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CLASSIFICATION AND MEASUREMENT OF INNOVATIONS

In the paper the innovations, their understanding and role in economy are shown. Then their main classification is presented and based on it, the examples are reviewed. Categories of activities and exemples of activities leading to creation of innovations are discussed in next part of paper. At the end, qualitative and quantitative approach to data on innovative activities are presented.

Key words: innovations, classification, measurement

1. INTRODUCTION INTO INNOVATION ISSUE

The ‘knowledge’ and ‘knowledge-based economy’, there are terms very often ocurred in media. It is common agreement that the generation, exploitation and diffusion of knowledge become the fundamental factors to economic growth, development and, in the consequence, the well being of nations. Over time the nature and panorama of innovations have changed, and so the need for indicators to capture those changes and provide policy makers with appropriate tools of analysis increased. Important to this is the necessity of better measures of innovation.

‘The knowledge-based economy’ is an expression coined to describe trends in advanced economies towards greater dependence on knowledge, information and high skill levels, and the increasing need for ready access to all of these by the business and public sectors. Knowledge and technology have become increasingly complex, raising the importance of links between companies and other organizations as a way to acquire specialized knowledge.

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‘Innovation’ is defined simply as a "new idea, device, or method". However, innovation is often also viewed as the application of better solutions that meet new requirements, unarticulated needs, or existing market needs. This is accomplished through more-effective products, processes, services, technologies or business models that are readily available to markets, public sector and society. The term ‘innovation’ can be also defined as a something original and more effective and, as a consequence, new, that "breaks into" the market or society.

The innovation is central to the growth of output and productivity. However, while the understanding of innovation activities and their economic impact has greatly increased lately, it is still deficient. As the world economy evolves, so does the process of innovation. Globalisation has led to significant increases in access to information and new markets for enterprises. It has also resulted in greater international competition and in new organizational forms in order to manage global supply chains. Owing to advances in technologies and greater flows of information, knowledge is more and more viewed as a central driver of economic growth and innovation. Yet, one can not fully understand how these factors affect innovation [OECD/Eurostat 2005]. It is also still not obvious that from innovation is the straight way to achieve excellence in business.

In business and economics, innovation can be a catalyst to growth. With rapid advancements in transportation and communications over the past few decades, the old world concepts of factor endowments and comparative advantage which focused on an area’s unique inputs are outmoded for today’s global economy. Entrepreneurs continuously look for better ways to satisfy their consumer base with improved quality, durability, service, and price which come to fruition in innovation with advanced technologies and organizational strategies.

In the organizational context, innovation may be linked to positive changes in efficiency, productivity, quality and competitiveness. However, recent research findings highlight the complementary role of organizational culture in enabling organizations to translate innovative activity into tangible performance improvements. Organizations can also improve profits and performance by providing work groups opportunities and resources to innovate, in addition to employee's core job tasks. As P. Drucker said: "Innovation is the specific function of entrepreneurship, whether in an existing business, a public service institution, or a new venture started by a lone individual in the garage. It is the means by which the entrepreneur either creates new wealth-producing resources or endows existing resources with enhanced potential for creating wealth." [Drucker 2013].

In this paper the problem of innovation is covered only for the business enterprise sector. It deals with innovation at the level of the firm, with attempt to show how to measure it.

2. CLASSIFICATIONS OF INNOVATIONS AND EXAMPLES

According to the authors of Oslo Manual Report, taking the enterprise position, an innovation is the implementation of a new or significantly improved product, in the form of a good or a service, or a process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations [OECD/Eurostat 2005]. This very broad definition encompasses a wide range of possible form of innovations.

An innovation can be more narrowly categorized as the implementation of one or more types of innovations, for instance product and process innovations. This narrower definition of product and process innovations can be related to the definition of technological product and process innovation used early [OECD/Eurostat 1997].

One can assume, as a minimum requirement, that an innovation is the product, process, marketing method or organisational method which must be new or significantly improved for the enterprise. This includes products, processes and methods that enterprises are the first to develop and those that have been adopted from other firms or organisations.

A common feature of innovations is that they must have been implemented. A new or improved products are implemented when they are introduced to the market. New processes, marketing methods or organisational methods are implemented when they are brought into actual use in the firm's operations.

There are several sources of innovation. It can occur as a result of a focus effort by a range of different agents, by chance, or as a result of a major system failure. According to P. Drucker [2013] the general sources of innovations are different changes in industry structure, in market structure, in local and global demographics, in human perception, mood and meaning, in the amount of already available scientific knowledge, etc.

In the simplest linear model of innovation: invention -> innovation -> diffusion, the traditionally recognized source of innovation is manufacturer innovation. This is where a person or business innovates in order to sell the innovation. Another source of innovation, only now becoming widely recognized, is end-user innovation. This is where a person or company develops an innovation for their own use because existing products do not meet their needs. E. von Hippel [2015] has identified end-user innovation as, by far, the most important and critical.

Innovation by businesses is achieved in many ways, with much attention now given to formal research and development for "breakthrough innovations". Research and development help spur on patents and other scientific innovations that leads to productive growth in such areas as industry, medicine, engineering and

government. Yet, innovations can be developed by less formal on-the-job modifications of practice, through exchange and combination of professional experience and by many other routes. The more radical and revolutionary innovations tend to emerge from research and development activities, while more incremental innovations may emerge from practice – but there are many exceptions to each of these trends.

The work of J. Schumpeter has greatly influenced theories of innovation. He argued that economic development is driven by innovation through a dynamic process in which new technologies replace the old ones. In Schumpeter's view, "radical" innovations create major disruptive changes, whereas "incremental" innovations continuously advance the process of change. Schumpeter [1934] proposed a list of five types of innovations:

1) introduction of new products,
2) introduction of new methods of production,
3) opening of new markets,
4) development of new sources of supply for raw materials or other inputs,
5) creation of new market structures in an industry.

It is obvious that the innovation activities vary greatly in their nature from company to company. Some enterprises engage in well-defined innovation projects, such as the development and introduction of a new product, whereas others primarily make continuous improvements to their products, processes and operations. Both types of enterprises can be innovative because an innovation can consist of the implementation of a single significant change, or of a series of smaller incremental changes that together constitute a significant change.

Classification of main categories of innovation, accepted now, is following:

– product innovation – the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses; it includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics,

– process innovation – the implementation of a new or significantly improved production or delivery method; it includes significant changes in techniques, equipment and/or software,

– marketing innovation – the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing,

– organizational innovation – the implementation of a new organizational method in the firm's business practices, workplace organization or external relations [OECD 2005 (3)]. Examples for each group, proposed in report [OECD/Eurostat 2005] are listed below in Table 1.

Table 1

Examples of innovations for different their categories

Category of innovation	Examples
I. Product innovations in the field of:	
1) goods	− global positioning systems (GPS) in transport equipment,
	− replacing inputs with materials with improved characteristics (breathable textiles, light but strong composites, environmentally friendly plastics, etc.), − global positioning systems (GPS) in transport equipment, − replacing inputs with materials with improved characteristics (breathable textiles, light but strong composites, environmentally friendly plastics, etc.), − cameras in mobile telephones, − fastening systems in clothing, − household appliances that incorporate software that improves user friendliness or convenience, such as toasters that automatically shut off when the bread is toasted, − anti-fraud software that profiles and tracks individual financial transactions, − inbuilt wireless networking in laptops, − products with significantly reduced energy consumption (energy efficient refrigerators, etc.), − programmable radiators or thermostats.
2) services	− DVD subscription service where for a monthly fee customers can order a predefined number of DVDs via the Internet with mail delivery to the home, with return via a pre-addressed envelope, − new services that significantly improve customers' access to goods or services, such as home pick-up and drop-off service for rental cars, − video on demand via broadband Internet, − Internet services such as banking, or bill payment systems, − new forms of warranty, such as an extended warranty on new or used goods, or bundling warranties with other services, such as with credit cards, bank accounts or customer loyalty cards, − new types of loans, for example variable rate loans with a fixed rate ceiling, − new forms of warranty, such as an extended warranty on new or used goods, or bundling warranties with other services, such as with credit cards, bank accounts or customer loyalty cards, − new types of loans, for example variable rate loans with a fixed rate ceiling,

Table 1 cont.

	– creation of websites on the Internet, where new services such as product information and various support functions can be offered to clients free of charge, – the introduction of smart cards and multipurpose plastic cards, – new, self-service bank office.
II. Process innovations in the area of:	
1) production	– installation of new or improved manufacturing technology, such as automation equipment or real-time sensors that can adjust processes, – new equipment required for new or improved products, – laser cutting tools, – automated packaging, – computer-assisted product development, – digitisation of printing processes, – computerised equipment for quality control of production, – improved testing equipment for monitoring production.
2) delivery and operation	– portable scanners/computers for registering goods inventory, – introduction of bar coding or passive radio frequency identification chips to track materials through the supply chain, – GPS tracking systems for transport equipment, – introduction of software to identify optimal delivery routes, – new or improved software or routines for purchasing, accounting or maintenance systems, – introduction of electronic clearing systems, – introduction of electronic ticketing system, – new software tools designed to improve supply flows, – new or significantly improved computer networks.
III. Marketing innovations dealing with:	
1) design and packaging	– implementation of a significant change in the design of a furniture line to give it a new look and widen its appeal, – implementation of a fundamentally new design of bottles for a body lotion intended to give the product a distinctively exclusive look, – first-time introduction of product licensing, – first-time introduction of direct selling or exclusive retailing, – implementation of a new concept for product presentation such as sales rooms for furniture that are designed according to themes, allowing customers to view products in fully decorated rooms, – implementation of a personalized information system, e.g. obtained from loyalty cards, to tailor the presentation of products to the specific needs of individual customers.

Table 1 cont.

3) pricing	− introduction of a new method that allows customers to choose desired product specifications on the firm's website and then see the price for the specified product, − first-time use of a method for varying the price of a good or service according to demand for it, − first-time use of in-store special offers that are only accessible to holders of the store's credit card or reward card.
4) promotion	− first-time use of trademarks, − first-time use of product placement in movies or television programmes, − introduction of a fundamentally new brand symbol intended to position the firm's product on a new market, − first-time use of product seeding through opinion leaders, celebrities or particular groups that are fashion or product trend setters.
IV. Organizational innovations:	
	− establishing of a new database of best practices, lessons and other knowledge so that they are more easily accessible to others, − first-time introduction of an integrated monitoring system for firm activities (production, finance, strategy, marketing), − first-time introduction of management systems for general production or supply operations, such as supply chain management, business reengineering, lean production, quality management system,
	− first-time introduction of training programmes to create efficient and functional teams that integrate staff from different backgrounds or areas of responsibility, − first-time implementation of decentralized job responsibility for the firm's workers, such as giving substantially more control and responsibility over work processes to production, distribution or sales staff, − first-time implementation of an anonymous incident reporting system to encourage the reporting of errors or hazards in order to identify their causes and reduce their frequency, − first-time introduction of quality control standards for suppliers and subcontractors, − first-time use of outsourcing of research or production.

3. APPROACH

The innovation can occur in any sector of the economy, including government services such as health or education. These considerations are essentially devoted to deal with innovations in the business enterprise sector alone, encompassing manufacturing, primary industries and the services sector and is concerned with the collection of innovation data at the level of the enterprise. It does not cover industry- or economy-wide changes such as the emergence of a new market, the development of a new source of raw materials or semi-manufactured goods, or the reorganization of an industry.

An enterprise can make many types of changes in its methods of work, its use of factors of production and the types of output that improve its productivity and/or commercial performance, what may lead to a wide range of changes in enterprises' 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. Organizational innovations refer to the implementation of new organizational methods. These can be changes in business practices, in workplace organization 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.

Innovation activities include all scientific, technological, organizational, financial and commercial steps which actually lead, or are intended to lead, to the implementation of innovations. Some of these activities may be innovative in their own right, while others are not novel but are necessary for implementation.

Innovation comprises of a number of activities that are not included in the area of research and development, such as later phases of development for preproduction, production and distribution, development activities with a lesser degree of novelty, support activities such as training and market preparation, and development and implementation activities for innovations, such as new marketing methods or new organizational methods, which are not product and process innovations. Innovation activities may also include acquisition of external knowledge or capital goods that is not part of research and development activities.

4. MEASUREMENT OF INNOVATIONS ACTIVITIES

Two groups of science and technology indicators plus one extra information are relevant to the measurement of innovation:

– resources devoted to research and development activities,

– patent statistics,

– bibliometrics and other types of indicators, providing complementary data or information, although information is not always available at the firm level.

Research and development data are collected through national surveys according to the guidelines laid down in the Frascati Manual [OECD 2002]. These data have proved valuable in many studies: for example, the effects of research and development on productivity have been estimated by econometric techniques, at the country, sector and firm levels.

These data have two main limitations. First, research and development is an input. Although it is obviously related to technical change, it does not measure it. Second, it does not encompass all the efforts of companies and governments in this area, as there are other sources of technical change, such as learning by doing, which are not covered by this narrow definition.

A patent is a legal property right to an invention, which is granted by national patent offices. A patent gives its owner sole rights, for a certain duration, to exploit the patented invention. At the same time it discloses the details of the patent as a way to allow broader social use of the discovery. Patent statistics are increasingly used in various ways as indicators of the output of research activities. The number of patents granted to a given firm or country may reflect its technological dynamism. Examination of the growth of patent classes can give some indication of the direction of technological change. The drawbacks of patents as innovation indicators are well-known. Many innovations are not patented, and some are covered by multiple patents; many patents have no technological or economic value, and others have very high value [OECD/GD 1994].

These two basic families of statistics are complemented by several others:

– statistics on scientific publications (bibliometrics), publications in trade and technical journals ("LBIO" or literature-based indicators of innovation output), skilled human resources, technology balance of payments, globalisation indicators,

– activity in high-technology sectors (investment, employment, external trade), information on innovation and innovative activities drawn indirectly from many other sources, such as business surveys or education statistics.

The globalisation process affects innovation in a number of ways, through increases in international competition, in flows of goods, services and knowledge across national boundaries, and in international interactions. The Handbook on Economic Globalisation Indicators [OECD 2005 (3)] discusses issues relating to globalisation and provides a set of relevant globalisation indicators.

Wherever possible, the paper draws on the concepts and classifications set out in other volumes in the set of OECD manuals for the measurement of scientific and technological activities [OECD/GD 1992, OECD/EU/Eurostat 1994, OECD 2001, OECD 2005 (1), OECD 2005 (2)], especially the Frascati Manual on the resources devoted to research and development. This remark applies particularly to a number of questions on research and development and other science and technology activities, recommended for inclusion in innovation surveys.

The innovation measurement framework encompasses outside the enterprise:
– innovation policies,
– education and public research system,
– infrastructure and institutional framework,
– other firms.

Other models of the innovation process, such as Kline and Rosenberg's chain-link model [Kline and Rosenberg 1986] or the innovation dynamo [OECD/Eurostat 1997], provide a useful theoretical overview for innovation processes but are less adapted to guiding survey design. The framework used here represents an integration of insights from various firm-based theories of innovation with those of approaches that view innovation as a system. The main characteristics of the described framework are:
– innovation in the firm,
– linkages with other firms and public research institutions,
– the institutional framework in which firms operate,
– the role of demand [OECD/Eurostat 2005].

5. MEASUREMENT OF INNOVATIONS

At enterprise level, innovation surveys can provide a breadth of information on the innovation process. They can identify motives and obstacles to innovation, changes in the way in which companies operate, the kinds of innovation activity that they engage in, and the types of innovations that they implement. In terms of the innovation process as a system, innovation surveys can provide information on firms' linkages with other actors in the local and global economy and on the methods they use to protect their innovations. These areas are discussed in greater detail below.

5.1. The components and coverage of innovation activities

Innovation activities can be grouped as shown in Table 2.

Table 2

Review of innovation activities

Category of activities	Examples of activity
1) research and experimental development	– intramural (in-house) research and development: Creative work undertaken on a systematic basis within the enterprise in order to increase the stock of knowledge and use it to de-

Table 2 cont.

	vise new applications. This comprises all research and development conducted by the enterprise, including basic research – acquisition of extramural research and development: Same activities as intramural research and development, but purchased from public or private research organisations or from other enterprises (including other enterprises within the group)
2) for product and process innovations	– acquisition of other external knowledge: Acquisition of rights to use patents and non-patented inventions, trademarks, know-how and other types of knowledge from other enterprises and institutions such as universities and government research institutions, other than research and development,
	– acquisition of machinery, equipment and other capital goods: Acquisition of advanced machinery, equipment, computer hardware or software, and land and buildings (including major improvements, modifications and repairs), that are required to implement product or process innovations, – acquisition of capital goods that is included in intramural R&D activities is excluded. Other preparations for product and process innovations: Other activities related to the development and implementation of product and process innovations, such as design, planning and testing for new products (goods and services), production processes, and delivery methods that are not already included in research and development,
	– market preparations for product innovations: Activities aimed at the market introduction of new or significantly improved goods or services, – training: Including external training, linked to the development of product or process innovations and their implementation

Table 2 cont.

3) for marketing and organizational innovations	– preparations for marketing innovations: Activities related to the development and implementation of new marketing methods. Includes acquisition of other external knowledge and other capital goods that is specifically related to marketing innovations – preparations for organizational innovations: Activities undertaken for the planning and implementation of new organization methods. Includes acquisition of other external knowledge and other capital goods that is specifically related to organizational innovations

Expenditure for innovation activities comprises current and capital expenditure incurred for the innovation activities defined above. Current innovation expenditures are composed of labour costs and other current costs. Capital expenditures for innovations are composed of gross expenditures on land and buildings, on instruments and equipment and on computer software. Capital expenditures that are part of research and development are included in intramural research and development, while non-research and development capital expenditures linked to product and process innovations are included in acquisition of machinery, equipment and other capital goods. Non-research and development capital expenditures specifically linked to marketing or organizational innovations are included in preparations for marketing innovations and preparations for organizational innovations, respectively. The remaining categories of innovation activity consist solely of current expenditure.

Innovation surveys can collect both qualitative and quantitative data on innovation activities. Qualitative data involves questions on whether or not enterprises have engaged in an innovation activity. Quantitative data involve questions on expenditures for an innovation activity.

5.2. Qualitative data on innovation activity

It is recommended that qualitative data be collected on innovation activities. Questions on whether or not firms have engaged in the above activities can either refer to a single year or the entire observation period. Surveys may wish to collect qualitative data on all categories of innovation activities or on a subset of these.

The multi-year approach has the advantage of capturing innovation activity for enterprises that may not perform innovation activity on a regular basis.

Additional information can also be collected on individual types of innovation activities. Examples are whether research and development activity is continuous or occasional, which types of external knowledge the enterprise has acquired, or a separate question on software expenditures.

Information on employee characteristics, such as the level of education and number of technical staff, can also be collected in innovation surveys. For example, the share of employees with a higher education certificate or degree and the share of personnel involved in innovation or research and development activity can be used as supplementary measures of the innovation capability of the firm's knowledge stock and employees. Furthermore, most enterprises are likely to possess information on their employees' level of education. An additional qualitative indicator is whether enterprises participate in national or supranational programmes that provide financial support for employee education/training or for the employment of research personnel.

5.3. Quantitative data on innovation activity

It is recommended that a breakdown by type of activity should be used for the collection of quantitative data on innovation expenditures. Surveys may wish to collect quantitative data on all categories of innovation activities or, as innovation expenditures are difficult to measure, surveys may opt to collect data on a subset of these.

Innovation expenditure can also be broken down by type of expenditure (current innovation expenditure versus capital expenditures for innovations) and by source of funds.

While collecting data on innovation activities for a multi-year period, it may be feasible for qualitative questions on innovation activities, restricted availability of data within firms to be serious obstacle to the multi-year approach for quantitative data. Therefore, it is recommended that quantitative questions on innovation expenditure refer only to the last year of the observation period (the reference year).

Concerning capital purchases, expenditures for the category, acquisition of machinery, equipment and other capital goods, should exclude purchases of capital goods that are already included in intramural R&D. Purchases of capital goods should be included in full for the period in which they took place. All depreciation provisions for building, plant and equipment, whether real or imputed, should be excluded from the measurement of intramural expenditure.

Enterprises often face severe problems for supplying reliable estimates of capital expenditure for innovation activities. To assist them, data on total capital expenditure (including capital expenditure not related to innovation activities) can be

collected as well. This will help in checking the reliability of innovation expenditure data.

These and other considerations are based on the those presented in the work [OECD/Eurostat 2005].

5. CONCLUSIONS

There are limitations to the types of data that can be obtained by innovation surveys:

– analysis will often require additional economic data on the firm, so that data from innovation surveys will often need to be combined with other information sources,

– innovation is a continuous process, and therefore difficult to measure, particularly for firms whose innovation activity is mainly characterized by small, incremental changes as opposed to single, well-defined projects to implement significant changes (innovations are defined in this paper as significant changes, with the intention of distinguishing significant changes from routine, minor changes). However, it is important to recognize that an innovation can also consist of a series of minor incremental changes,

– information on innovation expenditures is normally not specified in firms' financial accounts, making it difficult for firms to calculate them. While this does not preclude measuring innovation expenditures, these difficulties should be taken into account both in survey design and subsequent analysis,

– it is difficult for surveys to capture the timing of innovation activities, their implementation and their impact. Expenditures on innovation activities are intended to yield potential returns in the future. The outputs of these activities, from the development and implementation of innovations to improvements in innovative capacity to impacts on performance, are often not observable during the review period.

– innovation surveys are not well placed to provide information on the general institutional environment, such as the education system, the labour market and financial systems, with the exception of how these institutional factors are experienced by the respondent firms.

Innovation surveys can provide both qualitative and quantitative data on firms' innovation inputs. Collecting quantitative data poses practical difficulties, especially when firms have many divisions, but data on innovation inputs are one of the most useful outputs of innovation surveys.

Information on innovation activity is useful for a number of reasons. It can provide information on the types of innovation activity enterprises engage in, for example:

– whether innovative enterprises engage in research and development,

– whether they purchase knowledge and technology in the form of extramural research and development, machinery and equipment, or other external knowledge,

– whether the development and implementation of innovations also involves the training of employees,

– whether enterprises are engaged in activities to change part of their organization.

Innovation activities, including capital purchases, research and development and other current expenditures related to innovations, can be characterized as investments in that they may yield returns in the future. Such returns often go beyond the specific innovation the activity is directed towards. For example, investments in research and development and innovation-related training are often open-ended in nature, allowing their application to other tasks.

Quantitative measures of expenditures on each innovation activity provide an important measure of the level of innovation activity at enterprise, industry and national levels. They could be also treated as indicators of activities leading towards business excellence.

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Słowa kluczowe: innowacje, klasyfikacja, pomiar