
# Russian technological specialization
# Comparison with BRICs and EU

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**Abstract**

Russia, with its long scientific tradition and an extremely large R&D base, had been one of the major contributors to the world's knowledge during decades of years. But the collapse of the Soviet Union in 1991, and the transition to a market economy, radically affected the national R&D system that existed in USSR.

The main target of this paper is exploring technological specialization pattern of Russian manufacturing industry (26 sectors under observation) during the period of 1994-2008. For achievement this goal, firstly, using U.S. Patent and Trademark Office as the source of data for empirical investigation I try to find out if there were great changes in Russian manufacturing sectors' technological specialization connected with its re-orientation from military to civil needs. Secondly, dividing Russian manufacturing sectors in four groups ("Dynamic specialization", "Static specialization", "Lost opportunities" and "Retreat") I examine the nature of Russian technological specialization's changes and its relation with international technological changes. And thirdly, I provide comparison between technological specialization's models of Russian Federation, other countries of "BRIC", European Nordic Innovation leaders (Denmark, Finland and Sweden) and European Southern Moderate Innovators (Italy and Spain).

**Resumen**

Russia, con su larga tradición científica y extremadamente intensa base de I+D, ha sido uno de los mayores contribuyentes al mundo del conocimiento durante décadas. Pero el colapso de la Unión Soviética en 1991, y la transición hacia una economía de mercado, afectó radicalmente al sistema nacional de innovación que existía en la URSS.

El principal objetivo de este paper es explorara el patrón de especialización tecnológica de la industria manufacturera rusa (26 sectores bajo observación) durante el periodo 1994-2008. Para alcanzar este objetivo, primero usaremos los datos procedentes de la oficina de patentes de Estados Unidos como fuente de datos para el análisis empírico para detectar si hubo grandes cambios en los sectores de manufacturas rusos y su especialización tecnológica y su reorientación desde las necesidades militares a las civiles. En segundo lugar, dividimos los sectores manufactureros en cuatro grupos (de especialización dinámica, de especialización estática, de oportunidades perdidas y en retroceso). Examinamos la naturaleza de los cambios de la especialización tecnológica rusa y su relación con los cambios tecnológicos internacionales. En tercer lugar, realizamos una comparación entre los modelos de especialización tecnológica de la Federación Rusa con otros grupos de países como BRIC, líderes europeos como los países nórdicos (dinamarca, Finlandia y Suecia) y otros más moderados como Italia o España.

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# 1. Introduction

Since in the 1970's the technology started to be considered as a strategic factor of competitiveness, both in macro and micro economic levels (Hidalgo et al., 2002), technological change —as one of the principal drivers of competition (Porter, 1985), the patterns of technological evolution —as a shaping parts of the patterns of modern economies' growth (Dosi and Nelson, 2009), the processes of technological change and competitiveness have become an increasingly important area of study (Roberts, 1998) and the greater attention on the nature of technological progress and recognizing its fundamental role in determining a country's success has focused in the debate on economic growth and development.

Today technological competitiveness plays a major role in shaping international competitiveness and the types of activity that countries are undertaking, in particular in the technological domain, are important for their international and domestic performance.

Technological know-how and advantage in the various productive sectors is an essential indicator in determining the points of strength and weakness of the overall economic system.

Innovative activities contribute importantly to productivity growth at industrial level. International technological specialization is an important factor driving Total Factor Productivity (TFP) and both innovative activities and specialization affect TFP at the sectoral level, in particular, in large countries and also in traditional sectors.

Previous empirical investigations showed that specialization (or "Revealed Technological Advantage") in fast-growing technological fields is positively associated with the rate of growth of export, value added and employment; and the quality of technological specialization is found to positively affect countries' rates of growth (Meliciani, 2002).

The aim of this paper is to provide the empirical investigation regarding the changes that have happened in technological specialization of Russian Federation since the collapse of the USSR and to answer the following questions: How has Russian technological specialization changed between 1994 and 2008? Had country's industrial development been following to the direction of world innovative and technological tendencies during that period of time or no? Were any similarities in technological specialization's patterns between Russian Federation, the other BRIC's and some European countries (European Innovation leaders and Moderate Innovators)?

To sum this up, the objectives of this work are following:

1. Evaluation of Revealed Technology Advantages (RTAs) of 26 Russian manufacturing sectors and their changes during three periods of time: 1994-1998 (early post-soviet era), 1998-2003 (period after the financial Russian crisis of August of 1998) and 2004-2008 (five-year period before global financial crisis in 2008) using the data obtained from U.S. Patent and Trademark Office.

2. Identification how well Russia was adapted to international innovative and technological dynamics during the period under observation.

3. Comparison the changes that had happened with manufacturing industry's technological specialization in Russia and in the other BRIC's economies (Brazil, India and China) and five European innovation-driven economies for identification if there was any convergence in technological specialization between Russia and any of other 8 countries during the whole period of time under observation.

Why have I chosen BRIC economies and European Innovation leaders and Moderate Innovators for comparison with Russian Federation? The choice of BRIC's economies is explained, on one hand, by the fact that together with Brazil, India and China, Russian Federation currently account for more than a quarter of the world's land area and more than 40% of the world's population, and since the four BRIC countries are developing rapidly, by 2050 their combined economies could eclipse the combined economies of the current richest countries of the world; on the other hand, by the fact

that "BRIC" countries, in terms of their GDP per capita, belong to three different levels of development: Russia and Brazil are classified as a high income developing economies (GDP per capita equal to 19 833 and 11 239 USD current PPPs respectively), China is classified as a lower middle income economy (GDP per capita = 7 519 USD current PPPs), and India as a low income economy (GDP per capita = 3 339 USD current PPPs ) (OECD, 2010).

The choice of Finland, Denmark, Sweden, Italy and Spain for comparison with Russia is explained by my intention to define what had been composed the technological specialization patterns of countries that according WEF GCR 2011-2012 belong to countries with innovation-driven economies (three of which are European Innovation leaders and the other two – Moderate Innovators) and to find out if technological specialization's development of Russia had been following to one of these patterns.

The work is organized according to the following outline. The second section describes the economic situation in Russia after dissolution of USSR, its influence on R&D activities, and provides some Innovation Indexes for Russia and the other countries for understanding which position Russian Federation obtain today according to development of its National Innovation System.

The third section provides an outline of methodology on which is based empirical investigation.

Section 4, which presents the results obtained from empirical investigation are presented, consists of three parts. The first part of this section contains a detailed profile of the Russian technological specialization during 1994-2008. The second part determines the level of adaptation of Russian manufacturing industry to world's technological and innovative changes. The last part is the results of comparison of Russia with the other country.

Section 5 describes advantages and disadvantages of using patent data as a technological indicator.

Finally, Section 6 summarizes the main results of my research and offers some guidelines for future follow-up research.

## 2. Russian S&T two decades after collapse of USSR

World Economic Forum Global Competitiveness Report 2011–2012 (WEF GCR 2011-2012) distinguishes three stages of countries' economic development. Table below demonstrates to which categories each country under my investigation belongs to.

**Table 1. Stages of countries' economic development**

| Stage 1: Factor-driven | Transition from stage 1 to stage 2 | Stage 2: Efficiency-driven | Transition from stage 2 to stage 3 | Stage 3: Innovation-driven |
|---|---|---|---|---|
| India | | China | Russia<br>Brazil | Denmark<br>Finland<br>Sweden |

Source: GCR WEF 2011-2012

Russian economy in 2011 possessed 66th place out of 139 countries and was at transition from stage 2 (efficiency-driven economy) to stage 3 (innovation-driven economy).

But even being posed on a quiet low place, Russian economy has three strengths for its development. They are: natural resources, large domestic market size and high percentage of population with completed tertiary education.

Specific current weakness and the most critical bottlenecks in the Russian innovation system are:

- Most Russian businesses have no clear innovation strategy and are not used to investing in their own R&D capacity;

- The state R&D institutes stagnated during the transitional period and now experience a lot of problems with obsolete scientific equipment, older staff and loss of cooperation with world class research centres;

- The R&D system is still pretty much isolated

from market and society demands and needs to improve its performance and level of integration with business and civil society;
- The innovation gap with leading countries is widening.

Taken together, these weaknesses reduce the country's ability to take advantage of some of its strengths—particularly its high innovation potential (38th for capacity for innovation), its large and growing market size (8th), and its solid performance in higher education and training (27th for the quantity of education). According to indicators measuring of Production process sophistication, Availability of latest technologies and Firm-level technology absorption Russian positions are incredibly low: Russia performs much worse not than European economies only but also than the other countries of "BRIC" (Table 2).

It is important to say that economic structure of Russian Federation is different from that of most European countries –there is a predominance of large companies, concentration on mining and heavy industry, and a lack of high-tech and consumer goods' industries. However, recent Russian economic history is characterized by progress that has been accompanied by numerous setbacks.

Historically, Russia, as part of the former Soviet Union, had always owned a well-developed system of public R&D institutes. In the late 1980s, the Soviet Union was among the foremost leaders of world science, mostly thanks to its strong involvement in military programs and substantial number of researchers and R&D institutions.

Post-Soviet Russia inherited a system of innovation from Soviet Union that was marked by immense technical achievements (including Sputnik, nuclear weapons and aviation technologies) but, at the same time, many economic problems (Dynkin and Ivanova, 1998). During the period of transformation after the dissolution of USSR, the country experienced significant reductions in its R&D systems in terms of both expenditure and personnel. In early after-Soviet period there was deep decline of inversion in R&D, the amount of which became more than half-less (in % of GDP) than in latest Soviet period (Rosstat, Russia and World 2002).

During the socialist period science and technology (S&T) in the USSR was characterized by a significant state support and substantial variations between industries in the organization of R&D. The biggest difference was between priority (defense, aerospace) and civil sectors

**Table 2. Innovation Indexes presented by World Economic Forum in its Global Competitiveness Report of 2011**

| Country | Capacity for innovation | | Production process sophistication | | Availability of latest technologies | | Firm-level technology absorption | | Domestic market size | | Foreign market size | | Tertiary education enrollment, gross % | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Score | Place | Score | Place | Score | Place | Score | Place | Score | Place | Score | Place | Score | Place |
| Russia | 3.5 | 38 | 3.1 | 107 | 4.1 | 121 | 3.8 | 130 | 5.6 | 4 | 6.1 | 8 | 77.2 | 13 |
| Brazil | 3.8 | 31 | 4.8 | 29 | 504 | 53 | 5.2 | 48 | 5.7 | 8 | 5.5 | 24 | 51.0 | 47 |
| India | 3.6 | 35 | 4.2 | 44 | 5.5 | 47 | 5.3 | 41 | 6.1 | 3 | 6.2 | 4 | 13.5 | 100 |
| China | 4.2 | 23 | 4.0 | 52 | 4.5 | 100 | 4.9 | 61 | 6.7 | 2 | 4.0 | 1 | 24.5 | 85 |
| Denmark | 5.1 | 9 | 5.8 | 9 | 6.5 | 9 | 6.0 | 9 | 4.0 | 59 | 4.9 | 43 | 67.2 | 22 |
| Sweden | 5.7 | 4 | 6.3 | 4 | 6.9 | 1 | 6.5 | 1 | 4.4 | 33 | 5.2 | 33 | 70.6 | 18 |
| Finland | 5.6 | 5 | 6.2 | 5 | 6.6 | 5 | 6.0 | 11 | 4.0 | 52 | 4.7 | 54 | 94.4 | 2 |
| Italy | 4.0 | 26 | 4.8 | 28 | 5.0 | 71 | 4.3 | 102 | 5.5 | 10 | 5.9 | 15 | 78.1 | 10 |
| Spain | 3.5 | 36 | 4.5 | 35 | 5.9 | 33 | 5.2 | 46 | 5.4 | 5.7 | 5.7 | 20 | 71.1 | 17 |

Source: WEF GCR, 2011

(Radosevic, 1999). That's why the main idea of the transformation of scientific systems in Russia of early post-Soviet era was in the re-orientation of scientific activities from military to civilian goals (Yegorov, 2009).

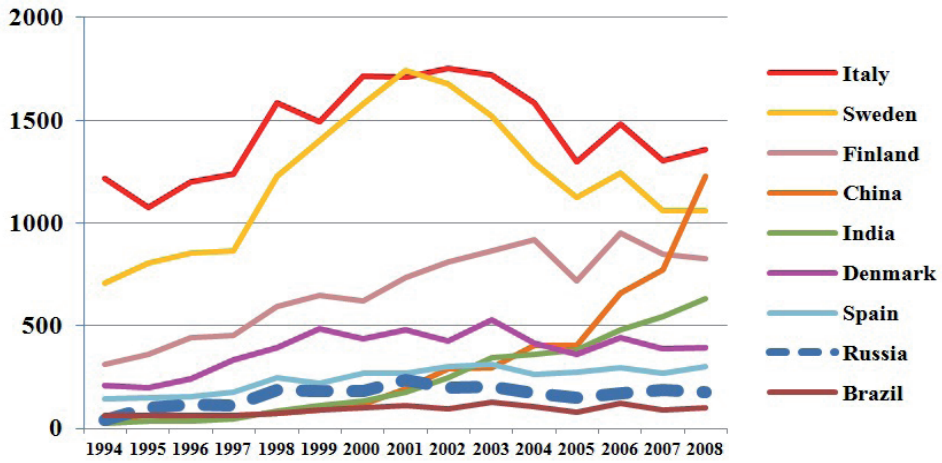
The collapse of the Soviet Union heralded the demise of most state-owned Soviet companies. As in all transition economies, the period of the 1990s was the time of massive privatization in Russia: a class of owners, known as "oligarchs", was swiftly formed in the mid-1990s in the process of distribution of state property among a handful of businessmen (Filippov, 2008). At this time Russia suffered from the deepest economic depression (with 2.600% inflation rate in 1992) what affected industrial sector a lot. The level of GDP on R&D in the government and business enterprise sectors in the 1990s has dramatically decreased in comparison with Soviet times. Since 1991 to 1994 the volume of industrial production had reduced twice. The "worst results" of that time was demonstrating by light industry which in 1994 produced only 1/3 part of its production of 1991 (Palazuelos, 1996). The most favorable situation for innovation in Russia of that time was registered in industries enjoying a high level of demand for their products in domestic as well as world markets: energy, metallurgy and chemistry (Dynkin and Ivanova, 1998).

The next shock for Russian economy that followed after the dissolution of the USSR was the result of a deep transition crisis of 1998, when Russian economic activity was in deep depressed again. In 1998 GDP reached only 56% of the level of 1989 (Rosstat, 2002). Industrial output was also deeply depressed and the production structure had to be changed. Before this financial crisis heavy industries performed better than light industry, but due to strong devaluation in 1998, these industries grew more competitive and regained an increasing share of the domestic market.

Although since the beginning of the 21st century, Russia have been demonstrating steady economic growth and improvement in the macroeconomic indices (Rosstat, Russia and World 2010), its R&D and innovation expenditures have increased so slowly that there has been no real growth in the national R&D/GDP ratio (INNO-Policy TrendChart, 2007), and patent activity stays still very low compared not only with European innovation-driven economies, but even with BRIC countries (Figure 1).

The comparatively low innovative activity of Russian industries is explained by negative external factors: poor incentives and low availability of resources in the industry. Surveys of large and mid-sized Russian companies demonstrate that there are rather serious problems with both incentives and resources for innovation (financial and human resources, research institutions, the quantity of suppliers, and the quality of higher education). There are big differences in the incentive levels between sectors. Incentives are relatively powerful in

**Figure 1. Number of utility patents granted by USPTO to Nordic Innovation leaders, Moderate Innovators and countries of BRIC since 1994 till 2008**




Source: USPTO, Patenting trends in the United States in 1963-2008

pharmaceuticals and the production of medical equipment. Less pronounced incentives are in the aerospace, defense, and oil and gas industries. However, the availability of resources for innovation in these industries is a little lower than the average level, according to the survey results (WEF CGR, 2011).

According to executives, the only sectors in Russia that possess both sufficient incentives and resources for innovation are the food processing industry and the information and communication technologies sector. At the same time, in the majority of sectors —including electronics, textiles and apparel, automotive, and utilities— neither incentives nor resources for innovation are sufficient.

In a survey of Russian innovative small- and medium-sized enterprises (SMEs), respondents were asked to name up to three barriers limiting innovation in their companies. The survey showed that the main barrier is a lack of available financial resources for investing in innovations (60%), poor availability of financing from outside sources (50%), and a high cost of innovative projects in Russia (40%) (WEF CGR, 2011).

In fact in Russia, since the transition from planned economy to a market economy, the state system of scientific and technical policy has not been formed and doesn't almost exist. For creating and proper orientation of it Russia must have a clear understanding, on the one hand, of the laws of modern economic growth, and, on the other hand, of the comparative national advantages, the use of which should form the basis for public policy development.

Next empirical investigation allows me to identify which technological advantages Russia has lost and obtained since the USSR dissolution and compare the technological changes that have happened in Russian manufacturing sectors with international technological and innovation changes.

## 3. Methodology

Industrial specialization can be measured in different ways: in employment terms, in value added terms, in terms of trade balance.

Aim of this paper is to examine industrial specialization in terms of international technological and innovation changes, in other words, to estimate Technological Specialization of industry or its Revealed Technological Advantages.

Many investigations for measuring of RTA have been done at the micro (firm) level where RTA of a firm in a given technological field is considered as the share of the firm's patenting in the field divided by the share of its total patenting in all fields (Granstrand et al. 1997; Chen, 2011).

The central part of current investigation is measuring of technological specialization at meso- and macro-levels. In this case Revealed Technological Advantage of a country in a given manufacturing sector is defined as the share of the sector in a country's total patent output in relation with the share of the same sector over world total patent output.

Empirical investigation is based on data obtained from U.S. Patent and Trademark Office (calendar year utility patents' statistics for 26 manufacturing sectors according North American Industry Classification System) and the whole period of time under investigation is divided into three 5-year periods: 1994-1998, 1999-2003 and 2004-2008.

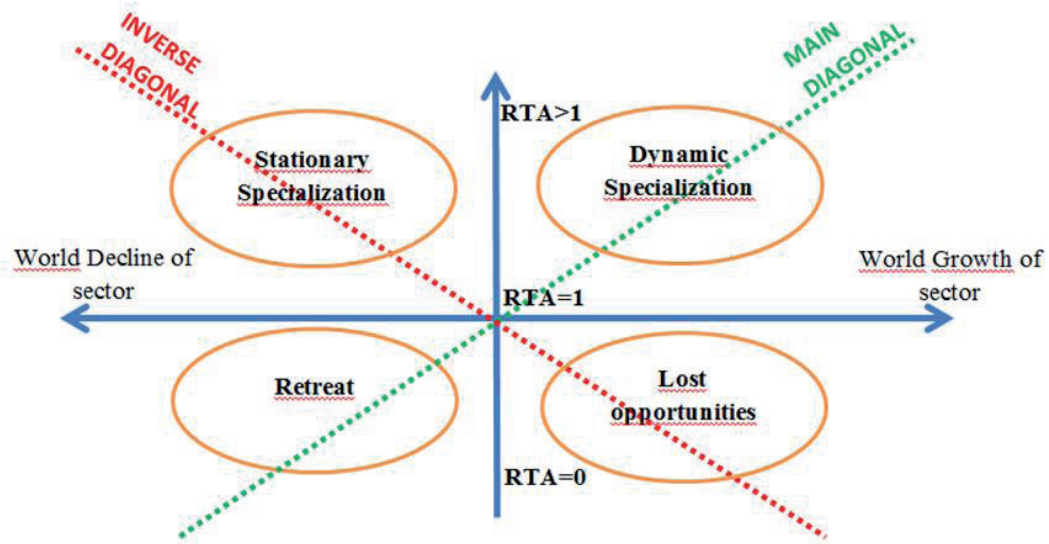
After obtaining the data, the first step of my investigation is calculation of RTA indexes for 26 Russian manufacturing industries for each of three periods of time.

RTA for a sector of a country is calculated in following way:

$$\mathbf{RTA_{ij} = (P_{ij} / P_{wj})/ (PT_i / PT_w),}$$

Where:
i is the country, j - the sector, w - the world total,
Pij - the number of patents granted to country i for sector j,
P**(wj)** - the number of patents granted to the world for sector j,
PTi - the total number of patents granted to the country i,
PTw - the absolute number of patents granted to world in total.

**Figure 2. Technological Sectoral Specialization classification**




Having Russian technological specialization indexes calculated during three periods of time, first of all, I will be able, using the Similarity Matrix, to estimate the magnitude of technological specialization's changes through which Russian manufacturing industry has passed since the collapse of the USSR. Taking into account the shortness of period of time under observation (15 years) and a lack of correct innovation policy in Russia during all post-Soviet time, I am not expecting to find out great changes in Russian technological specialization during the period under the observation.

The next step of my investigation is estimating technological dynamism of manufacturing sectors under observation which is provided through the difference between the percentages that each sector has in total patents in the posterior period compared with the same percentage in the previous one:

$$T_{din} = (P_{wj2} / PT_{w2}) - (P_{wj1} / PT_{w1}),$$

Where:

Pwj2 and Pwj1 - the number of patents granted to the world for sector j in posterior and previous period respectively,
PTw2 and PTw1 - the absolute number of patents granted to world in total in posterior and previous period respectively.

Having data about RTA indexes and technological dynamism of sectors calculated, I will be able to classify each Russian manufacturing sector in one of four categories according to the taxonomy suggested by Molero and García in 2008 (Figure 2) which allows me to estimate overall sectoral specialization of a country as a whole in terms of innovative and technological performance and to see how well Russia was adapted to international innovative and technological dynamics during the period under observation.

According to this figure there are following four categories of sectors' specialization:

1. "Dynamic specialization", with technological advantages in dynamic sectors (sectors with RTA > 1 and increasing participation in world technological dynamism).

2. "Lost opportunity", with technological disadvantages in dynamic sectors (sectors with RTA < 1 and an increase of its percentage in world patents); it is the worst possibility because the economy has not been able to adapt to the international dynamism.

3. "Stationary specialization", with technological advantages in sectors in retreat (RTA > 1 and a decreasing participation in world technological dynamism).

4. “Retreat”, with technological disadvantages in sectors in retreat (sectors with RTA<1 and a decreasing participation in total patenting in the world).

Identification of sectors that belong to first 2 groups (“Dynamic Specialization” and “Lost Opportunity”) will help me to determine which manufacturing sectors of Russia fit perfectly with the international technological dynamics and in which world’s fast-growing technological fields the country must obtain RTA for following world’s technological progress and growth of export, value added and employment.

The last step of my investigation is comparison Russian technological specialization with technological specialization of the other countries by estimation RTAs of the same manufacturing sectors in Brazil, India, China, Italy, Spain, Finland, Denmark and Sweden with subsequent correlation between their and Russian RTA’s indexes using the Matrix of Dissimilarities with measuring Euclidian distance.

## 4. Results of empirical investigation

The empirical investigation’s results that regarded to achievement of the first objective are represented in Figure 3 and Table 3 that contain the results of calculation of Russian manufacturing industries’ RTA indexes during three five-year periods of time since 1994 till 2008 and correlation between their vectors of values respectively.

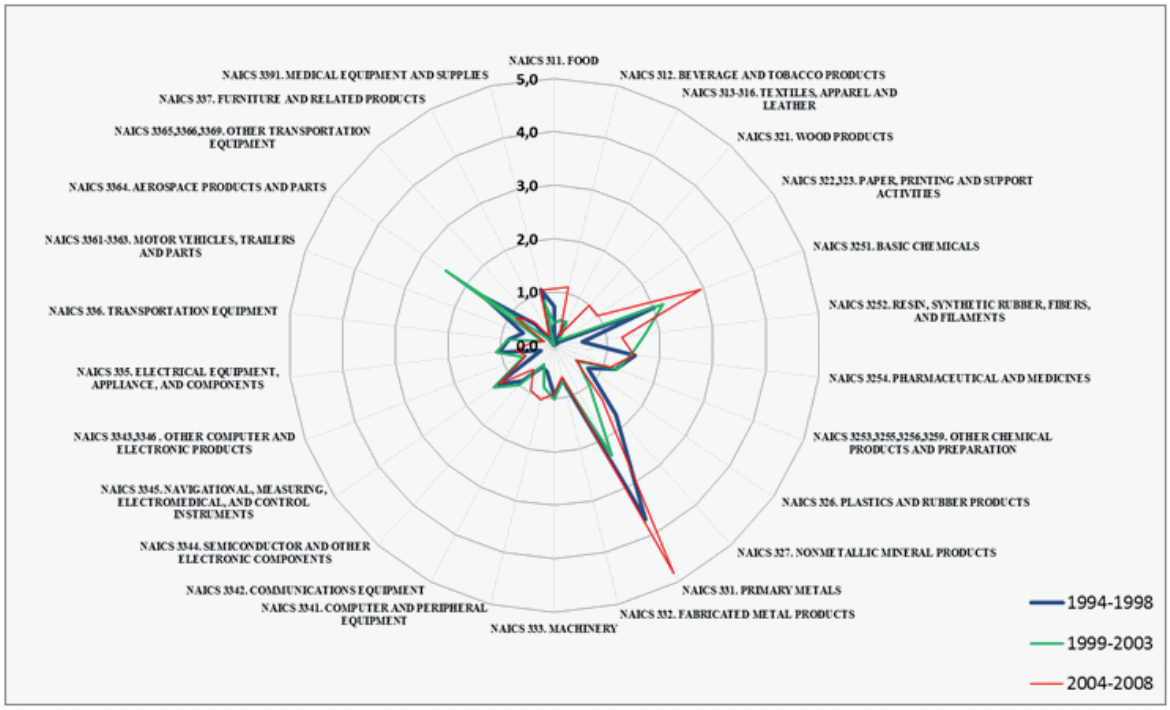
Both Figure 3 and Table 3 display that overall Russian patenting strategy was quiet stable and almost without any significant transformations during 1994-2008.

**Table 3. Similarity Matrix**

| | Correlation between vectors of values | | |
|---|---|---|---|
| | 1994-1998 | 1999-2003 | 2004-2008 |
| 1994-1998 | 1,000 | | |
| 1999-2003 | ,799 | 1,000 | |
| 2004-2008 | ,823 | ,664 | 1,000 |

The results of correlation between vectors of Russian technological specialization indexes’ values presented in Table 3 tell us that the changes that, of course, had happened with country’s RTAs during 15-year period of time were not so expressive what is explained by “sticky” nature of technological specialization

**Figure 3. Revealed Technology Advantages of Russian manufacturing sectors**



pattern and difficulty to remodel it in such quiet a short period of time, especially in terms of lack of adequate S&T policy.

Only by looking at the form of three graphics presented on Figure 2 we can say that the period of time under our observation was characterized for Russian industry by maintenance most existing technological advantages without obtaining great amount of the new ones.

The results of empirical investigation are shown that during the second part of the 90's (the first period under observation) the areas of strong technological opportunity in Russia have been concentrated within the Primary Metals' Production, followed by technologies linked to Chemicals, Nonmetallic mineral products, Pharmaceuticals and Medical equipment, Electrical Equipment, Aerospace and Navigation.

And the next 10-year period of time (from 1999 till 2008) didn't bring great changes to Russian manufacturing industry's specialization and technological re-orientation of Russian industry didn't appear noticeably. The country continued to build up its technological capacity in sectors of Primary Metals and Chemicals' production and maintain its technological specialization in Pharmaceutical and Medical Equipment, Nonmetallic Mineral Products and Navigation.

Entirely, it is impossible to call the country technological specialization's pattern unfavorable because most of technological advantages that Russian manufacturing industry possessed during 15-year period of time were focused in high-tech sectors mostly.

Primary Metals and Non-Metallic Products' Production are the only medium low-tech sectors where Russia has continued possessing strong technological advantages since the collapse of USSR. The strong position in these areas are fomented by one of the advantages of Russian economy – access to huge amount of natural resources – which the country (being one of the main world's exporters of natural resources) uses as an important contributor to the Russian economy.

Russia remains one of the world's largest metal producers, accounting for 20% of nickel and cobalt production, 5-7 % iron ore production, and also a large share of the output of some non-ferrous and rare earth metals and platinum group metals. Primary Metals' Production industry employs thousands directly and, in turn, supplies iron and steel products to many other key manufacturing industries.

Chemical industry is also one of the most developed industries of the countries which accounts for 10.4% of the total output of Russian processing industry and about 5.4% of export profits. There are about 800 large and middle-size industrial enterprises and more than 100 scientific and research bureaus.

What about the changes that had happened with Russian technological specialization? In total, there were not so many of them. The most significant ones:

- Losing RTA in Aerospace sector (inherited from the Soviet Union) during 2004-2008. Thus, lately in the world space market Russia can seriously compete only in putting paid load into orbit, especially using heavy carriers. But that accounts for less than 1/10 of the international market, whereas communications satellites account for 3/4. In aircraft, Russian manufacturers have the best prospects in exporting fighters and certain types of freight aircraft, while the most promising area there are passenger airplanes and helicopters (Gokhberg, 2003). But by 2005 Russia's entire civil aviation industry was building on average a total of 10 aircraft per year. In comparison, in 2005 Boeing and Airbus booked over 1,000 orders each for new aircraft (Department of commerce of USA, 2006).
- Losing technological advantage in Machinery sector (provider of equipment and machinery to all other industries). The problem of this sector is the same that exists in Aircraft construction's sector: orientation towards military sector needs while civil sector's needs do not seem to play an important role in formation of specialization inside of this sector.
- Obtaining technological specialization in sector of Computer and Peripheral Equi-

**Figure 4. Classification of Russian manufacturing sectors in 1994-1999**

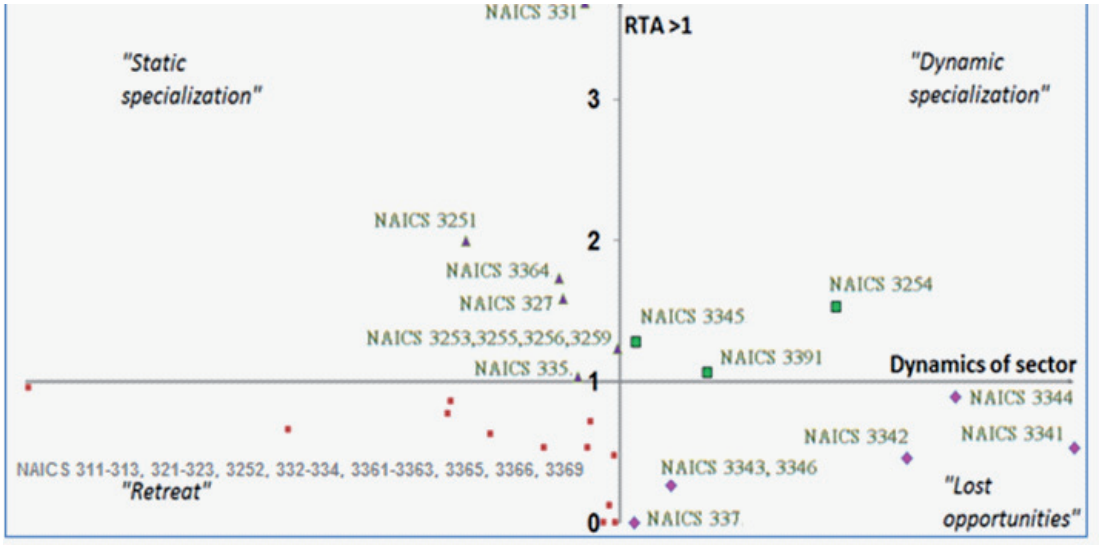



**Figure 5. Classification of Russian manufacturing sectors in 1999-2003**

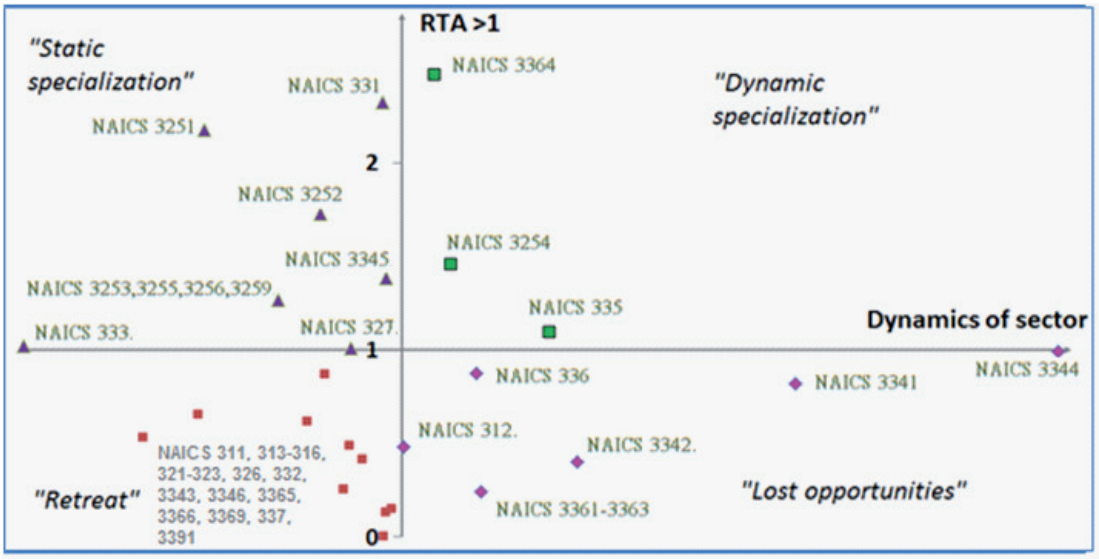
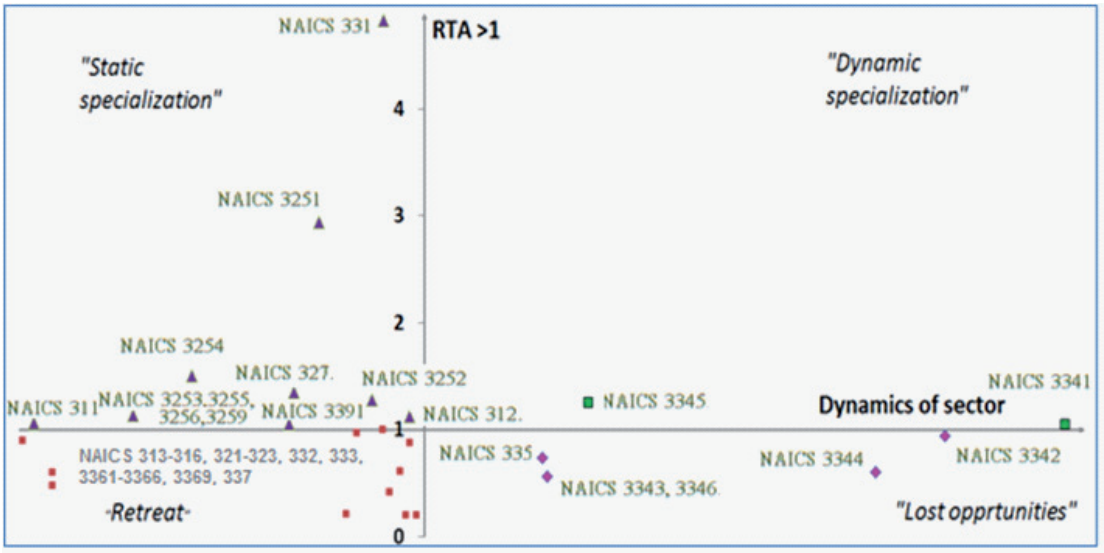



**Figure 6. Classification of Russian manufacturing sectors in 2004-2008**



| | |
|---|---|
| NAICS 311 | FOOD |
| NAICS 312. | BEVERAGE AND TOBACCO PRODUCTS |
| NAICS 313-316 | TEXTILES, APPAREL AND LEATHER |
| NAICS 321 | WOOD PRODUCTS |
| NAICS 322,323. | PAPER, PRINTING AND SUPPORT ACTIVITIES |
| NAICS 325 | CHEMICALS |
| NAICS 3251 | BASIC CHEMICALS |
| NAICS 3252. | RESIN, SYNTHETIC RUBBER, FIBERS, AND FILAMENTS |
| NAICS 3254 | PHARMACEUTICAL AND MEDICINES |
| NAICS 3253,3255,3256,3259 | OTHER CHEMICAL PRODUCTS AND PREPARATION |
| NAICS 326. | PLASTICS AND RUBBER PRODUCTS |
| NAICS 327 | NONMETALLIC MINERAL PRODUCTS |
| NAICS 331 | PRIMARY METALS |
| NAICS 332 | FABRICATED METAL PRODUCTS |
| NAICS 333 | MACHINERY |
| NAICS 334 | COMPUTER AND ELECTRONIC PRODUCTS |
| NAICS 3341 | COMPUTER AND PERIPHERAL EQUIPMENT |
| NAICS 3342 | COMMUNICATIONS EQUIPMENT |
| NAICS 3344 | SEMICONDUCTOR AND OTHER ELECTRONIC COMPONENTS |
| NAICS 3345 | NAVIGATIONAL, MEASURING, ELECTROMEDICAL, AND CONTROL INSTRUMENTS |
| NAICS 3343,3346 | OTHER COMPUTER AND ELECTRONIC PRODUCTS |
| NAICS 335. | ELECTRICAL EQUIPMENT, APPLIANCE, AND COMPONENTS |
| NAICS 336. | TRANSPORTATION EQUIPMENT |
| NAICS 3361-3363 | MOTOR VEHICLES, TRAILERS AND PARTS |
| NAICS 3364 | AEROSPACE PRODUCTS AND PARTS |
| NAICS 3365,3366,3369 | OTHER TRANSPORTATION EQUIPMENT |
| NAICS 337 | FURNITURE AND RELATED PRODUCTS |
| NAICS 3391 | MEDICAL EQUIPMENT AND SUPPLIES |
| NAICS 3391 | MEDICAL EQUIPMENT AND SUPPLIES |

pment during 2004-2008 by what the steady increase of country's ICT market's value and its growth rates during this period of time can be explained (Table 4).

**Table 4. ICT market in Russia in 2004-2008**

| | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|
| ICT market value (€ bn) | 19.8 | 25.0 | 31.6 | 39.1 | 42.3 |
| ICT market growth rate (%) | - | 26.3 | 26.4 | 23.7 | 8.2 |

Source: Rosstat, PMR Publications, 2012

There were also some changes in light industry (food and beverage) where Russia had acquired RTA during 2004-2008 and in sectors of wood and paper production where the country increased its technological capacity at the end of the period under observation. But entirely low-tech industry had not been the core of Russian manufacturing industry during the period under observation.

Next step of my investigation is conclusion if Russian technological specialization' pattern's changes had been formed by influence of international technological and innovative changes or the country had been following its own technological specialization pattern since USSR's collapse without taking into putting attention to world's changes.

Answer on this question can be obtained from the next three graphics that are the result of combination of two criteria: the position of the manufacturing sector in the Russian economy

according to its RTA and the international technological dynamism of the sector in terms of its percentage in world total patents.

The most significant changes that have happened in the world recently are connected with sector of ICT. According to international statistics the number of ICT-related patents grew steadily since the mid-1990s, at an average rate of 4.7% a year from 2000. The share of ICT-related patents in total patents taken by countries rose by five percentage points in 2003-05 as compared with the 1995-97 level. In 2005, more than 50 500 international patent applications were filed under the PCT to protect inventions in ICT. The number of ICT-related patents increased more rapidly than the total number of PCT applications: on average, there is a larger proportion of ICT related patents in countries' patent portfolios (OECD, 2008).

And the figures 4, 5, 6 prove this statistics demonstrating that during the 15-year period under the observation the steadily increasing international technological dynamism is discovered in sectors of Computer and Electronic products, especially in three following sectors: Sector of Computer and Peripheral Equipment, Sector of Communication Equipment and Sector of Semiconductor and other Electronic components, which were the most innovative ones and were increasing its innovative activity during 1994-2008.

At the begging of the period under observation some of the other high-tech sectors were able to compete with the sector of ICT. In 1994-1998 three the most dynamic sectors were followed by manufacturing sectors linked with Pharmaceutical and Medicines, Medical Equipment, in 1999-2003 – by sectors linked with Transportation Equipment, Aerospace and Pharmaceuticals. At the end of the period under observation during 2004-2008 the whole leadership in international technological specialization was obtained by Sector of Computer and Electronic products.

So, sector of ITC with the highest rate of growth is considered as one of the most promising areas for penetrating new technology markets today. All technological forecasters assign it top priority status, but Russian developments in this area are on the whole far behind the world state-of-the-art level. Thus Russia's prospects of entering international markets are limited to quite a small range of opportunities, further restricted by multiple trade barriers. The only sector of ITC where Russia always had been maintaining "Dynamic Specialization" during the whole period under observation is sector of Navigational, Measuring and Control instruments what can be explained by keeping military-oriented manufacturing industry's specialization inherited by Russia from USSR; the rest of sectors linked with production of ITC had always been sectors of "Lost opportunity" in Russia (the only exception – sector of Computer and Peripheral equipment, where Russia obtained RTA in 2004-2008).

Underdevelopment (compared with world's Innovation leaders) of high-tech sectors is one of the greatest problem of Russian economy today. High technology production in Russia is primarily focused on Chemicals, Pharmaceuticals and Navigational, Measuring, Electromedical and

**Figure 7. Technological specialization of BRIC's countries**

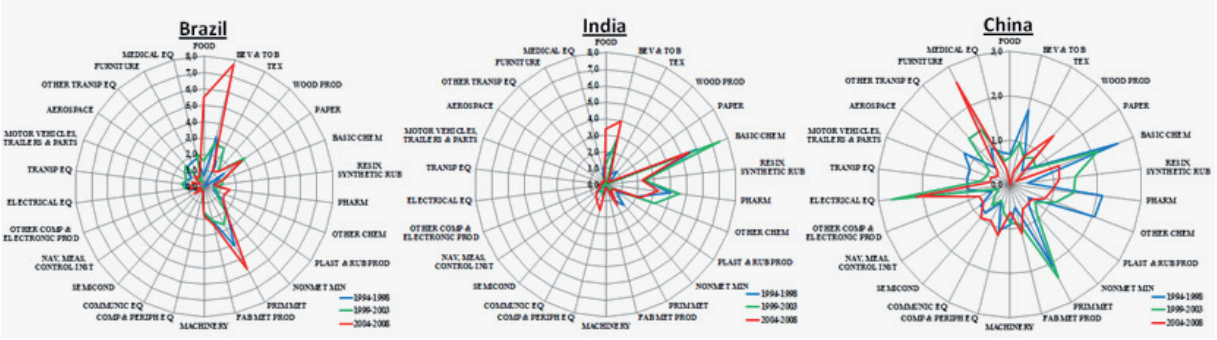


**Figure 8. Technological specialization of Nordic European "Innovation Leaders"**

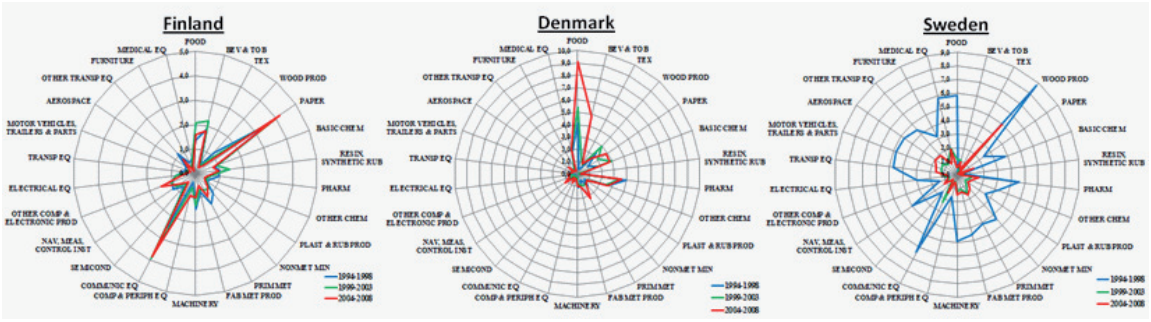
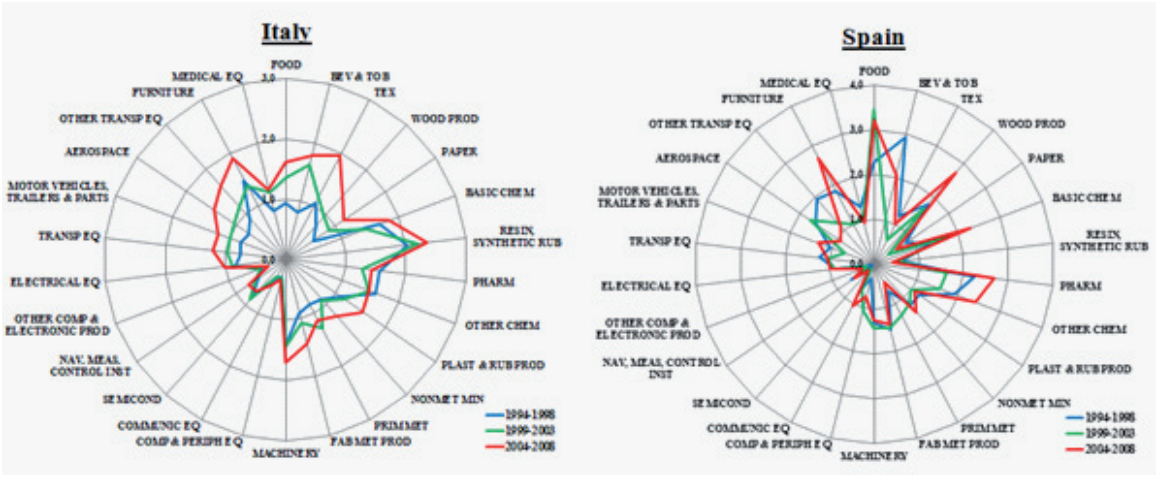



**Figure 9. Technological specialization of Southern European "Moderate Innovators"**




Control instruments, while the Computer industry (despite of obtaining RTA in Sector of Computer and Peripheral Equipment in 2004-2008) is very small (as it was mentioned before) and the Aerospace industry (which was always highly developed during Soviet era) is steadily decreasing.

Not sufficient development (compared with world's Innovation leaders) of high-tech sectors is one of the greatest problem of Russian economy today. High technology production in Russia is primarily focused on Chemicals, Pharmaceuticals and Navigational, Measuring, Electromedical and Control instruments, while the Computer industry (despite of obtaining RTA in Sector of Computer and Peripheral Equipment in 2004-2008) is very small (as it was mentioned before) and the Aerospace industry (which was always highly developed during Soviet era) is steadily decreasing.

What about international dynamics of manufacturing sectors in which Russian Federation had had the highest RTA indexes? As it can be noted from these 3 graphics Primary Metals and Basic Chemicals' sectors, in which Russia had maintained its technological specialization since the collapse of the USSR, didn't belong to the world's dynamics sectors.

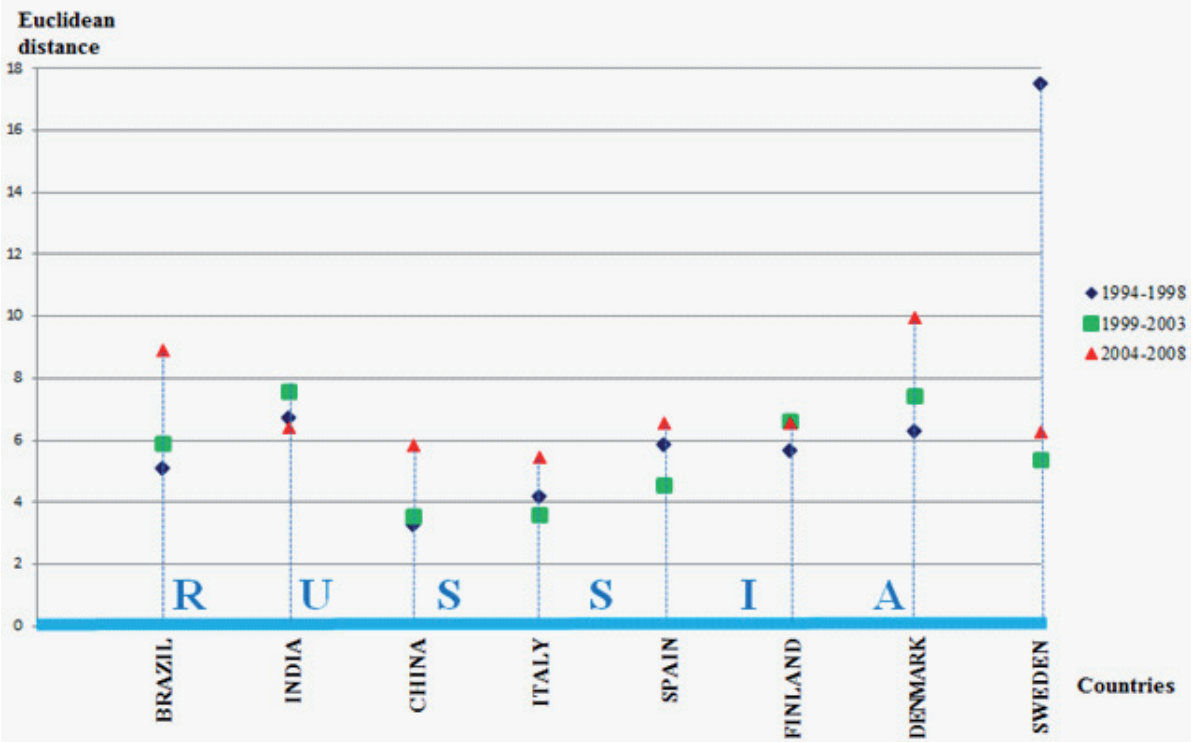
The results of RTA's estimation of BRIC countries and European innovation-driven economies are represented in Figures 7, 8, 9 and Table 3.

Analyzing these graphics below I can prove that

**Table 4. The distance between RTA indexes of Russia and the other countries under observation.**

| Country | Period of time | | |
|---|---|---|---|
| | 1994-1998 | 1999-2003 | 2004-2008 |
| BRAZIL | 5,062 | 5,887 | 8,906 |
| INDIA | 6,711 | 7,584 | 6,395 |
| CHINA | 3,262 | 3,513 | 5,844 |
| ITALY | 4,158 | 3,6 | 5,444 |
| SPAIN | 5,822 | 4,554 | 6,537 |
| FINLAND | 5,637 | 6,605 | 6,533 |
| DENMARK | 6,282 | 7,437 | 9,955 |
| SWEDEN | 17,463 | 5,34 | 6,258 |

**Figure 10. Changes of the distance between RTA indexes of Russia and the other countries in 1994-2008.**



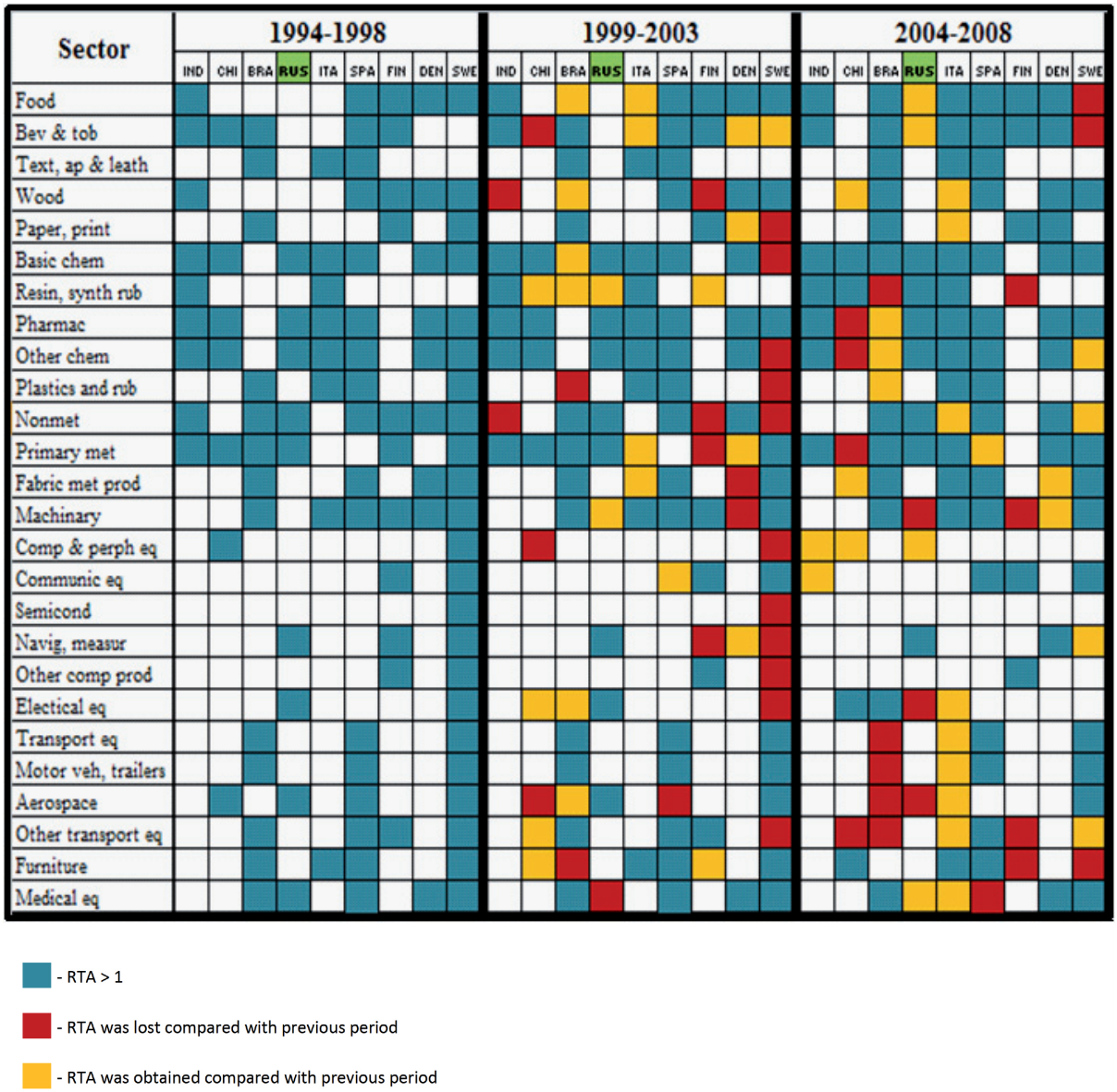

the stability of technological specialization's model was characteristic not of Russian manufacturing industry only but also the other countries of"BRIC" and European innovation-driven economies: the countries' technological specialization profiles presented in Figures below had not been changed significantly during 15-year old period.

For estimating magnitude of differences between technological specialization's models of Russian Federation and the other countries I have measured Euclidean distance between their RTA's indexes. The results of this calculation are presented in Table 4 and Figure 10.

During 1994-2008 mostly I observe the process of divergence between Russian Federation and the other countries and increase of the distance between their RTAs' indexes what is explained by the fact that vectors of changes of RTAs' values in Russia and other countries' had different direction. From what we can conclude that each country, being possessed different levels of technological and economic development at the beginning of the period under investigation, had been following its own technological specialization's model.
During 1994-2003 the smallest Euclidean distance was found between Russian RTAs' indexes and Chinese ones what does not mean that one of two countries had been copying technological specialization's model of the other because the distance between them, anyway, was quite big.

In 2004-2008 as a result of process of divergence, the distance between Russian and Chinese specialization increased almost twice; the smallest distance between RTA indexes of that period was calculated between Russia and Italy while the largest gap at this time Russia had with Brazil and Denmark.

**Table 5. Changes in technological specialization of BRIC countries, European Nordic "Innovation Leaders" and Southern "Moderate Innovators" during the period since 1994 till 2008.**



For better understanding the process of divergence between Russia and other countries' technological specialization I use the Table 5 that contains data about obtaining and losing technological specialization by Russian Federation and other countries during 1994-2008.
At first, we make analysis of technological development of China, technological specialization's core of which in 1994-2003 was formed by technological advantages in sectors of Primary Metals, Chemicals and Pharmaceuticals and Aerospace (like in Russian pattern). However, during the period of 2004-2008 Chinese technological pattern had changed and the gap with Russia had increased: from its previous technological advantages China had kept only technological specialization in sector of Chemicals focusing its strongest technological advantages in Electrical Computer and Peripheral Equipment, Furniture and Wood Products, Fabricated Metal Products.

What about the other two "BRIC" economies? The gap in technological specialization that existed between their and Russian technological specialization patterns was more significant than between Russian and Chinese ones.

India, like Russia, had been stepping up its technological specialization in sectors of Chemicals and Pharmaceuticals, Primary Metals, and besides it, in sectors of Food and Beverage and Tobacco during the whole 15-year period of time; while technological advantages of all the rest industries had been equal to zero or close to it. But during 2004-2008 the country obtained technological advantage in sectors of Computer and Peripheral Equipment and Communications Equipment and became closer to Russia which at the same time obtained technological advantage in production of Computer and Peripheral Equipment and Food, Beverage and Tobacco.

Brazil with its technological specialization's model, very different to Russian one, had increased its gap with Russian almost twice at the end of period under investigation. Main features of Brazilian technological specialization's pattern are: maintaining and stepping up strong technological advantages at such low-tech and medium low-tech industries as Primary Metals, Non-Metallic Mineral Products, Fabricated Metal Products, Machinery, Food, Beverage and Tobacco, Paper and Wood Products; high-tech sectors had been enjoying in less favorable positions in the country's industrial structure during the whole period under observation what made its difference with Russia grow.

Characteristic features of European Moderate Innovators (Spain and Italy) are that during the whole period under observation they had lost almost no one of their technological advantage; they had only been obtaining the new ones and maintaining already existing ones.

Spain was the only country which had not had technological advantage in sector of Primary Metals (one of the most important in Russia); the areas of strong technological specialization of the country were linked with low-tech Food and Beverage, Wood and Furniture production's industries and with high tech sectors of Chemicals and Pharmaceuticals.

Italy had been improving its technological performance during the whole period under observation; in 2004-2008 it had RTA>1 in all manufacturing sectors, excluding sector of ITC, but only three of them had RTA indexes close or more than 2: sectors of Resin and Synthetic Rubber, Textile and Leather and Furniture. Not very high RTA indexes and obtaining technological advantages in sectors of Primary Metals in 1999-2003 let the distance between technological specialization of Italy and Russian became much smaller in 2004-2008, but in 2004-2008 this distance had increased again because of obtaining by Italy technological advantages in sectors related with Wood and Paper products, Electrical and Medical Equipment, and Transport (sectors where Russia had been retreating).

Nordic Innovation Leaders were characterized by more changes at their RTA indexes, particularly, in 1999-2003 and had no a lot of similarities in technological specialization patterns with Russia.

Sweden at first period under observation were possessing the highest RTA indexes almost in all industrial sector and the largest gap in technological specialization Russia had with

Sweden, but in next period this gap became smaller because of significant decrease of Swedish RTA indexes and losing some technological advantages (particularly in ITC sector) by country. As a result, at 2004-2008 the distance between Russian and Swedish RTAs reduced almost three times. Sweden had been and continues to be strongly specialized in high technology industries with focus on Pharmaceuticals (like Russia) and Telecommunications (sector to which Russia has to put more attention). The other industries that had had great important for country's economy sectors linked with Production of Motor Vehicles and Forest related products.

Finnish technological specialization's core had been mostly was in sectors different to Russian ones: ITC sector (particularly, in Telecommunications) and sector of Paper and Printing, Food and Beverage, sectors that do not play great role in Russian technological specialization.

Denmark in its specialization had been very similar to the other two Nordic Innovation Leaders. It had had strong specialization in Food, Beverage and Tobacco, Wood and Paper, Chemicals and Pharmaceuticals.

After this comparison between the countries we can state that in 1994-2008 Russia had been following nor the models of developing countries "BRIC" neither the models of European innovation-driven countries, but its own model of technological development determined by technological, historical and organizational factors (Radosevic, 1999).

## 5. Advantages and disadvantages of using patents as a technological indicator

In this paper for estimating technological specialization pattern of the country I have used international patent data.

In practice to measure country's technological capabilities and their changes is more complicated than to measure other economic and social indicators what can be explained by the nature of technology that makes it difficult to aggregate its heterogeneous aspects and components into a single meaningful indicator (Archibugi and Coco, 2005; Archibugi et al., 2009). Patent database is one of the most available sources for estimation of technological capabilities and competitiveness of a country (Archibugi and Coco, 2005; Fagerberg et al., 2007) and using patenting data as a national technological indicator and as an indirect measure of its productive specialization is quite common, although like any other technological indicator, patents also have their advantages and disadvantages.

The advantages of using patent database for identification of country's technological specialization are:

- Patents are a direct outcome of the inventive process and particularly appropriate indicator for capturing the competitive dimension of technological change (Archibugi & Pianta, 1996).

- Patents are public documents and all information is not covered by statistical confidentiality.

- Patent statistics is available in large numbers for all countries and for a very long time series.

But using the number of patents as technological indicator also has several disadvantages. They are:

- Not all inventions are technically patentable and not all of them are patented by firms (Archibugi & Pianta, 1996; OCDE 2009).

- The value distribution of patents is highly skewed (Harhoff et al., 1999). With the exception of a very small number of patents, the value of most patents is low (Suzuki, 2011), whereas many patents have no industrial application (OECD, 2009).

- The propensity to file patent applications differs significantly across technical fields. For instance, in the electronics industry (e.g. semiconductors) a patented invention can be surrounded by patent applications on incremental variations of the invention,

with a view to deterring the entry of new competitors and to negotiating advantageous cross-licensing deals with competitors. As a result of this "patent flooding" strategy, some technical fields have a larger number of patents than others (OECD, 2009).

- Technological capability is composed by several elements. That's why using such single statistical sources, as the number of granted patents, is clarifying specific aspects about technological competencies, but not completely (Fagerberg and Srholec, 2008; Archibugi et al., 2009). For developing countries, technological progress comes mainly from two sources: domestic innovation and opening up of international technology spillovers. In this paper I analyze the technological change only by using data about country's domestic inventions without taking into account innovation "absorptive capacity" (Cohen and Levinthal, 1990).

- There are differences in countries' preferences to patent abroad, which depend on a number of factors, such as the efficiency of national offices, how familiar a patentee firm is with the administrative procedures in a country, and the cost of extending and legally protecting a patent abroad.

## 6. Conclusions

This paper examines the technological specialization of Russian manufacturing industry since early post-Soviet era till the times of World financial crisis of 2008 and compares it with the technological specialization's patterns of the other countries.

Several conclusions can be drawn from this analysis:

1. First of all, **Russian Federation is characterized by a very low level of overall patenting activity** not only in comparison with innovation-driven economies, but in comparison even with the other countries of "BRIC" China and India (the country which economies are at the lower stage of development).

There are several factors that make Russian Federation demonstrate such a low level of technological progress today.

First of them is a **lack of R&D activities' funding**: low level of financial support from the State budget and industry, low salaries for scientists and engineers and de facto stagnation of R&D activity. Current expenditure on technological innovation in Russia is not sufficient for fuelling a major innovation breakthrough in different sectors of the national economy. Their value is too small for meeting the real requirements of technological modernization of industry and expansion of the range of radically new domestic products. As a consequence of this, today Russian National Innovation System needs more resources, in particular from the private sector: in 2007 only 29.7 % of inversion in R&D in Russia was financed by the private sector (Rosstat, Russia and G-7, 2009).

At the same time a greater element of competitiveness is needed in the allocation of R&D resources. The structure of technological innovation's funding in Russian Industrial Engineering organizations is characterized by great predominance of funding of activities linked to acquisition of machinery, equipment, software, while the funding of their own R&D activities is only 1/5 of total technological innovation's costs (Table 6). The weak in-house R&D together with a lack of integrating research institutes with companies and a continued presence of institutional barriers, all have a negative impact on the raising competitiveness of products.

**Table 6. The structure of technological innovation's funding in Russian Industrial Engineering organizations by innovation activities (%)**

| R&D performed in-house | R&D performed by outside organizations | Acquisition of machinery, equipment, software | Acquisition of new technologies | Other expenditure on technological innovation |
|---|---|---|---|---|
| 10,5 | 4,5 | 60,8 | 2,5 | 21,8 |

Source: Rosstat, 2007

The second explanation is a **lack of clear innovation strategy** among most Russian businesses. Since the transition from planned economy to a market economy, the state system of scientific and technical policy has not been formed and doesn't almost exist in the country. The R&D system is too much isolated from market and society demands and badly needs to improve its performance and level of integration with business and civil society. There are low levels of R&D and innovation activities in Russian firms and weak framework conditions for innovation (particularly: weak competition and regulatory frameworks, corruption and lack of trust).

The third influencing factor is a **lack of adequate infrastructures**. According to WEF GCR Report 2011 Russian Federation takes only 47th place according to development of its infrastructure, while infrastructure accumulation is considered as an important factor for promotion of manufacturing sectors' specialization and long-run economic growth (Bougheas et al., 2000).

2. **Technological specialization of Russian manufacturing industry** which was following its own development pattern mostly without taking into account international technological trends **has been quite stable in post-Soviet era.**

   There are several features that characterize technological specialization pattern of the country during the whole period under my investigation:

- Overall Russia had tried to focus its manufacturing industry's technological specialization in high-tech sectors (Aerospace, Navigational, Measuring and Control instruments, Chemicals, Pharmaceuticals, Electrical and Medical Equipment) since USSR era. In spite of this, Russia's share of world high-technology exports is very small, because the commercial success of any technology comes as a result of its quality as compared to the best world analogues and demand on international markets, but Russian S&T potential, however, does not match much of global demand.

- The strongest technological advantages had been obtained by the country in sectors linked with production of Primary metals, Chemicals and Pharmaceuticals what is explained by the fact that the large Russian corporations specializing in these areas have enough resources to support in-house and contract research and get access to foreign resources that they lack, especially in technology, and rapidly learn to strategically use networking and alliances. Although it is necessary to remind that even being possessed high RTA's indexes the country is far from world's leader's position in these areas because of its low overall patenting activity.

- Companies in traditional Russian high-tech industries, like aerospace and defense, have inherited technologies that were at the world frontier and are capable of maintaining their superiority with strong political support from the government. They have become less competitive (Aerospace industry) in the new economic and political system and need more Federal support for R&D activities, as well as the growth of volume of public procurements, for further growth.

- Russia had kept variations between its prior industries (related with defense) and civil sectors in the organization of R&D. Reorientation from defense sector's priority to civilian goals, desirable in early post-Soviet era, had not appeared so quickly.

- The half of Russian manufacturing sectors under investigation belongs to the categories of "Static Specialization" and "Lost opportunity" and only two or three sectors in different periods belonged to the group of "Dynamic Specialization". One of the problems of Russian industry is that the country is still not able to obtain strong technological advantages in sector of ICT, one of the most dynamic and fast-growing world sectors, technological specialization in which is associated with growth of high-tech exports, value-added and as a consequence with economic growth. However, there were some changes in this sector: during the period of our observation the

country had acquired RTA in Computer and Peripheral Equipment what can be explained by the fact that ICT sector is one of few manufacturing sectors in Russia which enjoys sufficient incentives and resources for innovation (WEF GCR 2011).

On the positive side, Russia's innovation system has formidable strengths for improving its performance on international arena. They are notably a high level of education and long-standing excellence in several fields of science and technology. Recent policy initiatives to build further on these assets are themselves a sign of strength, reflecting the government's seriousness in making innovation a key national priority.

So, the primary goal of Russia's innovation policy should be to shift the national innovation system's core away from the publicly-owned R&D system and towards production firms, whether public or private.

3. Comparison Russian technological specialization with the developing "BRIC" economies and European innovation-driven countries has demonstrated that Russia, in spite of having some similarities with these countries in technological specialization models, was copying no one of them. Moreover, at the end of period under observation **divergence** between them became even stronger than it was at the beginning. For understanding better this process there is a need in observing technological specialization of Russia and the other countries during longer period of time taking into account the difference in their initial levels of technological and economic development, rates of economic indicators' growth and challenges of their National Innovation Systems, what can be issue for future investigation.

4. The first task for modern Russia, with its still quite high innovation potential and long-standing technological domination in particular industrial areas, is elimination of National Innovation System's disadvantages by **implementation of adequate innovation and patenting strategy which can make country's technological specialization's pattern more favorable**.

Taking into account the real present capabilities of Russian S&T and the situation in global and domestic markets, it would be advisable to **concentrate on developing and implementing support measures for the following R&D areas**:

- **Sector of Information and communication technologies and electronics** as one of the most dynamic and fast-growing industrial area in the world. This sector is one of few in Russian Federation today that possessed financial incentives and high-qualified human resources for its technological development. But disadvantages that exist in National Innovation System do not allow it to develop dynamically.

- Sectors linked with **Primary Metals and Chemicals' Production**, strong technological specialization in which Russia has maintained during decades. The country has to keep technological advantages in these industrial sectors till they stay ones of the main contributors to Russian economy.

- **Aerospace manufacturing sector**, which since USSR times have been one of the most important industrial sectors for Russian economy but have become less competitive in post-Soviet era, now requires great efforts for re-orientation of specialization inside of it: in Space Industry – towards communications satellites' production, in Aircraft Industry – towards passenger airplanes and helicopters' production.

- **Sector of Machinery**, which was principal provider of equipment and machinery to all other industries (civil and military) during Soviet period, is in retreat now and, like Aircraft industry, needs re-orientation its specialization from military sector's needs towards civil sectors' needs.

As it was mentioned before the types of activity that country is undertaking in the technological domain are important for its international and domestic performance. However, technological specialization is

found to have a significant impact on country' performance only with taking into account the overall technological competitiveness in terms of country' ability both to innovate and imitate.

If we want to understand the long-run processes of Russian technological and economic changes, the treatment of specialization's patterns as given is not satisfactory because it does not help in understanding why the country is what it is, in terms of its technological profile, and how it got there.

The results of this paper can be used for the future investigation of the issue of technological specialization of Russian Federation with taking into account the process of country's long-term development with possible misalignments between its innovation and economic performance and establishing relationships between Russian technological specialization and its economic performance (particularly: relations with export/import, value added and employment).

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