The Methodology of National Innovation System Analysis

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Abstract.

Many efforts have been done in developing the national innovation system (NIS) concept. However, there are the limitations, which do not allow to make it operable and effective in practice. This investigation attempts to eliminate some limitations of the approach. The NIS is presented as three interrelated macro blocs: business environment, environment producing new knowledge and knowledge transfer mechanism. The principles of performance and efficiency measuring of NIS are proposed. The system structure-object and functional approaches to NIS performance and efficiency are applied. The former is used for decomposition of NIS objects of high aggregation level. The latter is available for analysis of NIS efficiency and its factors. The methods allow to estimate the NIS component by component and identify the cause-effect chains of factors impacts on its elements. The key policy tools tailored to liquidate and mitigate market failure and NIS dysfunctions are proposed.

Keywords: innovation activity, structure-object decomposition, functional analysis, efficiency, factors, innovation policy, stages of development

INTRODUCTION

The conception of national innovation system (NIS) has arisen at the edge of 80th years of the last century. The founders of the new branch were Freeman (1997), Lundvall (1992) and Nelson (1993). For many researchers and experts the birth of the new conception was bound up with the demand for new approaches to finding ways of the effective economic development driven by innovations. There was also a need for "operable" approach focused directly on the design of public policy aimed at innovative development.

In the meantime, one cannot fail to recall Schumpeter who pointed out in his “Theory of Economic Development” that the principal function of an entrepreneur is a search of resource combination to obtain “new uses” or “new combination”, i.e. “innovation”. For long decades (until the beginning of the 1980s), the works of Schumpeter were outside of the mainstream of economics. To adopt the systemic perspective on innovative development, it became necessary to rely on a comparative historical analysis, on the one hand, and studies on institution governing of innovation actors’ interactions on the other (Soete et al; 2010). That is why the NIS conception has consolidated scholars of evolutionary theories (e.g., Metcalfe, 1988; Nelson and Winter, 1982) and economists in institutional traditions of innovation studies (e.g., Freeman, 1987; Lundvall, 1992).

The conception of NIS has been widely diffused between both academicians and decision makers at regional and national levels and became a framework for innovation studies in international organizations such as the OECD, the European Union, UNCTAD and UNIDO (Godin, 2009). OECD has published the whole series of the manuals of Frascati family. In this series, on the one hand, there is an attempt to harmonize the system of definitions of many NIS elements and processes. On the other hand, this set of manuals proposes the guidelines to construct the corresponding statistics database. Many of these recommendations are accepted in various countries of the world including Russia.

In the concept, a national innovation system is considered as a set of private and public organizations and nonlinear mechanisms of their interaction (Lundvall 1992; Nelson 1993). Within the framework of the system new knowledge and technologies creation, storage and distribution take place. The behavior of organizations is shaped under the influence of institutions (North, 1991) including laws, rules, norms, routines and established practices. While neoclassical economics uses methods based on the concept of an individual rational behavior in the market, institutional economics suggest that institutions interfere in the functioning of markets. The institutions regulate the relations, interactions, learning between individuals, groups and organizations. They make a basis for incentives and obstacles for innovation (Lundvall, 2007; Edquist 2006). According to Lundvall et al. (2002), the features of the institutional environment that enterprises are sunk determine to a considerable degree distinctions of technological results. The joint efforts of the state, enterprises and scientific environment build the NIS. The state creates framework conditions of the system, generates in many respects a motivation basis of system elements activity, develops the resources and institutions and acts as a catalyst of NIS processes and a partner reducing innovation risks.

Many efforts have been done in developing the NIS concept. However, they are not sufficient to provide the basis of the methodology of the NIS investigation. Particularly, there is an understanding of a need in "method to study national systems of innovation that moves from micro to macro – and back again to micro" (Lundvall, 2007, p.102) but the operable scheme of this method is lacking. Hekkert *et al*. (2007, p.414) pointed out that the innovation system approach focuses on a macro level institutions and less on actions of entrepreneurs. In other words, the ability to bridge the macro economic patterns and the behaviour of firms and other economic agents, which was demonstrated before by mainstream economic studies, has been lost in the NIS approach.

Edquist also notices a vagueness and diffuseness of the approach in some cases (Edquist, 2006, p. 186). The innovation system is often considered as an entity without its division into real subprocesses and its actors. Fagenberg (2006, p.20) noted, "our understanding of how knowledge–and innovation–operates on organizational level remains fragmentary and further conceptual and applied research is needed". Miettinen (2013, p.35) concludes that the NIS approach "is poorly connected to general or dynamic systems thinking".

At the same time, there are many valuable publications of various authors deal with the bottlenecks or imperfections of real systems. Among the authors of these publications are

Carlsson and Jacobsson (1997), Edquist et al. (1998), Johnson & Gregersen (1994), (Malerba & Orsenigo, 1997), Smith (2000). In the publications, one can find a description and analysis of infrastructural, institutional failures. Some papers try to identify functions served by innovation systems (Edquist, 2005; Hekkert et al, 2007; Wieczorek & Hekkert 2012). However, these functions often seem abstract and indirect.

Taking all the aforesaid into consideration, one can conclude the NIS concept allow to overcome many failures of mainstream economic theories. There are also valuable fragments of the methodology of NIS analysis, but the absence of an idea of the end-to end analysis is obvious. This limitation of the concept (Edquist, 2006) does not give an opportunity for its effective application of the empirically oriented research to study NIS (OECD, 2002). Particularly, the absence of the standard approach to a logically ordered NIS investigation cannot allow to trace and build up the cause-and-effect chains of factors. This does not facilitate finding out factors of the system and determining the measures of public policy addressed to their removing (see also Edquist, 2011).

Applying system approach and taking into account the valuable studies mentioned above, the methodology described below might assist to reduce conceptual ambiguities and provide applications of the concept of a national innovation system. To achieve this purpose, the system structure-object and functional approaches (Kleiner et al, 2007) to NIS performance efficiency are proposed below. The former is used for decomposition of NIS objects. The latter is available for analysis of NIS efficiency and its factors. It is worth noting that the considered methods have roots in many ideas of structural and functional approaches developing correspondingly in papers (Nelson, 1993; Lundvall, 1992; Edquist, 2006, Hekkert et al, 2007, Jonson, 2001).

Russia is taken below as an example of applying both methods finding bottlenecks and dysfunction of the NIS and building up the cause-and-effect chains of NIS factors. Besides, the system of key policy tools tailored to liquidate and mitigate failure and NIS dysfunctions are constructed. During the description of the policy system, the stages of country development are distinguished. Among the other things, this allows to include into consideration the ways of facilitating co-evolution of absorptive capacity and innovative capability of the NIS (Castellacci & Natera, 2013) during passing these stages by a country.

THE SYSTEM STRUCTURE-OBJECT ANALYSIS

The realization of the structure-object scheme of decomposition means that the innovation system and its corresponding blocs "break in" separate structures or interacting subsystems. In accordance with the structure-object approach, an object of the structural hierarchy is divided into an isomorphic set of interacting systems of the lower level of disaggregation. According to this scheme, three macroblocks present national innovation system (Golichenko, 2006). They are business environment and market, environment producing new knowledge and knowledge transfer and diffusion mechanisms. The fourth macro category is the state. It influences the activity in every block.

The macroblocks are interrelated. For example, the interactive learning and knowledge generating systems may have a feedback loop between them and the holders of the processes can be both business units and individual persons. This division into three macroblocks is remarkably close to Pavitt’s consideration of innovation processes in the form of three overlapping sub-processes. They are the production of knowledge; the transformation of knowledge into products, systems, processes, and services; and their continuous matching to market needs and demands (Pavitt, 2006, p.86).

Macrostructure of National Innovation System

To estimate mentioned blocs, relative indicator values attributed to OECD averages are used. In other words, to get a relative indicator value, it is necessary to calculate the ratio of the absolute value of the country’s indicator to the OECD average. In order to give a basis for comparative analysis, a hard work of developing the corresponding system of indicators was done during last decades (see, for example, Composite Indicators, 2008).

There are examples of profiling the NIS of some OECD countries. The NIS profiles were built up for Australia (OECD, 2004a), Austria (OECD, 2004b), the Netherland (OECD, 2004c) and France (OECD, 2004d).

Based on the outlined representation, the profiles of the national innovation systems for Russia and Poland (figure 1), the USA and Finland were build. This choice of the countries has been stipulated by the fact that the first two countries are post-socialist ones and the next two others belong to industrially developed world. The comparison of the four countries' profiles has demonstrated that Russia could be assigned to neither leaders of innovation development nor the countries taking average positions. For many indicators, Russia has occupied the position behind Poland even in the "fat years" of economic growth. The comparative analysis of the profile structures enables us to establish failures of Russian scientific and innovative policy at the macro level.

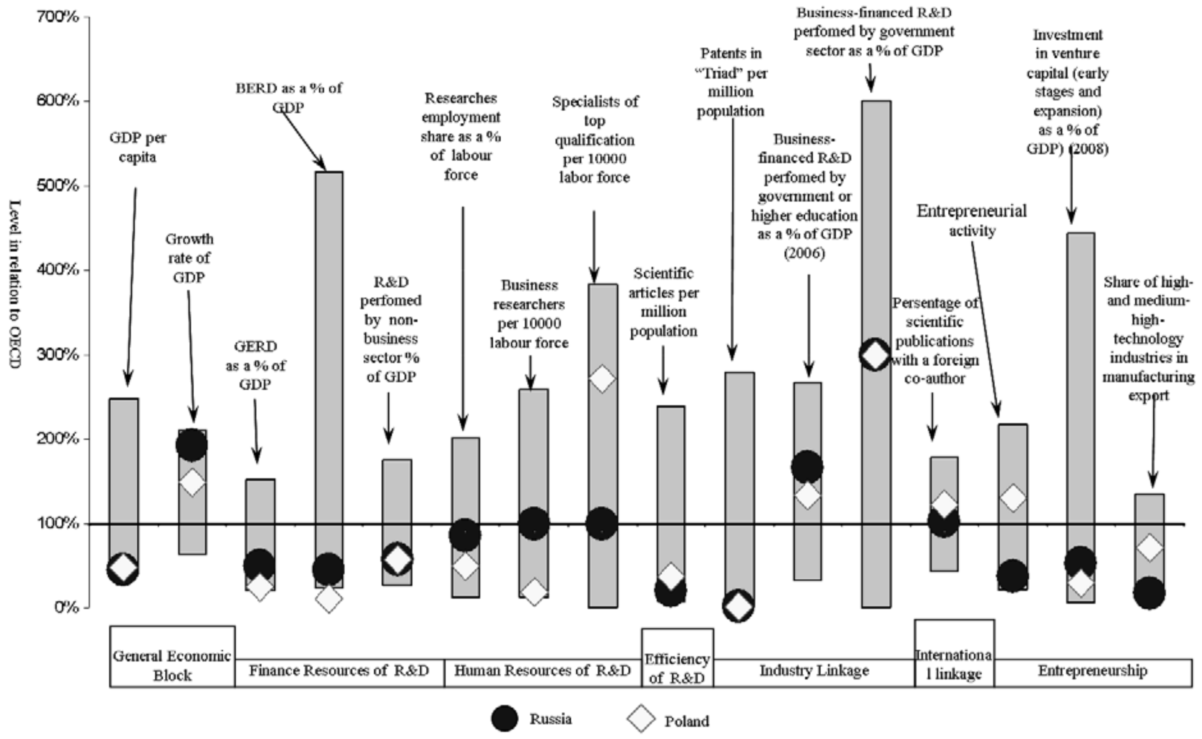

Figure 1. National Innovation System Profiles of Russia and Poland, 2007

Source: OECD Main Science and Technology Indicator, OECD Science, Technology and Industry Scoreboard

For all indicators of research and development expenditures (i.e. GERD, BERD and R&D performed by non-business sectors as % of GDP), Russia and Poland have the value of the indicator which is less than one half of the OECD average. The low level of R&D expenditures in many respects has caused not only by the insufficient government support of science but also by the government forced activity, which became rife in the business sector. As a result, the insufficient financing of basic science takes place. It suffices to say that even in 2007, which was the most favorable for the Russian science financing, the share of expenditures for basic research made only 0.19 % of GDP. In this year, even in the Czech Republic the similar share was equal 0.38% of GDP, let alone such countries as Japan (0.40%), the USA (0.47%), France (0.50%) and South Korea (0.55 %).

The state of human resources in R&D of Russia seems a bit better (figure 1). The country availability of researchers in the business enterprise sector and professionals of top qualification corresponds closely to the OECD average. However, the level of the number of researchers in the business enterprise sector in relation to 10000 labour force was above the OECD average in 2002, and it became equal to the OECD overage in 2007. The general level of the number of researchers also decreased. The number of researchers in relation to 10000 labour force was above the average (103 %) in 2002, and the availability of researchers in Russia turned out equal to 85.5% of the OECD average in 2007. The age structure of key scientific staff is extremely unfavorable in Russia. In 2008, 51.5 % of researchers stepped over a fifty years age, and 35.1 % of PhD and 59.4 % of doctors of sciences were older than 60 years.

The only indicators for Russia that are significantly surpassing the OECD average are the following:

- GDP share of R&D financed by business enterprise sector and performed by the government sector and sector of higher education (167 % of the average);
- GDP share of R&D financed by business enterprise sector and carried out by the government sector (300 % of the average).

The reason of these phenomena is weak research facilities of firms in Russia. The weakness induces the enterprises to use active outsourcing in R&D to compensate the shortage of their facilities.

Mesolevel of Decomposition

The macrostructure outlined above can be decomposed into the NIS sub-processes according to the following groups:

- Classes of manufacturing enterprises grouped according to technological intensity of economic activities.
- Size classes of organizations (i.e. organizations united in accordance with the number of employed people).
- Property classes of organizations (i.e. organizations clustered following types of property).
- Economic operators united in groups according to their belonging to certain regions.

The disaggregation directions just mentioned can be mixed up and applied in different sequences under the structural decomposition.

It is shown (Golichenko, 2010a) that the high-technology and medium-hightechnology manufacturing firms have the undeniable advantages in the share of innovative product in sales (see figure 2), the concentration of innovation processes and the usage of disembodied classes of middle size take advanced positions in structure of innovative entrepreneur activity. technologies among innovation-active enterprises (IAE) in Russia.

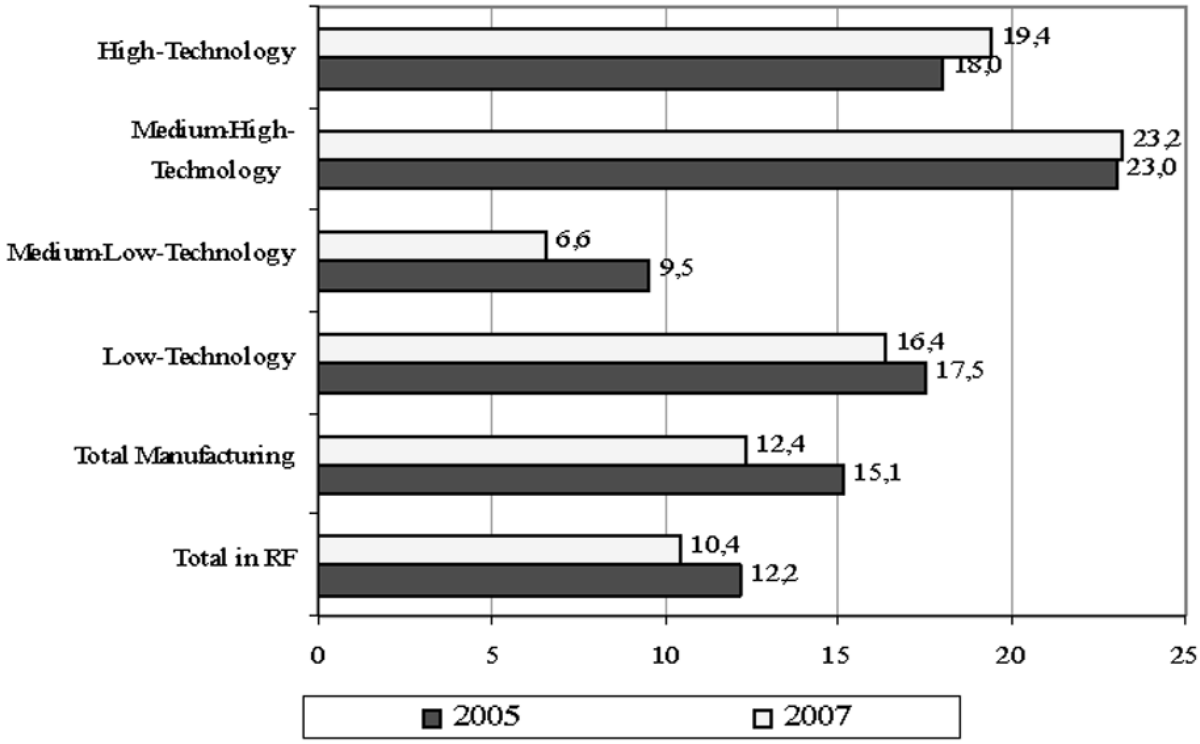

Figure 2. The share of product innovation in sales of IAE of manufacturing according to R&D intensity (%).

Source: Federal State Statistics Service of Russia (Rosstat)

This means that it is necessary to intensify innovation processes in these kinds of economic activities. This action gives an opportunity to improve the quality of innovation, increase the value of R&D intensity of product innovation and the number of entrepreneurs introducing innovation in order to enlarge a market share. As for size classes of enterprises, it is not difficult to demonstrate that dynamics of scale and economic effectiveness of innovation activity have been fully shaping in classes of large sizes. Nevertheless, these size classes are innovative passive (see figure 3). On the other hand, the highest share of product innovation in sales characterizes these classes and ones, which are close to them. They also have the considerable effectiveness of innovation processes and the high R&D intensity of product innovations. However, the number of employees in these classes is not dominant in Russia.

According to this finding, the main task of innovation policy in the business environment is to increase the competitive pressure on large enterprises and assist small and middle-sized enterprises in innovation development.

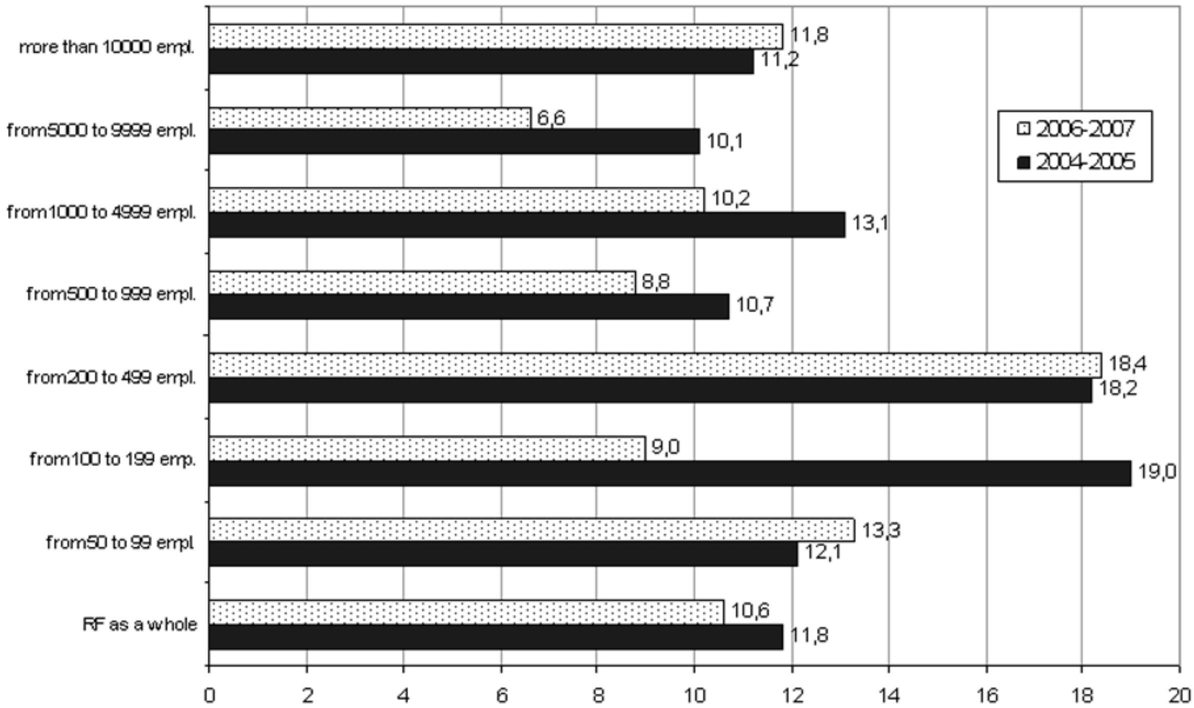

Figure 3. The share of product innovation in sales of IAE of manufacturing according to size classes (%)

Source: Federal State Statistics Service of Russia (Rosstat).

THE FUNCTIONAL ANALYSIS OF NATIONAL INNOVATION SYSTEM

The approach is applied for estimation and measurement of efficiency and performance of NIS. Unlike well-known integral criteria for the NIS efficiency (Porter et al., 2008 and MERIT, 2011), the new methods give an opportunity to get component-wise estimation of the NIS and identify cause-effect chains of factor impacts on its elements.

To realize this approach, a level of the structure-object analysis "is split" into a number of sublevels, i.e. into a set of strata. The first stratum corresponds to a process of the object identification with reference to the economic environment. On the second one, the efficiency and performance of the object activity are investigated. On the third one, factors of object's efficiency and productivity are studied. Finally, the fourth stratum is devoted to the study of framework conditions and institutional arrangement of the environment. The proposed methodology is reported in details for macro level, i.e. for NIS as a whole.

Object Identification in Relation to Environment (The First Stratum)

On closer examination of the first stratum, the fast-growing BRIC countries are considered. The hypothesis put forward proposes that the technological level of South Korea determines the medium-term frontier of technological opportunities for these countries. Therefore, the dynamics of parameters of technological development of BRIC countries are estimated in relation to this moving technological border. Parameters of the border are the follows: resource productivity, relative scales and technological contents of manufacturing and export, technological competitiveness of manufacturing activity in the world markets.

Among BRIC countries, China shows the greatest speed of convergence with the frontier of technological opportunities for the last and first decades of the previous and recent centuries accordingly. From 1990 to 2007, the gross labour productivity of China, i.e. GDP per employee (PPP, in 2000 USD) doubled in relation to Korea's (figure 4). The country's technology structure of manufacturing industries was considerably improved. It began to resemble uncommonly much the structure of Korea. The strengthened export orientation of China has been concerned, in the first place, high-technology and medium-high-technology activities. In 2007, the share of the high-technology activities in Chinese manufacturing export (30%) almost caught up with Korean one (33%). The shift of external competitiveness of China from low-technology to high-technology markets is demonstrated by the index of revealed comparative advantages (Balassa, 1965), (Utkulu and Seymen, 2004). In 1995-2007, its value increased almost in twofold for the high-technology activities, and it raised as much as 1.5 times greater for the medium-high technology activities (Chandra et al, 2009). Other BRIC countries did not move closer to Korean economy. Their distance from the technology frontier continued to increase. Though, for such an indicator as gross labour productivity, Russia remained closer to this frontier than others BRIC countries did, it also retreated from the medium-term frontier of technological opportunities. At the same time, in relation to Korea's level, the Russian gross labour productivity (figure 4) decreased on average 1.7 times and the share of high-technology industries in manufacture export reduced from 12% (1996) to 7% (2007).

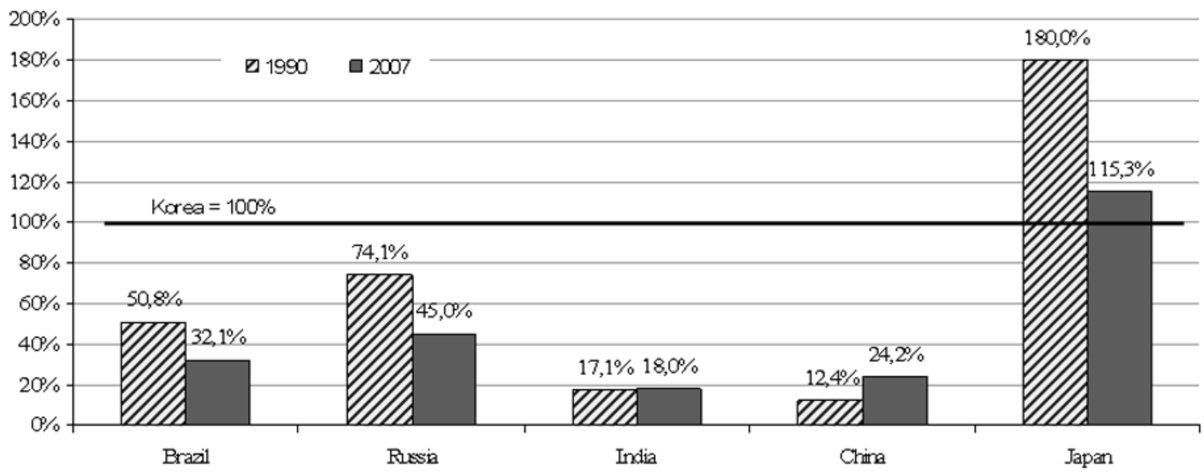

Figure 4. Indicators of gross labour productivity: GDP per employee in PPP USD of 2000

Source: World Bank, Federal State Statistics Service of Russia (Rosstat)

Effectiveness of Innovation Activity (The Second Stratum)

The full volume of innovation production is assumed to reach if the efficiency of creation of innovation product and efficiency of innovation resource distribution take place. The characteristics of fullness of innovation production are taken as output components of efficiency.

The efficiency of creation of innovation product is determined as the innovation production of maximum possible volume for given quantity and structure of inputs. In other words, the question is whether the achievement of the greatest possible scale (i.e. extensiveness) and intensity of the innovation process, particularly resource productivity have occurred. As far as the relative extensiveness of innovative activity is concerned, it is easy to show (Golichenko, 2011) that Russia has a position of an outsider among former socialist countries and old members of the European Union. The relative extensiveness is defined as a share of product innovations in sales of all enterprises of given sample. It is not hard to find out that the country has also low efficiency of resources use to create product innovations, i.e. the low resource productivity.

The efficiency of the distribution of innovation resources takes place if the NIS succeeded to get the innovation outputs, which are the most useful for the economic environment. This means that, for a given level of innovation product creation, it became possible to reach the greatest satisfaction of the current and perspective needs for innovation products. That is, the efficiency of resource distribution is the question of optimum combination of two subprocesses: that of generation of unknown-to-the market innovations and one of diffusion of innovations, which have been already known to the market. It is not difficult to demonstrate (Golichenko, 2011) that the optimum combination of these sub processes has not been reached for Russia.

Factors of Innovation Activity and Effectiveness and Performance of the Activity (The Third Stratum)

It is necessary to search factors of incompleteness of innovation production. To that end, the considered characteristics of factors have the following components:

- Balance of antistimuli and stimuli of innovative activity.
- A paradigm of innovative activity, innovation capacity (potential) of enterprises and scales of demand for innovation product.
- Formation of inputs of innovation processes as a result of interactions of enterprises and the NIS as a whole.
- Availability of the generated inputs of innovation processes.

The main components of anti stimuli are taken as follows: framework risks, risks caused by an action of spillover effect and disincentives determined by risks of "natural" uncertainty of innovation activity (Golichenko & Samovoleva, 2013). To examine the paradigm of innovation activity, the component comparison of innovative behavior of Russian enterprises with progressive innovative mode was made. The diffusion at inputs and outputs of innovation processes is investigated. The investigation gives an account of different approaches to the description of knowledge diffusion channels and analysis of their functioning (Golichenko, 2011). This has made possible to find out malfunctions of knowledge links, identify the lacking elements and suggest the necessary measures to reestablish them.

Stimuli and antistmuli of innovation activity. The framework risks will be examined in paragraph 3.4. The other kinds of risks are considered below.

Effect of spillover. An enterprise created an innovation is unable to adsorb all possible advantages of its application, and in many cases it is cheaper for another company to imitate products already in existence than to create new products at the frontier of innovation. As a result, the diffusion of the emerging innovation provides the current social-economic development of the country with new quality. The pure effect makes public support of innovation activity to be beneficial for society as a whole.

On the other hand, spillover effect or, more precisely, perception by a company that its innovation can be used by a company-rival, which does not invest in this innovation but enjoys an opportunity to use the ripe fruit. It ruins an incentive of firm-innovators to create radical innovations.

This antistimulus becomes efficient if legal protection of intellectual property and commercial secrets are not reliable in the country and the range of persons interested in "pirate" use of intellectual products is unusually wide. This can happen, for instance, due to the generic (cross-sectoral) or pre-competitive (sectoral) nature of the invented innovations. The long duration of innovation development and its implementation can also play an essential negative role. The longer this period is, the greater the danger for the firm-innovator is that free riders may use the innovative ideas.

Natural risk of innovation activity. The disincentive effect of spillover is reinforced by risk nature of innovation activity. To offset disadvantages of the natural risk, enterprises may use a mechanism of cooperation and partnership. The combination of different competences and finance resources in cooperation gives an opportunity to create generic and precompetitive technologies at lower risk.

The competition creates a considerable incentive for emerging inclination to risk among enterprises. The "whip" of intensive competition makes a company undertake the innovation risks (OECD, 1999). It turns on Darwinian selection: one survives who has proved to be strong, i.e. successful in innovation activity.

Paradigm of innovation activity and innovation potential of enterprises. During the technological revolution of the last decade, the shifts have been occurring in the following directions (OECD, 2005, p. 118):

- From preferred development of process innovations to that of product innovations.
- From incremental innovations to radical ones.
- From engineering based innovations to ones driven by basic research.
- From self-reliance to outsourcing, particularly developing early stage technologies, i.e. breeding enterprises based on one new technology.

These shifts give the basis of a new paradigm of innovation activity. Unfortunately, the Russian enterprises' paradigm of innovation activity is still at a great distance from the new one that could provide the country a new quality of economic development and assists to obtain a competitive advantage on international markets. The statistic data show the displacement of Russian enterprises preferences in favour to process innovations. Their innovations are mainly engineering-based and incremental ones.

Besides, the research facilities of Russian enterprises are rather weak. The business expenditure on R&D as a share of GDP is extremely low. It is four times as low as the world average and 3.5 as low as the average of Western Europe and Pacific region. It is worth noting that the number of researchers employed in firms gave only 5.6% of their total number in 2007 (5.2% in 2005).

Formation of inputs of innovation processes. The most influential inputs of innovation processes are human resources in science and technology (HRST), new knowledge and finance resources.

New knowledge. The scale of Russian scientific production can be estimated by the number of scientific articles taken into account by indexing service the Science Citation Index, as well as Social Science Citation Index. The service was introduced by the Institute for Scientific Information of the USA, which was acquired by Thomson Scientific & Healthcare in 1992. According to this source, the Russian publications made up 40% of Eastern and Central Europe articles amount in 2007 (60% in 1995). However, the number of the articles of the region as a whole is not great. In Western Europe, the number of articles was 7.3 times in 2007, and 6.1 times in 1995 as many as the number of articles in Eastern and Central Europe. Because of Russia dominating in the quantity of scientific articles in the region, the main reason of the increasing gap was a fall of the number of Russian publications during this period.

Human resource in science and technology. The availability of HRST of corresponding quality and structure is a necessary condition for providing a stable functioning of cognition processes by means of the organization of systematic knowledge generation, technology diffusion, applying scientific and technological knowledge to practice.

In Russia, the most crucial part of HRST becomes younger. The average age of professionals diminished from 40.7 to 40.4 years old in 2002-2006. This reduction was caused by inflows of young people in natural sciences, engineering and social sciences. In natural sciences and engineering, the rejuvenation was a result of intensive inflows of young people whose profession is associated with computing professionals, architects, engineers and related specialists. In social sciences, the lowering of average age is determined by inflows of young economists and jurists. The peak of demand for professionals of this kind happened in the middle of 1990s. At the same time, the innovation activity of Russian enterprises was not able to generate demand for well-educated professionals oriented in the fields of natural, medical sciences, agricultural sciences, the engineering and technologies. The state did not also become a qualified customer of their labour. The relative low salaries and the absence of popularization of scientific activity in mass media do not provide incentives for young people to obtain the qualification in these fields.

Diffusion processes in the business environment and availability of innovation processes inputs. The availability of innovation resources is determined not only by their properties, whether they are public or private assets, but also by the structural disproportions, i.e. by a deficit of some components and a surplus of others, the opportunities, which the NIS gives, and the organization capability for establishing linkages in the system. These opportunities are often arisen due to the coherence of NIS objects. This coherence is determined, to a great extent, due to existence and performance of knowledge diffusion and transfer channels. It is worth noting that the system of interactive learning imbedded in NIS theory by Lundvall (1992) may be implemented in many respects through these channels determining the essence of mechanisms of knowledge transfer.

Three main types of technology transfer and diffusion channels may be introduced (Golichenko, 2011) as follows: open information channel of transfer of pre-competitive knowledge that are public assets, channel of transforming open knowledge in pre-competitive and competitive one, channel of commercial knowledge transfer providing diffusion of embodied and disembodied technologies.

The performance of open information channel is of immense importance for a stage of applying basic research and generic and pre-competitive stages of technology development. The information transferred through the channel is often codified. The codification can be a significant obstacle for the information dissimilation, i.e. there is a need of specific organizations to decode the information for potential users.

The second channel should be divided into two parts. Cooperation and partnership institutions carry out the performance of the first of them, and the main components of the second channel are institutions of breeding new technology-based firms.

The action of the third channel takes place due to classic diffusion, including adaptation and imitation of well-known products, technologies, organisational and marketing innovations developed by other firms and companies.

The essential factor of ineffective performance of technological knowledge diffusion channels is system failures of Russian NIS. The country needs in structural innovations (Howells and Edler, 2011). Indeed, the elements of innovation infrastructure significantly increased in 2003-2008. By 2009 more than 80 techno parks were registered, there were more than 100 centers of technology transfer, 10 national innovative-analytical centers, 86 centers of science and technique information, 62 business-incubators, 15 centers of innovation consulting, etc. However, these elements of NIS did not manage to establish effective linkage between enterprises and research organizations. The communication gap has taken place. Institution rigidities were at the back of this communication breaking. In other words, the system crisis of Russian NIS has taken place. The monitoring and estimation of element NIS activity were not carried out as regular and wide-spread procedures.

Framework Condition and Institutional Environment (The Fourth Strata). The framework risks, i.e. the risks determined by framework conditions, are of considerable importance for innovation activity. For example, the incentives for investment (and hence for the most risky their part, i.e. investment in innovation) are considerably influenced by macroeconomic policy including monetary and investment one.

Among framework risk factors, there is also lack of development of entrepreneurship and competitive environment, insufficient legal protection of investment, shortage of law enforcement, a lack of tax systems, ineffectiveness of budget distribution schemes, imperfection of bankruptcy procedures and immaturity of stock exchanges, particularly for firms with a short history.

The framework risks give a ground for difficulties of doing business in Russia. It turns out that according to the inquiry of entrepreneurs from 120 countries, which was carried out by World Bank in 2009, the barriers of doing business are extremely high in Russia. For Russia, 116 units estimate their height. The unit of measurement of the ease of doing business index corresponds to the most business-friendly regulation in a country. In this survey, the most unfavorable rank (183) was associated with Chad. At the same time, the rank was equal to 78 and 15 for China and Korea correspondingly (World Bank, 2009).

To compensate for shortages of market performance, the Russian government tries to substitute for business. Its efforts are often made not to activate business environment but to replace market mechanisms by government ones.

The regulatory support of innovation activity has significant deficiencies (Golichenko and Samovoleva, 2008) and parts of the legislative system very often lack coherence and coordination. The conceptual and terminology framework in the field of innovations is not developed. It very often does not conform to international standards. Many actors of innovative activity are not stimulated, and the current system of indirect incentives does not have effectiveness even when its addressee is chosen rationally. The principle of risk compensation does not put into practice for innovation stages, which are far from market. At the same time, there are attempts of the state to support innovation activity at competitive stages, notwithstanding the fact that this contradicts principles of market competition development. Frequently, there are no legislative documents in which the organization forms of NIS institutions and their interactions are defined precisely (Golichenko et al., 2011).

The governance system of scientific and innovative activity is not provided by an effective organization of the feedback from the objects of regulation. The estimation and correction of accepted decisions is complicated due to the absence of constantly operating monitoring system.

MAIN AREAS OF ECONOMIC AND INNOVATION POLICY ADDRESSED TO BUILDING OF EFFECTIVE INNOVATION SYSTEM

To become a valuable participant in the international division of labour and have a powerful and effective economy, a country should pass through some long and complex stages of development. According to Michael Porter (Porter, 1990) they can be called as resource-based, investment-driven stages and innovation-driven stage, e.g. one based on national innovation. He named them as the competition stages of development. Below, they have been rather renamed to give them a sense of the stages of various types of technological and economic development but having kept in many respects the economic contents of these stages.

The simplest and fastest way of multifold increase of technological potential of a developing country is to organize inflows of technological knowledge from the outside world and their diffusion inside the country Polterovich, 2008; Malerba and Nelson, 2011), i.e. to pass from the resource based stage to the next one driven by investment and technology catching-up (Porter, 1990).

In many aspects, the success in technology catching up is in the well-adjusted cycle of interaction between market and processes of imitation and incremental improvement of product innovation (OECD, 2005a). The high elasticity of demand and low production costs underlie the cycle. These factors provide the successful feedbacks of the cycle. In particular, the growing demand encourages firms in the further reduction of costs and prices the latter in turn stimulate the demand increase.

It is possible to reduce the production cost at the expense of using the qualitative but relatively cheap labour. However, the impact of this national resource factor due to processes of improving economic well-being is decreasing and involving cheaper labour abroad did not always give necessary effect. In these circumstances, the decrease of production costs could be only achieved thanks to the fast absorption of new caught up technologies and their improvements, i.e. mainly by means of process innovations. Under the condition of intense competition, the second component of success is the incremental product innovation based on upgrading imported technology. The product innovation provides an opportunity for a domestic company to sell products that could not be reproduced by its competitors for a while. To do this, the simplest way was manufacturing the technologically sophisticated product whose novelty was provided by means of so-called "product closed architecture" (OECD, 2005a). In this case, a large variety of the product components could be well-known and the product was assembled through a complicated integration procedure presenting a firm's know-how. Besides, it was a product innovation driven by imported technologies.

To protect the advantage of the closed architecture, the careful control of the integrated technology implementation is necessary. This means that the participants of the value chain must be connected by rigid relations in vertically integrated corporation. Besides, by virtue of essentially incremental character of innovations, the main research resources concentrate at the end of the research cycle, e.g. at the stages of applied research and development. Therefore, the innovations have, as a rule, the engineering and closed character.

The mechanism of gaining and supporting competitive advantages by domestic companies outlined above has been successful in Japan (OECD, 2005a). For a long time, it provided technological and economic advantages of the country, but at the beginning of 1990th after removing the economic bubbles the situation has considerably changed. Last decade of 20th century was failed for Japan economy: the country came into long recession.

Among possible reasons of this failure, the following ones deserved the greatest attention:

- The falling productivity and long stagnation had been caused by “unnatural” selection in Japanese economy when many efficient firms left the market while inefficient firms remained due to the support of government and banks (Peek and Rosengren, 2005, Nishimura et al, 2005).
- Japanese firms have lost the technological capability which in many respects had provided them success in the market (Porter and Sakakibara, 2004). As a consequence, on the one hand, the share of high technology markets of the Japanese firms in the field of semiconductors and equipment for their manufacturing was significantly reduced. On the other hand, it has appeared that Japan was not able to keep pace with the USA in such new high technology industries as biotechnologies and information technologies.

Besides, the effective competitors of Japanese firms emerged in countries of South-East Asia. They imitated the Japanese firms’ competitive strategy based on costs reduction and incremental product innovations driven by imported technologies. At the same time, the consumer demand started to decrease.

As a consequence, elasticity of demand for high technology product has diminished; it ceased to be a driver of the feedback of market into innovation processes. Consequently, the need for process innovations as a tool maintaining the gained competitive positions has decreased. It was necessary to search for new niches in the market and the need for product innovations has risen. However, the opportunities to use incremental product innovations were essentially reduced because of taking place the technological revolution. The necessity of radical product innovations has increased.

The essence of this revolution was in technological shift towards the open architecture product known to participants of the market since the product consists of standardized modules and their interfaces (OECD, 2005a. The module concept and standardization erode the former market niches in the production of computer hardware and subsequently in other sectors. Development and introduction new standards of product architecture are possible only under the condition of their radical improvements and acceptance by main participants of the market. Therefore, for incremental product innovations there is only one niche, it is improvements of product architecture modules. Besides, in many industries of high technology the refusal of vertical integration of production chains (Ernst and Luthje, 2003), the reinforcement of specialization in fragmented value chains and the dissimilation of concepts of competence-core business were observed.

Because of the factors listed above, Japan has faced a problem: how to design post-catching up national innovation system that would give an opportunity for transition to the radical innovation-driven stage (Goto and Kazuyuki, 2009).

To address the challenges mentioned above the Japan government decided now to "catch up" not high technology products as it was before, but the elements of the U.S. institutional NIS mode. First, the process of "catching up" has affected the institutional mechanisms for basic science development, technology transfer from universities to industry, cooperation of public research organizations, universities and industrial enterprises.

For a long time Japanese government did not pay the sufficient attention to basic sciences. For Japan industry, the U.S. was the main source of progressive scientific ideas. In 1994, the government spent only 0.59% of GDP on R&D while the USA made up 0.88%. The basic research facilities became out of date: the ratio of them more than 20 years old to the total amount was 50% in national universities and 35% in government laboratories. Besides, the support for research personnel was also insufficient.

The accepted decision on modernization obliged the government to elaborate the Basic Plan for Science and Technology each five years, at the same time, the sharp increase of financing R&D by the budget was brought to the forefront (Goto and Kazuyuki, 2009). The other purposes were associated with the program of qualified personnel development and institutional transformations of R&D sector. The distribution function of competitive research funds was shifted further from the government to independent funding agencies. According to the Basic Plans, the universities and research organizations have received means for scientific facilities modernization. They increased additional positions for postdoctoral fellows and enlarged competitive research funding (Shimoda, 2009). The system of research support with its reliance on peer review and evaluation procedures became like the U.S. one.

The system of technological transfer was introduced, along with significant strengthening of intellectual property rights protection. The system was based on the principle of a transfer of ownership of inventions to university if the inventions were obtained with assistance of budget support. The legislation to promote the establishment of Technology Licensing Organizations (TLOs) of universities and government research organizations and its activities was enacted. Under this legislation, the TLOs can receive financial support for their activities as well as such assistance as reduced patent application fees.

The government encouraged cooperative research between universities, national laboratories and industry, as well as the incubation of new firms derived from these organizations.

The system of the government research grants supporting joint researches of universities and industries has been in action from 1999. The restrictions imposed on participation of national university professors in industrial activity of companies, especially as for technological transfers, have been relaxed.

To encourage R&D in the industry, the tax credit was changed. It started to be granted, not for annual increases in R&D expenditure, as it had been before, but for total annual expenditures of R&D. Besides, from 2003 to 2005 the individual tax reduction was given to the enterprises carrying out R&D.

The approach to support small and middle enterprises (SME) has been revised. The Small Business Innovation Research Program has been emulated related to the SBIR program of the USA. The components of the new policy concerning SME included: special grants on R&D; the debt guarantees connected with their innovative activity; greater tax indulgences than for the large firms.

How much effective were these reforms? On the one hand, they have given noticeable results: the companies annual expenses of R&D have increased. During 2001-2005, the amount of universities applications for domestic patents increased more than in 13 times, and their number was close to the level of U.S. universities. The number of joint projects of universities and industry considerably increased from 1500 in 1995 to more than 10000 in 2005. The number of university spin-offs became compared with the U.S. universities level (Shimoda, 2009).

On the other hand, licensing revenues of Japanese universities remained miserable. Only few academic start-ups reached IPO stage (Goto and Kazuyuki, 2009). The principal causes of the state of affairs were the following obstacles:

- A small number of ideas generators that would be able to give rise to radical new technologies.

- A weakness of scientific schools, particularly in the field of basic research in the country.
- A high degree of monopolization on high-technology markets.
- An insufficient account of the processes of value chains fragmentation.

Besides, it is necessary to note that there was a lack of significant university inventions, experience and knowledge for elaboration of license strategy; an insufficient infrastructure of economic growth support. In other words, it has appeared uneasy to get out of the catching up trap, which the country has fallen. It means that during the investment driven stage, the policy is to bring into being the resource and institutional foundation of transition to the next stage driven by national innovations.

Therefore, one needs to recognize that the pure catching up strategy leads eventually into a dead end under the modern level of the market and technology development (Golichenko, 2010b). According to Fagerberg and Godinho **(**2006, p. 522), “policies and institutions that worked well during the catch-up phase may not be equally well suited when this phase is completed, and the former catch-up country has to compete with other developed countries on an equal footing”. Besides, the country’s long orientation only towards problems of technology catching up can result in essential deterioration of creative facilities of the nation as a whole and its HRST particularly. Obviously, during passing the investment (catching-up) stage, the institution and resource base for transition to the next stage should be brought into being. In other words, there is a need for mixed policy implementing in some proportions the institutions and institutional instruments corresponding to both the current investment stage and the future stage driven by national innovations.

The areas of this mixed public policy must be grouped according to the following tasks (Golichenko, 2010b):

- Providing conditions for increase of business innovation activity.

- Extension of processes of knowledge diffusion and cooperation.
- Development of science and its orientation to solve problems of innovation development.
- Support of breakthrough technology development.

The first problem should be solved mainly on the investment-driven stage. The complete decision of the second and third ones cannot be adhered to the certain stage, i.e. there is a need to solve them gradually and systematically on the stages.

Let us consider the solving problems just outlined. It is worth noting that the key policy challenges and policy tools tailored to liquidate and mitigate market failure and NIS dysfunctions (Manjyn & Merino, 2012) are bound to the vertical and horizontal decomposition, which has been above introduced above. Besides, the stages of development such as investment-driven and innovation-driven ones are taken into account. Particularly, this gives an opportunity to describe the policy measures facilitating co-evolution of absorptive capacity and innovative capability of the NIS. Finally, the conditions of activities in each block are divided into two groups depending on whether they are framework or special ones.

Providing Conditions for Increase of Business Innovation Activity

The goal of the policy in this area is to create a competitive business environment whose subjects have strategic thinking, learning ability, knowledge and management capacity to acquire and use new knowledge.

The investment-driven stage of development or catching up mode. *Framework conditions*. On the stage, framework conditions are of vital importance. The problems of creation of favorable macroeconomic environment and conditions for business doing, particularly tax and investment climate come to the fore. The framework conditions must establish an elementary order in the country, liquidate corruption roots, separate business and authorities at all levels of governance. The reforms could reduce institutional rigidities. The development of effective regulatory environment facilitates the solution of these problems. Particularly for companies, which are active in absorption and adaptation of catch-up technologies, modern empirical studies (Johansson et al., 2008) show that there is a negative effect of many corporate tax rates determined by law. To increase the number of effective owners, it is necessary to improve the legal framework and practice of bankruptcy, impose tangible sanctions for false bankruptcy or deliberately precipitating bankruptcy. Besides, there is a need to increase radically the efficiency of public property service through the development of competition among candidates for official capacity and the estimation of enterprise management programs.

The reduction of regulatory and administrative barriers restricting new firm's creation (OECD, 2006) and the effective system of firms' access to finance are of considerable importance. The reforms could reduce institutional rigidities. To contribute significantly to achieving and maintaining reasonable competitive pressure, it is necessary (Jaumotte and Pain, 2005) to optimize antitrust laws, lower the barriers to market entry and exit (OECD, 2008).

To make a significant contribution to improving the absorption capabilities of NIS actors, it is crucial to provide public and business investing in the highly skilled labour force and technologies. The development of secondary, higher and vocational education is one of the basic factors for passing the stage.

The foreign direct investment (FDI) may be a key element of economic development on the stage (Guellec and van Pottelsberghe, 2001). The availability of the highly skilled workforce and the quality of knowledge institutions in the country has a considerable impact on foreign direct investment (Erken et al., 2005). The value of R&D performed by foreign firms in a country is a significant factor of economic growth is country (Guellec and van Pottelsberghe, 2001).

To obtain important for the country positive externalities from FDI, a balanced pro-active government policy and negotiating power by public authorities are required. As the experience of Brazil demonstrates, FDI does not bring the advanced technologies in the absence of such policy and negotiating power, even if FDI volume has and an impressive size. The most part of these investments in the country was concentrated on the non-competitive market protected form outside world (OECD, 2009a). On the other hand, China gives us an example of having a balanced proactive policies and bargaining power of the government.

Special conditions. During the stage, there must be a switch to competition driven by low costs and improvements of consumer attributes of products. This progress is a result of catching-up processes in innovation including incremental improvements of imported technologies and products. The special conditions designed to support innovative activity— together with the framework ones— should facilitate the development of country’s absorptive capacity, i.e. the country’s ability to rely on global knowledge and domestic R&D efforts.

The essential factor of the stage is demand and supply of HRST. The demand-side policy aims to enhance employment and development of highly qualified staff through regulation of labor markets, tax incentives to invest in R&D and encouragement of exacting consumer demand. In turn, the supply-side policy requires government support for education and training and conditions for transformation of "brain drain” into “brain circulation”.

The increasing dependence between innovation processes and R&D intensity give evidence for growth of investments in high and medium-high technology industries. If a country has rather significant HRST, the introduction of incentives to manufacture technologically complex products could leverage innovation activity. It is also essential to provide incentives to manufacture a technology-intensive product (China, Russia). These incentives may include tax reliefs, privilege credit conditions for equipment and licenses import, stimuli for international cooperation in R&D.

The enhancement of investment openness and attractiveness of high and medium-high technology industries for domestic and foreign investors, international trade and direct investment facilitation may also assist the absorption of knowledge and technologies. The growth of a share of manufacturing industries in the national economy is crucial. The technological component should become significant in determining the level of national competitiveness.

General measures to stimulate innovative demand, supply processes are in need of development. The supply (push) stimulation policy, above all, aims to shape a sufficiently complete and consistent government system of indirect and direct financial incentives (e.g. target grants and tax incentives for R&D). One of momentous policy dimensions is the removal of the institutional barriers restricting the legal capacity to participate in pre-competitive collaboration. Innovative activities are usually distributed unevenly among various size classes of enterprises. Therefore, public policy should aim both at overcoming the innovative passivity of large companies and at increasing the weight of innovative-active small and medium enterprises. At the beginning of this stage, the demand-pull policy is rather simple due to a certain degree of the rigidity and scarcity of production and market systems. Its content is technology-oriented government procurement, which must make demands on qualitative products in the framework of government contracts. Programs assisting diffusion of embodied technologies are required.

The national innovation-driven stage of development. On the stage, following the success already achieved during the previous stage the monitoring and evaluation of barriers to competition and entrepreneurship are taking place (the UK). Efforts are being made to overcome identified barriers. Calls for decentralization of decision-making processes in the economy become urgent. In most cases, the impulse to innovations comes from the private sector. Therefore, calls for decentralization of decision-making processes in economy become urgent. The government role consists in facilitating an environment for competition and entrepreneurship development by using mainly indirect forms of regulation.

The public policy assists to create opportunities for development of mature capital market, capital mobility and co-financing. Meeting new challenges, the access to capital for fast growing companies including new technology based firms is expanded. The flexible market of qualified and mobile labour becomes available for enterprises. To induce human capital accumulation, education systems including lifelong education and training systems are improved significantly. Growth of incomes, educational level and consumer's qualification can provide a basis for advancing facilities of high and medium-high technology industries, implantation of innovative-active firms in kinds of economic activities. The process of the value chain shaping which are able to guarantee the stability of innovation processes is accelerated (Porter, 1990). Under these conditions, domestic firms not only use and improve modern technologies and develop their absorption ability but also create new technologies. At the same time, the creation of new technologies is often associated with manufacturing new-to-the market products. The technology modularisation gives an opportunity of shifting to more flexible manufacturing and building up technology modules. The latter is easily clustered up to manufacture goods satisfying small consumer group demand. It is worth noting that the modularisation of some value chains gives a basis for the success of many Chinese companies on global markets. First, Chinese companies did not need technological innovations to compete in such chains. It was enough to deliver in time commercially effective modules components modules and their assemblies. Since the late 1990s, many Chinese firms have positioned themselves as contractors of the original high-tech equipment for international companies (OECD, 2009).

The innovative activity requires special conditions for its growth. They include encouraging the private and public investment aimed at the development of HRST, facilitating the creation of disembodied technologies, achievement of equilibrium between indirect and direct methods stimulating innovative activity, development and promotion of dual-use technologies. On this stage, the government continues to develop the technology push policy, but it places a significant emphasis on the market-pull policy focused on the end of an innovation cycle. Demand is a driving force that manages resources and innovative capacity to meet the emerging societal or market needs (Schmookler, 1966; Rosenberg, 1969). One needs also to take into account that the essential feature of this stage is a radicalization of innovations. While there does not usually exist a problem of the diffusion of incremental but radical innovations (Bower and Christensen, 1995). In order for the radical innovations could also quickly be adopted by consumers, the market demand often needs to be enhanced by market pull policy. The demand-side policy approach affects innovation activity reducing barriers to innovation and contributing to the emergence and reconstruction of markets. Examples of the components of such policy are the lead-market initiatives, particularly tax credit, consumer oriented schemes including rebates for consumers of new technologies, regulations and standards (OECD, 2011; Edler et al., 2012).

At the horizontal level, there is a need to expand a set of innovative-active firms having the activities both inside and outside of the value chains. The activities result in product and process innovations both in individual link and between chains. The firm's innovation activity can move to a new profitable value chain. The types of activities may be encouraged by competition processes and fragmentation of value chains (Pavitt, 2006; Golichenko, 2011). It is essential to note the role of national factors such as the networks of organizations carrying out R&D, the development of closely connected and related industries providing the stability of the innovation process. The necessary conditions of giving rise to the networks are vertical cooperation and partnership. Greater coherence of innovative resources requires conditions for high mobility of highly qualified personnel (particularly personnel in R&D). At the policy level, it is necessary to identify the advanced value chains in high and medium-high technology industries to assist national businesses with an organization of network information platforms.

Development of Mechanisms of Knowledge Transfer and Diffusion

The mechanism creates the opportunity for knowledge transfer and diffusion through open information channel, channel of transforming open knowledge in pre-competitive and competitive one and channel of commercial knowledge transfer (Golichenko, 2008).

The investment-driven stage or catching up mode. On this stage, catching-up countries achieve increases of productivity and improvements in welfare not from R&D performance and commercialization of their results but mainly due to absorption of already-known-to-the world technological knowledge (OECD, 2009a).

In order for the absorption takes place, actions are necessary to involve and support all eligible channels of knowledge diffusion, to focus efforts on the fast growth of absorption capacities of enterprises (China, Russia). Among the channels, the open information transfer channel and that of commercial knowledge transfer are of the greatest importance for successfully catching-up processes (Golichenko, 2011). The performance of the other channel such as the channel of transformation of open knowledge into pre-competitive and competitive one can have an influence on technology catch-up, but the impact of the just mentioned channels is much more significant.

For effective performance of the open information channel, it is extremely beneficial to develop education of secondary and tertiary levels and vocational training and processes of copying and inverse engineering. It is necessary to provide easy access to technical information in printed publications and through the Internet and draw on diaspora.

It is necessary for a country to have not only a highly literate population, but also labour force, which knows management methods of complex manufacturing processes and has necessary skills to produce technologically complex products. Aside from the strong improvement of quality and scales of technical education in higher school, it also requires an organization of professional and special intra-firm training. For the development of this form of vocational training, it is useful to leverage foreign direct investment. As the experience of China shows, the strong government bargaining power may assist to involve foreign investors in the processes of intra-firm training even outside of the field of FDI applying (OECD, 2009b). At the same time, the availability of high-quality human capital does not mean that this capital could be used effectively to provide a large-scale knowledge transfer if many other components of diffusion and transfer channels are missing and there is a lack of incentives for the participants of transfer processes.

Development of the traditionally understood diffusion of disembodied and embodied technologies requires a well-run commercial knowledge transfer channel. The effects of the channel action are associated with transfer, adaptation and upgrading of innovative products, services and processes including production methods, organization and marketing changes that are already known to the market but new to the firm. If this is the case of diffusion of the commercial knowledge of foreign origin, the substantial factors of this process are international trade, FDI and intellectual property rights. The acquisition of foreign technology companies by enterprises plays a certain role. Diaspora, if it is rather widespread, can also be involved in these processes.

To achieve large-scale diffusion of embodied and disembodied knowledge (obtained both from abroad and inside the home country), there is a need to place a premium on institutional infrastructure, particularly on services of technical support and institutes of standards and quality control (Golichenko, 2006).

Global market. The domestic markets of countries with relatively low income per capita do not usually contain drivers of economic development. The countries need to strengthen competition through strong export orientation of domestic firms and open the domestic market to foreign competitors. More generally, many economic historians have come to the conclusion (see, for example Crafts, 1995) that rapid growth is related to openness and competition in product markets rather than with protected monopolies. To create a more global landscape for innovation and enhance the opportunity for effective catch up, the countries need to strengthen competition through strong export orientation of domestic firms and open the domestic market to foreign competitors. The East Asian countries of modern miracle growth have had policies under which firms were forced to submit to competitive market pressures.

Nevertheless, it must be borne in mind that excessive strong competition may cause irreversible far-reaching negative consequences for national industry. Aghion et al. (2005; 2009) proposed and empirically proved the hypothesis that, in industries with a large gap between foreign technology leaders and domestic laggards, domestic innovative firms are forced to leave market due strong foreign competition. Under these circumstances, the opening of domestic markets without a supportive government policy may initiate the disappearance of many national industries and generate risks that the home country's innovative capacity can be dismantled. The intensive competition may discourage the emergence of new industries and make a negative impact on the national economy as a whole (Dixit and Stiglitz, 1977; Romer, 1990; Grossman and Helpman, 1991). At the same time, the classic protectionism maintaining high barriers to entry for foreign companies preserves backward technological structure and thus provides serious obstacles for economic development. In other words, in order to narrow the gap between foreign technology leaders and domestic laggards and provide for the latter an opportunity of development, there is a need to achieve a careful balance between processes of foreign competition and public support of domestic enterprises.

There are two ways to avoid the detrimental effects of vigorous competition. According to the first one, the government strongly supports the large export-oriented company-leaders (the Korean way). The government policy pursued the integration of the sophisticated outward-oriented and import-substitution strategy (Wang, 2007). At the same time, the intellectual property rights are strictly enforced. The domestic market begins to open up to international competition as soon as the domestic industry leaders of the industry became close to maturity.

The second way is to use the international competition for the development of the available pool of technology capacities and the formation of the potential threat of foreign competition for domestic producers. This could be made by means of special economic zone establishment. The threat may encourage domestic enterprises to innovate, and the use of the pool of technology capacities provides the prerequisites in order to survive in the future competition. The opening of the domestic market and intense competition with foreign firms became a reality for domestic producers as they reach a certain technological level due to technology diffusion.

Intellectual property rights. In the processes of transfer and diffusion of global technology knowledge, the role of intellectual property protection is ambiguous. To extend the scale of the diffusion of foreign technologies, it is reasonable to use a weak protection of intellectual property. However then, the risks of the unauthorized copying and reverse engineering of foreign technology are high. Therefore, foreign companies have considerable disincentives for bringing the new-to-the world technologies to the country, but maybe they are ready to export the modern known-to-the world technologies. These actions can significantly increase technology level of domestic firms and their absorptive capacity. The new technology level and capacity of domestic companies defines a problem of transition to a new advanced level of technology. The problem cannot be solved without the strong enforcement of intellectual property. This enforcement allows domestic companies not only to get access to the most advanced technology but also protect their own technology advantages.

According to this strategy, the protection of intellectual property regimes has one switch. This means, while the technological level of domestic enterprises is low, the regime of weak protection of intellectual property takes place. The regime of the safeguarding of intellectual assets becomes stronger if the level of technological development reaches a relatively high value (China, India).

The national innovation-driven stage of development. On the stage, there is a switch from supporting individual firms and organizations to setting up system-integration and network models of continuous innovation, i.e. development of clusters of interconnected firms and research organizations. Faced with increasing global competition and rising R&D costs, companies can no longer survive on their own R&D facilities, and they look for opener new modes of innovation. They include feedbacks facilitating the development of public-private partnership and establishment of modern value chains and infrastructural networks for technology export.

The effect of the channels becomes more widespread and sophisticated. The open information channel is in progress. The network of organizations appears that are translators of the results of academic research into practice. The government encourages cooperative interaction between universities, public research organizations and industry. The bridges to pass Death Valley by new technology base firms are constructed and supported. The human capital mobility, systems of disembodied technology transfer and fertile "breeding and growth grounds" for technology-oriented spin-offs are desirable for transition to the innovation-driven stage.

In the framework of channels of transforming open knowledge in pre-competitive and competitive one, cooperative processes take two dimensions. The cooperative processes take two dimensions. The first reflects a move away from traditional supply-push policies towards a model based on joint development including public-private partnerships and networks of firms and actors outside national borders. The second dimension is associated with the market-pull or contractual relationship between public research and demand from the business sector (OECD, 2011).

On the stage, the lack of business motivation to search new knowledge sources can be a major obstacle to the linking of business performance and R&D. This may be largely due to business focusing mostly on internal resources and using an outdated paradigm for innovation. The special programs to accelerate technology diffusion in areas of nascent demand assist in solving problems of increasing technological and organizational firm capabilities. There is also a need to remove obstacles and create incentives for horizontal and vertical interaction and development of networking between enterprises and organizations of different ownership forms. Technology platforms can play a significant role in shaping this stage.

Development of Science and its Orientation to Solve Problems of Innovation

The policy goal is to maintain and develop research environment, ensure knowledge production, to orient researchers towards meeting manufacturers' needs for innovation and encourage for cooperation with business communities.

The investment-driven stage, catching-up mode. On the investment-driven stage, the innovation activity mainly has a catching up character. Moreover, the applied research and engineering are of greater value than basic sciences. However, in order to achieve the strategic goals of the next stage driven by innovation, the arrangements for encouraging R&D should already occur on the stage (China, Russia**).** However, to achieve the strategic goals of the next stage driven by innovation the arrangements for encouraging R&D should already occur on this stage.

The most important of these arrangements are the following developments:

- Creating an attractive environment for carrying out R&D, in particular enhancing the prestige of scientific activity and increasing the effective researchers' income above the average industry-level wage.
- Setting up the modern engineering base for carrying out R&D including not only well-qualified people, but also high-quality scientific facilities.

One of the main problems here is the development and implementation of variant patterns of interaction between the research sector and the higher education to raise a researcher from a student. In order to find new fields of research and focus in the areas of global R&D, the equilibrium between portfolio of R&D related to the national priorities and complementary fields of research should be reached. The modern standards and the institutions of independent scientific examination should be introduced. Besides, the anti-corruption schemes of financing of scientific activity should be involved.

The national innovation-driven stage of development. In order to facilitate the transition to this stage, the country needs to stimulate a transfer of the final and intermediate R&D results from public organizations to industry, pursue a monitoring and eliminate obstacles constraining a legal transfer capacity of public research organizations (the UK). Public policy should boost knowledge production and supply to accelerate knowledge spillovers and externalities (Jones and Williams, 1998).

Considerable public and private efforts build conditions and incentives for joint orientation of government R&D sector and industry and their cooperative relations. The appropriate stimuli enabling domestic entrepreneurs to advance high technology manufacturing and enterprise's research base are necessary. The technology platforms play an important role in providing the interaction between industry and science. In areas of traditional responsibility of public authorities (defense, medicine, ecology and so on), reforms of programming processes are needed to achieve greater openness of procedures of program formation and their results estimation.

Faced with increasing global competition and rising R&D costs, companies can no longer survive on their own R&D facilities, and they look for the new opener modes of innovation. The intermediate consequences of corresponding political initiatives should be the following issues:

- Creation of joint engineering base of public research organizations, universities and small technology enterprises.
- Maintenance of voluntary labour mobility of researchers between public and private research sectors.
- Research sector participation in global value chains.
- Setting up attractive environment for foreign researchers in the home country.

Support of Disruptive Technologies

The country is in need of support of the development of disruptive technologies. However, it is worthwhile to do this if the reindustrialization of its industry has already occurred, and the advanced technological base has been built up. Therefore, the preliminary work must be done on the investment stage. It applies to preparing concepts and required policy toolkit to determine and set up the perspective directions of starting and running new technology firms. It should also provide legal and other conditions for cooperation between public sector and industry in researches and development. Finally, it is possible to use the toolkit if the certain degree of technological maturity is achieved, i.e. when the country is rather close to the stage driven by national innovations.

CONCLUSIONS AND RECOMMENDATIONS

Thus, the standard approach to NIS investigation to find out bottlenecks of the national innovation system and determine the measures of public policy addressed to their removing should include the system structure-object and functional approaches.

According to system structure-object approach, the national innovation system is considered as three interrelated macroblocs at horizontal level. They are business environment and market, environment producing new knowledge, and knowledge transfer mechanisms.

To estimate state and performance of the blocs and find out NIS bottlenecks on the macrolevel, profiles of national innovation systems should be build. To determine the main tasks of innovation structural policy addressed to improvements of the state of the blocs, the macrostructure could be decomposed into the NIS subprocesses. They can be clustered according to the following groups: enterprises of manufacturing activities at different levels of technological intensity, size classes of organizations, property classes of organizations, and economic operators united in groups in accordance with their belonging to certain regions.

In accordance with the described functional approach, each level of structure-object analysis should be divided into a set of strata. The strata correspond to the following items of the investigation.

1. Identification of an object and its economic environment.

2. Estimation of efficiency and performance of the object activity.

3. Search and analysis of factors of the object efficiency.

4. Consideration of framework conditions and institutional arrangement of the environment.

The principal part of the object identification associated with its environment **(**first stratum**)** is determination of a frontier of technological opportunities for the object and estimation of dynamics of object's technological development in relation to this moving frontier. To estimate the effectiveness of innovation activity of the object, the characteristics of fullness of innovation production must be considered. To find reasons of the insufficient state of effectiveness, the study of factors of the effectiveness take place on the third stratum. Among these factors are balance of antistimuli and stimuli of innovative activity, paradigm of innovative activity, innovation capacity and scales of demand for innovation product, formation of inputs of NIS processes, and availability of generated inputs of innovation processes.

The important distinctive feature of the proposed approach is a consideration of innovation input-shaping processes through transfer knowledge mechanisms, which include open information channels, channels of transforming open knowledge in pre-competitive and competitive one, channels of commercial knowledge transfer, i.e. diffusion of new embodied and disembodied technologies.

The formation of the idea of public policy as a system of interrelated institutions and institutional tools is a culmination of the approach. The areas of the public policy must be shaped in accordance with tasks of providing conditions for increase of business innovation activity, expansion of processes of knowledge diffusion and cooperation, development of science and its orientation to solve problems of innovation development. These areas of the public policy are considered in accordance with stages of economic development of countries, i.e. resource-based, investment-driven (or catching up) stages and innovation-driven one.

On the investment-driven stage, the public policy facilitates a shift from the mobilization of primary factors to technology leapfrogging driven by the sharp increase of utilization and up-grade of imported technologies and incremental improvements of products. An important part of this policy is the introduction of economic incentives to leverage technological absorptive capacities by integrating in the global economy and diffusing global knowledge. The high quality of secondary and higher education and vocational training must underpin necessary processes of technology absorption. Special measures shape the technology push policy of this stage.

On the innovation-driven stage, the policy principal purpose is to promote the formation of post-catching up NIS capable of generating radically new products and processes. Among the potential problems, support of public and private investment in HRST and development of flexible markets of highly qualified labour is of great importance. The government continues the technology-push policy to generate disembodied and dual-use technologies. At the same time, the government should increase emphasis on the market-pull policy involving incentive schemes focused on the end of innovation cycles. Besides, significant efforts must be directed at providing conditions and stimuli for reinforcement the cooperative relationship of government R&D sector and industry and establishment of non-linear network interactions including public-private partnerships.

It is worth noting that there is a danger that a country copes largely with phases of investment stage but then fails to transit to innovation-driven one. Therefore, there is a need to create preconditions for transition to innovation-driven stage. It means that the mixed policy must be implemented in some proportions. According to this policy, the institutions and institutional instruments corresponding to both the current investment-driven stage and the future stage driven by national innovations have to be constructed beforehand.

The proposed methodology provides an indispensable conceptual framework for the future debates over policies and strategies to enhance economic performance. The functional approach can be applied for estimation and measurement of efficiency and performance of NIS. Unlike well-known integral criteria for the NIS efficiency, the new methods give an opportunity to get the component-wise estimation of the NIS and identify the cause-effect chains of the factors impact on its elements. The combination of system structure-object and functional methods permit to analyze the factors of innovation activity in the business environment and the knowledge systems in European countries (including Russia), the US and South East Asia. The use of knowledge diffusion channels description and analysis of their functioning make possible to find out knowledge links malfunctions, identify the lacking elements and suggest the necessary measures to establish them.

To successfully use the proposed methodology, there is a need to substantially improve and significantly modify the existing system of indicators and expand the database for their measurement. The lack of the system of indicators and the database may be a significant limitation on the application of this approach.

The public policy measures addressed to eliminate market and NIS failures should be confined to passing a stage of economic development and/or a transition to next one. The aim of the work in this direction is to obtain a clear and sufficiently complete understanding of the necessary political institutional tools, which could assist to enhance the efficiency of the NIS and advance its absorption and innovative abilities.

Finally, it is worth noting that the proposed methodology is only the first step of the movement to the operable theory of national innovation systems. The future work will concentrate on deepening the proposed methodology and testing it during the studies of NIS of developed and developing countries.

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KEY TERMS AND DEFINITIONS

Key terms. Innovation, innovation activity, innovation-active firms, framework conditions of innovation activity, national innovation system, structure-object approach, functional approach, resource-based stage of development, investment-driven (catching up) stage of development, innovation-driven stage of development.

Key definitions. *Innovation.* Innovation is economic implementation of new idea. The innovation includes the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations. (OECD, 2005b).

Innovation activity. Innovation activities comprise scientific, technological, organisational, financial and commercial steps, which actually lead, or are intended to lead, to innovations (OECD, 2005b). The innovation activity can be presented as a sequence of the following processes: targets setting, action design, action implementation (innovation process), result analysis and comparison with the targets (Golichenko & Samoleva, 2013).

Innovation-active firms. The innovation-active firms are ones that have had innovation activities during the period under review, regardless of whether the activity resulted in the implementation of an innovation (OECD, 2005b).

Framework conditions of innovation activity. The framework conditions provide the necessary economic basis, which can facilitate an innovation activity. Among these conditions are competition and entrepreneur environment, openness of economy, market prices, investment and tax climate, government regulation and institutional arrangement of economy as a whole. The risks determined by the framework conditions are of considerable importance for innovation activity. For example, the incentives for investments (and hence for investments in innovations) are considerably influenced by macroeconomic policy including monetary one.

Structure-object approach. During the implementation of the structure-object approach, the object of the structural hierarchy is divided into an isomorphic set of interacting subsystems. On each next level, the system (or object) of the higher hierarchy is decomposed into a set of the simpler local sub-systems (sub-objects), which are isomorphic to this one. The approach gives an opportunity to clarify the structure of a “black box” of a higher-level system (or object) and increase its transparency. The number of disaggregation levels is constrained by desired deepness of transparency and measurement capabilities of components of the structural hierarchy.

Functional approach. In the framework of the functional approach, the aim of the analysis is to study functions of the object (or system). During the study, the functions are considered as a result of interactions between the object and its environment. According to this approach, the model of the object incorporated in its environment must be interpreted as an input-process-output one. The effectiveness of the functional approach is higher if it applies to components of the structural hierarchy while using structure-object decomposition.

The resource-based stage of development. On the resource-based stage, the domestic industries, which are successful in competition struggle in world market, actively use primary factors, which are the following ones: natural resources, favorable conditions of land tenure or cheap labour force. On the resource-based stage, economy is extremely sensitive to world economic crises, price trends, and exchange rate fluctuations (Porter, 1990).

The investment-driven (catching up) stage. On this stage, the dominant source of efficiency is standard products and services producing. The competition is based on consumer goods improvements, imitation and incremental improvement of technologies. Among the outstanding characteristics are the following ones: technology absorption and adaptation ability, intensive investments into the highly qualified labour, technologies, research and development. The inflows of technologies came abroad. The domestic business does not only assimilate foreign technologies but also develop the capacity to improve them (Porter, 1990).

Innovation-driven stage of development. On the stage, the crucial factors of competition are product and process innovations including creation and introduction of technologically new products and processes. The enterprises use horizontal and vertical capital spillovers in value chains. They enhance interlink, intra- and inter-chain diffusion of innovations and move ineffective kinds of industrial activity abroad. Among the most prominent qualities of the innovation-driven stage are a mix of strong competition and cooperation between enterprises, a sophisticated division of labor and increasing flows of workers between firms. The sophisticated division of labor takes place due to the emergence and extension of deep industrial clusters. Companies also invest heavily into upgrading and development of the work forces including human resources in science and technology (Porter, 1990).