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Position of the Countries in Nanotechnology and Global Competitiveness

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This paper deals with the position of the countries in nanotechnology by competitive groups in 2005 and 2009. We determined the global competitiveness of countries in the analyzed years and competitiveness in technologies and innovations as partial parameters which are important for their positioning in nanotechnology. Also, we analyzed the changes in the competitive position of the countries in nanotechnology and the global competitiveness of countries in order to determine the relation between the positions they had in 2005 and that they had in 2009. A stable relation between competitive positions of the countries in nanotechnology and a global competition will enable the evaluation of their future competitive position in nanotechnology based on global competition.

Keywords: competitive position of the countries, nanotechnology, global competiveness

1. Introduction

The national innovation systems approach stresses that the flows of technology and information among people, companies and institutions (universities, government research institutes and other research institutions) are key to the innovative process. Innovation and technology development are the result of a complex set of relationships among actors in the system. High levels of technical collaboration, technology diffusion and personnel mobility contribute to the improved innovative capacity of a country (in terms of products, patents, etc.) (OECD, 1996, p. 7). A key factor for commercialized innovation and economic development is the nanotechnology development and the «general technology development strength» of each nation (Hwang, 2010). Accordingly, nanotechnology innovations are one of the sources of the competitive advantage of a country.

The identification and analysis of competitiveness at the global level in modern conditions have become necessary. One of the components of macro-research involves the competitiveness of countries, companies and other market participants. "A nation's competitiveness depends on the capacity of its industry to innovate and upgrade" (Porter, 1990, p. 73), while a country's competitive behavior reflects on its competitive position and status. Competitive status mirrors the competitive behavior of all market participants (Kotler et al., 2007, p. 505) that are positioned competitively, protecting or enhancing their status by particular strategies (Hooley, Piercy & Nicoulaud, 2012).

Competitive status of a country in nanotechnology is determined by two indicators - the level of its nanotechnology activities (nanotechnology innovation) and the power of its technology development (Burns, 2005; Hwang, 2010). The level of nanotechological activity points to "the capabilities and resources of a nation's engine for nanotech innovation" (Hwang, 2010, website), and the power of technological development points to the possibility of a country to develop its economy on nanotechnology.

The parameters of nanotechnological activity levels are the following: nanotechnology initiatives from the local to the federal level, nanotechnology centers founded by governments or universities, government investment, risk capital, investments of companies, publications in nanotechnology, the number of international nanotechnology patents based on a U.S. patent base - the USPTO (*The United States Patent and Trademark Office*), the number of active nanotechnology companies (Burns, 2005; Hwang, 2010).

The parameters of the power of technological development are: high or medium-high technology manufacturing (share of gross domestic product coming from high or medium-high technology products), R&D spending, intellectual capital, technological and scientific workforce, knowledge emigration, infrastructure (Hwang, 2010).

According to these indicators and parameters, all countries can have one competitive status out of the four competitive statuses. The countries whose grade for the level of nanotechnological activity and the power of technological development is higher than 3 on a scale from 1 to 5 have the status of leaders. The countries whose grade is above 3 for nanotechnological activity and up to 3 for the power of technological development have the status of challengers. The countries whose grade is below level 3 for nanotechnological activity, and above 3 for the power of technological development have the status of nichers. And finally, the countries whose grades for the level of nanotechnological activity and the power of technological development are below 3 have the status of followers.

Countries that have qualified as active in nanotechnology and, according to these indicators, positioned in one of the four groups by *Lux Research* have different degrees of development and different power of global competition. Therefore, we have reasonably asked the following question - whether their position and competitive status in nanotechnology compares to their status in global competition. We have found support for that in the research methodology used by *Cientifica* (Harper, 2011), in assessing the economic significance of nanotechnology and nanotechnology impact factors which innovated its research methodology by integrating data from the annual report of *the World Economic Forum* on global competitiveness into the existing data. In this way we obtained an insight into how skillfully different countries can be or are in a position to take advantage of the funds invested into research and development. According to the research into the economic importance of nanotechnology and nanotechnology impact factors of Cientifica research institution (Harper, 2011, p. 7), China and Russia are ranked second i.e. third behind the United States. This indicates that nanotechnology represents an opportunity for all countries to reposition in this field and the global market in general. Although the Republic of Serbia, as well as many less developed countries, is not sufficiently respectable in nanotechnology at the global level, it does not mean that, as a passive participant in the process of globalization, it will be protected from the growth of competitiveness of the countries that participate actively in this field.

According to *the World Economic Forum* methodology (Schwab, 2009) the position of global competitiveness of a country is determined by the indicators within the defined pillars of competitiveness. These are: institutions, infrastructure, macroeconomic environment, health and primary education in the group of basic factors; higher education and training, goods market efficiency, labor market efficiency, financial market development, technological readiness and market size in the group of factors led by efficiency; business sophistication and innovation in the group of innovation-driven factors. Certain parameters within the global competitiveness indicators overlap with particular parameters of the above mentioned indicators of competitive status of countries in nanotechnology. In this regard, given the methodology that *Cientifica* uses in the study of global investment in nanotechnology and its importance for the country and its development, we were motivated to perform an analysis of the competitive position of countries in relation to nanotechnologies and in the global competition.

The existence of a balanced relationship between the analyzed positions of countries indicates that the change in global competitiveness of a country would cause a change in the position of the country in nanotechnology in the same direction and with the same intensity. The existence of uneven, diverse relationship will indicate that one cannot expect that change in global competitiveness of a country would cause a change in the position of the country in nanotechnology in the same direction and with the same intensity.

2. Research methodology

In this study we used the secondary data from external sources that are publicly available on the Internet sites of governments of individual countries and their bodies, such as government institutions and organizations in the field of nanotechnology (*US Congressional Research Service, The National Nanotechnology Initiative, European Commission, Asia Nano Forum*). Then, we also used the data from the Internet addresses of specialized global nanotechnology institutions and organizations (*Cientifica, Lux Research*). The data on

global competitiveness of countries were taken from the reports of the same institutions (*World Economic Forum*). The research results presented in scientific journals were also of great importance – Kobson database (*Journal of Nanoparticle Research, Scientometrics, Asian Business and Management, Journal of Technology Management in China, Journal of Asian Business Management*, *Nanotechnologies in Russia, Journal of Nanoscience and Nanotechnology* and other*).*

The research is done in several stages. First, we presented the competitive position of the countries in nanotechnology in 2005 and 2009 on the basis of the countries' rankings in nanotechnology by *Lux Research* (Burns, 2005, p. 4; Hwang, 2010, website).

Most countries engaged in the nanotechnology field began a national nanotechnology initiative in the first decade of the 21st century, adopting the national agenda of nanotechnology development, which relate to a period of at least five years (Roco, 2005; Liu, 2009; Shapira & Wang, 2009; Sargent, 2012). Guided by this, we set the year of 2005 to be the first comparison year in determining the competitive position of countries in nanotechnology. The global economic crisis in 2008 was the additional stimulus to determine the year of 2009 as a second comparison year, which is at the same time the final year to date in which the ranking of countries in nanotechnology is presented. For 2005 we analyzed the position of 14 countries, and for 2009, that of 19 countries. We determined which positions were occupied by the observed countries in the given years through competing groups (the competing groups of leader-countries, challenger-countries, nicher-countries and follower-countries).

In the next phase we analyzed the global competitiveness position of the observed countries and their competitiveness in the partial parameters - technology and innovation in 2005 and 2009 according to their competitive position in nanotechnology (competitive group). The data on the global competitiveness of the observed countries were obtained from The Global Competitiveness Index (Lopez-Claros, 2006; Schwab, 2009) and the data on competitiveness at the given parameters from the analytical screening of competitiveness at any given parameter (Lopez-Claros, 2006; Schwab, 2009). The Global Competitiveness Index is the most reliable general indicator of a country's competitiveness up to date, and its partial parameters and indexes are indicators of a country's macro-environment attractiveness. Therefore, we based this analysis on the reports by the *World Economic Forum* for the observed years. Since 1979 the *World Economic Forum* has been one of the most important global institutions analyzing and measuring the competitiveness of countries. The increasing number of parameters in the evaluation of the countries' competitiveness global index has placed the reports of this institution among the most cited in the field.

The limitation of the study of a relationship of the countries' competitive position in the field of nanotechnology and global competitiveness and the competitiveness in individual parameters in 2005 and 2009 resulted from the methodology applied by this institution during the observed years. Considering that the uneven relationship between the observed positions of most countries is the result of insufficient methodology compatibility due to the increasing number and restructuring of parameters used to measure competitiveness, this analysis was reduced to a comparison of the competitive position of countries in nanotechnology and global competitiveness according to the global competitiveness index. In the further analysis we excluded the observation of particular parameters of competitiveness and used the figures of the countries' global competitiveness for 2005, published in 2006.

3. Results of the research

3.1. The analysis of competitive position of countries in nanotechnology in 2005 and 2009

The analysis of the competitive position of countries in nanotechnology was conducted on the basis of their competitive statuses in 2005 and in 2009, according to the competitor groups. The position of countries in nanotechnology in 2005 is presented in Table 1.

The United States, Japan, Germany and South Korea were placed in a competitive status of a leader. The power of technological development of Japan and South Korea was higher when compared to the power of the U.S. and Germany, respectively. A more favorable position in the level of nanotechnology activity was achieved in the U.S. compared to other countries.

Great Britain and France were placed in the competitive status of the challenger. Significant competition between these countries was not demonstrated when observed through the level of nanotechnology activity, but it was demonstrated when observed through the force of technological development.

Taiwan, Israel and Singapore were positioned in the competitive status of a nicher. Singapore had an advantage in the power of technological development, while Taiwan and Israel had an advantage in the level of nanotechnology activity. Both indicators included, the best position was that of Taiwan.

China, Canada, Australia, India and Russia were assigned the competitive status of a follower. Canada, Australia and Russia had an advantage in the power of technological development, while China had an advantage in the level of nanotechnological activity.

Table 1: Competitive position of the countries in nanotechnology in 2005

The levels of nanotechnological activity									
	5					U.S.			
	4.5						Japan		
	4					Ger.			
	3.5			GB	Fr.		S.Kor		
	3		China			Taiw.			
	2.5			Canada		Israel			
	2			Australia			Sing.		
	1.5		India		Russ.				
	1	1.5	2	2.5	3	3.5	4	4.5	5
	The power of technological development								

Source: Adapted from Burns, 2005, p.4.

When it comes to nanotechnology, the global game is uneven. Different levels of public support, and corporate and economic interests contributed to the vitality and acceleration of the development and commercialization of nanotechnology at the end of the first decade of the 21st century. The position of countries in nanotechnology in 2009 is presented in Table 2.

Table 2: Competitive position of the countries in nanotechnology in 2009

The levels of nanotechnological activity									
	5				U.S.				
	4.5						Japan		
	4					Ger.			
	3.5			GB	China Fr.		Taiw.	S.Kor	
	3				Can. Russ.				
	2.5		The Neth. Italy				Israel		
	2	India			Aust.	Switz. Swed.	Sing.		
	1.5	Brazil							
	1	1.5	2	2.5	3	3.5	4	4.5	5
	The power of technological development								

Source: Adapted from Hwang 2009, website.

Taiwan joined Japan, Germany and South Korea in their competitive status of a leader. Taiwan is an ambitious player in nanotechnology. It launched its first phase of the Taiwanese National Nanotechnology Program in 2003. The second phase started in 2009 and continues until 2014. The aggressive building of infrastructure has been reflected in the launch of major nanotechnology infrastructure building programs for Taiwan in 2003 (Liu, 2009, p. 6).

Great Britain and France kept their position in the competitive status of a challenger. They were joined by China and the United States. The advantage of the United States is significant and viable in both indicators in relation to the rest of the countries in the group. The improvement of China's position in nanotechnology has been underwritten by the emergence of a series of regional centers of nanotechnology R&D activity (Tang & Shapira, 2011, p. 313). The rapid growth of Chinese nanotechnology research is mainly internally driven. Also, international collaboration has effects on raising the research impact of Chinese nanotechnology publications. China has suffered from a loss of talents in the past as its brightest students went abroad and never returned. With the rapid development of the domestic economy, the expansion of R&D spending, and the growth of technology-oriented industries, China is increasingly attracting Chinese returnees into academia and industry (Tang & Shapira, 2012, p. 106-107).

Israel, Singapore, Switzerland and Sweden had the competitive status of a nicher. As new competitors, Switzerland and Sweden have taken favorable positions due to the power of their technological development. As new competitors, Italy, the Netherlands and Brazil joined Russia, Canada, Australia and India in the competitive status of a follower. Italy and the Netherlands took favorable starting positions. Brazil took unfavorable starting position. However, Brazil is a leader in nanotechnology research in Latin America (Kay & Shapira, 2009). Russia achieved the best results in the group in 2009, compared to 2005. Russia, China and India are playing an increasingly important role in the global nanotechnology research and development (Liu et al. 2009).

3.2. The analysis of the position of global competitiveness and the competitiveness in technology and innovation of countries in nanotechnology in 2005 and 2009

In 2005 the *World Economic Forum* observed global competitiveness of countries through the *Global (extended) Competitiveness Index - The Growth Competitiveness Index* (GCI) and the *Business Competitiveness Index* (BCI). The Global (extended) competitiveness index is measured through the *Technological Readiness*, *the Quality of the Macroeconomic Environment Index* and *the State of the Country's Public Institutions*. The Business Competitiveness Index was measured by Company operations and strategy ranking and the *Quality of the national business environment ranking*.

In 2009 the *World Economic Forum* observed the global competitiveness of countries in the Global Competitiveness Index (GCI), as measured by 'the 12 pillars of competitiveness'. The importance of certain parameters (factors) of competitiveness is influenced by the degree of economic development of a country. For the countries in the first stage of development the main factors are the most significant (institutions, infrastructure, macroeconomic development, health and primary education). For the countries in the second stage of development the most significant are the factors that are key to efficiency (higher education and training, goods market efficiency, labor market efficiency, financial market development, technological readiness and market size). For the countries in the third and, for the time being, the last stage of development the most significant are the factors that are key to innovation (business sophistication and innovation).

In order to compare the global competitiveness of countries in nanotechnology in 2005 and 2009, for the year of 2005 we have used the data presented according to the methodology used in 2009. The position of the global competitiveness of countries in nanotechnology in 2005 is presented in Table 3.

Table 3: The position of global competitiveness of countries in nanotechnology in 2005

The competitive position of countries in nanotechnologies	Global competitiveness index
leaders	
The USA	1
Japan	10
Germany	6
South Korea	19
Challengers	
GB	9
France	12
Nichers	
Taiwan	8
Israel	23
Singapore	5
Followers	
China	48
Canada	13
Australia	18
India	45
Russia	53

Source: Lopez-Claros, 2006, WEF.

In 2005, all the observed countries were ranked down to the 53rd pposition, which is less than half of the total number of countries for which global competitiveness was measured. According to the *Global Competitiveness Index*, most countries were ranked down to the 30th position (excluding China, India and Russia). In the groups of leader-countries, challenger-countries and nicher-countries, with the exception of South Korea and Israel, all the countries were ranked down to the 15th position. They were joined by Canada from the group of follower-countries. Considering the Technological index, most countries were also ranked down to the 30th position (except China, India and Russia). Middle positions were reserved for most countries in the group of follower-countries (from 31st to 60th place).

The position of the global competitiveness of countries in nanotechnology in 2009 is presented in Table 4. In 2009, all the observed countries were ranked down to the 63rd position, which covers almost half the total number of countries for which global competitiveness was measured. According to the *Global Competitiveness Index*, most countries ranked down to the 30th position (except India and Russia, Italy and Brazil). In the groups of leader-countries, challengers-countries and nicher-countries, except South Korea, China, France and Israel, all the countries were ranked down to the 15th position. They were joined by Canada, Australia and the Netherlands from a group of follower-countries.

Considering technology and innovation, most countries were ranked down to the 30th position, with the exception of China, India and Russia, as the existing competitors, and Italy and Brazil as new competitors. The middle positions of global competitiveness and competitiveness in technology and innovation are reserved for most countries from the group of follower-countries.

Table 4: The position of global competitiveness of countries in nanotechnology in 2009

The competitive position of countries in nanotechnologies	Global competitiveness index
leaders	
Japan	8
Germany	7
South Korea	19
Taiwan	12
challengers	
The USA	2
GB	13
France	16
China	29
nichers	
Israel	27
Singapore	3
Switzerland	1
Sweden	4
followers	
Canada	9
Australia	15
India	49
Russia	63
The Netherlands	10
Italy	48
Brazil	56

Source: Schwab, 2009, *WEF*

3.3. The comparative analysis of the changes in the competitive position of countries in nanotechnology and global competitiveness for 2005 and 2009

The summary of the changes in the competitive position of countries in nanotechnology and their global competitiveness in 2005 and 2009 is given in Table 5.

Except the U.S., all the countries from the group of leaders and nichers improved their position in nanotechnology. The position of France in the group of challengers slightly worsened. Apart from Australia, all countries in the group of followers improved their position in nanotechnology.

The improvement in global competition was observed in Japan in the group of leaders, China in the group of challengers, Singapore, Switzerland, Sweden in the group of nichers, Canada, Australia, Brazil and the Netherlands in the group of followers. South Korea from the group of leaders kept its position. The deterioration in

the position was observed in Germany and Taiwan in the group of leaders, in the U.S., Britain and France in the group of challengers, in Israel in the group of nichers, and India, Russia and Italy in the group of followers.

The improvement of the position in nanotechnology and global competitiveness was observed in Japan, the group of leaders, China, the group of challengers, Singapore, Switzerland and Sweden, the group of nichers, Canada, the Netherlands and Brazil, the group of followers. Deterioration was observed in both the position of the U.S. and that of France, the group of challengers.

Germany and Taiwan in the group of leaders, the UK in the group of challengers, Israel in the group of nichers, and India, Russia and Italy in the group of followers improved their positions in nanotechnology, while their global competitiveness deteriorated. The position of Australia in the group of followers deteriorated in nanotechnology, while it improved its global competitiveness. South Korea in the group of leaders improved its position in nanotechnology and preserved its global competitiveness.

Table 5: The comparative review of the changes in the competitive position of countries in nanotechnology and global competitiveness for 2005 and 2009

The compet. position of countries in nanotech. 2005	**GCI 2005**	**The compet. position of countries in nanotechnol. 2009**	**GCI 2009**	**The change in competitiv. position in nanotechnol. 2009/2005**	**The change in the position of global competitive. 2009/2005**
leaders					
The USA	1				
Japan	10	Japan	8	+	+
Germany	6	Germany	7	+	-
South Korea	19	South Korea	19	+	=
		Taiwan	12	+	-
challengers					
		The USA	2	-	-
GB	9	GB	13	+	-
France	12	France	16	-	-
		China	29	+	+
nichers					
Taiwan	8				
Israel	23	Israel	27	+	-
Singapore	5	Singapore	3	+	+
	4	Switzerland	1	+	+
	7	Sweden	4	+	+
followers					
China	48				
Canada	13	Canada	9	+	+
Australia	18	Australia	15	-	+
India	45	India	49	+	-
Russia	53	Russia	63	+	-
	11	The Netherlands	10	+	+
	38	Italy	48	+	-
	57	Brazil	56	+	+

Legend:

+	The improvement of the position
-	The deterioration of the position
=	The preservation of the position

Based on the presented results we have concluded that there is no uniform, but there is varied relation of changes both in the position of countries in nanotechnology through rival groups and in the position of their global competitiveness (Table 6).

Table 6: The review of the changes in the position of countries in nanotechnology through competitor groups and in global competitiveness

The change in the position in nanotechnology		D		P		I	
	I	Great Britain Ch	Germany Taiwan L	Ch	South Korea L	China Ch	Japan L
		India, Italy Russia F	Israel N	F	N	Can., Braz., The Neth. F	Sing.,Sw., Swed. N
	P	Ch	L	Ch	L	Ch	L
		F	N	F	N	F	N
	D	USA France Ch	L	Ch	L	Ch	L
		F	N	F	N	Australia F	N
		Changes in global competitiveness					

Legend:

I	The improvement of the position
D	The deterioration of the position
P	The preservation of the position
Ch	The group of challengers
L	The group of leaders
F	The group of followers
N	The group of nichers

Conslusion

In comparison with 2005, in 2009 most countries improved both in nanotechnology and in global competitiveness (almost half of the total number). Considering competing groups, the majority of those who made improvements of both positions were in the groups of followers and nichers. Then there were countries whose position in nanotechnology improved, while in global competitiveness it worsened (almost a third of those observed). These were positioned in all competing groups. The deterioration of both positions, which is the minimum in quantity, was observed in only two countries that belong to the group of challengers.

Based on the above, we have found that there is an uneven, i.e. varied relation between the competitive position of countries in nanotechnology and global competitiveness. On one hand, individual factors of competitiveness have a different impact on the assessment of the country's competitiveness according to the methodology of the *World Economic Forum*. On the other hand, some factors that could be important for the competitiveness of individual countries were not included in the analysis by this institution. A number of highly ranked countries in global competitiveness were not ranked in any of the competitor groups in nanotechnology, according to the methodology of the *Lux Research* (e.g. Finland, Denmark, Norway, Austria, Belgium, Hong-Kong).

A step forward made by *Cientifica* as regards integrating data from the annual report of the *World Economic Forum* on global competitiveness into the existing data with the aim of assessing the importance of global investment in nanotechnology for the development of countries is particularly useful in the evaluation of the economic importance of nanotechnology for a country, but is not reliable in assessing a country's position in nanotechnology in the defined competitive groups.

Nanotechnology is important for the activation of countries and their participation in the globalization process, but it is not necessary that countries should be highly-ranked in global competitiveness. The indicators used by the *World Economic Forum* to assess global competitiveness of countries are important macroeconomic and microeconomic indicators of the country's ability to be active in nanotechnology. However, they are not a reliable indicator that a country will be a potential competitor in nanotechnology, even taking into account the improvement of its global competitiveness position.

The research results suggest an increase in competitiveness and the emergence of countries at medium levels of development in the role of new competitors in nanotechnology (e.g. China and Russia). Nanotechnology is an opportunity for all countries to position in this field and the global market in general. The results of this research are expected to be useful primarily to the countries - potential competitors in nanotechnology, including the Republic of Serbia.

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