies will aim at two goals in relation to continuously performed efficient innovation: *"To ensure the long-term efficient development and growth of the company with parallel continuous elimination or at least the mitigation of inefficiencies in its business processes"* (Vlček, 2011, p. 21).

The innovation process must be a key process in a company since innovation provides sustainable market success. Well-managed and successfully-introduced innovation into the market represents a tool for companies, by means of which they can achieve competitive advantages and enable their long-term prosperity. Therefore it is one of the key strategic success factors. Companies that do not innovate die (e.g. Bessant & Tidd, 2011; Davila et al., 2013; Hamel & Green, 2007; Skarzynski & Gibson, 2008). Their competitive success comes from “running differently”, by reinventing themselves through innovation capability (Fiorentino, 2010).

It is necessary to bear in mind that innovation must generate value for the customer as well as for the shareholders and employees of the company. Leading Czech authors (e.g. Košturiak & Chál', 2008; Muška et al., 2009) believe that it will be necessary to divide a company into two parts:

- A part that creates new products (development, technology construction and design), produces them and supplies them to customers. Project management and change management are typical for this part.
- A part that constantly improves its products, processes, business systems, innovation methods and the thinking of the people in the company. Process management, KPIs or benchmarking is typical for this part. The aim is to exploit implemented changes (innovations) to achieve excellence in standard activities.

However, innovation research is full of paradoxes. Bledow et al. (2009) summarize several kinds of conflicting demand inherent to the innovation process and demonstrate the commonality of tensions within this process. The main paradoxes of innovation are probably achieving a balance of new and old activities, of structured and chaotic activities, and of uncertain and reliable activities.

Innovation can be a complicated process. To be able to think about the innovation process clearly, it is better to divide it into two elementary parts (Farr et al., 2003; Jolly, 1997; Maidique, 1980; MIT CR, 2007): invention, which relates to the identification of a problem or opportunity, or the generation of an original new idea, notion or concept. The second part of innovation process, innovation, creating the invention and introducing it to the market. The distinction between the invention and implementation part of innovation is widely accepted in the literature. What makes innovation a really challenging is that the creative part and the implementation part of invention cannot be clearly separated.

Consequently, these parts are divided into six individual phases (see Figure 2). Then, on the way to innovation, an invention passes through a multistage, multiphase process. Each of these phases requires different instruments and methods. The following characteristics of the innovation process were drawn from the Czech and foreign professional literature (e.g. Cooper, 1998; 2008; Erner & Presse, 2010; Fagerber et al., 2005; Gerybadze, 2010; Goffin & Mitchell, 2009; Christiansen, 2000; Kislingerová, 2008; Koen et al., 2001; Košturiak & Cháľ, 2008; Mariello, 2007; MIT CR, 2007; Skarzynski & Gibson, 2008; Smith, 2009; Sommerlatte, 2010; Thomaschewski & Tarlatt, 2010; Tidd, et al., 2005; Vlček, 2011.)

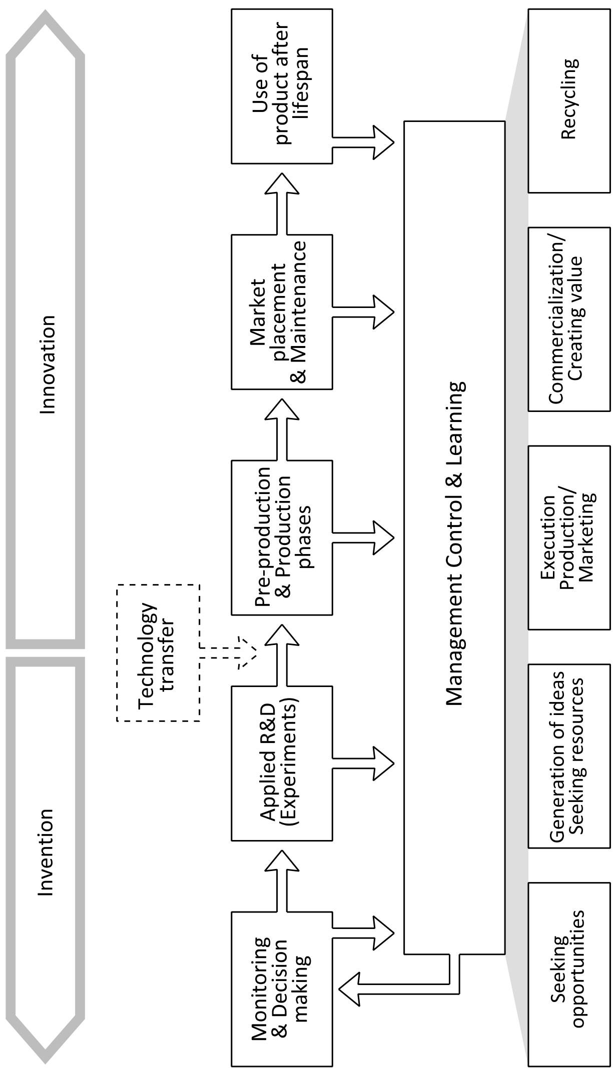

Figure 2 Design of an innovation process model

Phase 1 Monitoring & decision making

The starting line for new ideas and innovative designs is the studying and monitoring of the internal and external environments of the company. Market research is only one of the instruments used; much more important for premium companies is that they ask and train their sales, marketing and development people to put themselves into the shoes of the customers and to discover the deficits these customers suffer from, even though they may not (be able to) articulate them. The experience of several of the premium companies shows that recognizing and precisely formulating a customer problem is at least as important as developing ideas for solving it.

This initial phase of the entire innovation process should be driven by competitive pressure and the effort to investigate new possibilities – to invent something new. A company must be able to recognize and process the signals of potential innovations. However, having the capability of identifying innovation opportunities can be useless if there is no effective way to filter and prioritise those innovation signals. Therefore, upon this strategic view, it is then necessary to consider and compare the pros and cons of these signals.

First of all, innovation opportunity has to be analysed, studied and legitimated whether there is a significant value creation potential and then whether the company gains some competitive advantages with regard to this. These activities must run in parallel so as to eliminate ideas lacking innovative potential and also to prevent the rejection of new ideas simply based on the fact that they are new. This phase results in a strategic decision regarding which innovative idea the company should develop and support.

Phase 2 Applied R&D

The second phase of the innovation process, applied R&D, carries the hidden potential of a new idea through different stages of development to the final version of something new. It does not necessarily have to involve extensive R&D or the search for the correct sources, but can also be something as simple as buying a commonly available product or technology licence. It requires the sourcing of related knowledge and know-how.

This phase should involve testing the feasibility of new ideas in a given company, in a given time and for a given market. This is illustrated by prototypes and demonstration models. It is necessary to define who the consumers are and what they will use the new product or service for. This may lead to the discovery that an idea is good but that it may be either ahead of its time or else not suitable for the given market. In such a case, it does not have to be regarded as an innovation failure; the new idea may become a catalyst facilitating the birth of some other new innovation.

Box 2 Innovation "failures"

Charles Goodyear, inventor of the vulcanisation of natural rubber, first carried out experiments on adding various admixtures to rubber, unfortunately without much success. The properties of products made from raw rubber were not satisfactory and so Charles Goodyear started to colour them to at least have them not look like rubber. On one occasion he decided to remove the coating with nitric acid and found that the boots were blackened. He put them to one side. After a few days he discovered that they were smooth and no longer sticky. Later he became acquainted with Nathaniel Hayward, buying from him the patent for the hardening of rubber by adding sulphur. However not even this solution led to his desired goal. Only in 1839, apparently by chance, was there a breakthrough, when Goodyear accidentally dropped a piece of rubber treated in accordance with the purchased patent onto the hot surface of a stove. On scraping it Goodyear noticed that a certain part of the rubber had become firm and flexible. After a range of further experiments in 1844 he obtained the patent for the vulcanisation of natural rubber. It was a classic case of the American dream…

The transistor, first presented by Bell Labs in 1948, was first mentioned only on the back of newspapers and trade journals. However, this invention completely transformed the second half of the 20th century and shaped the development of 21st century industry. Today, large numbers of these components are contained in microchips as essential parts of computers, the Internet, mobile phones, digital cameras, and many other everyday items used by people all over the world.

Another example of an "unsuccessful" innovation is the post-it pad. In 1968, Spencer Silver was working for an American laboratory for the 3M corporation. He invented glue that seemed totally useless – it did not stick permanently, was much weaker than the adhesives already produced by 3M, and it came in tiny drops instead of a film. However, Silver sent samples to his colleagues hoping that someone would find a use for his invention. The non-stick glue finally found its purpose some years later. Art Fry, Silver's colleague, was a singer in a church choir. He was looking for a note that would not slip from a tilted songbook, would not damage the pages and could be moved easily. He remembered Silver's glue and started producing the first notes coated with this glue in 1974. The result was satisfactory. The note held to paper and other materials, but it was easily peeled off, did not leave marks and was reusable. A product with unexpected potential was born.

Phase 3 Pre-production & production

The described experimenting also reaches the next phase of the innovation process – the pre-production and production phase. This represents an imaginary thread linking knowledge and the final innovated product. Companies often implement innovation projects in conditions of uncertainty (we do not know the exact form of the final innovation or whether the market will accept it, etc.). These uncertainties are gradually replaced with concrete findings and knowledge. Innovations rarely relate to a single technology or a single market, but cover a number of different pieces of knowledge. Activities related to market preparation and marketing activities promoting the new product must take place alongside the resolution of technical problems. The company must eliminate uncertainty – although the final product may be technically excellent, there is no guarantee that customers will accept it. The output is an innovative product and a market ready for the final launch of the innovation.

The phase of applied R&D with the production phase is one of the longest and most expensive parts of the innovation process (Christiansen, 2000). As such, we must not forget the previous activities, i.e. generating ideas and searching for resources (especially finance, communication, strategies, goals and assistance). Improvement in these activities can significantly shorten the time from the discovery of an opportunity to the launching of an innovation on the market. It can also generate a product that will react to the market's needs much more efficiently.

Phase 4 Market introduction & maintenance

Innovation is a process starting with an idea or the imagination and followed by various stages of development, issuing with implementation. Without the launching of the innovation onto the market, the implementation process is not complete and the innovation cannot be considered to be implemented (Gailly, 2011; Tidd et al., 2005).

This phase involves the launching of the innovation on the market, the management of its initial acceptance and sustaining its long-term acceptance and use by the market.

All of these activities are supported by information-gathering from various sources as to whether the innovation solves the customers' problems or yields new uses. The key feature is marketing activity and promotion using this acquired information or the product design, etc., with the aim of minimizing the adverse attitudes of market participants towards the innovation.

During the initial phases after the innovation successfully enters the target market, the company may rely on competitive advantages based on the superior quality of the offered product. When the product breaks through to the market and starts being profitable, it is necessary to look further ahead and protect positions already occupied. Aside from the protection of industrial property relating to the engineering of innovations (patents or utility models) protection can also be used for other aspects of intellectual property, for example based especially on marketing values and design. To do this, innovative companies create close links between intellectual property management, R&D management and innovation process management. The further development of the innovation should follow after the market launch.

Phase 5 Living environment

Every company needs people, materials, technologies and energy. The effort to accelerate economic growth is often in conflict with environmental protection, the conservation of resources and the quality of nature and the landscape. Attention and finance that is given to technical, security and environmental requirements will repay a company when compared to losses due to production limitations, penalties or other sanctions relating to breaching environmental laws or regulations.

As time has passed products have been getting much safer and companies are becoming more aware of their own responsibility for protection of the environment. More and more companies are certified for environmental management systems according to ISO 14001. When assessing the impact of innovation on the environment a manager can follow Environmental Impact Assessment (EIA) methodology (EC, 2014c).

Phase 6 Management control & learning

The feedback phase of learning reflects whether the previous phases and analyses achieved success or failure. It is necessary to analyse deviations from the expected costs, term changes and their causes, and to assign responsibility to those things that caused them. The aim is to learn how to better cope with the innovation process and thus build knowledge upon any experience gained. This last phase faces many problems. Instead of learning and gaining experience from the previous innovation project, it is quite common for individual participants to blame each other and try to cover their errors. Efficient learning requires a willingness to perform open and informed revision. Another problem closely relates to the process of unlearning. Gaining new knowledge is important, but one must also learn to forget old ideas. Benjamin Franklin once said: *"We must learn to forget what we learned."* Indeed, when it comes to innovation activities, this quote rings absolutely true.

While the entire innovation process is described as being linear[1], it moves in non-linear cycles and must take place along the spiral of the long-term growth of a company (Kopčaj, 2007; Moss, 1989). Understanding a defined innovation process as such will enable the clearer definition of any tasks that must be continuously performed and their mutual linking (e.g. what must be done first and what comes next). The improvement of the innovation process includes the increasing of individual steps' efficiency, changing the sequence of steps or the identification and removal of unnecessary steps.

Therefore the innovative performance overarches the measurement of all stages from invention to patenting and new product introduction. In other words this definition of innovative performance in the broad sense focuses on both the technical aspects of innovation and the introduction of new products onto the market but it excludes the possible economic success of innovations (Ernst, 2001; Stuart, 2000).

Moreover the ideal innovation process includes a series of checkpoints that allow the innovation team to evaluate whether the project is in fact viable and whether the team

1 Rather, the innovation process is chaotic and non-linear (Anderson et al., 2004). The linear models of innovation are useful for describing key steps in the innovation process and in documenting projects but are not particularly helpful in understanding the process in real time. Linear models describe what happened but not how it happened, and tend to reinforce the belief in a kind of orderliness which does not exist (Carlsson et al., 1976).

is on a path leading to success. Therefore after each stage there is a checkpoint at which the contributors and commission decision makers or managers ("gatekeepers") decide to move forward or go back to resolve key issues or stop the project.

3.5 Effects of Innovation

Having defined the elemental terms and definitions such as innovation, innovative potential and innovative process, we can proceed to the effects of innovations and methods for their measurement.

According to Valenta (1969) the third link in the chain "activity–innovation–effects" represents a change in the behaviour of a production organism resulting from a complex innovative action. Activity is a creative human function resulting in invention. Invention is the thought foundation for innovation, and bringing innovation into business reality brings a resulting effect. The latter consists of any change in input, output and the stock of funds and any change in their mutual proportions. The resulting effect directly depends on the originality of the initial activity. The whole process is controlled and regulated by feedback between the effect and the activity and between the company's environment and the firm as such, which restores the balance of the whole system (Vlček, 2002). Valenta (1969) considers the following to be elementary effects:

- Changes in input values (such as costs over a period of time).
- Changes in output values (sales over a period of time).
- Changes in the stock of funds (the financial balance at a point in time – average).

From these elementary effects Valenta constructs complex effects which are as follows:

- Effects towards the extensity of development of the production organism, measured directly by the change in an output value.
- Effects towards productivity of operation of the production organism, measured as the difference between the degree of movement of output values and the degree of movement of input values.

- Effects towards utilisation, or effectiveness of the stock of funds, measured as the difference between the degree of movement of an input value/degree of movement of an output value and the degree of movement of the stock of funds.

In order to establish innovation success it is first necessary to decide at what level the process will take place. In this study we deal primarily with determining the success of individual innovation projects, i.e. the micro level (see Section 2.2).

Then we can continue by selecting the kind of criteria to be used in the process. Hauschildt and Salomo (2007) recommend measuring the value of innovation using three kinds of criterion: (i) technical, (ii) economic and (iii) others. The evaluation of innovations at these three levels is a prerequisite for identifying the overall success of an innovation.

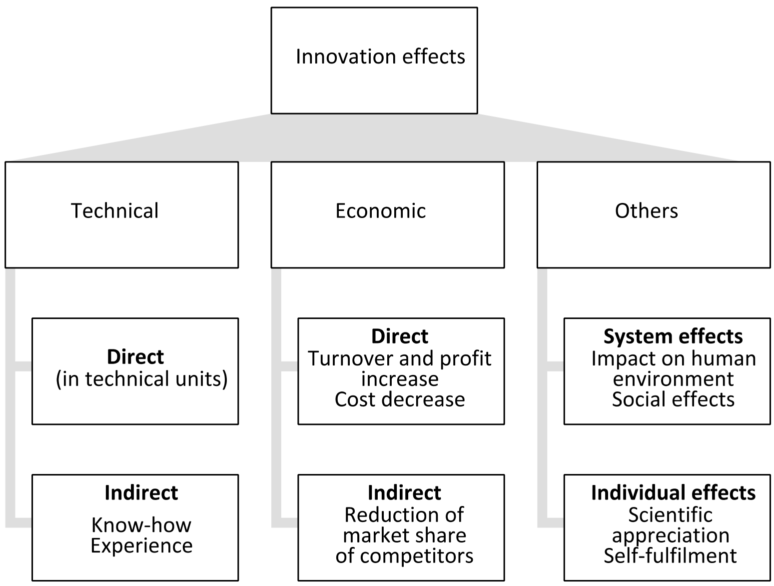

Figure 3 Types of innovation effect (modified from Hauschild & Salomo, 2007)

With respect to **technical criteria** the success of an innovation is assessed using specific technical parameters such as energy performance, fuel consumption, air resistance, etc. These parameters can be called direct characteristics. In addition to these, it is also possible to look for indirect characteristics in technical criteria. These include, for example, experience gained, transfer of know-how, identification of weaknesses, improved co-operation in the innovation team, etc. The degree to which such indirect effects can actually help increase effectiveness becomes apparent only when addressing subsequent projects.

Economic effects can also be divided into direct and indirect. For direct effects, the priority is to establish the amount of profit or expenditure on covering fixed costs and profits, or gross margin. As a rule it is either impossible to specify these factors in the initial phases of the innovation process or else the figure is extremely unreliable. In these cases it is possible to look for example for turnover or market share indicators, assuming that a product received positively by the market is likely to be effective also in terms of profitability. This approach is aimed at ascertaining whether bringing innovations into practice will result in lower costs thanks to improved quality, reduced quantity of defective products, etc. Another example of an indirect effect is impact on competition in a situation where, for example, an innovation enables the company to obtain a licence which increases competitors' costs or reduces their market share and sales.

Other effects of innovation include those which follow from the elimination of physically demanding and monotonous work, increased share of creative work, improved health and hygiene in workplaces, better work safety, etc. Innovations have a highly significant impact on the environment. For individuals they can include scientific recognition, receiving prestigious awards, increased publication activity, etc.

How is innovation measured in empirical studies? The first approach is to use the **number of implemented innovations**. This is the essential and most simple metric. However there is a distinct difference in the significance of individual innovations. The benefits of the ability to bring incremental innovations to the market can entail greater benefits for the competitive ability of companies than the ability to be the first on the market with radically new technologies (see Sections 3.2 and 3.5). Both radical and incremental innovation deserve appropriate attention within innovation management control.

A second approach is to use **bibliometric indicators** which are based on the number of articles published by the unit of analysis being studied (Thomas & McMillan, 2001; Verbeek et al., 2002; Zavadskas et al., 2014). However appropriate measures have been developed in order to evaluate the quality, impact, and importance of the publications

(Martin, 1996), to distinguish between short-term and long-term impact (Moed et al., 1985), and compare the actual and expected impact of publication. From the nature of these metrics follows their implementation only in R&D organisation, universities, etc. Therefore bibliometric measures rely on the information contained in research publications, which has significantly hampered their diffusion among practitioners.

A third approach is to use **technometric patent data** to measure "inventive output" indirectly. This involves patents, which a company has registered itself, not patents (generally licenses) that it has acquired or purchased from another subject for the purpose of commercial use – such an approach represents input metrics (Acs et al., 2002). However not all innovations are protected by patents and many patents are never translated into commercially viable products. There also is a great heterogeneity in a company's propensity to patent. Furthermore the propensity to patent may vary across sectors or company size classes. The relative importance of patenting as a barrier to imitation differs both between sectors and between types of innovation. From this point of view patent data can be considered as an inadequate indicator of innovation output, especially if not all of the innovations are patented, and patents may have very different economic impacts. In addition they do not allow for an adequate measurement of two innovation performance dimensions – cost and time, which are critical in today's competitive environments (Chiesa & Frattini, 2009).

Next approach is to use **R&D expenditure** (e.g. Chan et al., 1990; Doukas & Switzer, 1992; Woolridge & Snow, 1992). R&D, while it is typically well codified, is a measure of input to the innovation process rather than output. Also data on R&D expenditure have several disadvantages. First, companies, in particular small companies, may generate technological advances outside formal R&D laboratories which R&D expenditure may not capture (OECD, 2009). Second, there is evidence that small-scale and often informal R&D tends to be undercounted in R&D surveys and that the quantity of R&D measured in small companies may be quite sensitive to questionnaire design (Kleinknecht et al., 1991). Third, R&D covers a wide variety of activities, ranging from far from the market basic research, via applied research up to development. Fourth, companies can use their innovative resources with varying degrees of efficiency (Brouwer & Kleinknecht, 1996). Fifth, simply spending money does not automatically lead to market success. Therefore the validity of this figure as a key performance indicator on innovation should be questioned. Efficient usage of R&D expenditure can only be achieved by reducing the failure rate (see Box 1).

The last but not least approach is to follow **economic metrics**. All kinds of innovation are implemented on the basis of projects where the expected effectiveness is evaluated based on forecasts of the volume of sales and profits at an assumed price and cost. With these data available, which, however, are very difficult to determine, the company can carry out an evaluation using any proven method. The evaluation of innovation performance must be based on reality where sales generated from products that have been subject to innovations are separated from overall sales. This makes it possible to determine the proportion of innovated products of sales, the amount of operating profit and to look at their trends. Such simply and demonstrably obtained facts are difficult to question and can be used to counter any irrational demands of innovators.

Unlike most of the previous studies on innovation, in this study we not only measure innovation through R&D expenditure, patents or implemented innovations. There are several well-known limitations for these measurement (Brouwer & Kleinknecht, 1996; Griliches, 1990; Patel & Pavitt, 1995). The importance of other dimensions of innovation, such as managerial or organisational change, investment in design or skills and management of the innovation process itself is increasingly acknowledged (OECD, 2009). Therefore the thesis deals with economic indicators.

In additional scientific studies examining the relationship between the degree of novelty and economic benefits have given rise to contradictory results. Substantial evidence exists that the innovation process and resulting innovation outputs are important determinants of company performance, indicating that innovators outperform non-innovating companies (Baldwin & Gellatly, 2003; Calabrese et al., 2013; Goudis et al., 2003; Hoffman et al., 1998; Klomp & van Leeuwen, 2001; Mansury & Love, 2008; Prajogo, 2006;

Roper et al., 2002). The professional literature provides the following impacts of innovation on company performance:

- Positive correlation (Gatignon & Xuereb, 1997; Gronum et al., 2012; Guo et al., 2005; Li & Atuahene-Gima, 2001; López-Nicolás & Meroño-Cerdán, 2011; Pittaway et al., 2004; Rosenbusch et al., 2011; Song & Montoya-Weiss, 1998; van Wijk et al., 2008; Zhou et al., 2005; Zhou, 2006; Zirger, 1997).
- Negative correlation (Ali, 2000; Atuahene-Gima, 1996; Danneels & Kleinschmidt, 2001; McGee et al., 1995; Meyer & Roberts, 1986; Min et al., 2006; Vermeulen et al., 2005; Zirger & Maidique, 1990).
- U-shaped correlation (Avlonitis et al., 2001; Kleinschmidt & Cooper, 1991; Li & Atuahene-Gima, 2001).
- No clear correlation (Birley & Westhead, 1990; Calantone et al., 1994; Cooper & Kleinschmidt, 1993; Henard & Szymanski, 2001; Heunks, 1998).

3.6 Innovation Performance

The term **innovation performance** is defined on the basis of the above. The relationship between the definition of innovation and innovation performance is how fast and how well ideas are implemented and how much value is created. Hence, innovation performance is understood as the ability to transform innovation inputs into outputs, i.e. the ability to transform the potential of innovations into market implementation. Thus the innovation performance of a firm is the degree to which it has achieved its innovation potential (Žižlavský, 2011).

It can be measured by the number of implemented innovations depending on their importance for the competitive ability of the company, the number of patents obtained or through economic indicators.

All kinds of innovation are implemented in practise on the basis of (investment) projects. Then the process of examining the effectiveness of innovative activities is also likely to have much in common with the measurement of the effectiveness of investments

(Erner & Presse, 2010; Gailly, 2011; Huang et al., 2004; Mensch, 2002; Thomaschewski & Tarlatt, 2010). Considerable amounts are expended in this process which can bring the required effect only after some time (e.g. Mensch, 2002; Patterson, 2009). With these data available, which however are very difficult to determine, the company can carry out an evaluation using any proven method[2].

The evaluation of innovation performance must be based on reality where sales generated from products that have been subject to innovations are separated from overall sales. This makes it possible to determine the proportion of innovated products of sales, the amount of operating profit and to look at its trends. Such simply and demonstrably obtained facts are difficult to question and can be used to counter any irrational demands of innovators.

2 These can include traditional purely financial tools mainly focused on outputs, for example the profitability of the investment, payback period, break even time (BET), return on product development expenses (RoPDE), net present value (NPV) method, internal rate of return (IRR) method, economic value added (EVA) method, etc.

4 PERFORMANCE MEASUREMENT OF INNOVATION MATTERS

As stated in previous chapters of this thesis, innovation is generally considered a major cause of a company's performance growth. In addition the examination of the impact of innovation on a company's survival has shown that the ability to innovate increases survival probabilities for all companies across most manufacturing sectors (Cefis & Ciccarelli, 2005).

However it is not clear that innovation actually has a positive impact on a company's profits. Innovation may be considered as a largely random and unpredictable phenomenon (Brusoni et al., 2006). The relationship between innovation and performance (measured by R&D expenditure and return on assets) is a priori unclear and it is by no means clear that innovative activities really lead to higher returns at the microeconomic level. Furthermore a large part of all R&D expenditure may have no return at all and whether the innovations have a positive return on average is a matter that is not clear at the outset.

Therefore this chapter brings two case studies to shed light on the issue of why innovation performance measurement and management matters. The first case study focuses on European manufacturing industry in order to confirm *"Hypothesis 1: Innovations have an influence on company performance."* The second case study goes to Czech manufacturing industry to present the status quo in our country.

Many researchers are conducting studies to determine the degree to which innovations really improve a company's performance (Bae & Kim, 2003; Chauvin & Hirschey, 1993; Smith, 2006; Szewczyk et al., 1996; Youndt et al., 2004). Czarnitzki and Kraft (2010) have proved that innovation has a strong and robust impact on profitability. Therefore companies invest into innovation in order to maximize their individual profits.

There seems to be general agreement that the accounting definition of R&D is incredibly loose. It is also the case that output from various innovation processes may differ fundamentally. Research ranges, where the goal is to advance the state of the art, along a predetermined dimension (Marshall, 1980). More likely is that the R&D process is affected on the input side. Labour, capital, materials and energy are combined to produce knowledge.

In spite of the abundance of books and publications written over the past few years in the field of performance measurement, the problem of defining a rigorous model for measuring innovation and its impact on company financial performance has not yet been solved (Lazzarotti et al., 2011; Neely, 2005). Although some notable and interesting attempts have been recently published (Apergis et al., 2013; Carayannis & Provance, 2008; Smith, 2006; Tohumcu & Karasakal, 2010). The most typical indicator used is R&D expenditure (Gault, 2013; OECD, 2002; OECD, 2005).

In general we can understand R&D expenditure as expenses associated with the R&D of a company's goods or services. R&D expenditure is a type of operating expense that can be deducted as such on the business tax return. This type of expense is incurred in the process of finding and creating new products or services.

Box 3 R&D expenditure

Top performers in innovation are those companies that manage a persistent stream of innovations over a longer period of time. They often push the frontier and are considered innovation leaders in their industry. However, the balance between financial performance indicators and innovation-oriented investment projects needs to be mastered. Overstretched R&D budgets can be as bad as underinvestment in new product development.

Moreover, high development costs and long development periods characterize (at least radical) innovations. For example, the Motorola Company needed almost 15 years and US$ 150 million in order to achieve wide acceptance of the mobile phone. Corning Glas invested 10 years and US$ 100 million in the development of the fibre-optic-cable Gillette spent US$ 75 million to develop and launch a new safety razor. This list can easily be extended: an "innovative" cigarette needed about € 20 million, a new pharmaceutical about € 600 million, a new car model ranges at about € 1.5 billion and the Airbus A 380 approximately € 15 billion.

(Knott, 2008; 2009; Thomaschewski & Tarlatt, 2010)

R&D expenditure can be relatively minor, or can easily run into billions of dollars for large companies. R&D expenditure is usually highest for industrial, technological, healthcare and pharmaceutical companies. Some companies reinvest a significant portion of their profits back into innovation, as they see this as an investment in their continued growth.

World industrial R&D spending has reached a level of € 373 billion and is expected to grow continuously, in spite of the financial crisis and restructuring of the world economy after 2008 (Gerybadze, 2010).

4.1 Case study from European Manufacturing Industry

Since measuring performance and contribution of innovation to corporate performance has become a critical concern for managers and executives, this section illustrates a link between R&D expenditure and performance through a statistical model. The presumption whether and how innovation influences performance is tested. Therefore R&D expenditure (the independent variable) and other financial indicators of the company's performance (the dependent variables) are considered.

Dealing with R&D expenditure as an accounting item for which measurement under International Financial Reporting Standards (IFRS) are likely to differ considerably from measurements under domestic accounting systems across the EU countries prior to the mandatory introduction of the IFRS.

Here the most essential hypothesis of overall research project is considered – *"Hypothesis 1: Innovations have an influence on company performance."*

In order to test this hypothesis with data from European manufacturing companies the following research question is stated:

"Is there a relationship between performance (measured by return on assets) and R&D expenditure?"

From a theoretical point of view the goal of creating such a link is consistent with the data. The sample under our evaluation comprises 2,666 private companies active in the processing industry (NACE rev. 2 Main section C: Manufacturing) from the EU 28 countries in the period 2007 to 2012. The data was obtained from the Amadeus database provided to the company Bureau Van Dijk.

The performance of a company is measured by the return on assets indicator or in other words the EBIT and total assets (ROA) ratio. The reason we use ROA as a measure of performance is represented by the characteristics of this ratio. It allows the company financing strategy to be neutral with respect to performance (Ferrari & La Rocca, 2010) and comparison among companies in the sample to be favoured.

As regards R&D expenditure this investigation takes into consideration the total amount of expenses on innovative activities reported in the Amadeus database according to the IFRS. The relative R&D expenditure has been defined in the following ways:

- R&D expenditure and sales ratio (RD/S) – expresses the proportion of R&D expenditure per unit of sales in the given year. In other words the relative amount of R&D expenditure where sales represent the size of the company.
- R&D expenditure and number of employees ratio (RD/Empl.) – expresses the proportion of R&D expenditure per employee in the given year.
- R&D expenditure and fixed assets ratio (RD/FA) – expresses the proportion of R&D expenditure per unit of fixed assets in the given year.
- Employee cost and R&D expenditure ratio (EC/RD) – expresses the proportion of employee cost per unit of R&D expenditure in the given year.
- EBIT and R&D expenditure ratio (EBIT/RD) – represents the profits (EBIT) per unit of R&D expenditure.
- Added value per R&D expenditure ratio (AV/RD) – represents the degree of covering R&D expenditure from added value.

Values beyond the interval (μ-3σ; μ+3σ) were removed from the sample of data under examination.

The analysis of the relationship between performance and R&D expenditure was carried out in two stages; in the first stage the correlation was examined between the ROA values for 2012 and the values of relative R&D expenditure in the years 2012–2007. To this end, Spearman's correlation coefficient was applied, particularly due to its non-parametric assumptions.

In the second stage a regression model was set up with only those variables (relatively defined R&D expenditure) that showed a statistically significant correlation with the 2012 ROA, at least at a 5% significance level. The purpose of the model is to determine to what degree the current performance (ROA) is influenced by past R&D expenditure.

It is assumed that there is a quadratic dependence between the performance of companies and R&D expenditure. The reason is that on the one hand growing R&D expenditure suggests an innovative activity which, if successful, leads to lower cost or higher revenues. On the other hand these costs decrease profits or EBIT regardless of whether the innovation is successful. In other words it is assumed that there is a theoretical value of relative R&D expenditure which maximizes current ROA. To describe this dependence we shall apply the following generalized model of linear regression.

4.1.1 Current Situation in European Manufacturing Industry

Table 2 shows the values of correlation between ROA in 2012 and the given relatively defined R&D expenditure in the period *(t-i)*. It is obvious that the R&D expenditure and sales ratio (RD/S) does not have a statistically significant effect in any manner, at the 5% significance level, the company performance values evaluated using ROA in any of the past periods under survey.

However a statistically significant relationship existed in the same year, 2012, although only at a 10% significance level. This can be explained by the fact that R&D expenditure reduces EBIT. The employee cost/R&D expenditure ratio or added value/ R&D expenditure ratio does not have a significant effect on the ROA values in 2012 at any standard significance level in any of the periods under survey.

In contrast, the R&D expenditure per employee (RD/Empl.) values in the same year, as well as in the previous year, have an effect on ROA in 2012 at a statistically significant level, namely 5%. However, the correlation values reported are relatively low.

Stronger correlations can be identified between the 2012 ROA and the R&D expenditure/fixed assets ratio defined for the years 2007 to 2012. In other words such relatively defined R&D expenditure has an effect on performance measured by the ROA relationship up to five years in advance.

The strongest correlation of all was identified between ROA in 2012 and the EBIT/R&D expenditure ratio defined for the years 2008 to 2012. In other words such a relatively defined R&D expenditure has an effect on performance measured by the ROA relationship up to four years in advance.

Table 2 Values of Spearman's correlation coefficient between ROA in 2012 and the given relative R&D expenditure in the given period

	No.	Spearman	t (N-2)	p-value		No.	Spearman	t(N-2)	p-value
RD/S_12*	143	0.1447	1.7370	0.084572	EC/RD_12	297	-0.0761	-1.3109	0.190923
RD/S_11	147	0.1282	1.5571	0.12162	EC/RD_11	292	-0.0368	-0.6265	0.531455
RD/S_10	146	0.1193	1.4418	0.151528	EC/RD_10	288	-0.0331	-0.5607	0.57542
RD/S_09	147	0.1097	1.3296	0.185747	EC/RD_09	153	-0.0533	-0.6556	0.513102
RD/S_08	146	0.1127	1.3612	0.175572	EC/RD_08	27	0.1319	0.6652	0.512045
RD/S_07	154	0.1028	1.2747	0.204358	EC/RD_07	24	0.1670	0.7942	0.435538
RD/ Empl_12**	419	0.1493	3.0841	0.002177	EBIT/ RD_12***	368	0.6011	14.3894	0.000000
RD/ Empl_11**	412	0.1072	2.1838	0.029542	EBIT/ RD_11***	365	0.3757	7.7243	0.000000
RD/Empl_10	411	0.0725	1.4697	0.142417	EBIT/ RD_10***	356	0.3142	6.2274	0.000000
RD/Empl_09	276	0.0834	1.3857	0.166977	EBIT/ RD_09***	221	0.2786	4.2921	0.000027
RD/ Empl_08*	146	0.1379	1.6705	0.096999	EBIT/ RD_08***	99	0.3784	4.0259	0.000113
RD/Empl_07	154	0.1213	1.5065	0.134021	EBIT/RD_07*	106	0.1724	1.7853	0.077127
RD/FA_12***	422	0.1940	4.0528	0.000060	AV/RD_12	259	0.0312	0.5002	0.617335
RD/FA_11***	419	0.1761	3.6539	0.000291	AV/RD_11	254	0.0059	0.0931	0.925908
RD/FA_10***	404	0.1577	3.2017	0.001475	AV/RD_10	252	0.0069	0.1095	0.912896
RD/FA_09***	274	0.1730	2.8969	0.004076	AV/RD_09	135	-0.0609	-0.7037	0.482878
RD/FA_08**	147	0.1647	2.0111	0.046166	AV/RD_08	22	0.0322	0.1440	0.886933
RD/FA_07**	155	0.1652	2.0714	0.040003	AV/RD_07*	15	0.4857	2.0035	0.066426

Note: *significant at a 10% level, **significant at a 5% level, ***significant at a 1% level

Indicators that show a statistically significant correlation to ROA, at least at a 5% significance level, were used to set up a model or as an independent model variable in the Equation 1. These indicators were RD/FA and EBIT/RD defined for the years 2008 to

2012. The role of dependent variable is given to the ROA indicator defined for 2012. The following Table 3 shows the descriptive statistics of these variables.

Table 3 Descriptive statistics of ROA indicators (2012), RD/FA (2012-2008), EBIT/RD (2012-2008)

Variable	N.	Mean	Min.	Max	quant. (25%)	quant. (50%)	quant. (75%)	quant. (90%)	quant. (95%)	std.dev
ROA_12	2579	0.078	-0.541	0.711	0.023	0.068	0.126	0.207	0.262	0.1124
RD/ FA_12	424	0.196	0.000	2.296	0.008	0.043	0.197	0.663	0.960	0.3589
RD/ FA_11	421	0.202	0.000	2.389	0.008	0.044	0.184	0.606	0.957	0.3821
RD/ FA_10	406	0.154	0.000	1.578	0.011	0.047	0.169	0.475	0.711	0.2592
RD/ FA_09	275	0.154	0.000	1.719	0.004	0.043	0.165	0.466	0.716	0.2700
RD/ FA_08	148	0.165	0.000	1.362	0.000	0.043	0.221	0.491	0.755	0.2611
EBIT/ RD_12	370	10.419	-143.333	158.276	0.544	3.561	11.459	33.890	65.729	28.2159
EBIT/ RD_11	367	12.494	-157.118	202.778	0.863	3.286	13.018	42.750	61.333	33.5472
EBIT/ RD_10	359	9.107	-55.430	113.394	0.700	3.586	10.793	26.438	47.037	18.2143
EBIT/ RD_09	222	5.847	-90.114	127.641	-0.462	1.761	7.121	16.457	29.725	20.8587
EBIT/ RD_08	100	4.838	-20.524	46.810	0.417	2.374	6.410	13.933	23.291	9.2822

The model for these applied variables can be transformed into the following formula:

$$ROA_t = \alpha_{t-1} + \beta X_{t-1} + \gamma X_{t-1}^2 + \varepsilon = \alpha_{t-1} + \beta_1 x_{1(t-1)} + \beta_2 x_{2(t-1)} + \gamma_1 x_{1(t-1)}^2 + \gamma_2 x_{2(t-1)}^2 + \ldots$$
$$+ \beta_n x_{n(t-1)} + \gamma_n x_{n(t-1)}^2 + \varepsilon$$

Equation 1

Assuming that the parameters (γ_1, β_1, γ_2, β_2) are statistically significant in the given model, it is reasonable to look for the values of the indicators RD/FA_{t-i} or $EBIT/RD_{t-i}$ that maximize the ROA_t values. These values can be found when placing the first partial derivative of the ROA_t function under RD/FA or EBIT/RD at equal to zero, as follows:

$$\frac{dROA_t}{d(RD/FA)_{t-1}} = \beta_1 + 2\gamma_1 (RD/FA)_{t-1} = 0$$

Equation 2

Then the RD/FA$_{t-i}$ value maximizing ROA$_t$

$$\beta_1 + 2\gamma_1 (RD/FA)_{t-1} = 0 \rightarrow (RD/FA)_{t-1} = -\frac{\beta_1}{2\gamma_1}$$

Equation 3

This value will maximize ROA$_t$ if $\gamma_1 < 0$.

Or

$$\frac{dROA_t}{d(EBIT/RD)_{t-1}} = \beta_2 + 2\gamma_2 (EBIT/RD)_{t-1} = 0$$

Equation 4

Then the EBIT/RD$_{t-i}$ value maximizing ROA$_t$

$$\beta_2 + 2\gamma_2 (EBIT/RD)_{t-1} = 0 \rightarrow (EBIT/RD)_{t-1} = -\frac{\beta_2}{2\gamma_2}$$

Equation 5

This value will maximize ROA$_t$ if $\gamma_2 < 0$.

4.1.2 Regression Model Set-up

A total of five models were set up depending on the time span between the independent variables and the dependent variable. The first model, referred to as Model 12, explains the ROA values in 2012 using the values of the RD/FA and EBIT/RD variables defined in 2012. The second model, referred to as Model 11, explains the ROA values in 2012 using the values of the RD/FA and EBIT/RD variables defined in 2011. Analogously, only the last, fifth model (Model 08) explains the ROA values in 2012 using the values of the RD/FA and EBIT/RD variables defined in 2008. All the thus-created models are, as a whole, statistically significant at a 1% level (see Table 4).

Table 4 Overall characteristics of the models set up

	Model 12	Model 11	Model 10	Model 09	Model 08
Multiple R	0.4124	0.3305	0.3162	0.2648	0.3761
Multiple R^2	0.1701	0.1092	0.1000	0.0701	0.1415
Adjust R^2	0.1608	0.0991	0.0893	0.0527	0.1046
F-stat.	18.2937	10.8229	9.3889	4.0160	3.8318
p-value	0.000000	0.000000	0.000000	0.003671	0.006292
Std. Error	0.12642	0.13220	0.13383	0.14389	0.15582

The values of the multiple R^2 in the individual models vary from 7.01 to 17.01%; in other words the models can explain from 7.01 to 17.01% of ROA values using the values of relative R&D expenditure with various time spans. The following Table 5 provides details of the individual models. The parameters of these models are distinguished in the same way as the models themselves, e.g. EBIT/RD_12 is a variable of Model 12, EBIT/RD_11 a variable of Model 11, etc.

Table 5 Details of individual models

Variable	Param.	t-stat.	p-value	Variable	Param.	t-stat.	p-value
Constant_12***	0.040800	4.2183	0.000031	Constant_09***	0.050716	3.4954	0.000576
EBIT/RD_12***	0.001951	7.4900	0.000000	RD/FA_09**	0.215699	2.4795	0.013931
RD/FA_12***	0.222569	4.7733	0.000003	EBIT/RD_09***	0.001767	2.6411	0.008876
EBIT/RD2_12*	-0.000004	-1.8619	0.063434	RD/FA2_09	-0.10116	-1.5014	0.134738
RD/FA2_12***	-0.107245	-3.7203	0.000231	EBIT/RD2_09*	-1.2E-05	-1.6611	0.098168
Constant_11***	0.051003	5.0696	0.000001	Constant_08	0.012942	0.4326	0.666323
RD/FA_11***	0.190982	4.0820	0.000055	EBIT/RD_08**	0.0074	2.4574	0.015848
EBIT/RD_11***	0.001451	5.4218	0.000000	RD/FA_08**	0.425819	2.6103	0.010545
RD/FA2_11***	-0.08504	-3.2782	0.001149	EBIT/RD2_08	-7.8E-05	-0.9161	0.361997
EBIT/RD2_11***	-0.000006	-3.5363	0.000460	RD/FA2_08*	-0.28002	-1.8984	0.060744
Constant_10***	0.037308	3.1892	0.001560				
RD/FA_10***	0.229331	3.2004	0.001503				
EBIT/RD_10***	0.003511	4.9684	0.000001				
RD/FA2_10 **	-0.121305	-1.9701	0.049644				
EBIT/RD2_10***	-0.000026	-2.7965	0.005462				

Note: *significant at a 10% level, **significant at a 5% level, ***significant at a 1% level

The parameter for the RD/FA variable, i.e. parameter β_1 (see Equation 1), is statistically significant at a 1% level in Models 12, 11 and 10, and at a 5% level in Models 09 and 08.

The parameter for the RD/FA^2 variable, i.e. parameter γ_1 (see Equation 1), is statistically significant at a 1% level in Models 12 and 11, at a 5% level in Model 10, at a 10% level in Model 08 and is not statistically significant at any standard level of significance in Model 09.

The parameter for the EBIT/RD variable, i.e. parameter β_2 (see Equation 1), is statistically significant at a 1% level in models with the exception of Model 08 where it is significant only at the 5% level.

The parameter for the EBIT/RD² variable, i.e. the γ_2 parameter (see Equation 1), is statistically significant at a 1% level in Models 11 and 10, at a 10% level in Models 12 and 09, and it is not statistically significant at any standard level of significance in Model 08.

The constant, i.e. parameter α_{t-i}, is statistically significant at a 1% level in all models, except for Model 08 where it is not statistically significant at any standard level of significance. The value of the constant varies from 16.51 to 65.05% of the average ROA value in the sample.

4.1.3 Theoretical Values of ROA: Maximizing R&D Expenditure

Using Equation 3 and Equation 5, it is possible to deduce the theoretical values of RD/FA_{t-i} and EBIT/RD_{t-i} that result in maximization of the ROA_t value. They can provide a theoretical maximum value of ROA_t corresponding to these indicators RD/FA_{t-i} and EBIT/RD_{t-1} (see Table 6).

Table 6 Theoretical values of ROA-maximizing EBIT/RD and RD/FA under evaluation.

Variable	Value	Variable	Value	ROA**
EBIT/RD_12	243.8	RD/FA_12	1.04	0.3942
EBIT/RD_11	120.9	RD/FA_11	1.12	0.2460
EBIT/RD_10	67.52	RD/FA_10	0.95	0.2642
EBIT/RD_09	73.63	RD/FA_09	1.07*	0.2307
EBIT/RD_08	47.44	RD/FA_08	0.76*	0.3503

*calculated using parameters that were not statistically significant, **theoretical values of ROA_t in application of ROA maximizing EBIT/RD and RD/FA

The actual value of ROA in 2012 ranged from 0.541 to 0.711. The median value was 0.0681. Only the top 10, resp. 5% of the surveyed companies, reached values higher than 0.207, resp. 0.262.

Under optimal R&D expenditure (measured by EBIT/RD and RD/FA), it is theoretically possible to achieve ROA values in the range of 0.230 to 0.394. However, it should be noted that further growth in R&D expenditure would have led to a decrease in ROA.

A comparison of the actual and theoretical values shows that there are companies (approximately 5% of companies in our sample) that take advantage of this potential. Their

R&D expenditure are, in terms of the impact on ROA, optimal. The remaining 95% of the companies are below this theoretical limit.

4.1.4 Assessment of the Current Situation and Possible Development Trends

The performance of a company is influenced by a wide range of factors, including innovation activity. One of the methods of its evaluation is to use the expenses spent on that activity in the period in question. Innovation intensity can be evaluated by relating these expenses to some other variable. The potential benefits of innovation activity can be expected particularly in future periods.

Most previous studies (e.g. Bae & Kim, 2003; Smith, 2006; Zhu & Huang, 2012) utilized for the evaluation of the relationship between R&D expenditure and company performance show a linear relationship. In other words they are based on an assumption that higher R&D expenditure leads to higher performance. They have proved that innovation (measured by R&D expenditure) is consistent within a company from one year to another. They can be applied in planning within their own company. Moreover they can be used to analyse and predict the innovation levels of competitors.

Ferrari and La Rocca (2010) found a relationship between performance (measured by ROA) and types of innovation and industry structure. Through the linear model they proved that Pavitt's taxonomy (Pavitt, 1984) and the different typologies of innovation are capable of influencing ROA.

In this section the results of an empirical study on the effects of R&D expenditure on a company's performance are presented. This research extends previous studies by using a quadratic dependence that allows the derivation of optimal R&D expenditure, which maximize performance on the ROA level. The representative sample of European manufacturing companies contains mostly medium and large-sized companies.

In general by comparison of the actual and theoretical values it has been found that more than 95% of companies do not fully exploit their innovation potential to increase performance.

In particular, the research performed examined the effect of R&D expenditure in the period 2007 to 2012 on the values of the return on assets (ROA) of companies for the year 2012. It was ascertained that a statistically significant correlation can be found between the values of R&D expenditure/fixed assets ratio, or EBIT/R&D expenditure, defined in the period 2007 to 2012 and the return on assets value for 2012.

The fact that the current return on assets (ROA 2012) in the period 2012 to 2010 can be described using quadratic dependence where the coefficients in the quadratic member (see γ_1 and γ_2) are statistically significant and the negative values suggest that there are R&D expenditure degrees that maximize this current ROA value. Thus the assumption that there is a R&D expenditure degree which optimally contributes to performance was confirmed for the above period. In other words in the period concerned there is an optimum degree of R&D expenditure definable for up to two years back (i.e. back to 2010). Lower R&D expenditure values (compared with the optimum value) represent a reserve in increase in the performance of the company, while higher R&D expenditure values decrease this performance and it would be appropriate to reduce them.

Only the coefficients of those linear members of the models (see the β_1 and β_2 coefficients) that have positive values are statistically significant in the period 2009 to 2008. This can be interpreted in that the R&D expenditure values in a period dating three to five years back only increase the current performance while higher R&D expenditure values do not decrease current performance in the same period.

A statistically significant constant also exists in all the models, which can be interpreted in that the relevant part of the current ROA under examination (16.51 to 65.05% of the average value from 2012) can be attributed to other factors.

Although theoretical models for innovative activities performance measurement have been set, these models represent just one managerial tool and they should be combined with other techniques to contribute to optimal decision making. Moreover, innovation performance cannot be based solely on growth in R&D spending however. Reliable evaluations of corporate innovation performance need to take the following into account:

- Long-term and stable investments into the most promising innovation projects.
- The build-up of unique pools of knowledge and strong patent positions.
- Stable and above-average growth in revenues.
- High percentage shares of new products (introduced during the last five years).
- Growing market shares and above-average profit margins.
- Considerable increases in market capitalization (Gerybadze, 2010).

4.2 Case Study from Czech Manufacturing Industry

4.2.1 Case Study Background

How much money should companies invest in innovation? The answer is crucial also for owners of any innovative company interested in productivity and effectiveness. The total of such investments varies between companies, industries and owners and their attitude to innovation. Therefore, this section builds on the fourth approach to innovation performance measurement, i.e. R&D expenditure (see Section 3.5). It utilizes company--specific time-series data to study differences in R&D expenditure structure depending on company ownership.

In particular this section uses direct information from innovation surveys about a companies' innovation, R&D expenditure, number of R&D employees, financial resources, etc. conducted annually by the Czech Statistical Office (CZSO). CZSO monitors the characteristics of R&D using a VTR 5-01 direct statistical survey (see Section 2.4). CZSO provides data with the following structure:

- Basic research/applied research/experimental development
- For-profit sector/non-profit sector/governmental sector/universities
- Size of organisation according to Recommendation of the European Commission 2003/361/EC of 6 May 2003 (EC, 2003, p. 36). This standard established four groups: micro, small, medium and large company.

In this section we look at applied research in the for-profit sector since this approach is close to the innovation definition according the Oslo Manual (OECD, 2005) and manufacturing industry, which is generally considered the most significant and largest industry in the Czech Republic. This allowed a sufficient number of companies to be encompassed in the study.

Out of this target population secondary research focuses on medium and large companies (>50 employees) because they are considered innovation leaders, both in the Czech Republic (CZSO, 2014) and globally (OECD, 2009). This presumption is based on the Schumpeterian hypothesis, which generally asserts a positive link between company size and innovative activity.

Table 7 R&D expenditure structure

Item			Shortcut
R&D expenditure in total			RDE
Current expenditure (non-investment expenditure)			CE
There	Labour expenses including social and heal insurance		LE
	Contracts of services		CS
	Sundry non-investment expenses spent on R&D support (material, energy, equipment etc.)		SNE
Investment expenditure			IE
There	Long-standing intangible assets		LIA
	There	Activation of own R&D outcomes	AC
		Software	SW
		Other Long-standing intangible assets	OL
	L&B (land and buildings)		LB
	Other long-standing tangible assets (machines, equipment, facilities etc.)		OLSTA

The period taken into consideration is from 2007 to 2013 so as to examine the effect of the economic crisis on R&D expenditure in Czech manufacturing industry. The research sample consists of manufacturing companies with domestic Czech owners (550 subjects) as well as with foreign owners (332 subjects). R&D expenditure is examined in the above structure (see Table 7).

Considering the above-mentioned factors and the micro level of measurement, the following research hypothesis is defined.

"Hypothesis 2: Innovations are mainly performed by companies controlled by a foreign owner (or with foreign participation)."

The null fragmental hypothesis FH0 is going to be tested that random values are not dependent in comparison with the alternative fragmental hypothesis FH1.

FH0: The share of non-investment expenditure is higher in companies controlled by a domestic owner than in those controlled by a foreign owner.

FH1: The share of non-investment expenditure is the same or even lower in companies controlled by a domestic owner than in companies controlled by a foreign one.

4.2.2 Current Situation in Czech Manufacturing Industry

In 2011 the Czech economy's growth gradually slowed for each quarter both year-on-year and between quarters. On examining the figures between quarters it is clear that the move from positive to negative figures (GDP drop) actually occurred earlier than in the EU economy. One of the reasons for this was the government cuts in expenditure on final consumption in the Czech Republic, which was one of the steepest drops in the European Union in 2011. Furthermore, against a continued growth in investment reported by the EU27, the Czech Republic recorded a fall. Corrected real annual GDP growth in 2011 was 1.8% compared to 2.5% in 2010. This fall during the year was gentle, similar to that in the EU economy. In comparison the year-on-year drop in GDP in the Czech Republic was more significant in the second half of the year (CZSO, 2014).

The year 2012 was already for the Czech Republic a year of recession, with GDP falling by 1.0%. Not only was there a continued fall in government expenditure on final consumption but in that year there was also a significant drop in household expenditure on final consumption (in real terms by 2.1%). As a result of the fall in demand for example industrial production fell at an annual rate of 1.2%. Building production had been falling already from 2009. The most recent preliminary data shows that there was not an improvement in the state of the economy even in 2013 (CZSO, 2014).

Against these trends companies' expenditure on R&D are quite the opposite. In a crisis period it is especially important for companies to persuade customers to purchase specifically from them. Therefore, according to several theories, companies should invest in R&D above all in a period of crisis. Actual data for the Czech Republic does not conflict with these theories. In the years from 2009 to 2012 expenditure on R&D on average rose by 9% each year. In comparison between 2007 and 2009 companies' average R&D expenditure fell on average at an annual rate of 7%. This decrease was caused by coming economic crisis; with the rapid decline in sales and revenues, many companies scaled back or closed down offices. As a result, many executives cut R&D investment during the difficult economic conditions to maintain short-term earnings growth (CZSO, 2014).

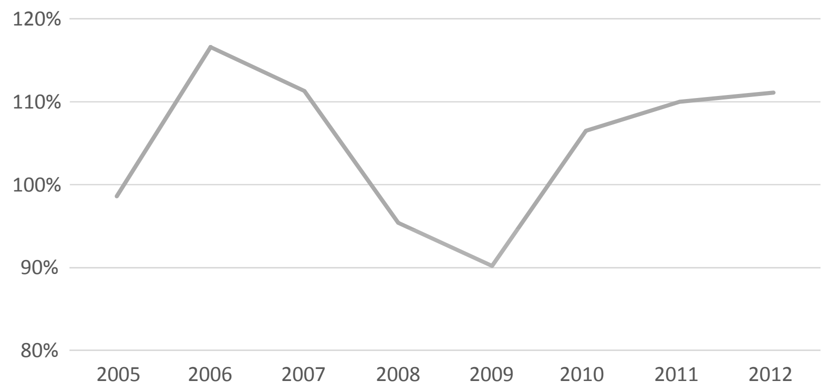

Figure 4 The R&D expenditure yoy index 2005–2012 (CZSO, 2014, p. 12-13)

The following tables show the basic descriptive statistics of the research sample. Table 8 shows only the shares of non-investment expenditure. For the purposes of differentiation between types of owner of the companies the following abbreviations are used: *(F)* denotes companies controlled by a foreign owner, *(D)* denotes companies controlled by a domestic owner.

We can see that the share of Current Expenditure (CE) ranges from 9.15% (in 2007) to 94.38% (in 2013) of all R&D expenditure in companies controlled by a domestic owner. The same share, but in companies controlled by a foreign owner, ranges from 6.26% (in 2007) to 93.49% (in 2013).

Moreover the mean share of Current Expenditure realized by companies controlled by a domestic owner is higher during the analysed period, with the exception of the years 2007 and 2011, than the mentioned share of current expenditures realized by companies controlled by a foreign owner. The difference between the mean values ranges from 2.89pp (in 2007) to 3.18pp (in 2013).

Table 8 Descriptive statistics of the sample – non-investment R&D expenditure

	n (D)	n (F)	Mean (D)	Mean (F)	Std. Dev. (D)	Std. Dev. (F)		n (D)	n (F)	Mean (D)	Mean (F)	Std. Dev. (D)	Std. Dev. (F)
CE 13	550	332	0.9438	0.9119	0.1514	0.1920	CS 13	550	332	0.0110	0.0049	0.0628	0.0280
CE 12	519	320	0.9269	0.9109	0.1909	0.1882	CS 12	519	320	0.0083	0.0042	0.0432	0.0358
CE 11	513	314	0.9270	0.9273	0.1901	0.1711	CS 11	513	314	0.0102	0.0063	0.0593	0.0380
CE 10	495	302	0.9389	0.9349	0.1629	0.1563	CS 10	495	302	0.0124	0.0037	0.0740	0.0168
CE 09	424	323	0.0994	0.0932	0.2887	0.2752	CS 09	424	323	0.1545	0.1963	0.3241	0.3637
CE 08	441	293	0.0951	0.1079	0.2817	0.2962	CS 08	441	293	0.2239	0.2669	0.3847	0.4093
CE 07	490	223	0.0915	0.0626	0.2781	0.2269	CS 07	490	223	0.1928	0.2433	0.3657	0.3906
LE 13	550	332	0.5983	0.5845	0.2565	0.2405	SNE 13	550	332	0.3345	0.3225	0.2458	0.2180
LE 12	519	320	0.5658	0.5823	0.2699	0.2415	SNE 12	519	320	0.3528	0.3243	0.2602	0.2227
LE 11	513	314	0.5782	0.5765	0.2694	0.2487	SNE 11	513	314	0.3386	0.3446	0.2567	0.2349
LE 10	495	302	0.5783	0.5754	0.2609	0.2490	SNE 10	495	302	0.3482	0.3558	0.2520	0.2413
LE 09	424	323	0.1657	0.2064	0.3395	0.3759	SNE 09	424	323	0.7349	0.7004	0.4135	0.4326
LE 08	441	293	0.2344	0.2796	0.3972	0.4233	SNE 08	441	293	0.6705	0.6125	0.4469	0.4625
LE 07	490	223	0.2002	0.2655	0.3770	0.4148	SNE 07	490	223	0.7083	0.6719	0.4360	0.4405

The components of Current Expenditure are going to be analysed. First, the share of labour expenses. We can see that the share of Labour Expenses (LE) ranges from 16.57% (in 2009) to 59.83% (in 2013) of all R&D expenditure in companies controlled by a domestic owner. The same share, but in companies controlled by a foreign owner ranges from 20.64% (in 2009) till 58.45% (in 2013).

When speaking of differences in mean values of these shares, we can see that the mean share of labour expenses realized by companies controlled by a domestic owner is higher than in companies controlled by a foreign owner in the years 2013, 2011 and 2010. In the years 2007, 2008, 2009 and 2012 is the situation is the reverse. The difference between the mean values ranges from -6.53pp (in 2007) to 1.38pp (in 2013).

The mean values of shares of expenditure spent on Contracts of Services (CS) ranges in the examined period from 0.83% (in 2012) to 22.39% (in 2008) of all R&D expenditure in companies controlled by a domestic owner. The same share, but in companies controlled by a foreign owner ranges from 0.37% (in 2010) to 26.69% (in 2008). The mean share of expenditure spent on Contracts of Services by companies controlled by a domestic owner is higher than in companies controlled by a foreign owner in the period from 2010 to 2013. In the period from 2007 to 2009 the situation is the opposite. The difference between the mean values ranges from -5.05pp (in 2007) to 0.87pp (in 2010).

The mean values of shares of expenditure spent on Sundry Non-investment Expenses spent on R&D support (material, energy, equipment, etc.), i.e. (SNE) ranges in the examined period from 33.45% (in 2013) to 73.49% (in 2009) of all R&D expenditure in companies controlled by a domestic owner. The same share, but in companies controlled by a foreign owner ranges from 32.25% (in 2013) to 70.04% (in 2009). The mean shares of expenditure spent on Sundry Non-investment Expenses spent on R&D support (material, energy, equipment, etc.) realized by companies controlled by a domestic owner is higher during the analysed period, with the exception of the years 2010 and 2011, than the mentioned share of SNE realized by companies controlled by a foreign owner. The difference between the mean values ranges from -0.75pp (in 2010) to 5.8pp (in 2008).

Table 9 shows shares of investment expenditure in the same notation as the previous table, i.e. *(F)* denotes companies controlled by a foreign owner, *(D)* denotes companies controlled by a domestic owner.

We can see that the share of Investment Expenditure (IE) ranges from 0.5% (in 2011) to 1.49% (in 2007) of all R&D expenditure in companies controlled by a domestic owner. The same share, but in companies controlled by a foreign owner, ranges from 0.49% (in 2013) to 1.86% (in 2008). Moreover, the mean share of R&D Outcomes Activation realized by companies controlled by a domestic owner is higher in the years 2008, 2011 and 2012 than the mentioned share of Current Expenditure realized by companies controlled by a foreign owner. The difference between the mean values ranges from -0.54pp (in 2008) to 0.50pp (in 2007).

Table 9 Descriptive statistics of the sample – investment R&D expenditure

	n (D)	n (F)	Mean (D)	Mean (F)	Std. Dev. (D)	Std. Dev. (F)		n (D)	n (F)	Mean (D)	Mean (F)	Std. Dev. (D)	Std. Dev. (F)
IE 13	550	332	0.0562	0.0881	0.1514	0.1920	OL 13	550	332	0.0044	0.0083	0.0373	0.0665
IE 12	519	320	0.0731	0.0891	0.1909	0.1882	OL 12	519	320	0.0043	0.0108	0.0356	0.0803
IE 11	513	314	0.0730	0.0727	0.1901	0.1711	OL 11	513	314	0.0033	0.0063	0.0259	0.0658
IE 10	495	302	0.0611	0.0651	0.1629	0.1563	OL 10	495	302	0.0068	0.0066	0.0407	0.0627
IE 09	424	323	0.6984	0.6680	0.4115	0.4264	OL 09	424	323	0.0140	0.0219	0.1033	0.1241
IE 08	441	293	0.6291	0.5727	0.4392	0.4506	OL 08	441	293	0.0165	0.0137	0.1113	0.1009
IE 07	490	223	0.6691	0.6096	0.4284	0.4206	OL 07	490	223	0.0105	0.0164	0.0858	0.1157
AC13	550	332	0.0067	0.0049	0.0469	0.0454	LB 13	550	332	0.0096	0.0063	0.0640	0.0495
AC12	519	320	0.0067	0.0083	0.0453	0.0724	LB 12	519	320	0.0116	0.0093	0.0844	0.0590
AC11	513	314	0.0050	0.0058	0.0364	0.0557	LB 11	513	314	0.0059	0.0022	0.0526	0.0133
AC10	495	302	0.0078	0.0060	0.0595	0.0555	LB 10	495	302	0.0057	0.0049	0.0477	0.0374
AC09	424	323	0.0150	0.0145	0.1176	0.1147	LB 09	424	323	0.0103	0.0044	0.0630	0.0422
AC08	441	293	0.0132	0.0186	0.1106	0.1276	LB 08	441	293	0.0083	0.0040	0.0582	0.0432
AC07	490	223	0.0156	0.0105	0.1157	0.0897	LB 07	490	223	0.0067	0.0024	0.0520	0.0346
SW 13	550	332	0.0078	0.0066	0.0408	0.0326	OLSTA 13	550	332	0.0278	0.0620	0.1009	0.1568
SW 12	519	320	0.0082	0.0058	0.0514	0.0239	OLSTA 12	519	320	0.0423	0.0549	0.1418	0.1341
SW 11	513	314	0.0073	0.0071	0.0322	0.0363	OLSTA 11	513	314	0.0515	0.0513	0.1628	0.1406
SW 10	495	302	0.0072	0.0056	0.0341	0.0236	OLSTA 10	495	302	0.0336	0.0421	0.1207	0.1199
SW 09	424	323	0.0051	0.0065	0.0496	0.0729	OLSTA 09	424	323	0.0064	0.0078	0.0516	0.0490
SW 08	441	293	0.0069	0.0024	0.0674	0.0224	OLSTA 08	441	293	0.0039	0.0041	0.0389	0.0383
SW 07	490	223	0.0022	0.0012	0.0229	0.0123	OLSTA 07	490	223	0.0031	0.0061	0.0290	0.0470

Now let's analyse the components of investment expenditure. First, the share R&D Outcomes Activation. We can see that the mean share of R&D Outcomes Activation (AC) ranges from 0.5% (in 2011) to 1.49% (in 2007) of all R&D expenditure in companies controlled by a domestic owner. The same share, but in companies controlled by a foreign owner, ranges from 0.49% (in 2013) to 1.86% (in 2008). Moreover the mean share of R&D Outcome Activation realized by companies controlled by a domestic owner is higher in the years 2008, 2011 and 2012 than the mentioned share of Current Expenditure realized by companies controlled by a foreign owner. The difference between the mean values ranges from -0.54pp (in 2008) to 0.50pp (in 2007).

The mean values of shares of expenditure spent on Software (SW) ranges in the examined period from 0.22% (in 2007) to 0.82% (in 2012) of all R&D expenditure in the companies controlled by a domestic owner. The same share, but in companies controlled by a foreign owner, ranges from 0.12% (in 2007) to 0.71% (in 2011). The mean share of expenditure on Software by companies controlled by a domestic owner is higher than in companies controlled by a foreign owner in the analysed period with the exception of 2009. The difference between the mean values ranges from -0.14pp (in 2009) to 0.45pp (in 2008).

The mean values of shares of expenditure spent on Other Long-standing Intangible Assets (OL) spent on R&D ranges in the examined period from 0.33% (in 2011) to 1.65% (in 2008) of all R&D expenditure in companies controlled by a domestic owner. The same share, but in companies controlled by a foreign owner, ranges from 0.63% (in 2011) to 2.19% (in 2009). The mean shares of Other Long-standing Intangible Assets expenses spent on innovations realized by companies controlled by a domestic owner is higher only in the years 2008 and 2010 than the mentioned share of OL realized by companies controlled by a foreign owner. The difference between the mean values ranges from -0.79pp (in 2009) to 0.29pp (in 2009).

The mean values of shares of expenditure on land and Buildings (LB) spent on R&D ranges in the examined period from 0.57% (in 2010) to 1.16% (in 2012) of all R&D expenditure in the companies controlled by domestic owner. The same share, but in companies controlled by a foreign owner, ranges from 0.22% (in 2011) 0.93% (in 2012). The mean shares of Land and Buildings expenses spent on innovations realized by companies controlled by a domestic owner is higher in all of the analysed years than the mentioned share of LB realized by companies controlled by a foreign owner. The difference between the mean values ranges from 0.07pp (in 2010) to 0.59pp (in 2009).

The mean values of shares of expenditure on Other Long-Standing Tangible Assets (machines, equipment, facilities, etc.) (OLSTA) spent on total R&D expenditure ranges in the examined period from 0.31% (in 2007) to 5.15% (in 2011) of all R&D expenditure in the companies controlled by a domestic owner. The same share, but in companies controlled by a foreign owner, ranges from 0.41% (in 2008) to 6.2% (in 2013). The mean shares of Other Long-Standing Tangible Assets expenses spent on R&D realized by companies controlled by a domestic owner is higher only in 2011 than the mentioned share of OLSTA realized by companies controlled by a foreign owner. The difference between the mean values ranges from -3.42pp (in 2013) to 0.02pp (in 2011).

Further analysis focuses only on non-investment R&D expenditure. For evaluation of the research hypothesis no. 2 it is necessary to conduct statistical testing. The results of the performed tests are listed in the following Table 10.

Table 10 The results of t-test application

	t-stat.[1]	df[1]	p-val.[1]	t-stat.[2]	df[2]	p-val.[2]	F-stat.	p-val.
CE 13**	2.7285	880	0.006488	2.5753	577.0632	0.010262	1.6084	0.00000092
CE 12	1.1886	837	0.23493	1.1926	682.8951	0.233422	1.0290	0.78310694
CE 11	-0.0245	825	0.980441	-0.0252	715.3092	0.979939	1.2355	0.03988108
CE 10	0.3459	795	0.72948	0.3494	656.3815	0.726895	1.0858	0.43267075
CE 09	0.2976	745	0.766098	0.2995	708.8546	0.764634	1.1000	0.36611757
CE 08	-0.5913	732	0.554525	-0.5853	603.7968	0.558544	1.1052	0.34393804
CE 07	1.3599	711	0.174283	1.4663	519.0540	0.143164	1.5016	0.00058679
LE 13*	0.7908	880	0.429262	0.8035	733.2363	0.421932	1.1377	0.19553118
LE 12	-0.8948	837	0.371142	-0.9187	732.2066	0.358556	1.2494	0.02912592
LE 11	0.0949	825	0.924386	0.0968	702.6585	0.922922	1.1740	0.11849689
LE 10	0.1548	795	0.877041	0.1565	659.1454	0.875658	1.0981	0.37217280
LE 09	-1.5499	745	0.121596	-1.5288	654.2851	0.126808	1.2255	0.05056812
LE 08	-1.4698	732	0.142058	-1.4510	597.7353	0.147313	1.1361	0.22773548
LE 07**	-2.0774	711	0.038126	-2.0045	394.9685	0.045701	1.2105	0.08896587
CS 13**	1.6717	880	0.094938	1.9754	822.1834	0.048562	5.0320	0.00000000
CS 12	1.3984	837	0.162375	1.4615	767.8905	0.144283	1.4567	0.00024951
CS 11	1.0427	825	0.297392	1.1534	823.2416	0.2491	2.4321	0.00000000
CS 10**	2.0054	795	0.045261	2.5046	574.0591	0.012536	19.4546	0.00000000

Table 10 The results of t-test application (continued)

	t-stat.[1]	df[1]	p-val.[1]	t-stat.[2]	df[2]	p-val.[2]	F-stat.	p-val.
CS 09	-1.6528	745	0.098791	-1.6273	648.7453	0.10415	1.2590	0.02677822
CS 08	-1.4446	732	0.148988	-1.4267	598.4864	0.154198	1.1322	0.24039089
CS 07*	-1.6722	711	0.09492	-1.6313	405.0973	0.103598	1.1413	0.23884520
SNE 13	0.7299	880	0.465669	0.7518	763.0531	0.452421	1.2714	0.01621967
SNE 12*	1.6271	837	0.104098	1.6878	753.2874	0.09186	1.3649	0.00238599
SNE 11	-0.3371	825	0.736109	-0.3444	706.8674	0.730661	1.1940	0.08459501
SNE 10	-0.4153	795	0.678019	-0.4197	657.4013	0.674845	1.0903	0.40971739
SNE 09	1.1072	745	0.26858	1.1004	676.7385	0.27153	1.0942	0.38627901
SNE 08*	1.6978	732	0.089973	1.6861	610.7081	0.09229	1.0709	0.51562666
SNE 07	1.0302	711	0.303278	1.0262	425.6808	0.305369	1.0207	0.84656687

Note: *** statistically significant at 1% level, ** statistically significant at 5% level, * statistically significant at 10% level.

The results of the test show that only a few differences are statistically significant. The difference between the mean values of Current Expenditure (CE) in companies controlled by a domestic owner or foreign owner is statistically significant at the 5% level of the t-test only in 2013. Moreover the mentioned share is higher in the companies controlled by a domestic owner. This confirms our hypothesis, but only in 2013, as the differences that occur in other years in the period examined were not statistically significant at any standard level of t-test.

The difference between the mean values of Labour Expenses (LE) in companies controlled by a domestic owner or foreign owner is statistically significant at the 5% level of the t-test only in 2007 and at the 10% level in 2013. In 2013 the mentioned shares are higher in the case of companies controlled by a domestic owner but in 2007 the situation was the reverse, i.e. the mentioned shared was higher in companies controlled by a foreign owner. The differences occurring in other years in the period examined were not statistically significant at any standard level of t-test.

The difference between the mean values of Contracts of Services (CS) in companies controlled by a domestic owner or a foreign owner is statistically significant at the 5% level of t-test in 2013 and 2011 and at the 10% level in 2007. In 2013 and 2010 the mentioned shares are higher in the case of companies controlled by a domestic owner, but in 2007 the situation was the reverse, i.e. the mentioned shared was higher in companies controlled by a foreign owner. The differences that occur in other years from the examined period were not statistically significant at any standard level of t-test.

The difference between the mean shares of expenditure spent on Sundry Non--investment Expenses (SNE) in 2012 and 2008 in companies controlled by a domestic owner or a foreign owner is statistically significant only at the 10% level of t-test. In 2012 and 2008 the mentioned shares are higher in the case of companies controlled by a domestic owner. The differences that occur in other years in the examined period were not statistically significant at any standard level of t-test.

5 DATA COLLECTION AND RESEARCH RESULTS

While the previous chapter dealt with secondary data, this chapter investigates our own primary data from original research conducted in Czech innovative manufacturing companies.

Thus this section provides an overview of the primary data used for this study and the main characteristics of the primary research sample. After extensively examining previous relevant, related literature and research in innovation, management control, performance measurement and related topics (Žižlavský, 2013; Žižlavský & Sághy Estélyi, 2013; Žižlavský & Senichev, 2013; Žižlavský, 2014a; Žižlavský, 2014b; Žižlavský & Karas, 2014) the field research was started in 2014. Three types of data were collected for this study: questionnaires and interviews, and company data and public information (data from a survey conducted every two years by the Czech Statistical Office were considered).

5.1 Determining Sample Size

The addressed companies were those that by their principal activities belong in manufacturing industry (according to CZ-NACE rev. 2, division C, section 10-33). Data on the total number of companies in the target population of the survey are taken from the Czech Statistical Office. It is estimated that the target population consists of over 11,000 manufacturing companies (CZSO, 2014). The research sample of these companies was obtained from the database Technological Profile of the Czech Republic. A random sample of 2,877 innovative companies was drawn from the target population.

In addition the answer to the most frequently asked question concerning sampling, "What size of a sample do I need?", was given at the beginning of the survey. In general three criteria usually need to be specified to determine the appropriate sample size: (i) the level of precision, (ii) the level of confidence or risk and (iii) the degree of variability in the attributes being measured (Miaoulis & Michener, 1976).

There are several approaches to determining sample size. It is often assumed that the samples in surveys are large enough that an estimate made from them is approximately normally distributed (Cochran, 1963). However, in social sciences, the populations from which samples are drawn are generally marked by a high degree of non-normality.

Applying central limit theorem, the scope and target population of survey, it can be assumed that the distribution of gained data is approaching a normal distribution. Therefore the total sample size (n_0) required in this study is calculated using the Cochran (1963) formula by taking 5% as the estimated percentage prevalence of the population of interest as follows:

$$n_0 = \frac{Z^2pq}{e^2} = \frac{1.96^2 * 0.5 * 0.05}{0.05^2} = 385 \, respondents$$

Equation 6 Calculated research sample for Czech manufacturing companies

Where:

(n_0) is the required sample size, *(Z^2)* is the abscissa of the normal curve that cuts off an area *(α)* at the tails (*(1-α)* equals the desired confidence level), *(e)* is the desired level of precision, *(p)* is the estimated proportion of an attribute that is present in the population, and *(q)* is *(1-p)*. The value for *(Z)* is found in statistical tables which contain the area under the normal curve.

5.2 Research Results

After the first posting at the beginning of April 2014, non-responding companies received a reminder at the end of May or the beginning of June, and a follow-up took place a few months later. At the end of November 2014, 354 completely filled questionnaires were collected. This number is very close to the calculated sample size. Hence the data gained are considered statistically significant.

The real response rate of more than 12% (354 completed questionnaires from 2,877 potential respondents) can be considered as good because the response rates of mail-back questionnaires are usually less than 10%. The detailed statistics of the questionnaire inquiries are shown in Table 11.

Table 11 Overall statistics and distribution of companies engaged in research survey.

Target population	Manufacturing companies in the Czech Republic					
Research sample	Innovative manufacturing companies in the Czech Republic					
Category (Number of employees)		Micro (1-9)	Small (10-49)	Medium (50-249)	Large (>250)	Total
Response	No	63	94	123	74	354
	%	10.08%	12.24%	12.60%	14.57%	
Non-response	No	562	674	853	434	2,523
	%	89.92%	87.76%	87.40%	85.43%	
Total	No	625	768	976	508	2,877
	%	100.00%	100.00%	100.00%	100.00%	
Response rate	%	10.08%	12.24%	12.60%	14.57%	12.30%

Source: Own research

Moreover, using the Pearson chi-square test and data from Table 11, no statistically significant difference between the two groups – the number of respondents and non-respondents – has been found. The null fragmental hypothesis FH0 is going to be tested that random values are not depended in comparison with alternative fragmental hypothesis FH1.

FH0: Size of the company and number of respondents are not related to each other.

FH1: Size of the company and number of respondents are related to each other.

Calculated test criterion for micro companies:

Chi-Sq = 3.662; DF = 1; P-Value = 0.056

(63 complete questionnaires and 562 potential respondents)

Calculated test criterion for small companies:

Chi-Sq = 0.004; DF = 1; P-Value = 0.949

(94 complete questionnaires and 674 potential respondents)

Calculated test criterion for medium companies:

Chi-Sq = 0.122; DF = 1; P-Value = 0.727

(123 complete questionnaires and 853 potential respondents)

Calculated test criterion for large companies:

Chi-Sq = 2.927; DF = 1; P-Value = 0.087

(74 complete questionnaires and 434 potential respondents)

For the selected significance level α = 0.05 a quantile chi-sq (1) is determined = 3.841. Because the value of the test criterion was not realized in the critical field (3.662 < 3.841 and P-Value = 0.056 for micro companies; 0.004 < 3.841 and P-Value = 0.949 for small companies; 0.122 < 3.841 and P-Value = 0.727 for medium companies; 2.927 < 3.841 and P-Value = 0.087 for large companies), the alternative fragmental hypothesis FH1 is refused on five percentage level signification and null fragmental hypothesis FH0 is accepted.

It is important to note that reminders were made for non-responding companies, and in many cases, the respondents answered that they would not fill the questionnaire, due to (i) little interest in surveys of this kind, (ii) bad experiences from analogous surveys, (iii) lack of time, (iv) the existence of internal policies related to non-participation in academic research, or (v) the vast majority of addresses listed in database were not targeted to specific competent executives. Thus, an important factor may be the fact that many e-mails could not arrive in the right hands. This could evidence the difficulties created by this kind of research and that innovation is a strategic issue for those companies.

5.2.1 General Characteristics

Questions from the first part of the questionnaire were related to the basic characteristic data of the company, such as the company's size, origin, market, etc. Company size is a traditional contingency factor in economic research.

Are large companies more likely to innovate than their smaller counterparts? The relationship between innovation, performance and company size has been investigated. Specifically, this section studies the impact of one factor linked to company size: number of employees (although, the revenue data were collected with help of the questionnaire as well. However only number of employees is concerned in most parameters.). In fact, this factor is usually the basis of company classification. Distribution of companies by size is based on EU law and the Recommendation of the European Commission 2003/361/EC of 6 May 2003 (EC, 2003, p. 36). This standard divides into four groups: micro, small, medium and large company. Figure 5 shows the percentages obtained from using the number of employees indicator.

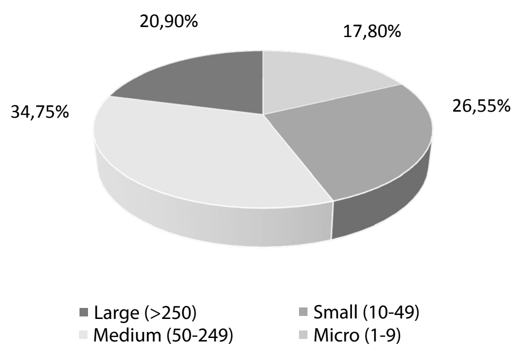

Figure 5 Distribution of companies engaged in research survey (n=354, number of employees). Source: Own research

The first empirical evidence of the survey emerged by way of descriptive statistics. It has been noted through the analysis of questionnaires that innovations are mostly performed by SMEs (80.51% in total), respectively by medium companies (44.63% of respondents) followed by small companies (28.53% of respondents) with large (19.49% of respondents) and micro companies (7.34% of respondents) at the tail.

It can be assumed that companies were aware of the threat of losing their competitiveness that could potentially lead to their end. While large companies focused on operational efficiency and cost saving, SMEs could react to changes in the environment through innovation. The often mentioned innovation advantages of small companies include entrepreneurial dynamics and flexibility, mostly derived from a simple, flatter organisational structure and translating into significantly more flexible responses to, and faster capitalisation of, market opportunities (Rothwell, 1989). In other words, small companies have their flexibility in shifting employees to R&D-related projects and less complex management structures in implementing new projects (Kamien & Schwartz, 1982; Acs & Audretsch, 1988; Bhattacharya & Bloch, 2004). Therefore, small companies seems to be more innovative (in term of the number of product innovation) relative to their size than large companies. In addition, product innovations coming from small companies appear to be more significant than those coming from large companies (Link & Rees, 1990).

The bigger the company the more organisationally demanding are any innovative changes, which is why mainly smaller businesses with flexible organisational structure innovate in these times. Large companies naturally strive to support innovation as well but due to more complicated organisation, bureaucratization in the innovation decision making process inhibits not only inventiveness but also slows the pace at which new inventions move through the corporate system toward the market. Large companies, it is argued, are in a better position to carry out the R&D necessary for innovation and may also be better placed to exploit the market potential of each innovation (Love & Roper, 1999) as well as the possibility of employing professional managers and technical experts, better protection of innovation against competition, strong marketing, etc. Large companies have stronger cash flows to fund innovation and their large sales volume implies that the fixed costs of innovations can be spread over a large sales base. Large companies have access to a wider range of knowledge and human capital skills than small companies, enabling higher rates of innovation (Rogers, 2004).

The importance of small and medium companies for the development of the Czech economy is therefore increasing. This is highlighted also by the Concept for Support of Small and Medium Entrepreneurs for the period of 2014–2020 carried out by the Ministry of Industry and Trade of the Czech Republic[3].

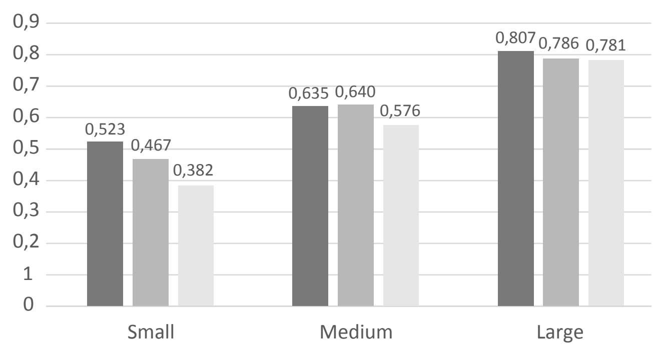

Figure 6 The ratio of innovative companies in total number of companies engaged in CZSO surveys by size (CZSO, 2010; 2012; 2014)

3 For more information see Ministry of Industry and Trade of the Czech Republic (2012)

However, these results contrast with studies of the CZSO (2010; 2012; 2014) that consider large companies as innovation leaders in the Czech Republic. Previous studies conducted within 2009–2011 under the sponsorship of the Internal Grant Agency of the Faculty of Business and Management Brno University of Technology have reached similar contradictory conclusions (Žižlavský, 2009; 2010; Žižlavský & Šmakalová, 2011). Thus, for better understanding a classification according to turnover has been considered (see Figure 7).

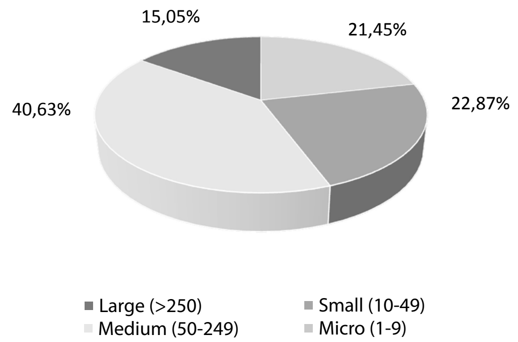

Figure 7 Distribution of companies engaged in research survey (n=354, turnover). Source: Own research

On the one hand, given a certain level of innovation inputs, larger companies might have higher innovative sales intensity because they can appropriate innovation benefits more easily than SMEs and/or because of economies of scale. However, SMEs might use innovation inputs more efficiently because of entrepreneurial abilities or greater flexibility in production processes. Previous evidence has indicated that although larger companies are more likely to sell innovative products this probability increases less than proportionately with size and that among innovative companies the share of innovative products in total sales tends to be higher in smaller companies (e.g. Brouwer & Kleinknecht, 1996).

The OECD study (2009) also provides mixed results: size is positively correlated, negatively correlated or not correlated with turnover (sales) from innovations. Economies of scope and scale and knowledge flows within companies seem to play a role in commercialisation.

Therefore, it is very difficult to confirm or invalidate *"Hypothesis 3: Innovations are mainly performed in the Czech business environment by medium and large-sized companies with sufficient resources."* based on these contrary results[4]. What is most important from a managerial point of view is the finding that companies perform innovation but however they differ in the form of innovation (see Table 16). The essential question is not whether to innovate or not, but how to innovate[5].

Table 12 Origin of companies

Category (Number of employees)		Micro (1-9)	Small (10-49)	Medium (50-249)	Large (>250)	Total
Czech	No.	26	78	112	27	243
	%	100.00%	77.23%	70.89%	39.13%	68.64%
Czech with foreign participation	No.	0	17	42	39	98
	%	0.00%	16.83%	26.58%	56.52%	27.68%
Foreign	No.	0	6	4	3	13
	%	0.00%	5.94%	2.53%	4.35%	3.67%
Total	No.	26	101	158	69	354
	%	100.00%	100.00%	100.00%	100.00%	100.00%

Source: Own research (n=354)

The vast majority of addressed companies (68.64% of respondents) have Czech owners, 27.68% of companies have foreign participation, and only 3.67% have foreign owners (see Table 12).

4 Schumpeter himself studied the effect of size on a company's innovation ability. He wrote, in 1909, that small companies were more inventive than large ones. But then, in 1942, Schumpeter reversed himself. Big companies have more incentive to invest in new products he decided because they can sell them to more people and reap greater rewards more quickly. In a competitive market, inventions are quickly imitated, so a small inventor's investment often fails to pay off. However, studies worldwide based on real economic data do not confirm any of his hypotheses. Important inventions are distributed between quite small and large companies.

5 The current trend is that new inventions do not come from big or small companies but come into being in an "ecosystem" in which numerous small companies are clustered around a big one, such as Apple or Google (Alphabet Inc.). The system is based on huge companies with sufficient means to invest in inventions. They exploit new inventions on a mass scale and reap appropriate rewards from them. Globalisation is a benefit to them. All companies must fight in a global competition, which often neglects copyright and may receive support from domestic governments. An invention must therefore be brought to the market promptly and on a mass scale, before it is replicated by others and the profits are lost. Big companies are able to do this. A small company may bring solutions to some problems of the system of public healthcare or invent a fantastic electric vehicle but is unable to translate them into practice. To do this, it needs a big company with sufficient capacity to change the entire healthcare system or build a network of charging stations for electric vehicles in a large part of the country.

Quite obviously, the innovation behaviour of companies is given by far more than just size. It is also influenced by the business activities of the company in question, the nature of the sector and markets where the company operates and the nature of innovations as such.

Here, 55.93% of the inquired companies are doing innovative business within the Czech Republic; of which, 12.99% operate on the domestic market within the whole CR, 42.94% of those questioned operate on regional markets only within the CR, 30.79% do business in EU member and candidate countries, and the remaining 13.28% do business around the world (see Table 13).

Table 13 Market orientation

Category (Number of employees)		Micro (1-9)	Small (10-49)	Medium (50-249)	Large (>250)	Total
Czech regional market	No.	5	16	21	4	46
	%	19.23%	15.84%	13.29%	5.80%	12.99%
Czech national market	No.	14	49	62	27	152
	%	53.85%	48.51%	39.24%	39.13%	42.94%
EU market	No.	6	31	49	23	109
	%	23.08%	30.69%	31.01%	33.33%	30.79%
Global market	No.	1	5	26	15	47
	%	3.85%	4.95%	16.46%	21.74%	13.28%
Total	No.	26	101	158	69	354
	%	100.00%	100.00%	100.00%	100.00%	100.00%

Source: Own research (n=354)

The majority of respondents (76.55%) is carrying out innovation irregularly and randomly, i.e. as a consequence of intuitive and immediate decisions, or reverse the negative development. Only 23.45% of respondents execute innovation regularly, i.e. as a standard part of their businesses that is systematically managed.

Table 14 Period of innovation

Category (Number of employees)		Micro (1-9)	Small (10-49)	Medium (50-249)	Large (>250)	Total
Regularly	No.	2	17	29	35	83
	%	7.69%	16.83%	18.35%	50.72%	23.45%
Irregularly	No.	24	84	129	34	271
	%	92.31%	83.17%	81.65%	49.28%	76.55%
Total	No.	26	101	158	69	354
	%	100.00%	100.00%	100.00%	100.00%	100.00%

Source: Own research (n=354)

Here, *"Hypothesis 4: Large companies perform innovation regularly – it is part of their business."* should be tested. Again, the Chi-Square test was applied. For this purpose the following question no. 5 "Does your company perform innovation randomly or regularly?" is used. The null fragmental hypothesis FH0 is going to be tested that random values are not dependent in comparison with the alternative fragmental hypothesis FH1.

FH0: Size of the company and period of innovation are not related to each other.

FH1: Size of the company and period of innovation are related to each other.

Table 15 Relation research of period of realised innovation and size of the company

Size of company/ Innovation evaluation	SMEs	Large	n_i
Irregularly	237	34	271
Regularly	48	35	83
n_j	285	69	354

Source: Own research (n=354)

Calculated test criterion:

Chi-Sq = 35.531; DF = 1; P-Value = 0.000

For a selected significance level $\alpha = 0.05$ a quantile chi-sq (1) is determined = 3.841. Because the value of the test criterion was realized in critical field (35.531 > 3.841 and P-Value = 0.000), the fragmental null hypothesis FH0 is rejected on five percentage level signification and the alternative fragmental hypothesis FH1 is accepted. It means that random values are dependent and a relationship between size of the company and period of realised innovation was demonstrated.

Next, respondents answered the question about what innovations had been implemented by the company during the last three years and the importance they carry for the company represented another part of the research. They could select from four predefined answers (see innovation classification according to the Oslo Manual (OECD, 2005)). The questionnaire includes a list of examples for each type of innovation. Since respondents were able to select more answers for this question, a recalculation had to be carried out where relative frequency was determined as a percentage of the number of selected answers out of the total number of respondents in the group. Some of the key research findings are summarized in Figure 8.

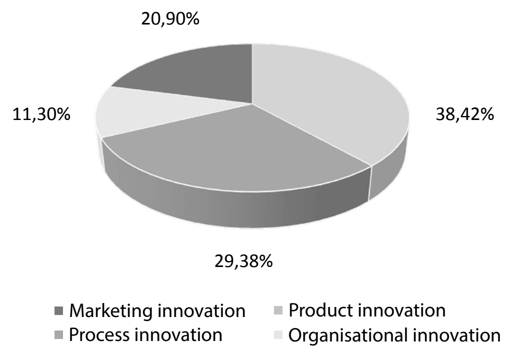

Figure 8 Implemented innovations (n=354).

The most performed innovation type is product innovation (38.42% of respondents), followed by process (29.38% of respondents) and marketing innovation (20.90% of respondent). Organisational innovation is at the tail with 11.30% of respondents. These balanced results highlight the fact that product innovations often require process innovations, e.g. in the form of acquiring new production technology, and in order for these product innovations to be successful on the market and bring the company higher value, it is often necessary to seek new distribution channels via marketing innovations. Moreover, many of the innovators in manufacturing industry implemented both product and process innovation.

The measurement instrument used in the questionnaire to estimate the importance of innovation was evaluated on a five-item Likert scale: 1 – very important, 2 – important, 3 – neutral, 4 – not important, 5 – completely unimportant. In the summary of the percentage ratio of positive answers, i.e. values 1 (very important) and 2 (important), the order of individual possibilities was determined. Therefore, results show that respondents see the importance of innovations for their company in the following order: innovation of products, processes, marketing, and organisation. Evaluation of the importance of individual types of innovation for companies is shown in Table 16. Cronbach's alpha coefficient for particular types of innovation is above 0.90, and overall Cronbach's alpha equals to 0.9828, which is higher than the commonly used benchmark value of 0.70. This indicates strong internal consistency and good reliability of scale.

Table 16 Importance of particular innovation types for companies

	1 very important		2 important		3 neutral		4 not important		5 un-important		Cronbach's Alpha
	No.	%	No.	%	No.	%	No.	%	No.	%	
Product innovation	103	29	85	24	67	19	42	12	57	16	0.9761
Process innovation	96	27	78	22	67	19	64	18	49	14	0.9730
Marketing innovation	62	18	99	28	85	24	69	19	39	11	0.9798
Organisation innovation	57	16	81	23	79	22	60	17	77	22	0.9794

Source: Own research (n=354)

The main motives leading to commencement of such innovation activities are growth of revenues/profits, reaction to demand, increased quality, increased market share, and last but not least, inspiration by competitors. Motives of innovative activities represent a starting point for innovation strategies. Strategic marketing and research, with a nomination by top management, participates in strategy proposal and formulation. The goal of every innovation strategy lies in achieving a competitive advantage leading to the company's improved position on the market, and other goals are derived (CZSO, 2014; Žižlavský & Šmakalová, 2011).

Innovation expenditure includes all expenses for both in-house and externally purchased activities that aim at the development and introduction of innovations, regardless whether these innovations have yet been introduced. They comprise of current (e.g. labour costs, externally purchased goods or services, etc.) and capital expenditure (e.g. on machinery, instruments, intangible assets, etc.).

Innovation expenditure is an important metric to determine the amount of resources that a company has provided for carrying out innovation activities (see Chapter 4). To overcome unwillingness of respondents to provide confidential information four categories were predefined; innovation expenditure based on actual needs, up to 5% of an annual budget, 5–10% of an annual budget and more than 10% of the annual budget.

Table 17 Innovation expenditure

Category (Number of employees)		Micro (1-9)	Small (10-49)	Medium (50-249)	Large (>250)	Total
Actual needs	No.	17	39	57	9	122
	%	65.38%	38.61%	36.08%	13.04%	34.46%
Up to 5% of annual budget	No.	6	37	75	20	138
	%	23.08%	36.63%	47.47%	28.99%	38.98%
From 5 to 10% of annual budget	No.	3	21	23	24	71
	%	11.54%	20.79%	14.56%	34.78%	20.06%
More than 10% of annual budget	No.	0	4	3	16	23
	%	0.00%	3.96%	1.90%	23.19%	6.50%
Total	No.	26	101	158	69	354
	%	100.00%	100.00%	100.00%	100.00%	100.00%

Source: Own research (n=354)

The phenomenon that the most frequent innovation expenditure is up to five percent of an annual budget, especially in small and medium companies, was noted. SMEs invest into innovative activities according to actual needs. The largest contribution to this fact is made by micro companies (65.38% of respondents) identically followed by small (38.61% of respondents) and medium companies (36.08% of respondents). In contrast, the reverse pattern is observed for expenditure from five to ten percent, from 11.54% for micro companies to 34.78% for large companies. Large companies (23.19% of respondents) devote more than ten percent of their annual budget for innovations, while micro companies invest into innovation according to actual needs (65.38% of respondents). In other words, the greater the company the higher the expenditure, regularly planned and annually spent on innovations.

The following research hypothesis *"Hypothesis 5: Large companies tend to invest greater sums of money into innovation (measured by percentage of annual budget)."* is going to be tested. First, the Chi-square test was used. The FH0 partial null hypothesis stating that random quantities are independent was tested against the FH1 partial alternative hypothesis. For this purpose the following question no. 8 "Estimate the total amount of expenditure for innovation by percentage of annual budget" is used. The null fragmental hypothesis FH0 is going to be tested that random values are not dependent in comparison with the alternative fragmental hypothesis FH1.

FH0: Size of the company and percentage of annual budget invested into innovation are not related to each other.

FH1: Size of the company and percentage of annual budget invested into innovation are related to each other.

Table 18 Relation research of percentage of annual budget invested into innovation and size of the company

Size of company/Investments into innovation	SMEs	Large	n_i
Actual needs	113	9	122
Up to 5% of annual budget	118	20	138
From 5 to 10% of annual budget	47	24	71
More than 10% of annual budget	7	16	23
n_j	285	69	354

Source: Own research (n=354)

Calculated test criterion:

Chi-Sq = 59.624; DF = 1; P-Value = 0.000

For a selected significance level $\alpha = 0.05$ a quantile chi-sq (1) is determined = 3.841. Because the value of the test criterion was realized in the critical field (59.624 > 3.841 and P-Value = 0.000), the fragmental null hypothesis FH0 is rejected on five percentage level signification and the alternative fragmental hypothesis FH1 is accepted. It means, that random values are dependent and relations between size of the company and percentage of annual budget invested into innovation was demonstrated. Moreover, result of this test correspond with the previous hypothesis *"Hypothesis 3: Innovations are mainly performed in the Czech business environment by medium and large-sized companies with sufficient resources."*

5.2.2 Performance Measurement of Innovation

Well-managed innovations successfully commercialized in the market are a tool that companies can use to win competitive advantages that will allow them to prosper even under the conditions of the recent recession. It is a modern trend to innovate, but innovations must be implemented prudently and in a targeted manner. Moreover, innovations are very costly and they tie up a substantial part of a company's available resources for a significant period of time. The effort and resources expended must be recouped if the company is to stand a chance of surviving in a strongly competitive environment. The need for a performance measurement system is crucial in innovations.

Table 19 Evaluation of innovation projects

Category (Number of employees)		Micro (1-9)	Small (10-49)	Medium (50-249)	Large (>250)	Total
Yes	No.	5	23	49	24	101
	%	19.23%	22.77%	31.01%	34.78%	28.53%
Rather yes	No.	11	62	72	35	180
	%	42.31%	61.39%	45.57%	50.72%	50.85%
Rather no	No.	8	9	21	8	46
	%	30.77%	8.91%	13.29%	11.59%	12.99%
No	No.	2	7	16	2	27
	%	7.69%	6.93%	10.13%	2.90%	7.63%
Total	No.	26	101	158	69	354
	%	100.00%	100.00%	100.00%	100.00%	100.00%

Source: Own research (n=354)

Therefore a key area of the survey was the question of evaluation and responsibility for innovations – where the key decisions are made and where it is decided whether the innovation is viable. When asked whether the companies had evaluated the implemented innovation projects, the vast majority (79.38% of respondents) answered affirmatively. On the other hand, what is disquieting is the fact that this area is neglected by 20.62% of the respondents even though innovations are implemented by them (see Table 19).

Based on these data, *"Hypothesis 6: Large companies tend to evaluate their innovative activities more than SMEs."* is tested. An independence statistical test of two qualitative characters is carried out for statistical dependency verification. For this purpose the following question no. 9 "Has your company implemented an innovation performance measurement system?" is used. The null fragmental hypothesis FH0 is going to be tested that random values are not depended in comparison with the alternative fragmental hypothesis FH1.

FH0: Size of the company and evaluation of innovations are not related to each other.

FH1: Size of the company and evaluation of innovations are related to each other.

Table 20 Relation research of evaluation of realized innovation and size of the company

Size of company/ Innovation evaluation	SMEs	Large	n_i
No/Rather no	63	10	73
Yes/Rather yes	222	59	281
n_j	285	69	354

Source: Own research (n=354)

Calculated test criterion:

Chi-Sq = 1.967; DF = 1; P-Value = 0.161

For a selected significance level $\alpha = 0.05$ a quantile chi-sq (1) is determined = 3.841. Because the value of the test criterion was not realized in the critical field (1.967 < 3.841 and P-Value = 0.161) the fragmental alternative hypothesis FH1 is rejected on five percentage level signification and the null fragmental hypothesis FH0 is accepted. In other words, SMEs are aware of the importance of innovation evaluation and they perform it as well as large companies. On the other hand SMEs use different techniques for performance measurement to large companies (see Table 25).

For companies which responded affirmatively to the above question (281 in total), the period since when the company has implemented innovation performance measurement system (PMS) was examined.

Table 21 Period of innovation PMS implementation

Category (Number of employees)		Micro (1-9)	Small (10-49)	Medium (50-249)	Large (>250)	Total
Less than 5 years	No.	12	29	25	8	74
	%	57.14	35.80	20.00	14.81	26.33
From 5 to 10 years	No.	7	33	56	25	121
	%	33.33	40.74	44.80	46.30	43.06
From 11 to 15 years	No.	2	14	36	15	67
	%	9.52	17.28	28.80	27.78	23.84
More than 15 years	No.	0	5	8	6	19
	%	0.00	6.17	6.40	11.11	6.76
Total	No.	21	81	125	54	281
	%	100.00	100.00	100.00	100.00	100.00

Source: Own research (n=281)

The initial hypothesis *"Hypothesis 7: Large companies have implemented their innovation performance measurement system for a longer time than SMEs."* is going to be tested. Independence statistical testing of two qualitative characters is carried out for statistical dependency verification. For this purpose the following question no. 10 "Since when has IPMS been implemented in the company?" is used. The null fragmental hypothesis FH0 is going to be tested, that random values are not dependent in comparison with the alternative fragmental hypothesis FH1

FH0: Size of the company and period of innovation performance measurement system implementation are not related to each other.

FH1: Size of the company and period of innovation performance measurement system implementation are related to each other.

Table 22 Relation research of period of MCS implementation and size of the company

Size of company/ Period of MCS implementation	SMEs	Large	n_i
Less than 5 years	66	8	74
From 5 to 10 years	96	25	121
From 11 to 15 years	52	15	67
More than 15 years	13	6	19
n_j	227	54	281

Source: Own research (n=281)

Calculated test criterion:

Chi-Sq = 5.835; DF = 3; P-Value = 0.120

For a selected significance level $\alpha = 0.05$ a quantile chi-sq (3) is determined = 7.815. Because the value of test criterion was not realized in the critical field (5.835 < 7.815 and P-Value = 0.120) the fragmental alternative hypothesis FH1 is rejected on five percentage level signification and null fragmental hypothesis FH0 is accepted. In other words, companies evaluate innovation processes no matter what the period of PMS implementation.

Then the relevant reasons for IPMS implementation and their importance were surveyed for the same group of respondents. Moreover they evaluated the importance of these reasons. The measurement instrument used in the questionnaire to estimate the importance of reasons for IPMS implementation was evaluated on a five-item Likert scale: 1 – very important, 2 – important, 3 – neutral, 4 – not important, 5 – completely unimportant. In the summary of the percentage ratio of positive answers, i.e. values 1 (very important) and 2 (important), the order of individual possibilities was determined (see Table 23).

Table 23 Reasons for innovation MCS implementation

	1 very important		2 important		3 neutral		4 not important		5 un-important		Cronbach's Alpha
	No.	%	No.	%	No.	%	No.	%	No.	%	
Motivation and remuneration	99	35	117	42	48	17	10	4	7	2	0.9840
Business strategy planning	123	44	82	29	45	16	23	8	8	3	0.9819
Reduction of wasting resources	126	45	77	27	38	14	26	9	14	5	0.9826
Idea improvement	91	32	104	37	43	15	28	10	15	5	0.9814
Communication	101	36	75	27	56	20	33	12	16	6	0.9813
Legitimacy to innovation	74	26	88	31	52	19	44	16	23	8	0.9865
Stakeholders relationship	58	21	74	26	87	31	32	11	30	11	0.9823

Source: Own research (n=281)

Respondents gave the following most important reasons for IPMS: motivation and remuneration, business strategy planning, reduction of wasting resources, idea improvement and communication, respectively. Cronbach's alpha coefficient for each construct is above 0.98, and for all seven factors it equals 0.9853. This shows strong internal consistency and good reliability of scale.

IPMS should therefore be based on the approach that on one hand minimizes the risk of wasting resources, avoiding the pursuit of bad opportunities, and on the other hand prioritizes the utilization of those resources, as companies want to allocate their limited means to the most promising prospects. Regarding various aspects of an innovation such as offer, the market or the competition, the innovation should be revisited and challenged from a strategic point of view, adjusted and improved. The key aspect of IPMSs includes convincing others about making up people's minds about innovation. Even if manager or owner is convinced about the value of innovation, telling colleagues "just trust me" or to do it because "I say so" can be poor ways of innovation effort capturing, engaging others effectively and mobilizing resources. Less significant reasons include legitimacy of innovation and stakeholder relations management.

In the area of responsibility for the innovations, it is characteristic of the surveyed companies that in the final stage the company management always has the main say. Moreover in SMEs the owner usually directly manages all the company. This phenomenon was particularly observed in small family companies.

Logically this is due to the fact that the company management bears the greatest responsibility for the implemented innovation projects and assumes the risks arising from the possible failure of a particular action, which is reflected in all the activities of the company (see Table 24).

Table 24 Responsibility for innovation projects

Category (Number of employees)		Micro (1-9)	Small (10-49)	Medium (50-249)	Large (>250)	Total
Owners	No.	23	82	105	15	225
	%	88.46%	81.19%	66.46%	21.74%	63.56%
Top managers	No.	0	0	32	34	66
	%	0.00%	0.00%	20.25%	49.28%	18.64%
R&D employees	No.	2	4	3	5	14
	%	7.69%	3.96%	1.90%	7.25%	3.95%
Individuals	No.	1	13	16	12	42
	%	3.85%	12.87%	10.13%	17.39%	11.86%
Others	No.	0	2	2	3	7
	%	0.00%	1.98%	1.27%	4.35%	1.98%
Total	No.	26	101	158	69	354
	%	100.00%	100.00%	100.00%	100.00%	100.00%

Source: Own research (n=354)

Focusing on companies implementing IPMSs, the following analysis investigates the application of evaluation techniques respondents use within innovations to provide the information for decision-making and control. The questionnaire focused on the 16 core project-level evaluation metrics of innovation performance. This set of metrics was formed after the literature review of the most frequent innovation management control tools (Carenzo & Turolla, 2010; Cokins, 2009; Davila et al., 2013; Griffin & Page, 1993, 1996; Niven, 2014; Skarzynski & Gibson, 2008; Tzokas el al., 2004).

Hultink and Robben (1995) made a distinction between measuring innovation performance in the short term and in the long term after launch. They found that the importance attached by managers to the indicators of innovation performance depended strongly on this time perspective. Therefore the research team decided to include the short-term as well as long-term performance assessment. Respondents were asked to indicate performance measurement tools they used within innovation projects in the previous five years.

Here again respondents were able to select more answers for this question, a recalculation had to be carried out where relative frequency was determined as a percentage of the number of selected answers out of the total number of respondents in the group. The innovation performance measurement tools were divided into two groups; financial and non-financial. The results are shown in the table below (see Table 25).

Table 25 Innovation performance measurement methods

Category (Number of employees)		Micro (1-9)	Small (10-49)	Medium (50-249)	Large (>250)
Financial tools	Balanced Scorecard	0.00%	2.38%	10.95%	33.91%
	Budget	67.45%	72.46%	84.27%	100.00%
	Cost accounting (with cost drivers)	11.33%	19.31%	35.13%	42.67%
	Cost accounting (without cost drivers)	20.38%	24.59%	22.54%	14.17%
	EBITDA, EBIT	28.16%	30.45%	36.19%	34.85%
	Economic value added EVA	1.08%	2.14%	17.50%	20.15%
	Payback period	3.15%	17.23%	24.49%	36.84%
	Profitability (ROI, ROE, ROA, ROS)	23.70%	20.13%	13.52%	7.92%
	Revenues from innovation	59.19%	74.28%	83.45%	100.00%
Non-financial tools	Cannibalization of existing products by innovation	4.12%	5.26%	6.43%	16.24%
	Customer satisfaction indicators	23.45%	17.33%	22.50%	26.67%
	Growth of market share	8.69%	13.17%	18.36%	36.13%
	Innovativeness	2.70%	2.56%	7.12%	13.41%
	Number of new customers	34.33%	32.73%	47.20%	52.48%
	Patents	7.81%	10.47%	28.49%	36.96%
	Productivity and quality indicators (lead time, etc.)	3.43%	6.81%	15.70%	32.76%

Source: Own research (n=281)

Finally, respondents were asked to state current situation in their companies regarding performance measurement of innovation processes. Most of medium-sized (62% of respondents) and large companies (78% of respondents) have clearly defined measurement and evaluation indicator for an innovation process. On the contrary, micro (14% of respondents only) and small companies (32% of respondents) do not use clearly defined indicators and utilize metrics randomly. More than half of the surveyed companies have determined the frequency of indicator measurement as well as having defined responsibility for its measurement. Correcting measures are set mostly in medium-sized (75% of respondents) and large companies (80% of respondents). More than three quarters of all companies agreed that innovation process assessments serve as the basis for their improvement (for details see Table 26).

Table 26 Yes-No questions about current situation about IPMS in company

Category (Number of employees)	Micro (1-9)		Small (10-49)		Medium (50-249)		Large (>250)	
	Yes	No	Yes	No	Yes	No	Yes	No
Is measurement and evaluation indicator for an innovation process clearly defined?	14%	86%	32%	68%	62%	38%	78%	22%
Is the frequency of indicator measurement determined?	10%	90%	41%	59%	73%	27%	82%	18%
Is responsibility for indicator measurement clearly defined?	11%	89%	43%	57%	86%	14%	89%	11%
Are correcting measures determined when exceeding values of the indicator?	8%	92%	38%	62%	75%	25%	80%	20%
Does innovation process measurement serve as the basis for its improvement?	73%	27%	78%	22%	88%	12%	93%	7%

Source: Own research (n=281)

5.3 Trends in Innovation Performance Measurement in Czech Manufacturing Industry

Focusing on companies adopting performance measurement and management control systems, the following analysis investigates the diffusion of performance measurement techniques. Table 25 shows that budget, revenues from innovation and EBITDA are the most frequently applied managerial tools in Czech innovative manufacturing companies. Based on these results it can be claimed that the prevailing approach is the monitoring of financial indicators. On the other hand, Economic Value Added EVA, Balanced Scorecard and innovativeness are implemented least. In other words, the Czech companies analysed and adopted rather traditional measurement tools less “modern” techniques. Here a gap between global and Czech companies has been discovered (cf. Davila et al., 2009; Chiesa & Frattini, 2009; Hendricks et al., 2012; Rigby, 2007).

A first reason that could explain the gap between Czech and foreign companies could stem from lack of knowledge. Especially small Czech companies are not usually familiar with these managerial instruments. A second reason is the fact that the owner in is management of the vast majority of these companies, who prefers his own experience to performance measurement tools. A third reason concerns cost aspects. Gaining valuable information is not free of charge. Hence adopting such “modern” performance measurement and management control systems requires heavy costs. A fourth reason could lie in the characteristics of the performance measurement tools. They are primarily designed to solve homeland company issues (such as BSC from USA, which represents the robust performance measurement system). Therefore, it is difficult to adopt them in a different context without making adjustments (see Chapter 6). Besides, the high level of uncertainty avoidance does not allow Czech companies to try out new performance measurement instruments. A similar situation has been discovered in Italian SMEs (cf. Carenzo & Turolla, 2010).

In addition, Table 25 demonstrates that financial indicators are more frequently adopted than non-financial indicators. Since we are studying the Czech manufacturing business environment, i.e. for-profit sector, innovation evaluation must always be based on a group of logically interrelated financial indicators.

Financial assessment is an integral part of every project. Simply speaking, only those projects that pay off should be implemented. Methods for economic analysis are currently the most diffused methods for the evaluation of innovation projects (Ryan & Ryan, 2002). Although the existing methods largely differ in their implementation, they all share a common principle, that is the capital budgeting approach for calculating the economic return of a project as a sequence of discounted cash flows (Chiesa & Frattini, 2009).

But how to assess objectively the rate of return of the invested efforts and time? Assessing the results of a project only in terms of its economic benefits may not be the most advantageous way, since it may also result in rejection of projects in which the qualitative benefits significantly exceed the potential costs associated with project implementation.

The development and improvement of innovation measurement systems therefore took the path of supplementing financial indicators with many other non-financial indicators used by companies seeking to measure and evaluate the development of basic success factors in their respective strategic areas (Chakravarthy, 1986; Ittner & Larcker, 1998b; Kaplan & Norton, 1992; Merchant, 1985; Meyer, 1994; Nanni et al., 1992; Neuman et al., 2008; Palmer, 1992, Vaivio, 1999). It was clear that traditional systems of measuring performance could not succeed in the changing conditions of global business (Hayes & Abernathy, 1980; Johnson & Kaplan, 1987). Then, many authors have concluded that, due to the complexity of the concept to be measured (i.e. innovation processes), multiple integrated measurements of output need to be utilised (Tipping et al., 1995; Utunen, 2003; Werner & Souder, 1997) in order to obtain both a quantitative and qualitative measurement and, in the meantime, more information on the effectiveness of the innovations measured (Werner & Souder, 1997).

Many large global companies as well as most of the surveyed Czech companies measure the results using financial indicators, although the majority of managers in these companies also feel that non-financial indicators should be used to monitor the undertaken innovative efforts and projects. The managers should rely more on non-financial indicators than on the financial ones because these indicators provide a better assessment of progress in real time and of the probability of success.

Non-financial indicators are not a new concept but they have enjoyed a huge interest among the professional public since the 1980s. Integration of non-financial metrics into systems for measuring performance allows managers to better understand relations between various strategic innovation goals, communicate the linking of these goals with workers' activity and, upon the defined goals to formulate priorities and allocate resources (Kaplan & Norton, 2001a).

The main contribution of non-financial indicators is the identification of key factors influencing the development of financial indicators (Ittner & Larcker, 1998a; Nanni et al., 1992; Neumann et al., 2008; Vaivio, 1999). These indicators are also more sensitive to changes, which can be considered a crucial characteristic in the current turbulent environment.

The results of the international study have confirmed that there is a strong association between the use of non-financial indicators and a strategy oriented on innovation and quality (Said et al., 2003). Other experts (e.g. Bessant & Tidd, 2011; Ryan, 2006) in the given field propose using – in addition to the already mentioned financial indicators – a number of other more specific indicators of internal processes.

Moreover there is also space for the measurement of other important factors that support the innovation, such as creative climate, commitment to innovative activity, the number and quality of ideas, communication inside the company, etc. (Humphreys et al., 2005). Scientific research in measurement methods and indicator creation describing innovations and their effects on the social environment has only just started (Hipp & Grupp, 2005).

In fact, profitability metrics, cash flow etc. – typically short-term indicators – are the most significant measures adopted by companies to evaluate their innovation performance. These financial metrics are connected with short-term aims and based on historical accounting data. This suggests that a short-term view, a typical European cultural feature, influences companies in the choice and structure of IPMSs.

However, empirical evidence highlights an increasing group of companies adopting non-financial measures. In particular, number of new customers and their satisfactory index are the most implemented when compared to the innovativeness and cannibalization of existing products by innovative ones, which was assessed by the respondents as an insignificant indicator. Thus the most significant effect of innovations was shown on the satisfaction of customer needs, which should subsequently be reflected in the growth of sales or, more precisely, operating profit.

To evaluate the ability or performance it is necessary to have a full perspective, which is why the author sees a solution in using a complex system with several individual indicators. However complex indicators clash with economy and sometimes also with functionality as they contain subjective or hard-to-forecast indicators. Despite these shortcomings the use of complex innovation indicators is probably the best option. If they measure innovation capability, performance or a combination of these they always study the innovation process from more perspectives and from multiple angles. It strives to reflect the full picture of the studied area, which cannot be achieved with individual innovation indicators.

The Balanced Scorecard seems most appropriate for introducing a complex system of measuring innovation performance (e.g. Bremser & Barsky, 2004; Donnely, 2000; Donovan et al., 1998; Horvath & Partners, 2002; Kaplan & Norton, 1996a; Kaplan & Norton, 2001a; Kerssens-van Drongelen & Cook, 1997; Li & Dalton, 2003; Niven, 2005; Niven 2014; Pearson et al., 2000). It is one of the most popular and powerful concepts of company performance measuring systems. Although its original idea focused on business strategy it can be applied to any company process including innovation.

However the empirical evidence demonstrates the low adoption rate of the Balanced Scorecard. Most Czech companies, especially medium and large, monitor performance of innovation by using specific financial and non-financial measures but without any logical link between them. In other words only a small number of companies, especially large ones and those having different perspectives, actually understand the importance of the cause-and-effect relationship between metrics. In addition, after overcoming the barriers and reluctance of the managers to communicate more detailed information about their systems of innovation evaluation, these systems proved not to be very appropriate, while being biased in favour of financial indicators.

As concerns the number of employees indicator, empirical data demonstrates that medium and large companies adopt instruments to a greater extent than smaller companies. In addition, Table 25 suggests a positive correlation between company size and the adoption of innovation performance measurement tools. For instance, focusing on budget, it has been noted that the percentage of diffusion increases from 67.45% in micro companies to 100.00% in large companies. In other words, the larger the company, the more common the adoption of a budget system. Similarly the same positive trend even if with different percentages for revenues and cost accounting with cost drivers, number of new customers and their satisfactory index was noted.

Simple cost accounting (a single-basis cost allocation without cost drivers) and profitability indicators shows a negative trend. This suggests that the bigger and more complex the company the greater the need for more reliable and quicker information. Therefore it requires analytical and advanced performance measurement tools. In this context, simple cost accounting becomes less productive for managers, whereas cost accounting with cost drivers meets the new need.

Focusing on a advanced performance measurement approach, the Balanced Scorecard, a gap between micro and small companies and medium and large companies was found. In the first two groups (micro and small companies) BSC is implemented only in the minority group. Less than 3% of respondents adopted this method. However, this percentage increases in medium and large companies.

During preliminary research in 2009–2012 the word "scorecard" was mentioned to several managers who immediately recalled the Balanced Scorecard system. However, there are still just a few companies using the BSC system in Czech business practise. The majority of questioned companies in the 2014 survey did not use this system, but had established different systems of measuring performance. This misbalance reflects the reality of a historic concentration on savings.

In addition there is confusion about what BSC is and what its purpose is in the Czech business environment. If executives were asked to describe the BSC system in their companies, widely different description was delivered. Some executives have successfully transformed their old columnar management reports into visual dashboards with flashing red and green lights and directional arrows. Some realise a scorecard is more than that and have put their old measures on a diet, compressing them into smaller, more manageable and relevant measures. However neither of these methods may be the correct one.

Unfortunately, the introduction of an integrated BSC system is very difficult for Czech SMEs. In the current situation Czech companies must also deal with problems in company culture and the motivation of workers towards an active approach to increasing innovation performance. Based upon contacts with managers and owners of Czech corporations it can be said that although they are interested in modern management methods there are many barriers preventing the implementation of BSC.

In addition the same positive link between company size and performance measurement tools, both traditional and "modern", was noted. For instance, the percentage of adoption budget, revenues, number of new customers, Economic Value Added EVA, payback period, market share, patents, etc. grow with the increasing number of employees.

In summary the empirical results show that the companies use different metrics within innovation process performance measurement. Moreover, they suggest that innovation performance measurement tools, especially "modern" techniques, are mainly implemented in medium and large companies. In addition, the study shows a positive correlation between company size and innovation performance measurement systems. The larger the company size, the higher the adoption of managerial techniques.

6 INNOVATION SCORECARD: CONCEPTUAL FRAMEWORK FOR INNOVATION PERFORMANCE MEASUREMENT AND MANAGEMENT

6.1 To Measure or not to Measure?

Efficient and complex measurement systems are essential and crucial to the success of innovations. Therefore measuring the performance and contribution to value of innovation has become a fundamental concern for managers and executives in recent decades (Kerssen-van Drongelen & Bilderbeek, 1999). Many studies have been written aimed at discussing the issue and suggesting possible approaches to performance measurement, innovation and R&D management literature (e.g. Bassani et al., 2010; Chiessa & Frattini, 2009; Merschmann & Thonemann, 2011; Wingate, 2015).

Moreover, previous research on innovation performance measurement has mainly focused on how managers choose their management control mechanisms (e.g. Harmancioglu, 2009; Jaworski & MacInnis, 1989; Kirsch, 1996; Snell, 1992); on the effects of individual control mechanisms on specific outcomes (e.g. AtuaheneGima & Li, 2006; Bonner et al., 2002; Cardinal, 2001; Jaworski & MacInnis, 1989); how these effects may be moderated (e.g. Carbonell & Rodriguez-Escudero, 2013; Koller & Langmann, 2008); or how they pay off in the innovation process (e.g. Poskela & Martinsuo, 2009). Investigating such PMSs in isolation may be useful but has limited practical validity (Rijsdijk & van den Ende, 2011).

After studying the indicators on the efficacy and efficiency of innovations proposed in the literature and applied in practice many authors have concluded that multiple integrated measurements of output need to be utilised, owing to the complexity of the concept to be measured (Hauser & Zettelmeyer, 1998; Tipping et al., 1995; Utunen, 2003; Werner & Souder, 1997).

Among all the PMSs the BSC seems most appropriate for introducing a complex system of measuring innovation performance. The effects and potential of implementing BSC may be great and very tempting (e.g. Atkinson et al., 1997; Bremser & Barsky, 2004; Burkert et al., 2010; Faupel, 2012; Ittner & Larcker, 1998b; Horvath & Partnes, 2002; Kaplan & Norton, 1996a; 1996b; Otley, 1999; Wang et al., 2010).

However there are many barriers preventing the implementation of BSC (e.g. Horvath & Partners, 2002; Ittner and Larcker, 2003; Kaplan & Norton, 1996a; Norreklit, 2003). While a company may not choose to adopt a formal BSC management system, it can learn and use the key concepts. The BSC helps managers to implement strategy through the development of an integrated set of relevant financial and non-financial measures. The non-financial measures, if properly selected, should be drivers of sustained profitability.

There are no uniform guidelines in the professional literature for measuring the performance of innovations (Adams et al., 2006). The author therefore advises combining utilization of traditional techniques of measurement of returns focused on the cost control of innovation process with strategic measurements in the long-term and with financial objectives. In this process of integration of selected features and indicators of the mentioned methods of measuring and management of innovation performance and to create one's own specific innovation scorecard that would best capture the factors and metrics of innovation activities of the individual company is suggested. The selection of the relevant indicators must be tailored to the company as each innovation is unique, specific, and intended to bring competitive advantage and company growth (Bonner et al., 2002).

Because of the characteristics and specifics of Czech business environment discussed above, the Innovations Scorecard is based on "the needs led" and "audit led" procedures and the "consultant led" approach (see Section 2.6). It is based on BSC methodology, where balance is the equilibrium between operative and strategic (short-term and long-term) goals, required inputs and outputs, internal and external performance factors, lagging and leading indicators, and also the already mentioned financial and non-financial indicators. Each measurement is part of a chain of cause-and-effect links.

6.2 Innovation Scorecard Core

The design of an Innovation Scorecard must happen in an orderly, structured and logical sequence. Only a strictly logical approach can ensure that all the characteristics and essentials of such an exceptional activity as innovation will be respected. In this way the effectiveness of the Innovation Scorecard is guaranteed.

Keegan et al. (1989), for example, argued that the process of deciding what to measure consisted of three main steps. The first involved looking at strategy – defining the strategic goals of the company and determining how they could be translated into divisional goals and individual management actions. The second encompassed deriving an appropriate set of measures by populating a performance measurement matrix. The third focused on instilling the PMS into management thinking, possibly through the budgeting process. Critical here is closing the management loop and ensuring that the measurement system actually drives daytoday decisions and actions – thereby ensuring that the company's strategy is implemented.

Suggestions on how to do this in practice however are not offered. The basic structure of the Innovation Scorecard draws on Horvath's long-term experience (Horváth & Partners, 2002) with the implementing of the BSC and involves the following phases: (i) defining innovation strategy; (ii) setting strategic goals; (iii) constructing a relationship of cause and effect with the help of a strategic map; (iv) the choice of metrics; (v) establishing target values. In content these five phases collectively form an integrated whole. This gives rise to a sample approach, conceived in the form of concrete instructions for the process of implementing the Innovation Scorecard.

Figure 9 Innovation Scorecard implementation (modified from Horváth & Partnes, 2002)

Clarification of innovation strategy

Strategy formulation has to precede any process, including innovation. In connection with the goal of the company as the foundation of the corporate strategy, the innovation strategy must be developed and derived in a second step. There has been widespread recognition that innovations do not exist as independent isolated operations but rather as a critical component of strategy execution (e.g. Klein, 1998; Kerssens-van Drongelen & Bilderbeek, 1999; Pearson et al., 2000). Consequently the innovation process is a key strategic issue that must be aligned with corporate strategy (e.g. Pearson et al., 2000; Roberts, 1988; Rogers, 1996; Roussel et al., 1991).

The innovation strategy needs clear strategic leadership and direction plus optimum allocation of resources to make it happen. The innovation strategy embraces all the strategic statements for the development and marketing of new products and processes, for opening up new markets and for the introduction of new organisational structures and social relations in the company.

The formulation and definition of innovation strategy is definitely a top-management task. Setting the direction of the company, defining the corporate goals and describing corporate vision cannot be delegated. There is no menu of generic strategies from which to choose. Each company's management has to craft its own innovation strategy, adapt to changing conditions and choose the right time to make key moves.

Setting goals

Setting goals serves to reduce the great number of potential innovation goals and the selection of a few which have true strategic significance for the business. The Innovation Scorecard cannot contain a large number of goals[6]. That would go against the concept of targeting, maintaining clarity and concentrating on what is important. By this process the innovation strategy is specified.

6 The management of the company must assert the principles of "Twenty is plenty" which is to say that an unambiguously presented innovation strategy must not have more than 20 goals. Despite the great importance of this we can find in the contemporary literature only a few practical recipes on how to proceed in this phase. A surfeit of goals leads rather to chaos than to clarity and intelligibility. The same can of course be said even for having too few goals. The fewer the goals that are set, the more general and financially demanding they are likely to be.

Corporate innovation initiatives come to nothing when the goals are too vague, the supply and demand drivers are not in place and the performance metrics are undefined or too limited. Innovation leaders set explicit performance targets based on some of the innovation metrics, and commit divisional executives to reaching them. To be clear however these and other companies do not set identical targets and metrics. Leaders within these and other companies understand that metrics are part of a broader system and that they must reflect the unique culture of the company as well as the competitive realities of their respective markets. The quality of the goals is the main quality criterion for the Innovation Scorecard as a whole and has a significant influence on its successful launch and implementation.

In this context, balancing innovation and performance has to be mentioned. A frequent error on the part of managers is too great a concentration on operational performance. It is true that the incessant improvement of operational performance can sustain above average profitability for the company. Nonetheless this is not sufficient in and of itself. Few companies manage to survive successfully in the long-term in the competitive environment only thanks to their operational performance (Porter, 1998). Therefore it is crucial to manage the inherent and ongoing tension between innovation and company performance.

Innovation strategy maps

Processing and documenting the relationships between cause and effect among individual innovation goals represents one of the key elements in the Innovation Scorecard. There is a relationship between the causality and logicality of innovative considerations. On the basis of these relationships the implicit assumptions of the management and staff of R&D departments takes a specific form. This allows the reconciliation of various ideas concerning the modes of action of innovation strategy. Innovation goals are not separate and independent, but are connected and influence each other. The success of an innovation strategy is thus dependent on the collective action of many factors. The creator of the BSC, from which the Innovation Scorecard is developed, uses the term Strategy Maps for the chain of cause and effect (Cokins, 2009; García-Valderrama et al., 2008a; Kaplan & Norton, 2001a).

Innovation strategy maps and their derived scorecard are navigational tools that guide the company to execute the innovation strategy, but not to formulate the strategy. They are first and foremost a communication tool translating innovation strategy into vital goals necessary to execute the plan. With all the information contained on a single page, it is possible to visualise the cause-and-effect relationships described in the Innovation Scorecard.

Selecting innovation metrics

The metric serves for the clear and unmistakeable expression of innovation goals, and at the same time makes it possible to follow the extent of their achievement. The measurement of innovation goals should make it possible to steer behaviour in the desired direction. So that the assessment of the extent of achievement of innovation goals is unambiguous no more than two or exceptionally three metrics should be used for any individual innovation goal. If more metrics are needed then in that case the goal should be subdivided.

An overview of existing innovation metrics allows for making an effective selection. We can thus in a timely fashion identify which existing metric can be used within the bounds of the Innovation Scorecard. Metrics management first requires their description (definition, formula, parameters, units, etc.). In existing metrics we must verify their utility within the Innovation Scorecard or possibly redefine them (ascertaining for example the data source, frequency of measurement, availability of the planned values, etc.). Lastly, when choosing metrics we must constantly consider the possibilities of their integration into the reporting system.

Regardless of which method is used to identify measures for innovation process performance, these metrics ideally should reflect the innovation team's strategic intent and not to be reported in isolation and disconnected. This is the peril of the Innovation Scorecard. Its main purpose is to communicate the innovation strategy to employees in a way they can understand it and report the impact of their contribution to attaining it. But starting with metrics definition without the context of the mission and vision precludes this important step.

Establishing target values

An innovation goal is only fully described once its target value has been set. A proper target value should be demanding and ambitious, but at the same time credible and achievable. It should be rooted in reality, i.e. linked to the starting point and required investment in such a way that the level can be changed. Particularly for the innovation goals of financial evaluation there frequently exist concrete tasks from strategic planning or benchmarking, which must become part of the Innovation Scorecard. For other innovation goals it is generally still necessary to set target values for the metrics. By setting target values the responsibility of the relevant person for the goal is achieved and their adoption by the MCS and the goal negotiation system is made possible.

Comparing current values measured at predefined intervals also makes possible conducting variance analysis. From these consequences and measures for achieving the outlined goal can subsequently be inferred.

Putting together a business model of innovation is probably the most challenging part of designing an innovation performance measurement system. It forces managers to make their assumptions explicit about how to achieve innovation and to agree on an innovation model. The "input–process–output–outcomes" model (Brown 1996; Cardenas et al., 2011; Cooper, 1993) presents a useful approach describing the causal relationships behind an innovation model. It can be applied to describe innovation not only at the business unit level but at any level within the company. Moreover it encourages executives to pay attention to the horizontal flows of materials and information within the company, i.e. the business processes.

Then the performance of innovation should be measured on the basis of four classes of indicator. This model is made up of various inputs and outputs in the form of a whole series of scientific, technical, organisational, financial and commercial activities. An overall perspective on innovation can be gained by examining the relationships between inputs and outputs, and between innovation sources and performance.

Due to the scope of the thesis the following Section 6.3 is focused only on the design of conceptual innovation performance measurement framework. Therefore, it is based on the presumptions that:

- The company has already defined its innovation strategy (according to e.g. Bessant & Tidd, 2011; Bonner et al., 2001; Hayes, 2007; Klein, 1998; Kerssens-van Drongelen & Bilderbeek, 1999; Lafley & Charan, 2008; Moscho et al., 2010; Pearson et al., 2000; Roberts, 1988; Rogers, 1996; Roussel et al., 1991; Skarzynski & Gibson, 2008; Thomaschewski & Tarlatt, 2010; Tidd et al., 2005; Vahs et al., 2010).
- The company has already set performance goals and fine-tuned the balance (e.g. Kaplan & Norton, 1993; Porter, 1998; Skarzynski & Gibson, 2008).
- The company has already established its innovation business model (e.g. Davila et al., 2013).

6.3 Design of an Evaluation System: Putting the Tools Together

Following the Stage Gate model by Cooper (1993; 1998b; 2008), PMS design rules (see Section 2.6) and the methodology of Innovation Scorecard (see Section 6.2), the innovation process can be divided into distinct stages and should be separated by management decision gates. This means an effective as well as an efficient approach, so that the new product can be moved from idea to launch in a systematic way. The stage gate process divides the innovation process into different stages and gates. Usually five, six or seven stages are defined. Every innovation starts with an idea and ends – when the idea is followed up until the end – with the launch of a new product, service or company process. The way to this point can be divided into a series of activities (stages) and decision points (gates). Stages on the way to the launch are preliminary investigation (stage 1), detailed investigation (stage 2), development (stage 3), testing and validation (stage 4) and launch (stage 5). A complete stage gate process is illustrated in Figure 17. Nevertheless it is not a linear process, nor is it a rigid system to handle different types and sizes of innovation projects (Cooper, 1998; Cooper, 2008; Hart et al., 2003; Ozer, 1999).

Every stage is preceded by one gate. At each stage information is gathered to reduce project uncertainties and risks which is then evaluated at the following gate. Gates represent decision points with deliverables (what the innovation team brings to the decision point) and must-meet/should-meet criteria where the company can decide if it will proceed with the innovation project or if it is to be stopped, held or recycled. Thus gates are also referred to as "Go/No-Go check points" where a decision to invest more or not is made (Cooper, 1998; 2008). At the gates below-average projects should be stopped and resources should be allocated to other promising projects.

Every gate encompasses mandatory and desirable characteristics which evaluate the information about the project (Cooper, 1998). The stages are multifunctional and encompass parallel activities which are carried out by employees from different departments (e.g. R&D, marketing, production or engineering).

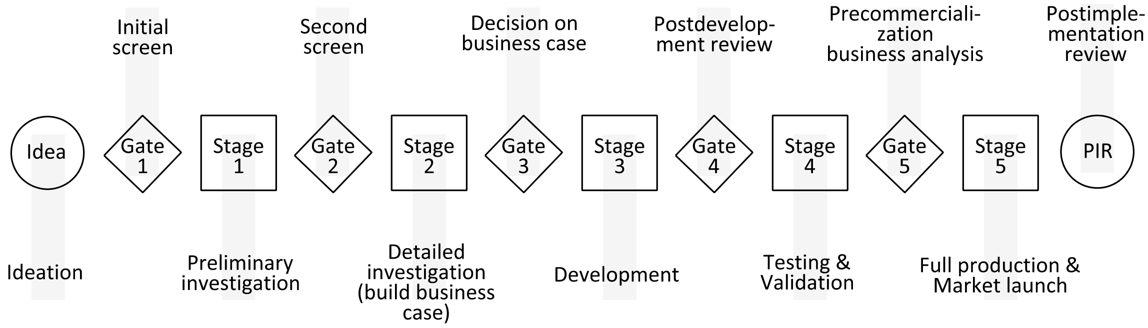

Figure 10 A generic Stage Gate innovation process (modified from Cooper, 1998, p. 108)

Such a stage gate system is designed to work as a "funnel" that begins with screening the ideas or projects in the early stages of the project when fewer resources are utilized and continues throughout the life of the project. An innovation project leader is in charge in each stage to ensure that the innovation project meets all the required criteria to pass the gate and moves forward to the next stage. In the implementation of the stage gate system the team and leader of the project work together from the start of the stage until the end. Beside, many research reviews that such an innovation process is commonly used (e.g. Cooper, 1993; Griffin & Page, 1993; Schmidt & Calantone, 1998). And the stage gate system can also improve the effectiveness, efficiency and productivity in the execution of key project tasks.

The stage gate model provides a mechanism to connect technology development with sales, marketing and ultimately the customer. In this process research and marketing efforts are performed concurrently with an emphasis on early efforts to define and measure customer needs and marketplace conditions. With integrated customer needs assessment and market-focused R&D efforts the result is a stream of products reaching the market faster and focused on customer needs (Bremser & Barsky, 2004).

The success or failure of a given innovation project is to a marked extent dependent on information and findings of a marketing, technical/technological, financial or economic nature. Even though processing these analyses is usually not cheap this should not deter us from careful project preparation since in this manner we can frequently avoid the losses linked with investing in poor innovation projects that end in failure.

By comparing models of the innovation process (see Section 3.4) and for the original purpose – to create a simple IPMS framework for the Czech business environment – five distinct evaluation gates are selected: (i) idea screening; (ii) project selection; (iii) innovation preparation and market test; (iv) analysing market test results, after-launch assessment; and (v) post-implementation review. Each of these phases is important for the success of innovation.

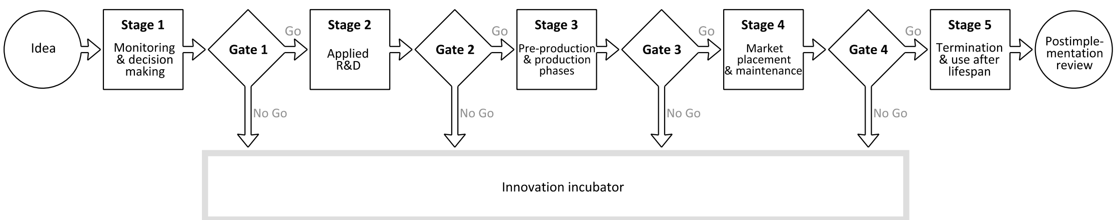

Figure 11 Modified Stage Gate process according to innovation process illustrated in Figure 2

After each of these stages an evaluation takes place, essentially to determine whether the new product should advance further or should be terminated. Such an evaluation requires the collection and consideration of information and the application of criteria against which this information can be assessed.

The criteria act as guideposts against which the performance of the innovation effort can be evaluated and adjustments can be made if necessary. To the extent that these criteria are derived from the corporate and innovation strategy of the company and are focused on the specific requirements of each stage of the innovation process, they can help reduce managerial uncertainty and can identify areas where additional attention and resources are needed. Furthermore, they can strengthen the strategic decision-making process of the company by helping management to develop and deploy the right competencies and resources across the innovation effort. As Hauser and Zettelmeyer (1997, p. 32) maintain: *"Select the right metric for each activity and you can encourage the right decisions and actions by scientists, engineers, and managers."* That said, key writers observe that the "Go/No-Go" decision points often are missing from representations and studies of the innovation process.

Gate 1 consists of measurement inspiration related to activities which are devoted to identification of ideas for innovation projects. This phase is divided into factors which depend on whether ideas are actively generated or collected from existing resources, as well as if they originate from internal or external stakeholders. Therefore idea screening is the first of a series of evaluations of whether the idea is according to the strategy of the company. It begins when the collection of inventive ideas is complete. It is an initial assessment to weed out impractical ideas. This initial evaluation cannot be very sophisticated as it is concerned with identifying ideas that can pass on to the applied R&D stage to be developed into concepts and can be evaluated for their technical feasibility and market potential.

The project proposals which are considered best are chosen and innovation projects are started for proof-of-concept and prototype development. At Gate 2 the project is re-evaluated based on the criteria of Gate 1 and additional variables such as market potential. A first financial calculation measures the potential return on investment of the new product. After that a more detailed investigation follows. The project is defined in detail, opportunities and threats are assessed and a project plan, i.e. a business case, is elaborated. Additional criteria can be used in project assessment, e.g. risk, effort needed, and time horizons for when the market is estimated to be ready for the innovation. This stage is therefore seen as critical; however it is often neglected. The business case includes a clear definition of the innovation. Then the market and competition are analysed. Market research studies are undertaken. Further the technical aspects of the product are assessed and detailed financial analysis is carried out. At the end of this applied R&D stage the product is finally developed physically. The result of this stage is a tested prototype. Apart from technical and qualitative aspects it is important to involve the customers or users for feedback in order to better understand their unmet and unspoken needs and problems and benefits sought in the innovation. Economic data and detailed plans, e.g. production and marketing plans, are reviewed. Based on this in Gate 2 the product is tested again for overall operability. This includes testing the product in the market. Cooper (1998) suggests field trials, pre-tests or test markets in order to assess customers' reactions and calculate approximate market share or revenues.

Gate 3 assesses the product a last time before its launch. The gate reviews the quality of the measures taken in the previous stage. The last stage implements the production and marketing plans of the innovation. The innovation is launched on the market. After 6–18 months the innovation project is finished. It becomes a regular product.

At Gate 4 the product is assessed once more. Actual performance is compared to forecasts. Further, strengths and weaknesses of the innovation project as well as customer acceptance and satisfaction and unit sales are primary considerations for evaluation in a post-implementation review in order to improve following projects.

Within Gate 5 there should of course be a post-implementation review which investigates the causes of the problems in the implemented innovation, not to seek out the culprit in terms of the poor decisions, but so that in future in a similar innovation process can discover and avoid similar problems.

Before the evaluation of the innovation process, an essential factor of innovation assessment has to mentioned – **timing**.

Timing is key for innovation success as well as the reason for most failures in the context of innovation (see Box 1). The timing of innovation should be measured not only against the market which is where people have a strong tendency to focus but also towards organisational readiness. The latter is especially true if the project has a radical or disruptive element to it. Then the biggest opponents can often come from the inside.

One challenge here is that promising projects – with the wrong timing – can be killed off in a very linear stage gate project. If an idea falls through the stage gate processes then it is just gone, even though it might hold promise at a future point when the company is better prepared to execute it.

A solution could be an "Innovation incubator" – if the projects are interesting, but the timing is off, then the competent manager can catch the falling projects in the innovation incubator. There is one cautionary point when setting up such an incubator. Some projects need to be killed because they are just not right for your company under any circumstances. If this does not happen, then they can end up as zombie projects that are often the pet project of someone with influence. They can suck up lots of resources and attention that could be better used elsewhere (Lindegaard, 2015).

6.3.1 Innovation Metrics

So-called perfect measures don't really exist

(Niven, 2014, p. 236)

After having designed an individual stage gate process for innovations in a company the criteria of evaluation for each gate have to be determined in order to maintain a continuing assessment of the process. This enables the company to react immediately so that the company may adjust its process and take adequate measures.

What criteria should be selected for a certain gate? Werner and Souder (1997) reviewed the literature from 1956 to 1995 on techniques for measuring innovation performance. They concluded that integrated metrics that combine several types of quantitative and qualitative measures which are the most complex and costly to develop and use are the most effective. They viewed the choice of innovation measurement metric to be based on needs for comprehensiveness of measurement, the type of innovations being measured, the life stage of an innovation effort, the available data and the perceived information cost/benefit. Schumann et al. (1995) proposed a quality-based approach to innovation performance measurement that viewed innovation as a process. Their framework encompassed people, process, outputs and consequences linked to a market-driven objective.

The pioneering proposal put forward by Kerssens-van Drongelen and Cook (1997) is based on the argument that all the output measurements utilised in the literature and in practice can be placed under one or several of the following five high level parameters: (i) cost (efficiency), (ii) quality, (iii) time, (iv) innovatory capacity, and (v) contribution to profits, and that these high level parameters can in turn be aligned with the five perspectives of Innovation Scorecard. Quality corresponds to the perspective of the customer, cost (efficiency) and time to the perspective of the internal processes, innovatory capacity to the perspective of learning and growth, and contribution to profits to the perspective of financial results.

A study by Hart et al. (2003) examines the evaluation criteria which are used most frequently by different manufacturing companies in the UK and the Netherlands. They selected 20 evaluative criteria. These criteria were allocated to four dimensions: (i) market acceptance (e.g. customer acceptance, customer satisfaction, revenue growth and market share), (ii) financial performance (e.g. break-even time, margin goals and profitability goals), (iii) product performance (e.g. development cost, launched on time and product performance), and (iv) additional indicators (e.g. technical feasibility and intuition). The findings demonstrate that although companies vary in their choice of evaluation criteria at different gates, companies apply customer and market orientation at all stages, i.e. they fulfil the requirement of customer integration (Desouza et al., 2008). The companies participating in the study estimated financial performance to be especially important during business analysis and after product launch. This enables management to judge the outcome of the product and to assess if resources are allocated properly. The next dimension, product performance, is basically applied during product development and market testing. And additional factors are notably applied during idea screening.

Since it is not reasonable to measure for example the technological success of a product at the development stage, and if the economic success of an innovation is indisputable, it is less meaningful to start evaluating the technical elegance of the innovation. This leads to the conclusion that different measures and different criteria are important at the variable gates of the innovation process and it is not one criterion that may be sufficient but multiple criteria should be considered (Hauschildt & Salomo, 2007). Moreover researchers (e.g. Donnelly, 2000; Hart et al., 2003; Hauser & Zettelmeyer, 1997; Vahs et al., 2010) assume that the process of evaluation has to be adapted to each stage.

Therefore the following sections deal with evaluation of innovation in various phases of the innovation process based on a modified stage gate model: (i) idea screening; (ii) project selection; (iii) innovation preparation and market test; (iv) analysing market test results, after-launch assessment; and (v) post-implementation review. Moreover at each gate the Innovation Scorecard framework provides a set of factors and for each factor a set of inspiration metrics to choose from or be inspired by (see Table 27–Table 30).

6.3.2 Gate 1: Initiation Phase – Measures for Ideation

In the initiation phase the influence of innovation ideas is generally still very unclear and technical or economic success is therefore difficult to estimate. The typical innovation killer is a question like “How profitable is this new opportunity?” Of course, asking detailed questions about profitability is not wrong but many companies tend to ask this question very early – at a stage when it is impossible to answer it.

There are only rough economic estimates and data collection concentrates primarily on the sales volumes of overall and submarkets as well as the distribution of market shares. Risk analyses are regularly carried out in the initiation phase as regards technical feasibility and economic success (Gaiser et al. 1989). Precise cost and revenue estimations and allocations can still not be made since the use of the innovation and its associated products or services has not been specified yet. The recorded values cannot be allocated to the innovation yet. The recording process only indicated possible leeway. The extent to which this can be filled by the innovation remains open in this phase. The first things a company should ask when evaluating a new idea are:

- How radical is the idea?
- How big or how important could it be?
- What kind of impact could it have on customers, on the competition, on the whole industry?
- How big is the potential market?
- Would customers actually want it?
- How much would they care about it?

In other words, the evaluation criteria should initially be focused on assessing the upside – how interested the company should be in a new idea, how hard it should work to push the idea forward and how committed it should be.

The flow of ideas with which to fuel innovation depends on the ability to leverage the human capital of the company. The measurement system for innovation needs to track the various pieces of the human capital equation: (i) culture, (ii) exposure to innovation stimuli, (iii) understanding of innovation strategy, and (iv) management infrastructure for ideation.

A significant amount of qualitative information is generated through the regular human resources mechanisms, including performance evaluations, exit interviews, and external audits that can be used to diagnose the state of the innovation culture. In addition, employee surveys can enrich the understanding of innovation culture. In combination these can give a quite accurate picture of the state of the innovation culture and climate in the company (e.g. Becker et al., 2001; Žižlavský & Senichev, 2013).

Goal measures like employee turnover, applicants per position, or employee involvement in innovation initiatives also exist. But even goal measures need to be carefully applied. The second aspect of a healthy idea flow is the exposure that the company has to innovation stimuli. Similar to the sales process, in which lead quality and volume depend on the depth and breadth of the marketing process, the quality and quantity of ideas depend on the exposure of the company to internal and external innovation forces (e.g. Chesbrough, 2003). The effectiveness of internal innovation efforts – quality circles, brainstorming groups and training sessions – can be measured to give the company a sense of whether it is devoting sufficient resources to these efforts and whether they are successful. A company can quantify the number of efforts and their effectiveness by using satisfaction and effectiveness surveys.

Box 4 Internal innovation effort measures

Sears Roebuck and Co.'s turnaround relied to a large extent on carefully measuring the quantity and quality of the workforce as a key input to success. A significant part of Sears' measurement system was devoted to monitoring the investment on recruiting the right talent and training it, as well as to monitoring the workforce commitment to change and the generation of ideas .

(Rucci et al., 1998)

Chrysler conducted assessments of the range of innovation efforts across its platforms and measured employee attitudes and their understanding of the strategic framework to gain a better understanding of its innovation efforts.

Siebel Systems developed internal knowledge-management software, later commercialized as Employee Relationship Management Systems, to put relevant information at the fingertips of each employee, enable access to the people throughout the company's network, and provide targeted training. This software allowed the company to track how it was using its network of people and training processes.

For collaboration projects with universities, IBM tracks the quality of the people involved, the meetings that take place, the achievements throughout the project, the quality of the ideas generated, and the follow-up work undertaken.

(Davila et al., 2013, p. 162–163)

Measurement of external stimuli – from suppliers, customers, partners, infrastructure providers, and experts – is also a key to success. Each particular external interaction has an execution model governing the inputs required to maximize the potential value of the collaboration, the processes in place to execute the strategy and outputs such as the quantity and quality of ideas generated.

The third leg of a healthy idea-generation process is a clear strategy backed up with access to competitive knowledge that is used to direct and catalyse innovation. One of the purposes of a strategy is to clarify what efforts are within the bounds of the company's playing field and therefore should be pursued. By clarifying these boundaries, the company focuses creativity and energizes action (Simons, 1995). Assessments of the types of ideas and projects combined with employee surveys can provide a good indication of whether the company understands the strategic framework for innovation and uses it to generate ideas.

The last lever of a healthy environment for ideation – the infrastructure element of the measurement system – should track whether adequate resources and processes are in place including these:

- Talent, which measures the level and effectiveness of recruiting, training, and resource allocation.
- Money, which measures funding available for ideation from the budgeting process and from discretionary pools within the company.
- Knowledge, which measures the development and use of effective knowledge management platforms to support internal and external groups.
- Management systems that track the quality of information, planning (such as strategic planning mechanisms), resource allocation and incentive systems that reward ideas. These systems enable the "friction" that leads to creativity.
- Communication, which tracks the level and effectiveness of planning and constructive conversations regarding the need and direction of innovation.

The following Table 27 provides a set of inspiration innovation measures to choose or be inspired from.

Table 27 Measurement inspiration for Gate 1

Inputs	Funding availability Individual networking skills Knowledge depth Number of incoming proposals from different sources Number of patents or prototypes further developed based on existing patent portfolio Number of, and time between, collection activities focused on specific external stakeholders (different types of users, customers, competitors, owners, public authorities, etc.) Percentage of R&D budget that is non-internal Quality IT infrastructure to support interest groups Quality of resources allocation process Research agreements with partners
Process	Innovation and creativity workshops Longitudinal change of proposal (e.g. to see peaks after presentation activities) Number of projects based on ideas from external stakeholders Number of workshops with customers on future needs Number of, and time between, activities of presenting the work of the innovative team Number of, and time between, activities of systematic idea generation Participation of suppliers in stage gate process Quality of development innovation process Quality of external collaborators Quality of planning systems Quality of training programs
Outputs	Alliances to further develop ideas Employee commitment Employee suggestions Funds committed to innovation Change in core competencies Improvement in knowledge stock Investment in new projects Map of upcoming innovations to the market Percentage of growth covered by innovation Quality of ideas funded R&D staff turnover
Outcomes	Actual versus budgeted costs for planning and knowledge management Costs of developing and maintaining infrastructure Effort spent in giving feedback Elapsed time from proposal to feedback Expected sales from incremental innovations against competitors Expected sales from radical innovations against competitors Change in revenue per employee Number of submitted proposals from people with rejected proposals (it is important that people continue to give proposals even if not all ideas become projects) Percentage of sales from ideas originated outside Percentage of sales together with partners

6.3.3 Gate 2: Development Phase Measures for Applied R&D

At the end of the inventive phase in the innovation process the company may have a list of many projects that senior management would like to complete. Each project may (or may not) possibly require different degrees of innovation. If current funding will support only a few projects then how does a company decide which of the twenty projects to work on first? This is the project selection and prioritization process. Project selection is a necessity for all projects but usually more difficult to perform if some degree of innovation is required. Predicting the degree of complexity is difficult. Based upon the company's financial health the company may select projects not requiring innovation but have a high expectation of generating short-term cash flow.

Project selection decisions are not made in a vacuum. The decision is usually related to other factors such as funding limitations, timing of the funding, criticality of the project and its alignment with the strategic plan, timing of cash flow expected from the completed project, fit with other projects in the portfolio, availability or the required resources and perhaps most important, the availability of qualified project managers and team members.

The selection of an innovation project could be based upon the completion of other projects that would release resources needed for the new project. Also the project selected may be constrained by the completion date by which resources must be released to other activities. In any event some form of selection process is needed.

Project selection decision-makers frequently have much less information to evaluate candidate innovation projects than they would like. Uncertainties often surround the success likelihood of a project and market response, the ultimate market value of the project, its total cost to completion and the probability of success and/or a technical breakthrough. This lack of an adequate information base often leads to another difficulty – the lack of a systematic approach to project selection and evaluation. Consensus criteria and methods for assessing each candidate project (see Table 28) against these criteria are essential for rational decision-making. Though most companies have established organisational goals and targets these are usually not detailed enough to be used as criteria for project selection decision-making. However they are an essential starting point.

Project selection and evaluation decisions are often confounded by several behavioural and organisational factors. Departmental loyalties, conflicts in desires, differences in perspectives, and an unwillingness to openly share information can hamper the project selection and evaluation process. In addition to these, the uncertainties of innovation and possibly a lack of understanding of the complexities of the innovation project can make decision-making riskier than for projects where innovation may be unnecessary. Much project evaluation data and information are necessarily subjective in nature. Thus the willingness of the parties to openly share and put trust in each other's opinions becomes an important factor.

The risk-taking climate or culture of a company can also have a decisive bearing on the project selection process as well as creating additional problems for the project manager during project execution. If the climate is risk averse then high-risk projects requiring innovation may never surface. Attitudes within the company toward ideas and the volume of ideas being generated will influence the quality of the projects selected. In general the greater the number of creative ideas generated the greater the chances of selecting projects that will yield the greatest value.

In the second gate the evaluation of the innovation is based primarily on an estimate of the total investment costs and the forecasted market potential. Potential analyses provide information on the revenue potential which could be tapped in the market by the innovation and how the company's competitive situation could alter as a result (Gaiser et al. 1989). The extent to which the potential can be exploited remains open initially. The analysis is deliberately kept on a superficial level since a more precise analysis would require too much time and too many resources and would be repeated in subsequent phases anyway.

Table 28 Measurement inspiration for Gate 2

Inputs	Amount and quality of customer data acquired related to innovation Free time allowances for R&D employees Market and technology research resources Number of experienced innovation team members Number, complexity and size of competitors, customers, partners, and suppliers Objectives for innovation efforts clearly communicated to senior managers and employees Percentage of performance measures and rewards aligned and linked to innovations Quality of information for innovation Quality of it infrastructure Success of ideas passing through selection and execution processes Time dedicated to innovation
Process	Alignment between innovation strategy and resource allocation Cost, development time, delivery time, quantity, and price of products and services offered Estimated project effort Innovation contribution to R&D projects in progress Number of terminated/unsuccessful projects (a certain degree of risk-taking is good) Percentage of innovation efforts devoted to radical, semi-radical, and incremental innovation Portfolio balanced over time, returns, risk, and technologies Product platform effectiveness Rate and quality of experimentation Reduction in new product/process development time/cost within target sales/profits Subjective assessment of project risk (feasibility, technical challenge, etc.)
Outputs	Estimated lead time to market launch of project results Number of projects with future customer or new market relevance Percentage of innovation projects outsourced Percentage of sales from new products Potential loss (alternative cost) of not selecting a project (worst-case scenario) Projected residual income Projected sales growth R&D productivity Ratio of short-term and long-term projects Residual income growth Sales growth
Outcomes	Customer profitability Customer satisfaction with innovation activities Frequency of repeat customers Margin of product and services offered to customers Market share New customers gained through innovation Number of customers through existing products/services who buy new products/services Number of new customers of new products/services who go on to buy existing ones Number of new product and service lines introduced Profitability of innovation operations Revenues generated through innovation efforts

At this early stage the investment appraisal methods are still not applied since they require much more detailed information on the time of occurrence of input values. The estimate is limited to a basic comparison of investment costs and the revenue and growth potential of the market addressed, augmented by risk-related statements. The cost sheet is to provide an idea of the financial and organisational expenses to be expected.

Demanding a lot of financial precision about a promising project, particularly during the embryonic stages of experimentation, is highly counterproductive. Rather than making a quick decision about an idea at a very early stage, the goal should be to create an extremely fast iterative cycle that allows prospective innovators to get started, quickly test whether their hypotheses are valid or invalid, see what they learn from their experimentation and rapidly iterate that learning. Questions to consider in Gate 2 are:

- How feasible is this?
- How mature is the technology?
- Do we have the resources, the competencies, the capabilities to make it happen or can we get them somewhere else (through partnerships)?
- Do we have the distribution channels to bring this to the market?

6.3.4 Gate 3: Production Phase – Measures for Realization

Choosing the right projects is only half of the way to ensure a company's long-term competitiveness. Even if the right innovation projects are selected it remains important to assess whether the execution of every single project is successful. More precisely companies face the challenge of measuring the performance of innovation projects.

As questions of feasibility from the previous gate get resolved, the final questions to start asking are those that concern business model economics:

- Can we actually make it profitable?
- What sorts of revenue might this idea generate?
- What are the costs involved?
- What sort of margin can we put on this?

Therefore the planning phase is used to prepare and develop innovation concepts. These concepts build the framework for the values to be considered in this phase. Forecast, potential revenues from products and services and OPEX form the basis for the calculation. Depending on the nature and design of the innovation, revenues can be broken down into detailed reference values such as customer groups or sub-segments.

The project organisation allows project costs to be recorded and allocated directly by project control. The more difficult task is the allocation of overheads with regard to other projects and innovation projects and general revenues from other products. For revenues in particular, an analysis of other similar products is a central component of revenue analysis and forecasts. In the context of interconnected or network products the determination and allocation of the innovation‘s value contribution is particularly important.

In order to assure performance of innovation projects a number of tools can be applied such as milestone trend analysis, project reporting, project status analysis or cost trend analysis. Another tool which can be applied is target costing. This strategic cost management allows the entire life cycle of product and influencing the performance of innovation project in the early stages of product development to be considered (e.g. Sakurai, 1989). Table 29 provides a set of inspiration innovation metrics to choose or be inspired by for Gate 3.

Sequence – asking first about the size of the idea, then about the feasibility and only then adopting the profitability – is one that many venture capitalists understand but many companies do not. Large companies are often so afraid of overinvesting in a lousy idea that they fail to appreciate the concomitant risk of prematurely killing a great but immature idea. By asking the profitability questions first instead of last they make it almost impossible for the innovator to present a compelling case to those responsible for budgeting. As a result the project either gets flatly rejected at its embryonic stage – as a "bad" or "uncertain" idea – or alternatively the innovator is forced to create some false certainty about the project that can later blow up in people's faces.

Table 29 Measurement inspiration for Gate 3

Inputs	Budget allocation to innovative activities Distribution of team members' background, experience, age, gender, etc. Estimated remaining investment needed to implement innovation in real products Number of competence are that are mastered within the team Number of process changes which are considered significant improvements Number of projects which shift from innovation to normal development Project resources (effort, budget, etc.) Share of prototype construction which can be reused directly in normal product development Share of total effort spent on creative work compared to, e.g. administration Subjective assessment of how well strategic competence areas are covered Time allocation devoted to each team member's own proposal
Process	Implementation of new organizational method Involvement in the innovation processes Lead time per project Level of communication and information flow Level of coordination among R&D, marketing and production units Number of projects each team member has managed or participated in Share of budget on outsourced projects Subjective assessment of the benefit of each process change Subjective assessment of the effectiveness of innovation assessment methodology Time between deadlines for each project member Work environment and relations with co-workers
Outputs	Average development cycle time stages Average expenses for innovative activities Degree of match between the R&D budget and the objectives set Degree of match between the resources deployed and R&D results achieved Degree of success in keeping costs to budget New products approved/released Number of implemented process improvement proposals Number of projects per year, number of people involved per project Percentage of innovation projects abandoned before their end R&D expenses as percentage of sales Team work effectiveness
Outcomes	Average cost of each finished project CAPEX Cost reduction (derived from innovation projects) Monetary rewards for achieved personal and group goals achieved Monetary rewards for patent proposals OPEX Optimization of the use of capital (human and material)

Asking the right questions in exactly the right sequence will help a company to avoid the premature culling of promising opportunities. It will also help senior management to identify the ideas that – if they worked – would be most likely to give their revenues a dramatic boost.

6.3.5 Gate 4: Commercialization Phase – Measures for Innovation Execution (Short-term Assessment)

The specified product concepts are launched on the market using traditional marketing tools and on the basis of the product launch processes in the commercialization phase. Internal accounting provides cost and service allocation and forecasts as basic information for this phase. Therefore metrics provided by Table 30 can be chosen.

The innovation profitability analysis focuses on individual products, service offers, product bundles, dedicated customer segments and sales areas in this phase. There is already a clear idea of production costs and willingness to pay, enabling detailed data to be recorded.

As the data pool improves, the relationship between innovation and origin of cost gradually becomes clearer. Specifically the level of detail and the specific nature of the data make it easier to allocate innovations. Cost accounting becomes increasingly helpful and offers more precise information, especially with regard to OPEX and the determination of flat rates. However integration with internal accounting only helps with cost allocation; revenue forecasts and measurement of innovations continue to be problematic. In particular, the difficulty in identifying the share of revenue induced by the innovation remains and is rendered all the more difficult by the problems concerning interconnected products, as mentioned above.

The data quality of the values also continually increases. As mentioned above, with regard to measuring costs, the actual values can increasingly be referred to as a basis for comparison. Despite the problems concerning revenues from interconnected products, the knowledge of customers‘ willingness to pay in particular increases through market and acceptance tests.

Table 30 Measurement inspiration for Gate 4

Inputs	Budget percent allocated to innovation effort Number of collaboration activities with internal and external stakeholders Number of end users of released product features that originate from the team's work Number of change requested which originate from the team's work Number of released product features impacted by the team's work Number of results from the team accepted by product planning (or other stakeholders) Percentage of innovation projects outsourced Performance-based compensation linked to innovation success Product uniqueness Success of ideas passing through selection and execution processes Time dedicated to innovation
Process	Alignment between innovation strategy and resource allocation Cost, development time, delivery time, quantity, and price of products and services offered New product acceptance rate Number of gateway returns Percentage of innovation projects that respect the cost and outputs planned Portfolio balanced over time, returns, risk, and technologies Product and process quality score R&D productivity Rate and quality of experimentation Reduction in new product/process development time/cost Share of project effort spent on internal marketing
Outputs	Achievement of quality and time objectives Brand image Customer acceptance Customer satisfaction improvement Enlargement of product variety General quality of work undertaken in innovation activities Market share growth Percentage of projects that directly involve the customer Percentage of sales from new product R&D efficiency (time to market) Sales growth
Outcomes	Break even time Customer profitability Margin of product and services offered to customers New customers gained through innovation Number of customers through existing products/services who buy new products/services Number of new customers of new products/services who go on to buy existing products/services Number of new product and service lines introduced R&D value creation in commercialisation stages Return on capital employed Turnover from and to R&D units

Company accounting and the company's planning systems provide a wide range of tools in this phase with which both cost and revenue-related planning and control can be achieved. In the measurement, the project-induced revenues must be compared with capital expenditure over time. Data for the forecast revenues and investment costs should be agreed with the product owners. For interconnected and network products this is difficult since there are generally several product owners. Financial mathematics provides above all the net present value method as a dynamic investment appraisal method (e.g. Žižlavský, 2014a). Under this method, payments received and made over the product life-cycle are compared and discounted to their present value. Corporate earnings and innovation risk are controlled using the specified interest rate.

6.3.6 Gate 5: Post-implementation Review (Long-term Assessment)

The post-implementation review is a process that after an appropriate interval follows completion of the innovation project and is a comprehensive review of the completed innovation.

The aim is a factually accurate and precise as possible analysis of the actual implementation of the innovation project in all phases, and after comparison with the plans the identification of all the factors that resulted in deviation of the project from the fulfilment of the original goals. Organisationally it is advisable to make the post-implementation review part of the management of the company innovation processes, by which better preconditions for its implementation are created.

The post-implementation review thus becomes a key element in control feedback, which makes possible the incorporation of the results into further projects, so becoming also the first ex-ante input in future projects. We can therefore see the post-implementation review as a learning process, the results of which translate into the success of further innovation projects and so also into the future prosperity of the business.

The post-implementation review is not primarily intended for the evaluation of the degree of success or failure of an innovation project and the assigning of responsibility for any such failures but rather for the determining of the key causes leading to the non-achievement of the original goals. For this reason it is important to pay just as much attention to analysis of projects which in terms of value creation and company growth were actually more successful than planned. Uncovering the causes of such results can help in setting up the future innovation control in such a way as that the company can focus precisely on those factors that support its success.

The post-implementation reviews of innovation projects are suitable for focussing primarily on the setting up and evaluation of:

- Degrees of fulfilment of the project goals; not only quantitative, but also qualitative ones which were only formulated verbally. A part of this evaluation is assessment of the conformity between the anticipated financial results and the values of efficiency indicators and the results and values actually achieved.
- Compliance of the implemented innovation project with the strategic focus of the company. The essence is an assessment of whether the implemented project deepened the strategic orientation of the company and helped to fulfil its strategic goals. The strategic accent of the post-implementation review must also include an answer to the question of whether the company is correctly strategically oriented and whether it has appropriately set strategic goals.
- The methods for the preparation of the innovation project, the evaluation of its versions and the choice of the version implemented.
- Keeping to the planned budget and duration of the project.
- Compliance of the basic initial premises of the project with the reality after its implementation. These premises relate both to micro-environmental factors (demand and selling price, the prices of basic inputs, behaviour of competitors, etc.) and the macro-environment (economic trends, interest rates and exchange rates, legislative changes, etc.).
- Significant factors which led to problems at various stages in the implementation of the innovation project (identification of the causes of failure). These can be internal

factors (shortcomings in the preparation, evaluation, choice, planning and realisation of projects), external factors, or risk factors (whether identified beforehand and made part of risk management), or overlooked or completely unforeseeable factors.

- Significant factors which made the biggest contribution to the success of the project (identification of the causes of success). These factors can once again be internal (high quality of the preparation and implementation of the project) or external (a combination of favourable circumstances or luck).
- Lessons learned from the post-implementation reviews for the preparation, evaluation, choice and realisation of future innovation projects (what to avoid, what to do differently and what to strengthen and continue to apply).

It is obvious that the above-listed content of post-implementation reviews of innovation projects is not exhaustive. Depending on the field of the innovation project the content of their post-implementation reviews may have, aside from what they hold in common, certain specific features and nuances (certainly post-implementation reviews of innovation projects in IT and in industrial oil refining will differ). Varied project size can also lead to specific features, etc.

A basic requirement for carrying out a comprehensive evaluation of any event in the past is a quality information platform, which means reasonable information on the whole course of the innovation process – from the initial inventive phase all the way through to after its completion. The information base should be reliable and complete – if it is incomplete it will make it impossible to find the original causes of some deviations. This basic information is of an internal character and is not just accounting but also regularly evaluated data from the information system. Operational documentation, including the assigned responsible person, is important – not in order to be able to pursue them for imperfect decisions but so that it is possible to return, not just in documents, and discover some causes of a soft character that cannot be identified from quantified characteristics (from which only the results can be found). In external information it is important to give the primary source from which the original data has been taken, then eventually the treatment process, the system for converting information into data, in order to be able to assess whether this process is not wrongly set up and so that it is possible to adjust the instructions or methodology for processing.

In a company it is necessary to create a climate within which the post-implementation review is seen not as a means of monitoring R&D employees but as an instrument for evaluating the innovation process with the aim of drawing lessons for the future – in accordance with the basic principles of management control there must be a clear declaration of its orientation on the future. This will then make it possible to win the interest of people, which in turn will improve the quality of the outputs of the post-implementation review so that all can see that it is not just a game with numbers from the past but that the result is a source of guidance and that its future use will help to promote the greater success of innovation projects.

7 CONTRIBUTION OF THE STUDY

7.1 Implications

Based on the theoretical review and the empirical findings from primary research, major implications relevant to academics and practitioners stem from this study.

First, the work has implications for the field of business performance measurement. Research has outlined a number of metrics, various methods and performance measurement frameworks for innovation process evaluation that exist in Czech manufacturing companies. From a managerial viewpoint the Innovation Scorecard may provide useful guidelines for focusing attention and expending resources during the entire innovation process. It is argued that the informed use of evaluation metrics as guideposts for increased managerial attention and the identification of problems may help management to prevent drop-and-go-errors in their innovation efforts. Managers may compare and contrast findings from this study with their own innovation practices and, by doing so, enrich the knowledge pool upon which they draw to make well-informed decisions.

The second unique feature of the present study is the research methodology adopted. It is one of the few comprehensive studies to address the question of what methods of innovation performance measurement are implemented in innovative Czech manufacturing companies. Moreover the research takes into account the specifics of the investigated issue, such as measurement in soft systems, the core micro-level of measurement (see Sections 2.2 and 2.6), and the specifics of the Czech business environment after the financial crisis (see Sections 4.2 and 5.2).

Third, the research can aid practitioners, since it provides organisations with new insights and findings which managers can translate into the context of their own companies. Specifically, companies know that with a clear innovation strategy they can be more innovative, improve innovation processes and achieve better financial results.

Next, this study has created a basis for further research in the field of innovation performance measurement and management control (see next Section 7.2). An extensive theory about innovation management and performance measurement has been reviewed in this thesis. Moreover, the literature overview has been completed by primary research in Czech manufacturing industry. Therefore it could serve as guideline for case studies or further research conducted by Ph.D. candidates.

Last, the knowledge gained can be applied within various courses, classes or lectures given at the Faculty of Business and Management Brno University of Technology (e.g. Controlling or Analysis of a Company´s Capability).

However the benefits need to be assessed in a purely realistic manner. The proposed methodology is not an all-powerful guide which would lead to problem-free innovation performance management in all circumstances. It identifies and highlights potentially problematic areas and shows managers all that they should take into account when managing innovation. It is also only one of many possible approaches, given how extensive economics has become and the wide availability of its results.

7.2 Limitations and Future Research Proposal

The research projects have helped better define the complexity and structure of innovation process evaluation in Czech manufacturing companies. However, as with any other research, the methods employed have inherent limitations, which lead to opportunities to improve future research in this area.

First, the results of this study are limited to the analysis of a single case study, representing a starting point for further research in other industries and countries. In this sense, the findings may be extrapolated to other CEE countries, since economic and technological development in the Czech Republic is similar to that in other OECD Member countries.

Second, respondents were asked to answer the questions in relation to a representative innovation they had developed and had launched in the previous five years. This retrospective methodology has several limitations. For example halo bias effects may be present because the performance of the innovations chosen was known prior to completing the survey. There may also be differences between respondents' recalled and actual measurements. For example selective recall, rationality bias and reconstruction bias may cause respondents to massage their responses upwards in order to make their firms look good.

Next, this research investigated the use of metrics in the innovation process. In addition, the Innovation Scorecard proposes splitting the entire innovation process into phases with evaluation and decision-making gates. An obvious next step would be to measure the perceived importance of the metrics at the different evaluation gates in order to observe their advances in innovation and the existence of innovation performance measurement system implementation. Although it may be suggested that the frequency of use of a certain metric reflects or is related to the importance of measuring this metric, additional research is necessary to substantiate this.

The last limitation to be noted is that the measurement of the performance of the innovative process was, is and always will be encumbered by a certain inaccuracy associated with the creative nature of this process. The real challenges for managers come once they have developed their innovation measurement system for then they must implement the measures. As soon as they seek to do so they encounter fear, politics and subversion. Individuals begin to worry that the measures might expose their shortcomings. Different people seek to undermine the credibility of the measures in different ways. Some seek to game the system. Others seek to prevent it ever being implemented. Research into these issues and particularly into how they can be addressed is much needed. Once these questions have been answered then the challenge lies in how the measures can be used to manage the business: What is the role of measurement and how can the measurement system itself be managed? How can managers ensure that the measures they use remain relevant over time? This is a full and challenging research agenda, and in view of the importance of the innovative process for the development of the company and the amount of resources put into it, also a vital one.

CONCLUSION

The thesis is based on current knowledge in the area of innovation management and management control and on specific conditions in today's business environment. It summarises the issues of managing and measuring the effectiveness of the innovation process. It identifies and explains from a theoretical perspective shortcomings in today's approaches and offers possible solutions. This work builds on knowledge from significant Czech and foreign authors, summarises it and tries to develop it further.

The purpose of this study was to investigate companies' approaches to measuring their innovation performance. For this, it was necessary to study the individual definitions, processes and means of measuring and managing innovation performance as available in the current state of scientific thinking (see Chapter 3). This review phase was oriented to the study of Czech and foreign specialised literature as found in books, articles in journals, information servers and the databases of libraries, universities and other organisations. The positive impact of innovations on both corporate performance and competitiveness is well established in theory and research as reviewed in Chapter 4.

The subsequent primary research phase was performed following the primary research procedure presented in Section 2.5. The survey consisted of the preparation, processing and evaluation of questionnaires and subsequent semi-structured in-depth interviews with managers from middle and higher management as well as experts in the selected companies, making use of their practical experience. The purpose of these interviews was to provide any missing qualitative data, to supplement concrete data, to allow for a subsequent discussion over the conclusions drawn and to test the possibility of their implementation in practice. Such data provided a basis for processing the proposal for conceptual innovation performance measurement and management framework. Then, data from primary research are evaluated with the help of statistical methods in the Minitab® 15.1.1.0 statistical software (see Section 5.2. and Appendix 6).

Primary research in Czech manufacturing companies (see Chapter 5) has shown that companies dealing with innovations constantly look for corresponding indicators in order to determine the benefits of innovations. Innovation metrics should motivate managers and employees to carry out successful innovations directly linked to the company's strategy consisting of marketing, strategic planning, corporate processes and people.

Moreover, research has outlined a number of metrics; various methods and performance measurement frameworks for innovation process evaluation that exist in Czech manufacturing companies. Most of the surveyed Czech companies measure the results using financial indicators, although the majority of managers in these companies feel that also non-financial indicators should be used to monitor the innovative efforts and projects undertaken.

On the basis of this literature review and an empirical study in Czech manufacturing industry, a management control system approach to innovation performance measurement suitable for Czech business environment called the Innovation Scorecard was proposed (see Chapter 6). It specifically extends the work of Kerssens van Drongelen et al. (2000) and Pearson et al. (2000) by integrating popular innovation management frameworks, the input–process–output–outcomes model (Brown, 1996) and the Stage Gate approach (Cooper, 1998), with the Balanced Scorecard (Kaplan & Norton, 1996).

As with any other research the methods employed have inherent limitations, which lead to opportunities to improve future research in this area. Therefore this study is supposed to motivate researchers to conduct more largescale studies in the area of innovation performance measurement system implementation in different business sectors and areas.

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APPENDIXES

APPENDIX 1 LIST OF ABBREVIATIONS

BET	Break even time
BSC	Balanced Scorecard
CEO	Chief executive officer
CR	Czech Republic
CZSO	Czech Statistical Office
EBIT	Earnings before interest and taxes
EBITDA	Earnings before interest, taxes, depreciation and amortization
EU	European Union
EVA	Economic value added
GDP	Gross domestic product
IFRS	International financial reporting standards
IPMS	Innovation performance measurement system
IRR	Internal rate of return
KPIs	Key performance indicators
MCS	Management control system
NACE	Nomenclature générale des Activités économiques dans les Communautés Européennes
NPV	Net present value
OECD	Organization for Economic Co-operation and Development
PMS	Performance measurement system
R&D	Research and development
ROA	Return on assets
ROI	Return on investment
RoPDE	Return on product development expense
SMEs	Small and medium-sized companies

APPENDIX 2 LIST OF FIGURES

APPENDIX 3 LIST OF BOXES

APPENDIX 4 LIST OF TABLES

APPENDIX 5 QUESTIONNAIRE

This appendix indicates a selection of the questionnaire submitted to companies.

General information section

1. What is your company's number of employees?

2. What is your company's turnover?

3. What is your company's origin?
   - Czech
   - Czech with foreign participation
   - Foreign

4. In which geographic markets does your company sell products or services?
   - Czech regional market
   - Czech national market
   - EU market
   - Global market

5. Does your company perform innovation?
   - Irregularly and randomly, i.e. as a consequence of intuitive and immediate decisions, or reverse the negative development.
   - Regularly, i.e. as a standard part of their businesses and systematically managed.

6. What type of innovation did your company introduced? (Multiple responses possible)
   - Product innovation
   - Process innovation
   - Organisational innovation
   - Marketing innovation

7. Please, evaluate importance of introduced innovation (based on Likers scale 1 – very important, 2 – important, 3 – neutral, 4 – not important, 5 – completely unimportant.

8. Please, estimate the total amount of expenditure for innovation by percentage of annual budget.
   - We invest in innovation based on actual needs.
   - Up to 5% of annual budget.
   - 5-10% of annual budget.
   - More than 10% of annual budget. Please, note sum:

Information about innovation management control systems

9. Have your company implemented R&D management control system?
   - Yes
   - Rather yes
   - Rather no
   - No

10. Since when has the company implemented innovation management control system?
    - Less than 5 years
    - From 5 to 10 years
    - From 11 to 15 years
    - More than 15 years
11. What are the reasons for innovation management control system implementation in you company? Evaluate their importance.
    - Business strategy planning
    - Reduction of wasting resources
    - Idea improvement
    - Legitimacy to innovation
    - Communication
    - Motivation and remuneration
    - Stakeholders relationship
12. Who is responsible for innovation management control?
    - Owners
    - Top management
    - R&D employees
    - Individuals
    - Others
13. What management control tools does your company use? (Multiple responses possible)
    - Balanced Scorecard
    - Budget
    - Cost accounting (with cost centers)
    - Cost accounting (without cost centers)
    - EBITDA, EBIT
    - Economic value added EVA
    - Payback period
    - Profitability (ROI, ROE, ROA, ROS)
    - Revenues from innovation
    - Cannibalisation of existing products by innovation
    - Customer satisfaction indicators
    - Growth of market share
    - Innovativeness
    - Number of new customers
    - Patents
    - Productivity and quality indicators (lead time, etc.)
14. Is measurement and evaluation indicator for an innovation process clearly defined?
15. Is the frequency of indicator measurement determined?
16. Is responsibility for indicator measurement clearly defined?
17. Are correcting measures determined when exceeding values of the indicator?
18. Does innovation process measurement serve as the basis for its improvement?

APPENDIX 6 MINITAB® STATISTICAL TESTS RESULTS

Tests for statistically significant difference between the size of respondents and non-respondents.

```
Chi-Square Test: Response; Non-response for micro companies
Expected counts are printed below observed counts
Chi-Square contributions are printed below expected counts

       Response  Non-response  Total
    1        63           562    625
          76,90        548,10
          2,513         0,353

    2       291          1961   2252
         277,10       1974,90
          0,698         0,098

Total       354          2523   2877

Chi-Sq = 3,662; DF = 1; P-Value = 0,056
```

```
Chi-Square Test: Response; Non-response for small companies
Expected counts are printed below observed counts
Chi-Square contributions are printed below expected counts

      Response  Non-response  Total
    1        94           674    768
          94,50        673,50
          0,003         0,000

    2       260          1849   2109
         259,50       1849,50
          0,001         0,000

Total       354          2523   2877

Chi-Sq = 0,004; DF = 1; P-Value = 0,949
```

Chi-Square Test: Response; Non-response for medium companies
Expected counts are printed below observed counts
Chi-Square contributions are printed below expected counts

	Response	Non-response	Total
1	123	853	976
	120,09	855,91	
	0,070	0,010	
2	231	1670	1901
	233,91	1667,09	
	0,036	0,005	
Total	354	2523	2877

Chi-Sq = 0,122; DF = 1; P-Value = 0,727

Chi-Square Test: Response; Non-response for large companies
Expected counts are printed below observed counts
Chi-Square contributions are printed below expected counts

	Response	Non-response	Total
1	74	434	508
	62,51	445,49	
	2,113	0,297	
2	280	2089	2369
	291,49	2077,51	
	0,453	0,064	
Total	354	2523	2877

Chi-Sq = 2,927; DF = 1; P-Value = 0,087

1 = member of appropriate group
2 = Non-member of appropriate group

“Hypothesis 4: Large companies perform innovation regularly – it is part of their business.”

```
Expected counts are printed below observed counts
Chi-Square contributions are printed below expected counts

         SMEs   Large  Total
    1     237      34    271
       218,18   52,82
        1,624   6,707

    2      48      35     83
        66,82   16,18
        5,302  21,898

Total     285      69    354

Chi-Sq = 35,531; DF = 1; P-Value = 0,000

1 = Irregularly
2 = Regularly
```

Cronbach's Alpha: Importance of particular types of innovation

Correlation Matrix

	Product	Process	Organizational
Process	0,968		
Organization	0,930	0,927	
Marketing	0,923	0,947	0,935

Cell Contents: Pearson correlation

Item and Total Statistics

Variable	Total Count	Mean	StDev
Product	354	2,471	1,376
Process	354	2,529	1,331
Organizational	354	3,000	1,326
Marketing	354	2,676	1,173
Total	354	10,676	5,085

Cronbach's Alpha = 0,9828

Omitted Item Statistics

Omitted Variable	Adj. Total Mean	Adj. Total StDev	Item-Adj. Total Corr	Squared Multiple Corr	Cronbach's Alpha
Product	8,206	3,748	0,9620	0,9460	0,9761
Process	8,147	3,783	0,9710	0,9571	0,9730
Organization	7,676	3,812	0,9475	0,9049	0,9794
Marketing	8,000	3,954	0,9535	0,9211	0,9798

“Hypothesis 5: Large companies tend to invest greater sums of money into innovation (measured by percentage of annual budget).”

```
Chi-Square Test: Investments into innovation (by % of annual budget)

Expected counts are printed below observed counts
Chi-Square contributions are printed below expected counts

         SMEs   Large  Total
    1     113       9    122
        98,22   23,78
        2,224   9,186

    2     118      20    138
       111,10   26,90
        0,428   1,769

    3      47      24     71
        57,16   13,84
        1,806   7,461

    4       7      16     23
        18,52    4,48
        7,163  29,587

Total     285      69    354

Chi-Sq = 59,624; DF = 3; P-Value = 0,000
1 cells with expected counts less than 5.

1 = Actual needs
2 = Up to 5% of annual budget
3 = 5-10% of annual budget
4 = More than 10% of annual budget
```

“Hypothesis 6: Large companies tend to evaluate their innovative activities more than SMEs.”

Chi-Square Test: Evaluation of innovation projects

Expected counts are printed below observed counts
Chi-Square contributions are printed below expected counts

	SMEs	Large	Total
1	63	10	73
	58,77	14,23	
	0,304	1,257	
2	222	59	281
	226,23	54,77	
	0,079	0,327	
Total	285	69	354

Chi-Sq = 1,967; DF = 1; P-Value = 0,161

1 = No/Rather no
2 = Yes/Rather yes

"Hypothesis 7: Large companies have implemented their innovation performance measurement system for a longer time than SMEs."

```
Chi-Square Test: Period of innovation project evaluation

Expected counts are printed below observed counts
Chi-Square contributions are printed below expected counts

        SMEs  Large  Total
    1     66      8     74
       59,78  14,22
       0,647  2,721

    2     96     25    121
       97,75  23,25
       0,031  0,131

    3     52     15     67
       54,12  12,88
       0,083  0,351

    4     13      6     19
       15,35   3,65
       0,359  1,511

Total    227     54    281

Chi-Sq = 5,835; DF = 3; P-Value = 0,120
1 cells with expected counts less than 5.

1 = Less than 5 years
2 = From 5 to 10 years
3 = From 11 to 15 years
4 = More than 15 years
```

Cronbach's Alpha: Reasons form MCS implementation

Correlation Matrix

	Business plannin	Resources	Idea
Resources	0,935		
Idea	0,941	0,923	
Legitimacy	0,888	0,830	0,870
Communication	0,938	0,925	0,966
Motivation	0,901	0,942	0,942
Stakeholders	0,918	0,931	0,920

	Legitimacy	Communication	Motivation
Communication	0,881		
Motivation	0,797	0,943	
Stakeholders	0,903	0,925	0,899

Cell Contents: Pearson correlation

Item and Total Statistics

Variable	Total Count	Mean	StDev
Business planning	281	2,036	1,170
Resources	281	1,929	1,120
Idea	281	2,250	1,236
Legitimacy	281	2,464	1,232
Communication	281	2,286	1,272
Motivation	281	2,000	1,018
Stakeholders	281	2,643	1,254
Total	281	15,607	7,978

Cronbach's Alpha = 0,9853

Omitted Item Statistics

Omitted Variable	Adj. Total Mean	Adj. Total StDev	Item-Adj. Total Corr	Squared Multiple Corr	Cronbach's Alpha
Business planning	13,571	6,850	0,9585	0,9319	0,9819
Resources	13,679	6,907	0,9498	0,9402	0,9826
Idea	13,357	6,778	0,9659	0,9502	0,9814
Legitimacy	13,143	6,862	0,8901	0,8694	0,9865
Communication	13,321	6,739	0,9694	0,9536	0,9813
Motivation	13,607	7,015	0,9384	0,9390	0,9840
Stakeholders	12,964	6,774	0,9536	0,9249	0,9823