Chapter 17

Innovation Measurement in the Czech Republic and People's Republic of China

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Additional information is available at the end of the chapter

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Abstract

For companies innovations are vital to ensure their continued growth and ability to survive in a highly competitive business environment. Realization of successful innovations has positive impact on countries and their economies. At the same time strong economy in a country is an assumption of strong economy of its regions. Interested party receives an information feedback about innovation performance and character of innovation environment and enables to implement measures to eliminate any shortcomings. Innovations can be measured at enterprise, state and global levels. Measurement of innovations in connected with following questions: What is emphasized in measuring innovation at appropriate level? What structure do indicators that are used when measuring have? What types of indicators are used when measuring? What are the differences in innovation measurement at the level of the Czech Republic and People's Republic of China? These questions are answered in this chapter. Aim of the chapter is to monitor possible ways of innovation measurement at the enterprise, state and global levels and at the same time to compare differences in innovation measurement in the Czech Republic and People's Republic of China. For that purpose, analysis, synthesis, description and comparison were used.

Keywords: innovations, technical innovations, measurement

1. Introduction

Not only advanced economies but also developing nations recognize that innovation is one of the main drivers of economic growth, leading to emergence of new industrial enterprises and branches, develops manufacturing, increases production level while inputs remain unchanged and lead to increasing revenues. Several authors (Brynjolfsson and McAfee,

2015; Zelený, 2011) point out that innovations are fundamental great inventions, or recombination of things that have already existed. Contemporary innovations take the form of digital technologies, based on hardware, software, and network. At the same time, digitalization enables the use of a huge amount of data that can be reproduced again. Innovation measurement represents necessary assumption for the right innovation management. Qualitative and quantitative methods are used for innovation measurement in business practice, while qualitative methods alone do not enable to quantify relationship among given values. We can divide them into nominal values (in the case of two values it can be determined whether they are the same or different) and ordinal values (in the case of two values their order can be determined). On the other hand, quantitative values can quantify the relationship between two values and can be divided into interval values (in the case of two values their difference can be determined) and indicators for shares (we can determine how many times the values vary).

Innovations are measured at the enterprise, state, and global levels. Enterprise innovation activities are measured at the enterprise level. At the state level, state innovation activities are assessed while at the global level innovation is measured by the capacity of a given economy in a particular territorial unit (state unit).

The aim of the chapter is to monitor the way of innovation measurement at the enterprise, state, and global levels. The chapter also involves the comparison of innovation measurement at the level of two states, concretely the People's Republic of China and the Czech Republic. Data from the Czech Statistical Office, EUROSTAT, and other sources are used in this chapter.

We address the question of how enterprise innovations have been measured under the conditions of two very different states. For that purpose, analysis, synthesis, description, and comparison are used. First, the Czech system of innovation measurement at the enterprise level is analyzed and structured into blocks, dimensions, and indicators which are described in more detail. Concrete data from the Czech Statistical Office focused on innovative enterprises are analyzed. Second, description of innovation measurement at the state level in the Czech Republic including actual results of more and less innovative states in EU follow. We also introduce a third level—a global level of innovation measurement represented by Global Innovation Index. In Section 4, the China's national innovation system is described. Comparison and synthesis are needed for finding the differences between innovation measurement in the Czech Republic and People's Republic of China and for final conclusion.

2. Theoretical background

Considerable variety exists in the definition and measurement of concepts related to what can be broadly termed "innovation". A range of labels such as radical, discontinuous, breakthrough, and new is given to phenomena touching upon different dimensions of inventive outcomes (Verhoeven et al., 2016). This section structures different meanings of innovation and provides an overview of different classification of innovations introduced by firms.

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2.1. Characteristics of innovation

According to broad approach, innovation means any change in social life (Valenta, 2001). Innovation can be represented by a new way of working, which results in a positive change (Gallo, 2011). Therefore, innovation in business practice is a narrow segment. According to OECD innovation goes far beyond R&D. It goes far beyond the confines of research labs to users, suppliers, and consumers everywhere—in government, business, and nonprofit organizations, across borders, across sectors, and across institutions. Scholars define innovation as a creative process of devising a useful product, service, or mode of action from a pure concept located within a company (Bogdanienko et al., 2004; Amabile et al., 1996). Anything new may be perceived as innovation, if its qualities or attributes distinguish it from its existing counterparts (Burnett, 1953; Damanpour, 1991). Drucker (1993) claims that innovation is a specific tool of entrepreneurs, the means by which they exploit change as an opportunity for a different business or a different service. Entrepreneurs need to search purposefully for the sources of innovation, the changes, and their symptoms that indicate opportunities for successful innovation. The innovation equation model considers creativity as generating an idea and risk-taking as taking action on the idea, innovation = creativity + risk-taking (Pearl, 2011). Innovations are beneficial for enterprises as well as for customers in terms of value for customer.

2.2. Different classification models used for discussing innovation types

The Oslo Manual, developed jointly by Eurostat and the Organization for Economic Co-operation and Development (OECD), provides a framework to enable innovation measurement. The manual proposes innovation types of:

- product (good or service that is new or significantly improved; this includes significant improvements in technical specifications, components and materials, software in the product, user friendliness, or other functional characteristics);
- process (a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment, and/or software);
- marketing methods (a new marketing method involving significant changes in product design or packaging, product placement, product promotion, or pricing);
- a new organizational method in business practices, workplace organization, or external relations.

Innovations may also be classified according to "type." Schumpeter (1934) distinguished between five different types: new products, new methods of production, new sources of supply, the exploitation of new markets, and new ways to organize business. In economics, most of the focus has been on the first two types. The terms "product innovation"' and "process innovation" have been used to characterize the occurrence of new or improved goods and services and improvements in the ways to produce these good and services, respectively. However, the focus on product and process innovations, although useful for the analysis of some issues, should not lead us to ignore other important aspects of innovation.

Considering originality Kuratko (2009) distinguishes four types of innovations: invention (a totally new product, service or process), extension (new use of or different application of an already existing product, service, or process), duplication (creative replication of an existing concept), and synthesis (combination of existing concepts and factors into a new formulation or use).

Classification of the Slovak researcher Valenta (2001) introduced eight types of innovations from the zero level to the seventh level:

- innovations of the zero level: generation of initial properties,
- innovations of the first level: the simple target adaptation to quantitative requirements while preserving the functions of a business system or its parts,
- innovations of the second level: regrouping or organizational change,
- innovations of the third level: adaptation changes,
- innovations of the fourth level: the elementary qualitative change
- innovations of the fifth level: higher qualitative change of functional properties of system or its parts,
- innovations of the sixth level: qualitative change of functional properties of a business system or its part.
- innovations of the seventh level: the highest radical change of functional properties of a business system or its part changing its basic functional principle.

According to Albury (2005), successful innovation is the creation and implementation of new process, products, services, and methods of delivery which result in significant improvements in outcomes, efficiency, effectiveness, or quality. However, current experts suggest that in order to gain competitive success, business needs to be able to effectively implement, monitor, and measure the innovation process (Hassanien and Dale, 2013).

3. Innovation measurement

3.1. Innovation measurement at the enterprise level

While measuring innovation at the enterprise level it is necessary to distinguish two other levels. One measurement of business innovations is realized by the Czech Statistical Office and the second one is worked out by enterprises alone. Czech Statistical Office monitors innovations according to the Oslo Manual 2005. The manual was developed on the basis of OECD initiative. The same method of measurement has been used in all the EU member states. The main sense of using identical statistical data gathering lies in obtaining comparable data about innovation environment and innovation activities in businesses with the whole European Union. According to Oslo Manual 2005, innovations are divided into technical and nontechnical innovations—see according to actualized methodology of EUROSTAT, in 2010 enterprise that introduced product or process innovation or had continuing or had interrupted innovation activities (technical innovations), or introduced marketing, or organizational innovation

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(nontechnical innovation) is considered to be innovative enterprise. The Czech Statistical Office that realizes statistical gathering in two years' cycles found out that between 2004 and 2012 the share of innovative enterprises in the whole group of enterprises was around 50% which means that each second enterprise innovated, see **Figure 1** and **Table 1**.

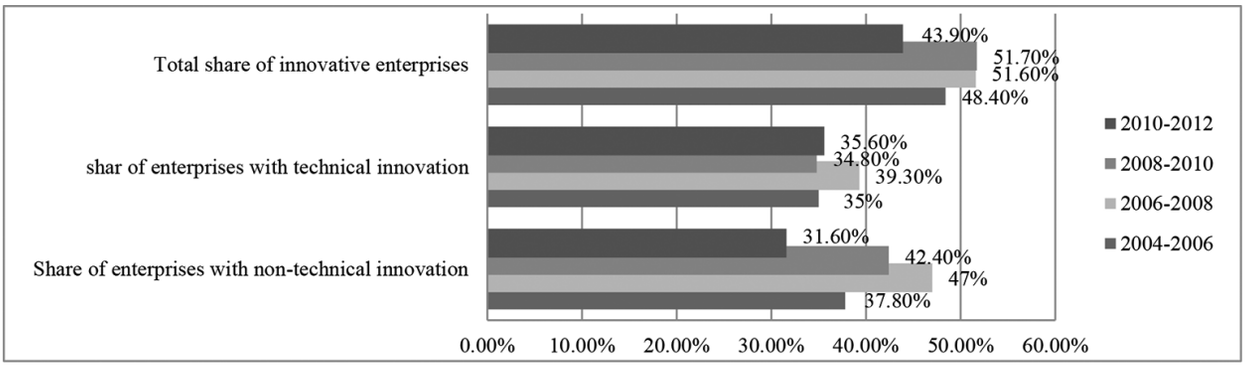

Figure 1. Number of innovative enterprises from the whole group of enterprises including classification of technical and nontechnical innovations.

Blocks	Dimensions	Indicators
Technical innovations	Product innovations	Introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness, or other functional characteristics. Product innovations can utilize new knowledge or technologies, or can be based on new uses or combinations of existing knowledge and technologies.
	Process innovation	Implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software. Process innovations can be intended to decrease unit costs of production or delivery, to increase quality, or to produce or deliver new or significantly improved products.
Nontechnical innovation	Organizational innovation	Implementation of a new organizational method in the firm's business practices, workplace organization, or external relations.
	Marketing innovation	Implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion, or pricing.

Source: Peterková and Ludvík (2015) and www.global-innovation.net

Table 1. Innovation measurement at the enterprise level.

The Czech Republic first worked out statistical innovation survey in 2002 in the framework of being a new member of European Union. In European Union, the first statistical survey focused on innovations was worked out in 1993. In the Czech Republic, seven surveys about innovations were carried out, while some changes in methodology of gathering the data appeared. Last survey covered period 2010–2012. The period of 2008–2010 seems to be favorable for

innovations (51.7%), on the other hand the period of 2010–2012 seems to be less favorable, as the share of innovative enterprises is 43.9% from the whole number of economically active enterprises. In the period of 2004–2008, technical innovations dominated (35.6%) over nontechnical innovations (31.6%). According to statistical survey in 2010–2012, the biggest number of innovative enterprises appears in information and communication technologies (64.8%), while technical innovations were introduced mostly (57%), and were followed by nontechnical innovations (45.7%). The second most innovative branch is finance and insurance (55.9%) followed by manufacturing (48.3%) with predominance of technical innovations over nontechnical ones. The last place belongs to mining and quarrying branch (23.2%) and enterprises in transportation and storage (10.8%). In all branches with the exception of wholesale, technical innovations predominated over nontechnical. Measurement of innovations at enterprise level belongs to managers' and owners' competencies. They use their own innovation techniques. Managers use hard metrics which are available without any additional costs and are transferrable to financial expressions, or soft metrics which are used for evaluation of the rate of meeting internal targets in the area. One-third of all companies appeared at the list of top-ranked companies Fortune 1000 uses innovation metrics published by Innovation Point, see **Table 2**.

Innovation metrics
Annual R&D budget as a percentage of annual sales
Number of patents filed in the past year
Total R&D headcount or budget as a percentage of sales
Number of active projects
Number of ideas submitted by employees
Percentage of sales from products introduced in the past X year(s)
Source: http://www.innovation-point.com/innovationmetrics.htm

Table 2. Set of innovative metrics.

3.2. Innovation measurement at the state level in the Czech Republic

In order to become the most competitive and dynamic knowledge-based economy with sustainable growth, the European Union established European Innovation Scoreboard. The first scoreboard was proposed of 17 countries increased to about 30 and the number of indicators increased to 29. Scoreboard is divided into three parts: enablers, firm activities, and outputs. Enablers are the main drivers of innovations such as new doctorate graduates, finance support, or venture capital. Firm activities contain firm investments, collaborating enterprises, or intellectual assets. Outputs include innovators such as SMEs with product and process innovations or with marketing or organizational innovations and economic effects such as license and patent revenues from abroad (Gupta and Trusko, 2014).

This scoreboard was later renamed innovation union scorecard that helps to provide benchmarking among 27 member states in the sphere of innovation implementation. The aim of the benchmarking based on innovation union scorecard is to strengthen research and innovation. The structure of the scorecard has three blocks, eight dimensions, and 25 indicators, see **Table 3**.

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Blocks	Dimensions	Indicators
Enablers	Human resources	New doctorate graduates Population aged 30–34 when tertiary educationYouth with at least upper secondary education
	Open, excellent, attractive research systems	International scientific co-publications top 10% most cited scientific co-publications Non-EU doctorate students
	Finance and support	R&D expenditures in the public sector Venture capital
Firm activities	Firm investments	R&D expenditures in the business sector Non-R&D innovation expenditure
	Linkages and entrepreneurship	SMEs innovating in-house Innovating SMEs collaborating with others Public-private co-publications
	Intellectual assets	PCT patent applications PCT patent applications in societal challenges Community trademarks Community designs
Outputs	Innovators	SMEs with product and process innovations SMEs with marketing or organizational innovations High-growth innovative firms
	Economic effects	Employment in knowledge-intensive activities Medium and high-tech product exports Knowledge-intensive services exports Sales and new-to-market and new-to-firm innovations License and patent revenues from abroad

Source: Gupta and Trusko (2014).

Table 3. European Union innovation scoreboard framework.

According to average innovation performance, the member states are grouped into four performance groups: innovation leaders, innovation followers, moderate innovators, and modest innovators. To be an innovation leader, the member state has to demonstrate a balanced innovation system.

In comparative assessment of the research and innovation performance of the EU member states was found following findings: Sweden has confirmed its innovation leadership. It is followed by Denmark, Finland, and Germany as European innovation leaders. Compared to 2014, innovation performance has increased in 15 EU countries, while it declined in 13 others. Latest results showed that (Innovation Union Scoreboard, 2015):

- Sweden, Denmark, Finland, and Germany are "innovation leaders" with innovation performance well above that of the EU average;
- Austria, Belgium, France, Ireland, Luxembourg, the Netherlands, Slovenia, and the United Kingdom are "innovation followers" with innovation performance above or close to that of the EU average;
- The performance of Croatia, Cyprus, Czech Republic, Estonia, Greece, Hungary, Italy, Lithuania, Malta, Poland, Portugal, Slovakia, and Spain is below that of the EU average. These countries are "moderate innovators";
- Bulgaria, Latvia, and Romania are "modest innovators" with innovation performance well below that of the EU average (Innovation Union Scoreboard, 2015).

Sweden's innovation system is once more in the first position in the EU with the overall ranking remaining relatively stable. The performance group memberships have remained relatively stable compared to the previous IUS edition, with Cyprus and Estonia being the only countries that changed group membership, in their case changing from the innovation followers to the moderate innovators. Within the moderate innovators, Estonia is the top performer followed by the Czech Republic that has overtaken Italy and Cyprus. The most innovative countries have balanced innovation systems with strengths in all dimensions, but some other countries reach top scores in individual dimensions. Sweden, Ireland, Finland, and the United Kingdom score the best in human resources; the Netherlands, Sweden, and Denmark reach top positions in open, excellent, and attractive research systems; Estonia, Denmark, Finland, and Sweden perform best in finance and support; Germany, Sweden, Estonia, and Finland are the best performers in firm investments; Belgium, the United Kingdom, and Denmark are top performers in linkages and entrepreneurship; Sweden, Denmark, Finland, and Germany reach the top positions in intellectual assets; Ireland, Luxembourg, and Germany are the best performers in the innovators dimension; and Ireland, Denmark, and Luxembourg reach the highest results in economic effects. Over a longer time period of 8 years, the EU has been improving its innovation performance, with Latvia, Bulgaria, and Malta being the innovation growth leaders but innovation growth differences exist also within the groups and the innovation gap between the member states closes slowly. However, compared to the last year, innovation has not been improving. A direct comparison with the results of last year's edition is not possible as there have been some changes in the measurement framework, but a comparison with innovation performance as it would have been last year using the same measurement framework shows that innovation performance has declined for 13 member states, in particular for Romania, Cyprus, Estonia, Greece, and Spain. For the EU at large innovation performance has not changed and for 15 member states it has improved, most notably for Malta, Latvia, and Bulgaria (Innovation Union Scoreboard, 2015).

At a wider European level, Switzerland confirms its top position outperforming all EU member state. Taking into account European countries outside the EU, also this year Switzerland confirms its position as the overall innovation leader by continuously outperforming all EU member states and by being the best performer in as many as six indicators. Internationally, South Korea and the US defend their positions as the top global innovators.

3.3. Innovation measurement at the global level

For the measurement of country's innovation extent and how is integrated into its political, business, and social aspects we can use the Global Innovation Index. For the first time, this index was published by the business school INSEAD, World Intellectual Property Organization, an entity of United Nations (WIPO). Global Innovation Index measures the capability of economy to innovate, and its innovation performance (Jewell, 2012). Global Innovation Index is based on two pillars: innovation input subindex and innovation output subindex. The area of institutions, human capital resources, infrastructure, market

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sophistication, and business sophistication create innovation input subindex. Innovation output subindex results from knowledge and technology outputs and creative outputs, see **Table 4**.

Blocks	Dimensions	Indicators
Innovation input subindex	Institutions	Political environment Regulatory environment Business environment
	Human capital	Education
	Infrastructure	ICT General infrastructure Ecological sustainability
	Market sophistication	Credit Investment Trade and competition
	Business sophistication	Knowledge workers Innovation linkages Knowledge absorption
Innovation output subindex	Knowledge and technology outputs	Knowledge creation Knowledge impact Knowledge diffusion
	Creative outputs	Creative intangibles Creative goods and services Online creativity

Source: Gupta and Trusko (2014).

Table 4. Global innovation index framework.

Practical use of Global Innovation Index showed that average innovation ranking increases with the income level of a country. North America leads in innovation followed by Europe, Southeast Asia, Northern Africa, and Western Asia, Latin America and Caribbean, Central and Southern Asia, and sub-Sahara Africa (Gupta and Trusko, 2014).

Although there exist many global indexes or other measurement systems of innovation activities, each country can use its own measurement corresponding to the particular conditions. The following section of the chapter focuses on comparison of innovation measurement in China and in European Union.

4. Comparison of innovations measurement in the Czech Republic and People's Republic of China

4.1. China's national innovation system

Measurement innovation in China has been more focused on assessing intellectual capital in terms of patents, literature citations, and growth in research and development in terms of addition of R&D functions in corporations, R&D expenditures, and R&D personnel as a percentage of total employment (Gupta and Trusko, 2014). Literature citations are based on published total and joined Chinese science and technology papers. The measures are shown in **Table 5**.

Blocks	Dimensions	Indicators
Total and joined Chinese science and technology papers	Universities	Total university papers University papers as % total Joint papers with universities (%) Joint papers with R&D institutes (%) Joint papers with firms (%)
	R&D institutes	Total R&D institute papers R&D institute papers as % total Joint papers with universities (%) Joint papers with R&D institutes (%) Joint papers with firms (%)
	Firms	Total firm papers Firm papers as % total Joint papers with universities (%) Joint papers with R&D institutes (%) Joint papers with firms (%)
Technology-based spin-offs from universities and research institutes	Universities	Number Profit (RMB)
	Research institutes	Number Profit (RMB)
Patenting activity by organization type and patent type	Invention patents	R&D (% total) Universities (% total) Firms (% total)
	Utility patents	R&D (% total) Universities (% total) Firms (% total)
	Design patents	R&D (% total) Universities (% total) Firms (% total)
Sources of R&D funding	Government	Share of total (%) Increase (%) Amount (RMB billion)
	Enterprises	Share of total (%) Increase (%) Amount (RMB billion)
	Banks	Share of total (%) Increase (%) Amount (RMB billion)
	Other	Share of total (%) Increase (%) Amount (RMB billion)

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Blocks	Dimensions	Indicators
Total and joint patenting activity	Universities	Total university patents University patents as % total Joint patents with universities (%) Joint patents with R&D institutes (%) Joint patents with firms (%)
	R&D institutes	Total R&D institute patents R&D institute patents as % total Joint patents with universities (%) Joint patents with R&D institutes (%) Joint patents with firms (%)
	Firms	Total firm patents Firm patents as % total Joint patents with universities (%) Joint patents with R&D institutes (%) Joint patents with firms (%)
Share of national R&D expenditure by sector	Research institutes	Share (%)
	Universities	Share (%)
	Enterprises	Share (%)
Regional variation in innovation inputs and outputs	Eastern Region	Invention patents (number and % China) Regional GDP (RMB billions and % China) RRD&E Personnel (thousands and % China) R&D expenditure (RMB millions and % China)
	Zhejiang	Invention patents (number and % China) Regional GDP (RMB billions and % China) RRD&E Personnel (thousands and % China) R&D expenditure (RMB millions and % China)
	Central region	Invention patents (number and % China) Regional GDP (RMB billions and % China) RRD&E Personnel (thousands and % China) R&D expenditure (RMB millions and % China)
	Western region	Invention patents (number and % China) Regional GDP (RMB billions and % China) RRD&E personnel (thousands and % China) R&D expenditure (RMB millions and % China)

Source: Liu and White (2001).

Table 5. Measurement of innovation activities in China.

Chinese system of innovation measurement at the state level points out that the most important institutions in the area of innovation are universities, firms, and research institutes. Significant attention is paid to design, utility, and invention patents. Sources of research and development funding are divided into three main groups: enterprises, banks, and others.

Funding of innovation activities is also monitored in connection with sectors or branches as source acceptors. Total and joined Chinese science and technology papers are also evaluated.

From historical point of view although the Chinese government has made dramatic progress toward a more effective and efficient national innovation system compared to its performance under central planning, a number of important issues remain such as an inadequate legal environment that cannot yet provide a reliable environment for inter-organizational relationships that are crucial in the innovation process. This issue is the biggest and growing discrepancy among regions in terms of innovative activity, which the Chinese government has recognized but has been largely ineffective in addressing (Liu and White, 2001).

Beijing has a strong science base, including the Chinese Academy of Sciences (CAS), and top universities; these are national R&D centers with global connections. Shanghai has a large-scale, R&D-intensive industry base. Guangdong province has a foreign (manufacturing) firm-based innovation system and accounts for more than half of China's PCT patent applications (almost two-thirds in ICT). In contrast, China's western regions lack the absorptive capacity needed to capture knowledge flows from coastal areas and abroad. Collaboration, as shown in patent data, is weak across regions.

4.2. Comparison of innovation measurement in the Czech Republic and People's Republic of China

The state level of innovation measurement provides data about innovation investments and innovation performance of particular state, which refers to system ex post. In the Czech Republic, innovations are measured by using innovation scoreboard which is focused on innovation conditions (human resources, research systems, finance, and support), enterprise activities (firm investments, partnership and enterprise, intellectual property), and innovation outcomes which include effects of enterprise innovation activities (economic effects). Innovation scoreboard takes into account character of realized innovations which means that technical (product, process) and nontechnical innovations (marketing, organizational) are evaluated.

In China, measurement of innovations at the state level is based on seven factors. Significant attention is paid to the evaluation of patents, scientific papers, and research and development. Simultaneously research and development expenditures as well as sources of financing are monitored. In China and European Union, we can find monitoring of spin-off firms founded by universities and also research organizations. The used measurement system shows that technical and also nontechnical innovations are monitored separately in China and also in the Czech Republic.

Both measurements at the state level point out an importance of cooperation among universities and business practice and commercialization of research findings. Both countries monitor a number of spin-offs and cooperation businesses with nonprofit organizations.

5. Conclusion

Innovations are an important assumption of economic growth of enterprises, states, and even global economies. Innovations represent quantitative or qualitative improvement of product, process, or business model. A process of innovation measurement depends on the innovation

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type and institution approach to innovations success measurement. At the same time, each innovation has a different character and institutions in various countries have different priorities, which lead to the fact that particular method frameworks and approaches differ. Mainly combinations of quantitative as well as qualitative indicators have been used. Differences are obvious at all levels: enterprise, national, and global. For enterprise level of innovation measurement, own business innovation metrics are used. Czech Statistical Office monitors technical and nontechnical innovations separately.

In the Czech Republic, for the state level innovation scoreboard is used. This innovation measurement is focused on enablers, firm activities, and outcomes as effects from carried out innovation activities by firms. The innovation scoreboard includes 25 indicators.

At global level innovation measurement is focused on innovation performance and innovation environment, wider regions such as European Union, Central and Southern Asia.

Comparison of innovation assessment in two different countries the Czech Republic and People's Republic of China showed that both states emphasize commercialization of university outputs in business practice and at the same time in both states, research expenditures are reported. Provided comparison did not show whether character of innovation (technical or nontechnical) is recorded.

Systems for innovation monitoring and later evaluation of these two countries come out from different business environment that is influenced by various political, legal, and cultural values. This implies that the united system of innovations management and measurement cannot be implemented globally.

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