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Regional variety of biotechnology development in Asia

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Abstract

Today's biotechnology is widely regarded as a one of the most important sectors of the technology, a new wave of knowledge-based economy. It is characterized by innovation and a very fast pace of development, which is connected with the involvement of highly qualified specialists, research centers, varied sources of information, investments, as well as interconnections to guarantee the flow of information. Potentially, biotechnology has a wide range of applications, such as the food industry, production of genetically modified organisms, pharmaceutics, healthcare, detergents and bioremediation, forestry and agriculture. There is a huge variety in the world when it comes to the structure and space where the biotech development occurs. According to the collected data, there is an obvious dominant role of highly developed countries such as the United States and European countries: the UK, Germany, Switzerland, Italy and Sweden as well as Canada. Nevertheless the dynamic expansion of biotechnology occurs in new centers of biotech development in eastern European countries such as Lithuania and Slovakia as well as in Asian countries, including Turkey, India, South Korea and Japan. Furthermore, biotech development is determined by several factors. A distance from scientific centers, location of universities, financial sources and international cooperation must be taken into consideration. Country policies also come as the major determinants. With the Internet and common access to a very sophisticated piece of information and a very fast-developing technology, it's even easier for the biotech to make a step forward.

Keywords: Asia; biotechnology; development; patent; company.

1. Introduction

Nowadays, the biotech industry is regarded as one of the most important high-tech sectors of the economy and as

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a significant factor in the socio-economic and knowledge economy development (Herb, 2006, 2008; Dorocki, Jastrzębski, 2012; Pugatch, Torstensson; Chu, 2012). According to the definition adopted by the authors, biotechnology means the application of processes that make use of living organisms or their components to produce or to modify products of specific use. Therefore, biotechnology is an interdisciplinary science that integrates life sciences and technology. The biotech industry focuses primarily on the production of starter cultures in the food industry, production of genetically modified organisms, as well as on pharmaceutical sector, sector of detergents and bioremediation, non-food biotechnology in agriculture, and forestry. It can help developing countries in tackling poverty, hunger and disease more effectively as well as evolve norms of bio-safety (Chaturvedi, Rao, 2004).

The development of biotech companies occurs mainly in the vicinity of the world-class universities, providing access to a highly skilled workforce and research infrastructure, and it is associated with a high investment risk resulting from rapid technological changes (Baum, Silverman, 2004). For this reason the development of biotechnology is mainly linked to the United States and other highly developed, Western European counties in particular. However, in recent years, many developing countries in Asia such as the People's Republic of China, India, Singapore, Malaysia, the Philippines, Thailand and others have begun investing in biotechnology. This article deals with the issues related to the development of biotech industry, in the light of prerequisites discussed above.

The subject of the article is the biotech industry. The study aims to determine the differentiation of the processes of biotechnological companies' development, and their potential and structure changes in various regions and countries in Asia.

1.1. Study area

A particular emphasis of the biotech industry development analysis is put on the following regions: South Asia, Southeast Asia, East Asia extended for Middle East and Oceania (Fig. 1). Some of the countries of these regions are case studies.

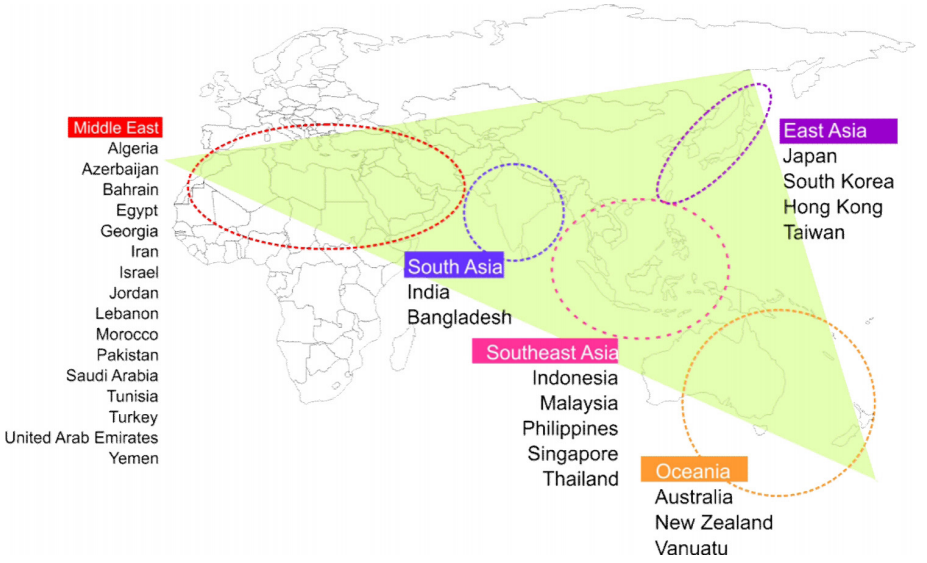

Fig. 1. Study area.

1.2. Material

The analysis is mainly based on the data derived from commercial BiotechGate database, containing information on companies and institutions as well as on biotechnology and pharmaceutical products worldwide. The information stored in the database represents only approximate values as it does not take into account all biotech entities in the

world, or the data is incomplete (e.g. in many cases, date of establishment or number of employees is missing, etc.). The additional source of the data was The World Intellectual Property Organization (WIPO).

1.3. Methods

To present the topic of the paper and its objectives, the authors employed a number of methods facilitating identification of differentiation in the biotechnological industry development in selected regions and cities.

The authors applied a real (analytical, qualitative) set of methods which allowed for analyzing the observed facts, thus leading to formulation of new concepts and hypotheses regarding the biotechnological industry as well as a formal (mathematical, quantitative) set of methods in order to quantify the analysed facts and phenomena related to the biotech sector companies and their relations to emphasis similarities and differences between the analysed and compared features. Application of a deduction method help to verify the existing general biotechnology-related concepts on the example of selected countries. On the other hand, the induction method played an important role in the process of drawing conclusions on the basis of specific data characterizing the development of the biotech industry in the analysed regions and countries as well as their position in the global biotech industry. The applied methods involved in-house studies in the literature in the field. The historical method is responsible for presentation of the evolution and gradual changes occurring in the biotech industry. Technical methods are indispensable from the point of view of the subject-matter and the purpose of the paper such as cartographic, statistical, empirical and graphic method.

2. Biotech companies

In 2011, the global space was largely differentiated when considering the number of biotech companies (Fig. 2). The highest number of such companies can be found in the USA i.e. 5,700 entities, representing nearly 24.9% of the total number of the biotechnological entities globally. Germany, the UK, Switzerland and Canada come after the USA in the ranking, each with a similar number of biotech companies. In total, these four countries represent 33.5% of the biological sector companies worldwide. A significantly lower number of biotech companies operates in Italy, Sweden, Spain, France, the Netherlands, India and South Korea, representing shares from 5.6% to 3.2% in their total number. One may conclude then that the biotechnological sector is the most developed in the developed countries in Western Europe and the North America, while it is only at the initial stage of its development in such economic powers as China or Brazil.

Considering the number of biotech companies in each continent (in particular, in Russia) in the period 1950 – 2011 one may notice that the biotech sector experienced a growth in 1990.ties in all the regions and, in particular, the growth was very strong at the turn of the centuries (Fig. 3). Among the continents, Europe and the North America lead in terms of the number of biotech entities. Next comes Asia, which in 2000 reached the North America's number of new biotechnological companies, In other regions (Russian, Africa and Oceania), the number of newly established companies did not exceed 10.

The decrease in newly established companies since 2005 was the result of the global crisis, mainly in the area of fundamental research and a decrease in the volume of investments (fewer investments in the U.S. and Europe in 2009 at about 46% although the profits of listed biotech companies reported a 12% growth) (Ernst & Young's Global Biotechnology Report, 2009). This applied mainly to high-risk investments in new and small businesses, which led to the acceleration of the process of concentration and monopolisation of biotechnology industry by large biotech companies (Schimmelpfennig, Pray, Brennan, 2004). Biotech industries in the West certainly felt these changes. However, the global biotech industry has proven to be relatively immune to the world economic crisis, which is indicated by only a 10% decrease in the number of biotech companies worldwide . Currently, research and major investments in the biotechnology sector are mainly aimed at the pharmaceutical industry (primarily oncology, diabetics and autoimmune diseases) (Aggarwal, 2010). The decline in the attractiveness of biotechnology research in the field of DNA and genetic modifications was also attributable to restrictive provisions in the legislation (including patent law) in many countries, and changes in social attitudes to transgenic products (Neo-Luddism).

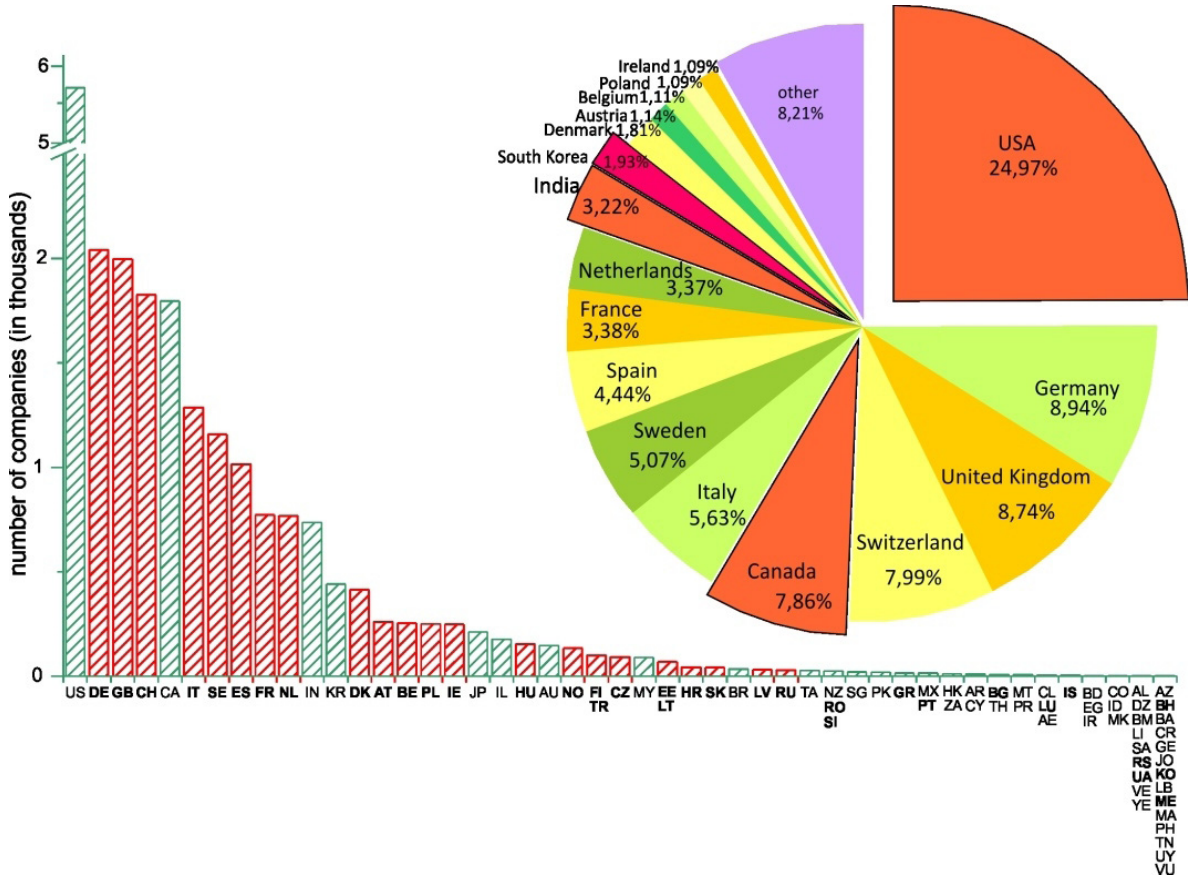

Fig. 2. The number and global share of the biotech companies in 2011.

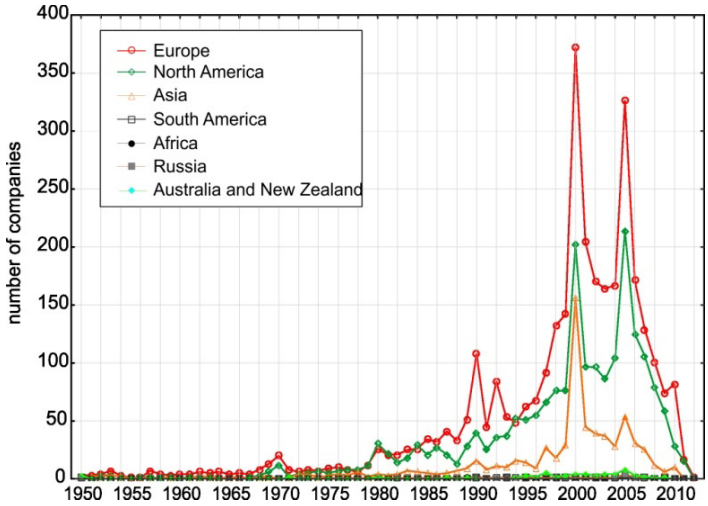

Fig. 3. Number of newly established biotech companies in the continents in years1950-2011.

Between 1950 and 2010, in the analyzed regions the number of biotech companies came up from approximately 800 to more than 2,000 (Fig. 4), which represents a nearly 3-fold growth. In the period, the biggest number of biotech companies operating in South Asia, increasing from 300 to nearly 740, representing 36% of the total (Fig. 4, 5a) and Eastern Asia, with the number going up from 230 in 1950 to nearly 700 in 2010 and its share grew from 28.5% to 33.7% of the total. The Middle East is less developed in this respect with 115 companies in 1950 and more than 300 biotech companies in 2010 i.e. reporting a growth from 15% to 16% of all biotech companies globally. The fewest biotech companies operate in Oceania – from 80 companies in 1950 to nearly 170 companies in 2010, i.e. approx. 11% to approx. 8% of the total as well as in the South-Eastern Asia, with the number of biotech companies coming up from 20 to nearly 120 and its share dropping from 7% to 6%. The earliest and the highest growth in the number of biotech companies was reported in Eastern Asia in 2000 and, next, in South-Eastern Asia (Fig. 5B).

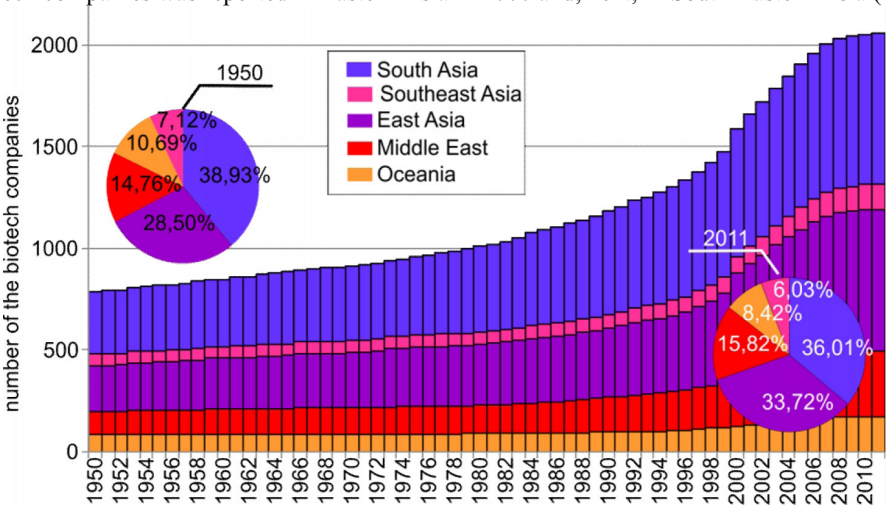

Fig. 4. Number and share of the biotech companies in studied regions in years 1950-2010.

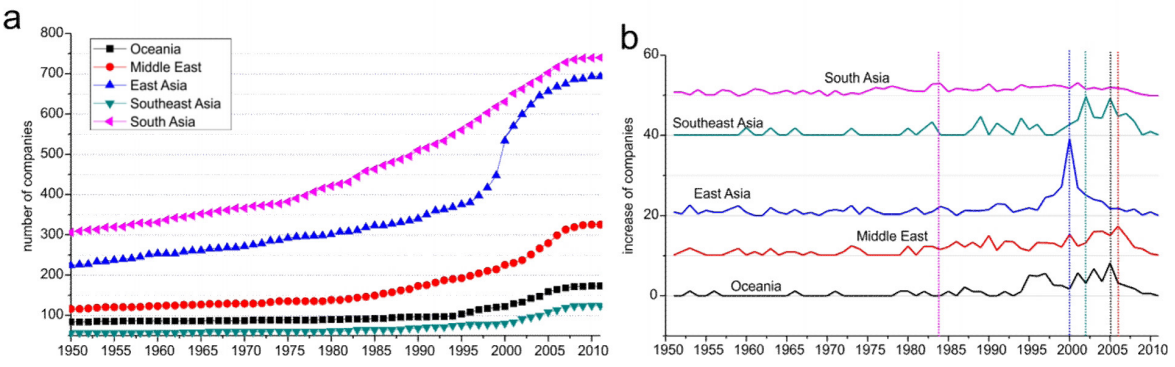

Fig. 5 (a) Number of the biotech companies in studied regions in years 1950-2010; (b) increase of the biotech companies in studied regions in years 1950-2010.

The biotech industries of many Asian economies have developed competitive niches in specific industry segments. Analyzing the biotech industry sectors in Asia one may notice that between 1950 and 2010, they were dominated by the public sector companies from 200 to approx. 375 and companies from other sectors – from 125 to 350 (Fig. 6a). Pharma sector companies played an important role, with their number going up on a regular basis from approximately 100 to 250. In the late 1990., a rapid growth in the importance of companies from the R&D and

Technology and Diagnostics sectors was reported, with their number increasing from approx. 170 and 140 in 1998 to 325 and 270, respectively in 2010 (Fig. 6a), going significantly above the number of companies from the pharma sector. Partnering strategies offer an important way forward in health R&D, i.e. enable access to non-dilutive financing and help companies to build a global network of partners that can support core commercial activities and give companies a foothold in emerging economies that are increasingly important to their commercial strategies (Biotechno. Bring Innovation to Neglect Research and Development, 2012). The Medical Technology and Professional Services and Consulting sectors reported the lowest number of biotech companies but, having said that, their number was also growing on a regular basis in the period.

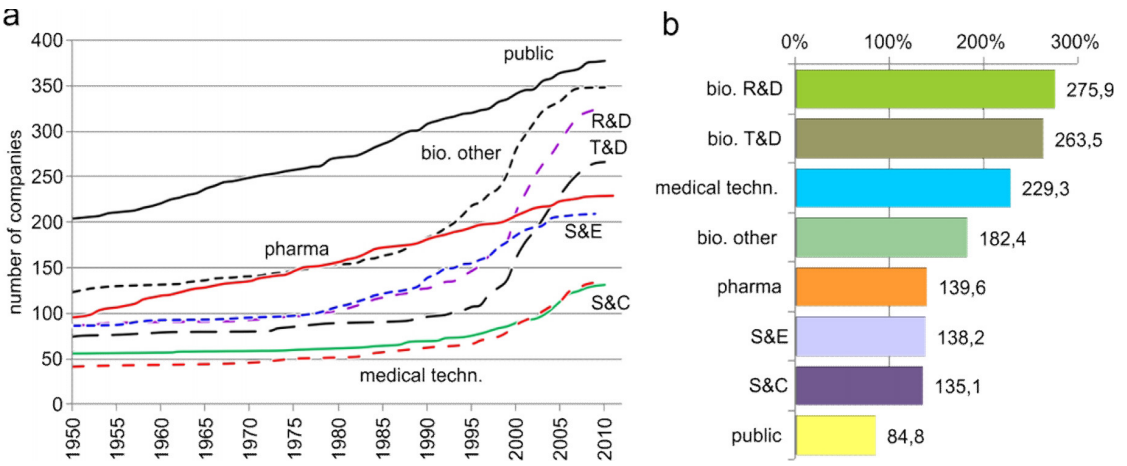

Fig. 6. (a) Number of the biotech companies by sectors in years 1950-2010; (b) increase of the biotech companies by sectors in years 2010.

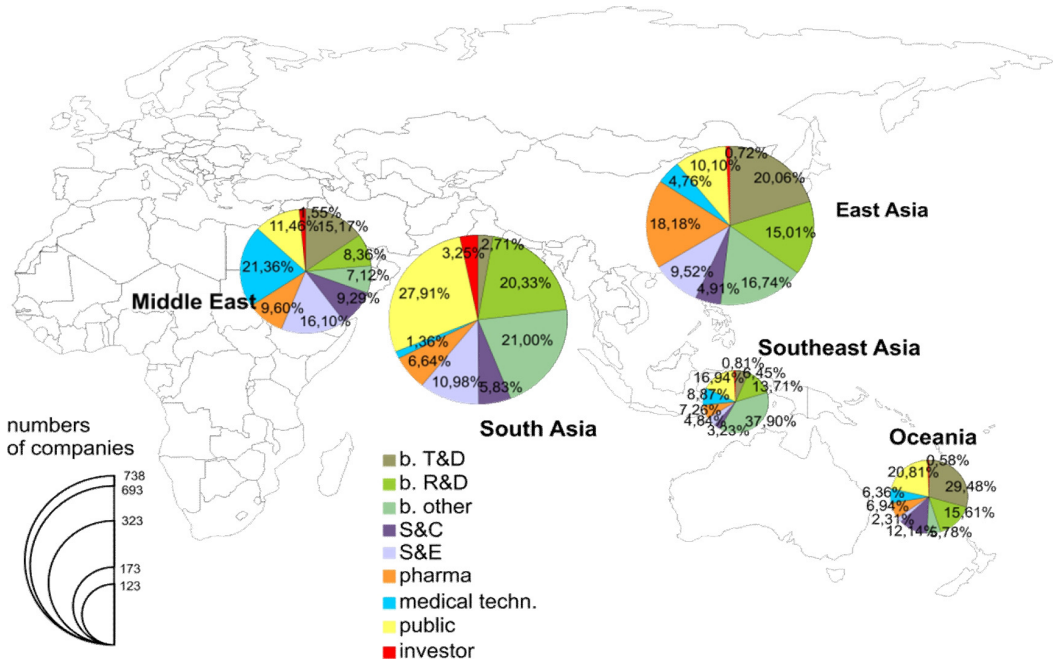

Fig. 7. The structure of the biotech companies by sectors in 2011.

The variety of the biotech sectors is large in the analyzed regions. In South Asia, the public sector reported the largest share of the biotech companies in 2011 to reach nearly 28% of all companies (Fig. 7). Eastern Asia and Oceania is dominated by the Therapeutics and Diagnostics sector with their share at 20% and 29.5%, respectively. The Medical Technology sector dominates in the Middle East (approaching 22%) and others in South-East Asia (nearly 38%).

Another factor illustrating differentiation in the biotech sector development in Asia is their number and their structure. India is the most developed country in the analyzed regions in the biotech sector, with the number of biotech companies growing between 1950 and 2011 from 300 to 734 (Fig. 8, 9). The main factors of rapid growth of the India's biotechnology industry in recent years are low costs, skilled workers, patents reforms and a support of the government who is responding with the reforms to encourage innovation and streamline regulations (Beyond borders. Global biotechnology report, 2009, Wilkie, 2004). The next one is South Korea, where the number increase from aprox. 130 to 441 companies, where is relatively well-developed educational, research, financial and industrial infrastructure as well as the government support who revised "Patent Law" and creates a more optimal legal environment for health biotechnology development (Wong et. al., 2004). Japan, Israel, Australia, Turkey and Malaysia follow suit. In addition, the countries boast the highest annual average growth in the biotech-involved companies (Fig. 9). The Japanese government has been taking steps to improve Japan's regulatory and framework and promote the development of a globally competitive drug-development industry. The financial crisis could bring new buying opportunities and increased deals for Japanese big pharma companies (Beyond borders. Global biotechnology report, 2009). Israel has a very open scientific regulatory environment, and has become one of the leading countries in stem cell research. What is more, it is a part of the international stem cell forum. Israel has universities with excellent quality of their research in the life sciences which provide the basis for a vibrant biotechnology industry (Bell et all, 2006). Australia is characterized by well developed research facilities, world-class scientist and a strong but flexible regulatory. There are many opportunities for investment, from investing with Australian research entitles to setting up operations as a gateway to the fast growing Asia-Pacific market and establishing R&D collaboration and centers. The fewest biotech companies are located in the Philippines, Tunisia, Morocco, Lebanon, Jordan, Georgia, Bahrain, Azerbaijan and Vanuatu (1).

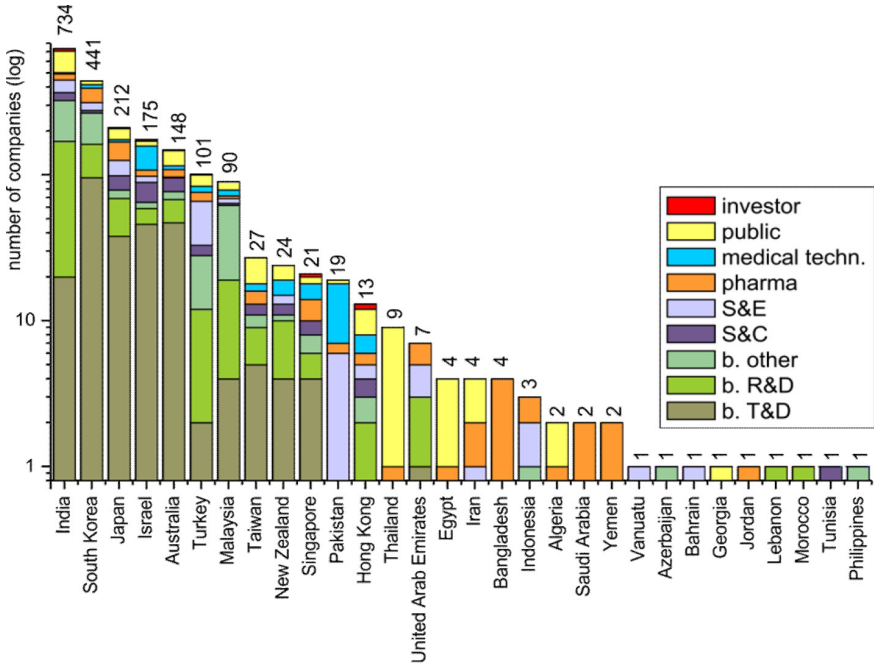

Fig. 8. The number and structure of biotech companies by country in 2011.

Differentiation of biotech sector companies is very large in Asian countries, with the highest differentiation reported in countries with highly developed biotech sector, where typically all types of biotech companies are represented (Fig. 8). These countries are clearly dominated by Technology & Diagnostics sector companies and R&D companies as the second largest branch of the sector (Fig. 8). Furthermore, these are the countries which work rapidly on developing their international financial and consulting relations (Winiarczyk – Raźniak and Raźniak, 2012; Raźniak and Winiarczyk-Raźniak, 2013). On the other hand, countries at the initial stage of their biotech industry development have a significantly less differentiated structure of the industry as it is typically represented by several companies which are typically not in the avant-garde of innovation. These are mainly pharmaceutical companies (production companies often taken over by international corporations in order to give an easier access to the domestic market), Supplier & Engineering sector companies and other biotech companies, which typically work for the agriculture or service companies). In developing countries, one can clearly see a large share of public institutions (hospitals, universities, non-profit organizations or societies) which also exist in developed countries; however, their role is different, as in the developing countries they represent both scientific support and stimulate commercialization of research. Note that the share of the R&D sector in the biotech reported the highest growth from approx. 276% and the T&D sector to reach nearly 264% (Fig. 8). The share of the public sector reported the lowest growth to approx. 85%.

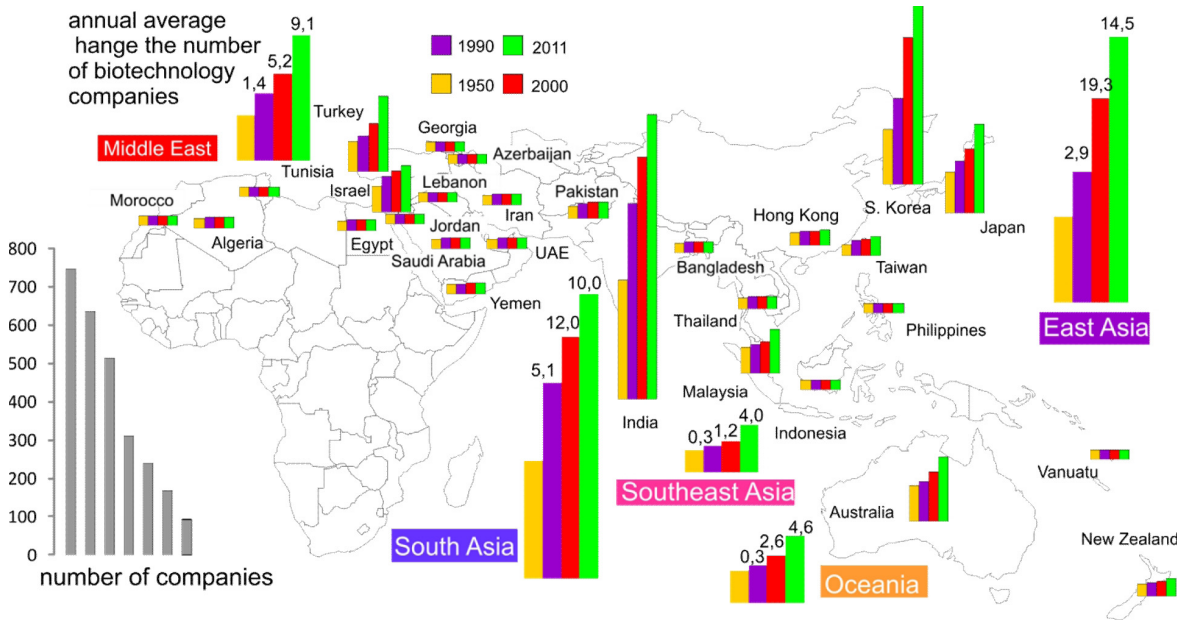

Fig. 9. The number of biotech companies in analyzed regions and countries.

Analyzing the ownership structure of biotech companies in Asia, one finds that, in most countries, the institutions which specialize in the field are privately owned and represent nearly 82% of all corporations (Fig. 10). The ownership structure depends on the industry sector: in the Supplier & Engineering, Service & Consulting and Medical Technology sectors, approximately 89% of companies are privately owned compared to 80.5% in the biotech sector and nearly 51% in the pharma sector; owners are often global companies (Raźniak, 2012). In most countries analyzed for the purpose of this paper, it is the only type of ownership. The largest share of public and state-subsidised biotech institutions was reported in developing countries such as Jordan or Pakistan. Biotechnology is the economic sector having the strongest links to scientific and research institutions when considering innovative economy sectors. However, the links in developed and developing countries have a different dimension. In developed countries, private institutions stimulate research activities of public institutions, while in developing

countries research is financed by the state (research grants, scholarships), while research results are used by private companies or spin offs (Rothaermel and Deeds, 2004; Ukropcova and Sturdik, 2009). India is the leader in terms of the number of universities and spin-offs – 36, i.e. approx. 5% of all biotech companies, followed by Japan with 16 i.e. 7.5% and Australia with 14 i.e. 9.5% (Fig. 11). The share of universities whose offer is linked to the biotech industry is also high in Turkey. The Turkish State recognizes biotechnologies as the priority are and one is likely to see a greater emphasis on the subject. Currently, there are few biotechnology-based industries in Turkey but the government is very eager to promote such industries (Sevarcan, Ozan, Haris, 2000). In case of such countries like Algeria, Hong-Kong or Iran, the number of institutions ranges from 1 to 3, representing as much as 50% of all biotech companies.

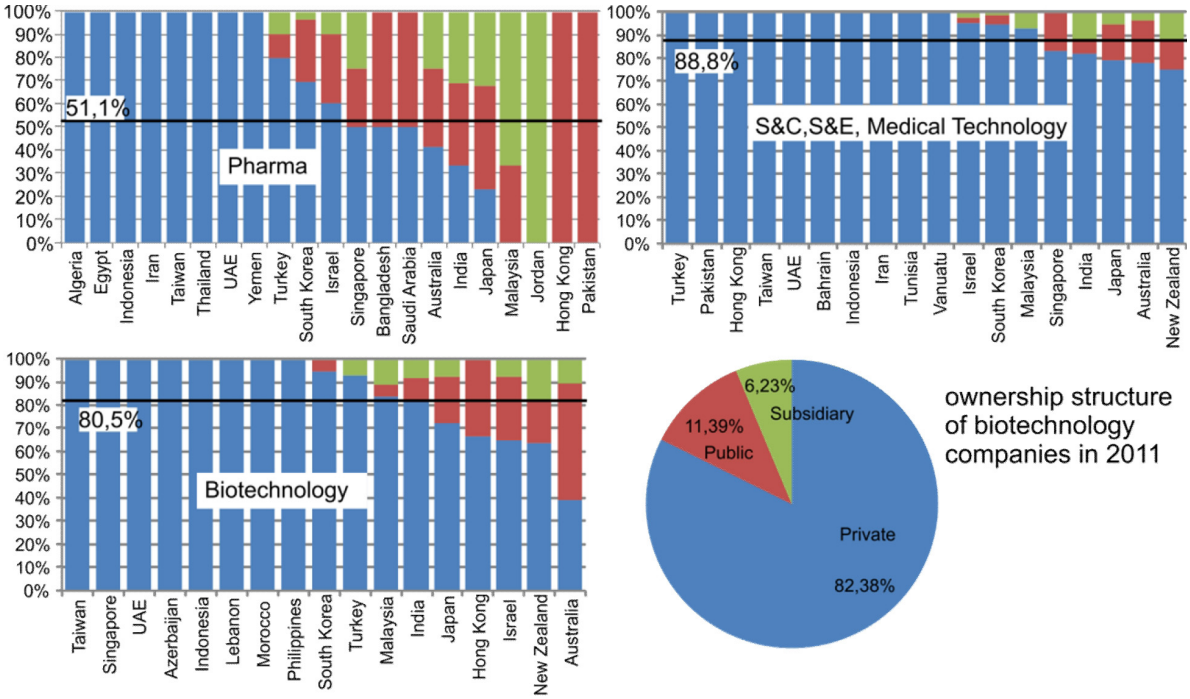

Fig. 10. The ownership structure of biotech companies in 2011.

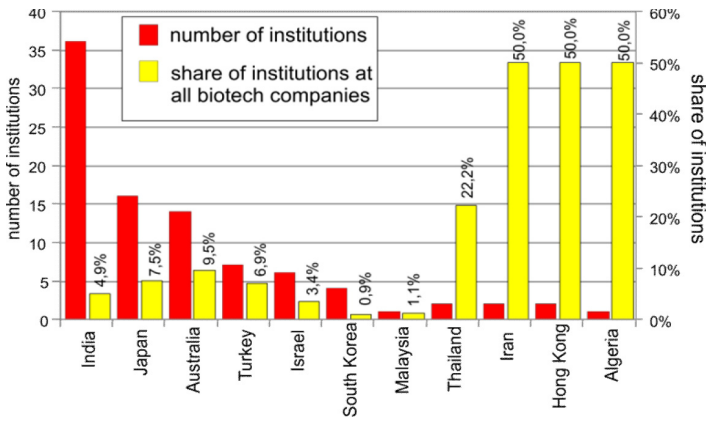

Fig. 11. Number of the universities and spin off institutions in the biotech industry in 2011.

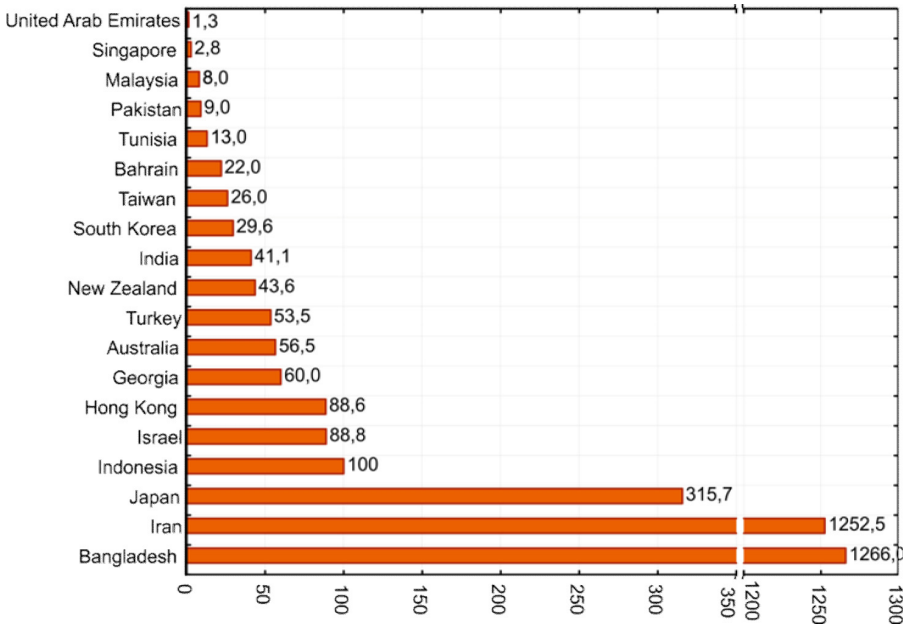

Fig. 12. Number of empoyees in biotech companies in 2011.

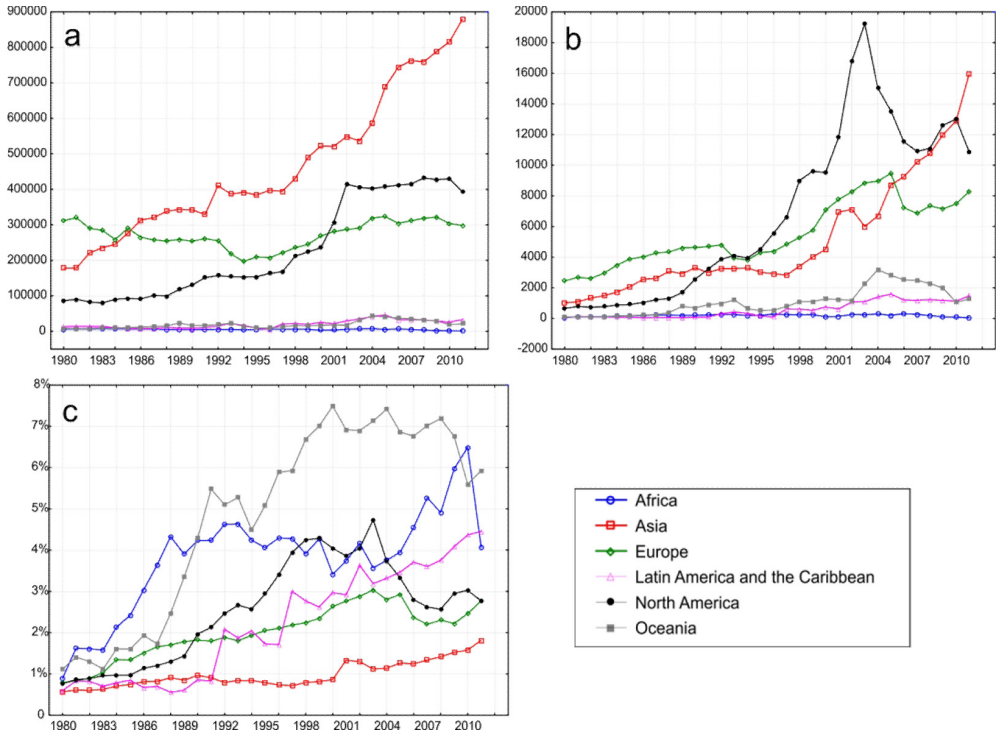

Fig. 13 (a) The number of patents publications in the world ; (b) biotech patents publications; (c) share of biotech patents publications in patents publications in general.

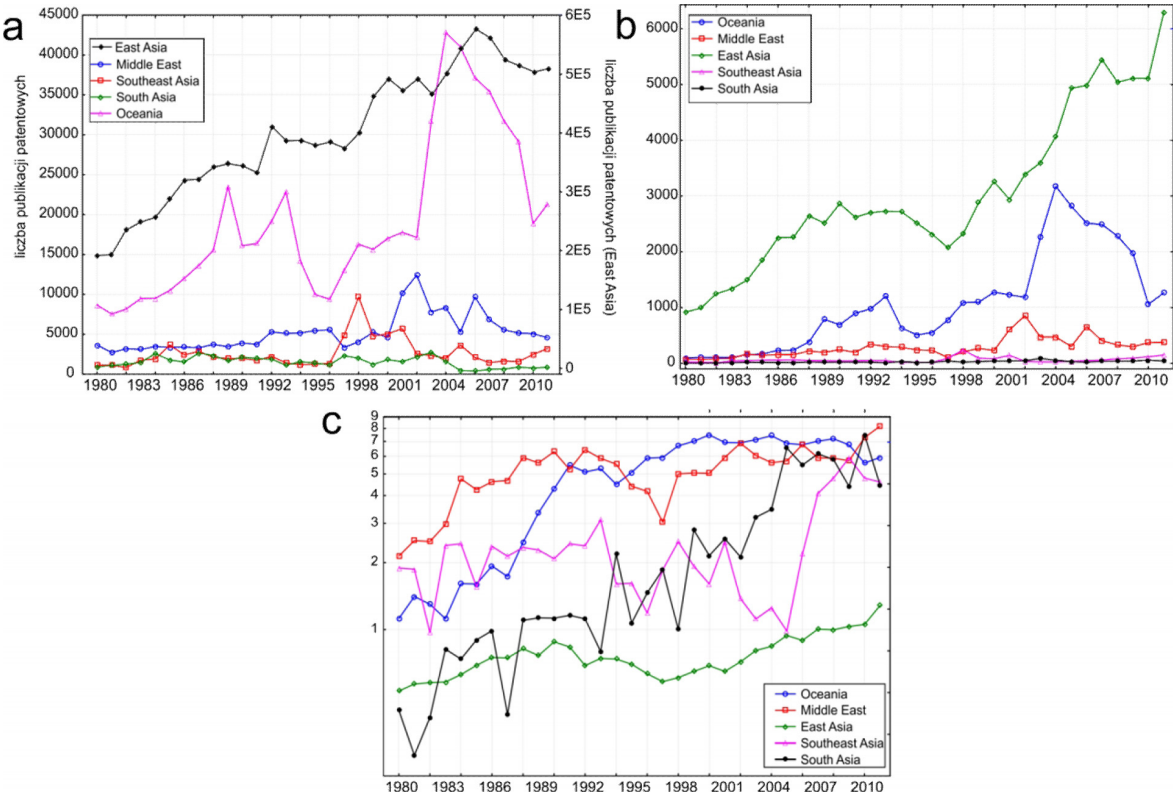

Fig. 14 (a) Number of patents publications in studied regions; (b) biotech patents publications; (c) share of biotech patents publications in patents publications in general.

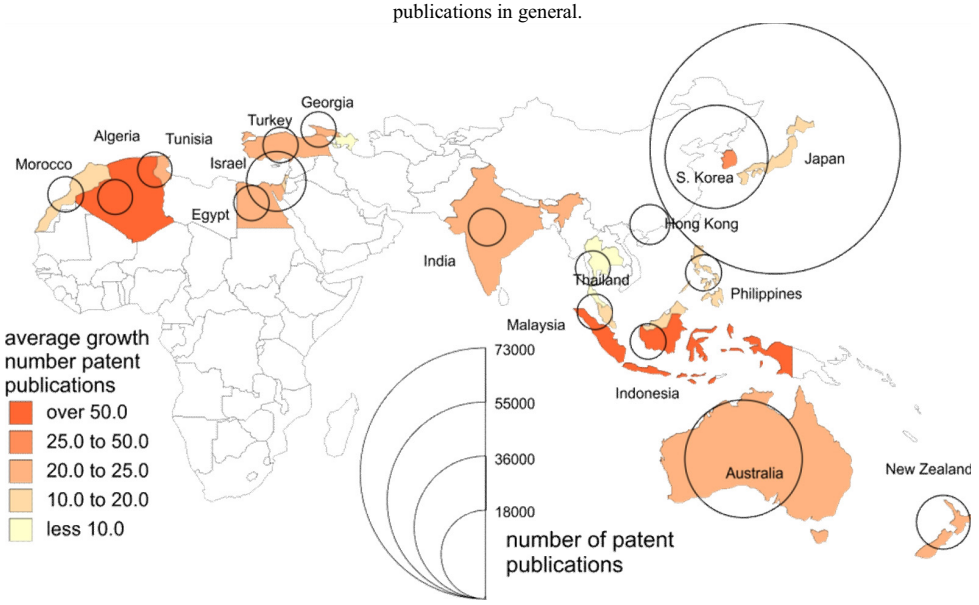

Fig. 15. Patents publications by countries in 2011.

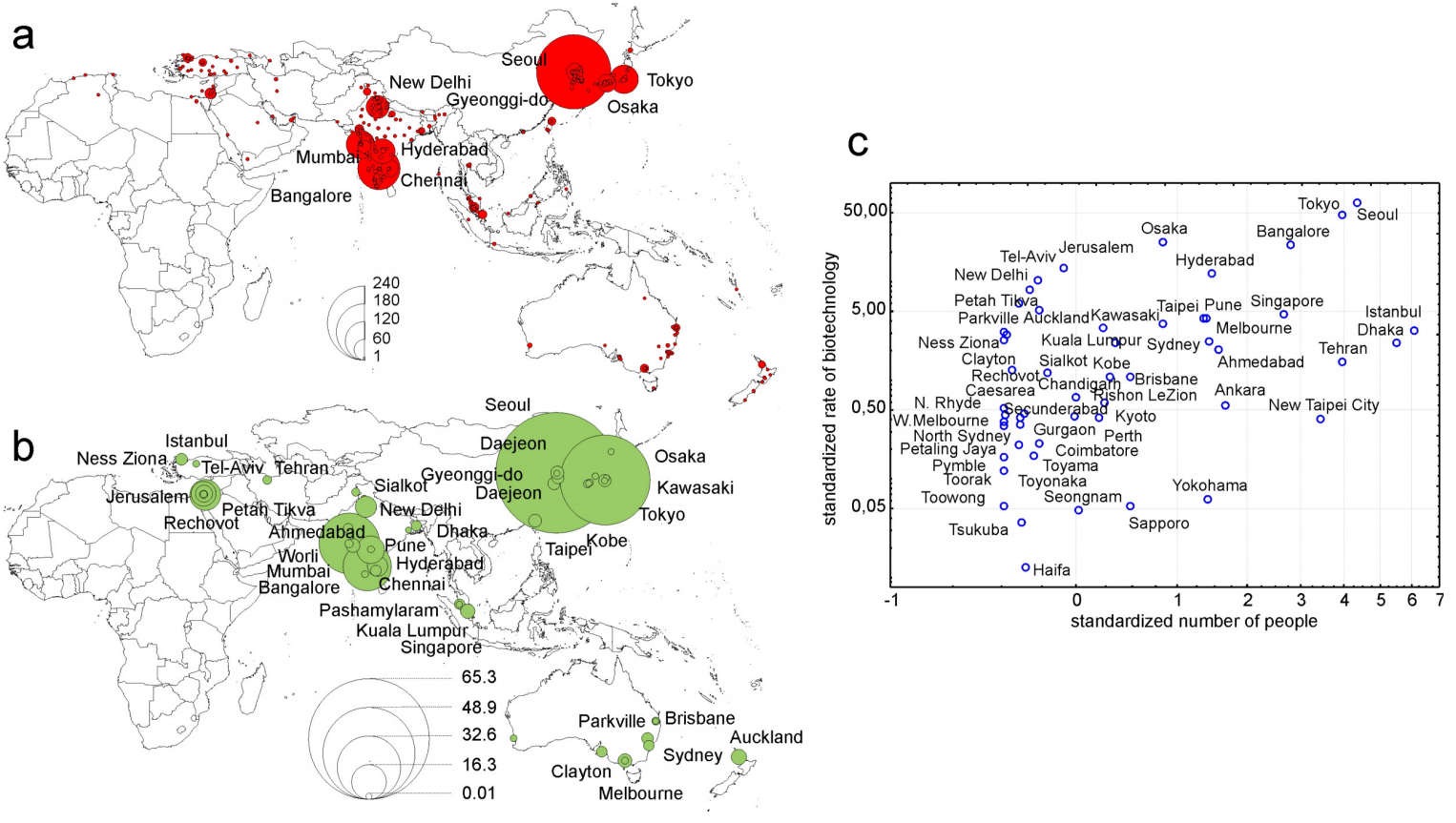

Fig. 16. (a) The number of biotech companies in cities of the analyzed regions in 2011; (b) standardized value of the biotech the development in the cities; (C) the relation between the number of the biotech companies and the size of the city.

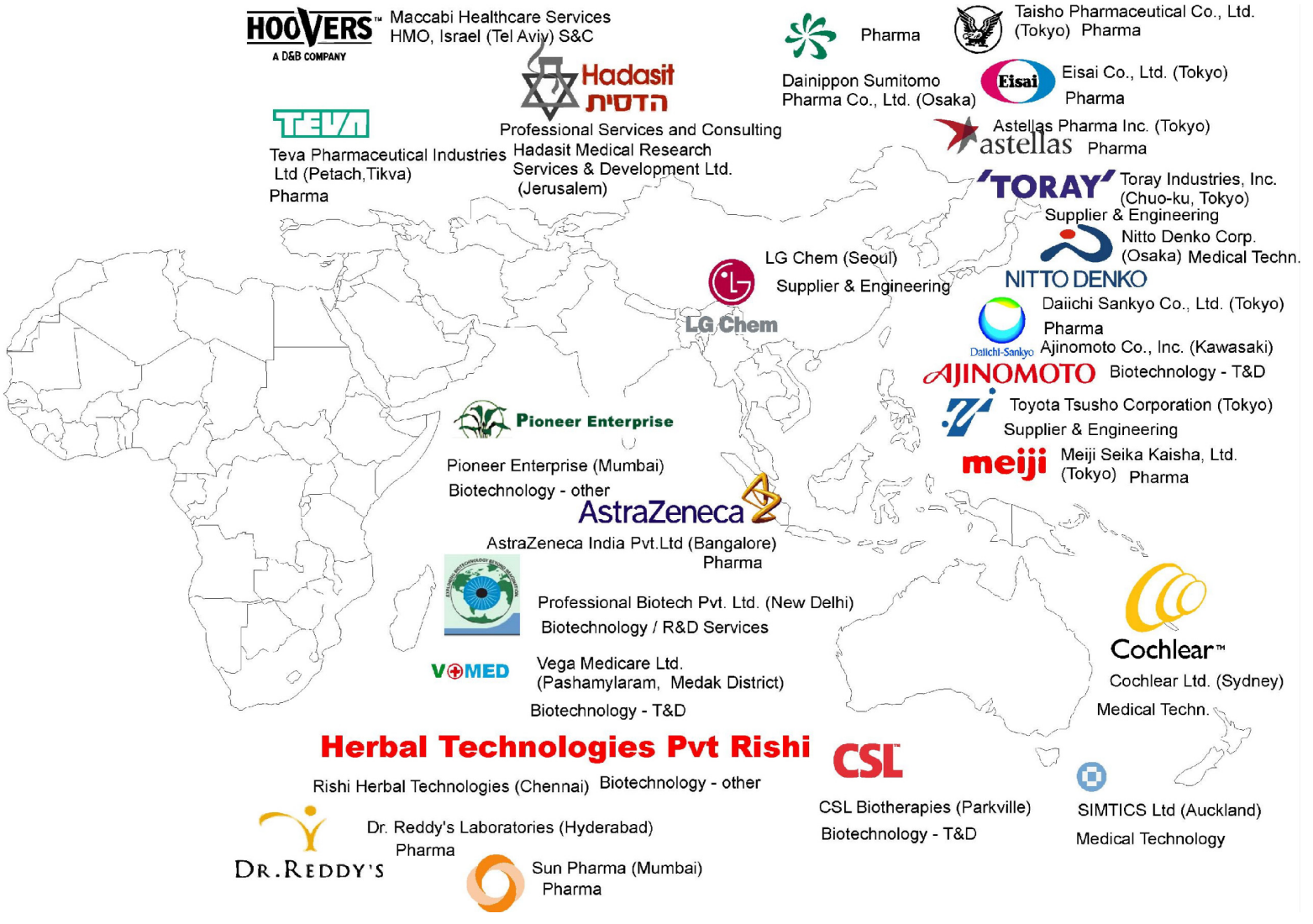

Fig. 17. The biggest biotech companies in studied regions in 2011 by the synthetic index based on: income value, production and employment.

Another indicator which illustrates the differentiation in the biotech sector in Asia is the average size of companies, determined by the number of staff. In 2011, biotech companies from Bangladesh and Iran reported the highest number of staff among companies in the sector, with more than 1,250 employees, followed by Japan – 315 (Fig. 12). The United Arabic Emirates with 1 employee and Singapore with 3 employees reported the lowest number of staff.

3. Publications

Commercialization of the biotech sector often requires remote completion dates as a result of difficulties in raising funds for high-risk investment. For this reason, legal regulations and protection of the intellectual property rights in the form of patents are so important for development of biotechnology.

Between 1980 and 2002, the number of patent publications in Asia went up from nearly 200,000 to more than 5 million to grow rapidly later on and, while other continents remained stable or even reported a decline in the number of publications, in 2010 it went up to reach 9 million (Fig. 13a). Research institutes and universities are the biggest contributors to knowledge production on the basis of the biotechnology publications. Universities play the key role in training experts and lead in publishing.

A growth in the biotech patent publication number was the same as the growth above, to reach a 16-fold increase between 1980 and 2010 i.e. 16,000 (Fig. 13b), and their share in total patent publications increased from 0.5% to nearly 2% (a 4-fold increase) (Fig. 13c). This rapid growth of patent submissions in 1990 came as a consequence of intensified research in human genome. The current drop results from more restrictive patent criteria applied to genetic inventions and restricted opportunities for drawing benefits from technological development.

East Asia was the leader in the analyzed region when considering the number of patent publications from 1980 to 2010 with 1,500 to nearly 4,000 publications, while South Asia came last with the number of patent publications at nearly 2,500 to drop to 1,000 from 2002 (Fig. 14a). The same applied to biotechnology sector patent publications, with their highest number published in East Asia and growing from 1980 to 2010 from 1,000 to more than 6,000 publications and the South Asia publishing around 100 publications (Fig. 14b). The Middle East and Oceania had the largest share of biotechnology patent publications in total publications (Fig. 14c).

In 2011, Japan had the highest number of biotech publications (73,000) followed by Australia and South Korea (36,000 each) (Fig. 15). The highest average growth in the number of publications was reported for Indonesia, Malaysia and Algeria – not more than 50 publications per year. Indonesia and Algeria demonstrated the highest dependence between the number of biotech patent publications and their change in 1980 – 2010 (Fig. 15).

Biotech firms show a great diversity in terms of their numbers in various cities in Asia. The great number of cities where companies of this type are present are the biggest cities, mainly the capital cities and the industrial centers. Typically, biotech companies are located in the vicinity of universities, providing access to the highly skilled workforce, highly developed research and technical infrastructure as well as to financial resources. For this reason the development of biotechnology is mainly linked to: Seoul, Tokyo, Osaka, Bangalore, Mumbai, Hyderabad and Chennai (Fig. 16a). The interdependence between the standardized value of biotechnology and a standardized population in Asian cities varies e.g. the interdependence is high in case of cities like Seoul or Tokyo, where both figures are high; on the other hand, it cannot be observed in Jordan or Tel-Aviv which have a high standardized value of biotechnology and a low standardized value of the population figure (Fig. 16c). The standardized value of biotechnology development is another indicator illustrating the varied spread of biotech industry development. It indicates that the most biotech advanced cities in the regions are: Seoul (the indicator at 65.3) and Tokyo (48.9), followed by Mumbai (32.6) and Bangalore (16.3) (Fig. 16b).

The largest biotech companies operating on the Asian market specialize predominantly in the biotechnology service and biotech devices sector e.g. Professional Biotech PvT. Ltd w New Delhi, Hadasit in Jerusalem and, in the pharma sector, e.g. Astra Zenca India PvT.Ltd in New Delhi, Meiji Seika Kaisha. Ltd., Astellas Pharma Inc., aisho Pharmaceutical Co.Ltd. in Tokyo (Fig. 17). Biotech companies operating in the field of farming, agriculture and food sector (GMO) come second, followed by biotech R&D companies. These are international corporations,

chiefly from the pharma sector, typically located in developed countries such as Japan, India and Israel as well as in Australia.

4. Conclusions

The spatial and structural diversity of the biotech industry in the world is very large. Most significant role in the development of this sector is played by economically developed countries, namely United States of America and then by European countries, mainly Germany, Great Britain, Switzerland, Italy and Sweden. Nevertheless the dynamic expansion of biotechnology takes place in new centers of biotech development in Asian countries Turkey, India, South Korea and Japan.

The analysis of the data in Asian regions showed that the biotech industry is mostly developed in large cities, mainly due to the access to highly qualified specialists, scientific and research centers, and developed infrastructure. Generally, pharmaceutical sector, biotechnology services and device servicing sector are the most advanced and developed, followed by the food industry and the R&D sector. At present, the majority of biotech companies operates in Easter and Southern Asia, with the dominant position of India followed by South Korea and Japan. Biotech companies are typically private.

However, the challenges and opportunities of Asia in the biotech industry need to be explored.

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