487

Int. J Sup. Chain. Mgt   Vol. 9, No. 5, October 2020

Supply Chain Management in High-Tech Industries Clusterization: Market Monopoly or Development of Competitive Advantages?

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Abstract— **With the rapid industrial cluster development, in particular the development of high-tech cluster, the supply chain management strategy in cluster is also undergoing profound changes. The study uses open-source statistical data, as well as research results and world rankings as the basis for a descriptive analysis of the external environment for the development of high-tech industries. Two main indicators were selected for the analysis: the GDP per capita growth rate and the level of information and communication development, which are used to assess competitiveness, the level of economic development, innovation and entrepreneurship. The purpose of the study is to examine the features of the innovation policy of developed countries and its impact on supply chain management in high tech industries for clustering them. As a result, it was concluded that the modern macroeconomic environment is characterized by digital transformation trends, as well as decreased geographical influences. Industrial supply chain managements are developed based on the interaction of environmental factors, demand conditions, production factors, and auxiliary industries.**

Keywords—*supply chain management, high-tech industry, clustrization, innovation, competitiveness, information and communication technologies, blockchain technology.*

1. Introduction

Technology supply chain managers are under significant pressure to manage costs and minimize time to market—all while optimizing logistics and maximizing ROI, especially with increasing budgets for ever-growing infrastructure, development and research efforts. The competitiveness of a country is usually determined by the competitiveness of its enterprises directly involved in the domestic and foreign market competition. The Fourth Industrial Revolution (Industry 4.0) is rapidly changing all economic sectors both at the national and macroeconomic levels. The competitiveness of a country is related to the competitiveness of national companies in both domestic and foreign markets. In the modern world, the competitiveness of a country is determined by long-term factors: the use of innovations and global integration.

Economic development specialists around the world are increasingly using industrial supply chain models to identify, validate and support local and regional industry groups. SCM as an economic model seem quite promising in terms of providing competitive advantages. Michael Porter, the author of The Competitive Advantage of Nations [1] popularized the use of cluster methodology for regional analysis. The competitiveness of a nation or region is based on the ability of industries to integrate into a deep network that supports the geographic concentration of companies, institutions, customers and their complementarity [2].

Clusters go beyond the scope of agglomeration — they describe agglomeration in sets of related industries rather than in general economic activity. Clusters are found both in cities and rural areas. Clusters are also sectors that reflect specific geography of economic activities. The emergence of industrial clusters around the world is an organizational manifestation in the development of the economy, which plays an important role in regional competitiveness. An industrial cluster is a group of enterprises formed by the same, similar and related industries. Industrial clusters are naturally formed in response to the development of industrial parks or high-tech industrial zones.

The Fourth Industrial Revolution is associated with new fundamental changes in the functioning of national economies. Clusterization of high-tech industries has a significant impact on the formation of competitiveness and sustainable development of the economy. First of all, it should be noted that supply chain clusters are the sources of innovation; therefore, researchers and practitioners have been paying more and more attention to the identification of factors that stimulate innovation in a cluster, especially in a high-tech one.

2. Literature review

The structure of competitiveness is based on a number of important factors, ranging from broad institutional and macroeconomic political conditions to specific microeconomic factors. Among microeconomic factors, the emphasis has traditionally been placed on the rules governing competition in the market, as well as on the analysis of the skills, infrastructure and capital that form the entrepreneurial ecosystem [3]. In [1] notes that clusters are a component of a broader concept of competitiveness. Local competitiveness is determined by a combination of factors that reflect differences related to productivity and prosperity in different places. Porter also emphasizes that these factors interact systemically, that is, their impact on productivity depends on the quality of many other aspects of the local business environment.

Most studies on regional clusters focus on identifying factors and processes that contribute to cluster growth. However, sometimes technologies and market conditions change. This leads to a change and reduction of clusters. The article [4] analyzes the decline of the wireless cluster in Denmark. Entrepreneurship has a positive impact on the cluster adaptive capabilities while multinational companies have a contradictory effect: they bring new resources to the cluster and quickly disappear in times of crisis [4].

The twentieth-century literature on agglomerations, industrial districts, and industry clusters laid the groundwork for understanding industrial concentration, the ways it is supported, as well as the role of a company in this process. After Alfred Marshall recognized the concentration of industry in certain regions, there were many studies on the phenomena of agglomerations, industrial areas and industrial clusters. The monograph [5] analyzes research on the development and deployment of skilled workers in the regions, as well as the establishment and management of relationships in the regions and outside their territory.

The emergence of industrial clusters around the world is an organizational manifestation in the development of the economy, which plays an important role in increasing regional competitiveness. The article [6] analyzes the formation of various types of industrial clusters and investigates the development trends of the integration of urban agglomerations, industrial clusters and industrial parks.

Industry dynamics in a region is analyzed based on cluster theory. However, the definitions and categorization of clusters differ, which makes it difficult to develop econometric models for cluster analysis. The authors of [7] propose empirical measures to identify reliable clusters that are important for prosperous regions. In addition, they evaluated the correlation between cluster performance indicators and four traditional indicators of economic efficiency: GDP growth, employee productivity, remuneration per employee and personal income.

The article [8] states that the effective development of local policies requires a deep understanding of spatial diversity laws, including the integration of the knowledge from geography, economics, and management. Based on the empirical analysis of UK diversity over the 1995 to 2002 period, the authors of [8] conclude that policies promoting long-term diversity are an essential complement to key sector-oriented policies.

Microdata-based methods for analyzing spatial models of firms are presented in a number of works. In this context, the spatial distribution of firms is regarded as a point structure and an industrial cluster is formed due to the excessive concentration of one industry relative to the concentration of comparative spatial distribution. The paper [9] suggests a parametric approach to the analysis of spatial heterogeneity through the example of spatial distribution analysis of high-tech industries in Milan (Italy) in 2001. The authors believe that economic space is heterogeneous; they evaluate the nature of heterogeneity and use it to separate spatial heterogeneity from spatial dependence. The work [10] analyzes the influence of cluster linkages on innovation at the firm level in the context of one cluster, in which there is a network of high-tech manufacturing firms. The authors of [11] examine green technology companies operating in San Francisco, New York, and London in order to determine their specialization and underlying technological and market complementarity, as well as specific clusters.

The study [12] notes that an effective cluster policy should start with the identification of the areas with high cluster potential. The article presents an original method for identifying potential clusters and its practical evaluation in Russian regions. The authors show that most government-supported pilot innovation territorial clusters are being developed in regions and sectors with high cluster potential.

Thus, it can be concluded that many researchers agree that economy clusterization leads to the development of competitiveness. However, the authors of some studies note that globalization and the transition to the post-industrial society significantly modify the traditional spatial approach to determining the factors that influence the cluster formation and development. It should be mentioned that high-tech industries are characterized by the active use of information technologies, including blockchain technologies, digitalization and the introduction of the concept of Industry 4.0. This points to the fact that there is a need for a more in-depth study of the phenomenon of clustering in the new economic and technological conditions. Based on empirical research and literature review, this paper uses the system dynamics methodology to establish variables and their interrelations of two key approaches that were, to the

489

Int. J Sup. Chain. Mgt   Vol. 9, No. 5, October 2020

best of our knowledge, only analyzed independently up to now: i) Industrial cluster organization; and ii) Supply chain networks.

2.1. Problem Statement

The creation of an innovative economy based on entrepreneurship is one of the main goals of modern transformations. The process of developing economic relations in the countries that are reforming or developing their economic systems is difficult and contradictory. According to global statistics, investments in information and communication technologies have a positive impact on productivity, unemployment and GDP. The key factors distinguishing digital economy from the traditional one are as follows: geographical location is no longer a competitive advantage; trading platforms, the development level of communication networks, as well as the use of big data in business play the major role [13]. On the other hand, traditional industrial structures and business models are being destroyed due to innovations in new products and services, changes in the structure of costs, lower entry barriers and value changes. To respond to these challenges, a successful economy has to create appropriate mechanisms to reduce the risk of new financial crises and manage the socio-economic effect of innovation.

It is important to stress that the process of identifying, analyzing and supporting industry clusters requires a significant amount of time, resources and cooperation between regional and local stakeholders. In the same manner that it takes a region several years to develop a competitive economy of interconnected industries, the process of developing a broad and comprehensive understanding of industry clusters is of long continuance and may never end.

The Fourth Industrial Revolution is associated with new fundamental changes in the functioning of national economies. High production rates and the formation of new demands reveal important business opportunities and quickly introduce a big amount of new information. It is in digital technologies that the investments are being made and the world's human and financial resources are being accumulated. Modern information technologies have become more popular in the countries with a high level of GDP to economically active population. Therefore, it is important to analyze the features and prerequisites for the development of socio-economic factors contributing to the development of advanced technologies.

The purpose of the study is to examine the features of the innovation policy of developed countries and its impact on cluster formation. To achieve the goal, it is necessary to analyze the key indicators affecting the competitiveness and innovativeness of economies at the macro and micro levels.

3. Methods and materials

In this sense, a supply chain cluster can be defined as follows: "A geographical concentration of local processes, activities and/or services that can be put gathered to add value to one or more global supply chains.". The main criterion for determining the level of development of the country's economy is GDP per capita. The study is based on the publicly available statistics for various countries [14-16]. In addition to the level of economic development, it is important to determine the factors affecting the development of entrepreneurship and competitiveness. To do this, we analyze the values of advanced indices that study this problem from various perspectives.

The Global Competitiveness Index (GCI) 4.0 assesses the factors that collectively determine the productivity growth in the era of the Fourth Industrial Revolution (Industry 4.0) [17]. The new index [17] allows conducting the most complete analysis of various factors that determine economy competitiveness.

The Global Entrepreneurship Index (GEI) is an economic activity index compiled by the American Global Entrepreneurship and Development Institute, which examines how individual countries around the world allocate resources to promoting entrepreneurship development [18]. It should be noted that the entrepreneurship development conditions are associated with the presence of shadow economy [19, 20]. Even countries with a developed system of economic relations are not immune to the shadow economy. This is due to the dual nature of the shadow economy and its close relationship with entrepreneurship.

One of the central functions of entrepreneurship is the development and implementation of innovative technologies in production. Given the fact that entrepreneurial activity forms the basis of market relations, it is advisable to study external factors affecting the development of enterprises. Modern scientific literature offers many approaches and analysis methods for forecasting the external environment of enterprises. Each of these methods can be used to analyze the external environment of the enterprise. However, it should be noted that none of them provides an unambiguously correct assessment of the environment due to the subjectivity of the significance and influence of each factor. The analysis of entrepreneurial activity around the world is carried out by the Association of Universities, Business Schools and Research Centers (GEM), which conducts entrepreneurship research based on surveys [21]. The studied data are internationally comparable and show the structure and level of entrepreneurial activity, as well as evaluate its impact on economic growth.

To achieve the research objectives, it is necessary to conduct a descriptive analysis of developed and rapidly developing countries based on the indices listed above. The initial assessment of the statistical data collected

490

Int. J Sup. Chain. Mgt   Vol. 9, No. 5, October 2020

from various independent sources allows us to identify the factors determining the external conditions for the clusterization of high-tech industries and the trends for increasing their competitiveness.

4. Results

The high-tech industry tries on transformation and efficiency—creating world-leading products in supply chain management, then manufacturing and distributing them quickly and easily. Of course, behind every innovation is a vast, complex, international, high-tech supply chain. For supply chain teams in technology companies, managing raw materials, parts and finished products through the high-tech sourcing and manufacturing process is a massive challenge. Based on the publicly available statistics, the GDP indicators are assessed. GDP per capita and GDP growth rates are analyzed. Table 1 shows the information that was used in the analysis.

Table 1. GDP growth rates [22]

	2013	2014	2015	2016	2017	2018
Japan	2.0	0.4	1.2	0.6	1.9	0.8
Singapore	4.8	3.9	2.9	3.0	3.7	3.1
South Korea	3.2	3.2	2.8	2.9	3.2	2.7
China	7.8	7.3	6.9	6.7	6.8	6.6
Thailand	2.7	1.0	3.1	3.4	4.0	4.1
India	6.4	7.4	8.0	8.2	7.2	6.8
Russia	1.8	0.7	-2.3	0.3	1.6	2.3

China is the largest export economy in the world. In 2017, China exported and imported 2.41 thousand dollars and1.54 thousand dollars, respectively. In 2017, China's GDP was 12.2 thousand dollars and its GDP per capita amounted to 16.8 thousand dollars. India is the 17th largest export economy in the world. According to experts, Russia is the 14th largest export economy in the world. In 2017, Russia's export surplus amounted to $ 120 billion. Russia's GDP amounted to 1.58 thousand dollars, and GDP per capita - 25.5 thousand dollars.

The GCI Index analyzes competitiveness along 12 pillars: institutions, macroeconomic environment, infrastructure, higher education and training, health and primary education, technological readiness, goods market efficiency, labour market efficiency, business sophistication and innovation [17]. They are assigned different weights depending on each economy development stage; this is expressed through GDP per capita and the share of exports represented by mineral raw materials. Let us consider the data calculated for various groups of countries (Fig. 1). The analysis shows that European and North American countries traditionally lead the world; therefore, the competitiveness index also correlates with income levels.
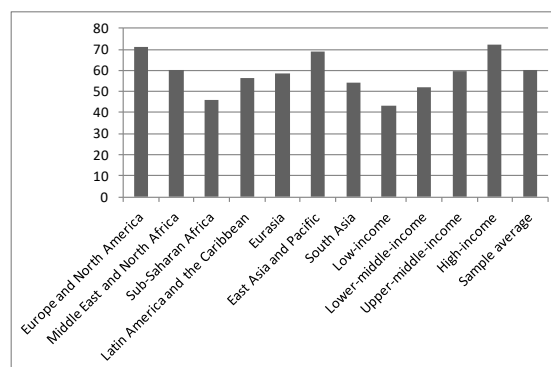

Figure 1. Global Competitiveness Index 4.0 (based on [17])

The regional analysis showed that the ICT Adoption Index is very low in raw material producing countries; it approaches the value of the Competitiveness Index in the regions dominated by developed countries. Based on the data presented in the World Economic Forum report [17], it can be concluded that Singapore ranks first with the total score of 84.8 out of 100 and the United States is the country closest to the border of competitiveness (83.7 points). The United States is followed by Germany (81.2), Japan (82.3) and the United Kingdom (81.2). There is a 30-point gap between the United States and Argentina (57.5), which is the worst economy in terms of competitiveness. Hong Kong also ranks in the top ten countries; in 2019, it won the third place. The Asia-Pacific region is the most competitive region in the world, followed by Europe and North America. The Nordic countries are the most technologically advanced, innovative and dynamic in the world: they provide the best living conditions and social protection. Denmark, Uruguay and Zimbabwe have significantly increased their share of renewable energy compared to other countries with the proper competitiveness level.

Europe consists of a very competitive northwest, a relatively competitive southwest, a growing northeastern region and a lagging southeast area. Russia ranks 43rd in the world; it has not changed its position despite the improvement of 1.1 points. It is worthy of note that the macroeconomic environment (43rd place) has improved significantly (+2.5 points and increased by 12 positions). In addition, Russia has improved its innovation potential by 2.2 points (32nd place) due to the quality improvement of its research institutes (9th place) and constant R&D expenses (1.1% of GDP, 34th place). Innovation is also supported by the ICT implementation (+4.9 points, 22nd place) due to the rapid penetration of the Internet that has reached 81% of the population (39th place). Human resources are characterized by a less positive trend (–0.2 points, 54th place). Although the level of education is relatively high (38th place), the quality of education does not meet the requirements of the modern economy. Financial system is the second area where Russia still

491

Int. J Sup. Chain. Mgt   Vol. 9, No. 5, October 2020

has to bridge the competitiveness gap (55.7, 95th place).

The competitiveness of the Latin American and Caribbean region remains unstable and can be negatively affected by a number of factors. The competitiveness in the Middle East and North Africa is different: Israel (76.6) and the United Arab Emirates (73.4) are leaders in the region. Seventeen out of the 34 sub-Saharan countries that were surveyed are among the 20 countries with the lowest competitiveness.

The Global Entrepreneurship Index (GEI) takes into account various aspects of the entrepreneurial ecosystem, including how individual countries around the world allocate resources to promoting entrepreneurship development [18]. The use of digital technologies in all spheres of social and economic life affects almost all economic and social aspects: the way individuals and organizations interact, communicate, learn, work, do business and spend their free time. Digitalization affects business, healthcare, education, culture, government, human services, transportation, people's lifestyle with no regard to their place of living. Table 2 shows the dynamics of the Index for the leading countries.

Table 2. Global entrepreneurship index (fragment), based on [18]

	2015	2016	2017	2018	2019
The USA	85.00	86.20	83.37	83.61	86.80
Switzerland	68.60	67.80	77.96	80.45	82.20
Canada	81.50	79.50	75.60	79.25	80.40
Great Britain	72.70	67.70	71.29	77.75	77.50
Australia	77.60	78.00	72.51	75.45	72.10
Denmark	71.40	76.00	74.06	74.31	79.3
Iceland	70.40	68.90	73.49	74.15	73.00
Ireland	65.30	65.60	70.96	73.72	71.30
Sweden	71.80	75.90	75.47	73.11	70.20
France	67.30	66.40	64.09	68.51	67.10
Holland	66.50	65.40	67.79	68.15	72.30
Finland	65.70	61.80	66.91	67.9	70.20
Hong Kong	45.90	45.40	46.38	67.35	67.90
Austria	64.90	62.90	63.46	66.02	73.10
Germany	67.40	64.60	64.87	65.93	66.70
Israel	59.90	57.40	59.08	65.44	67.90
Belgium	65.50	62.10	62.98	63.7	62.20
Taiwan	69.10	69.70	60.68	59.48	62.10
Chile	63.20	62.10	58.85	58.52	58.30
Russia	31.70	32.20	25.43	25.22	24.80

Predictably, the countries influenced by low GDP factors are at the bottom of the entrepreneurship ranking. At the same time, the entrepreneurial activities of these countries are the most balanced. However, in some countries, including Russia, a higher level of entrepreneurship should be noted, which is determined by their development trends and more effective use of entrepreneurial resources. Entrepreneurial relations, abilities and aspirations are used as sub-indices and determine the final value of the index. For Russia, the values of these sub-indices are 27.0 (80th place), 27.6 (67th place) and 19.6 (93rd place), respectively.

Many researchers note that the main motive that determines shadow entrepreneurial activity is the natural struggle for survival and raising the standard of living, as well as the desire to be rich. According to the study [20], the share of the shadow sector in GDP does not exceed 12-15%, while in outsiders this indicator reaches 64%. This suggests that a high level of the shadow economy creates conditions for inadequate enrichment, development of corruption schemes and bureaucracy. Empirical studies have shown that the main shadow economy factors are the tax rate, the employment rate, the import of goods and services, GDP and the participation of people of working age in the labor market. On the other hand, shadow economy makes it possible to develop entrepreneurship in the context of transforming economic relations through the realization of natural needs for wealth. The positive side of the shadow sector is confirmed by the fact that developed economies are also characterized by the presence of the shadow sector; in this case, shadow economy makes up 12-15% of the country's GDP.

The analysis results indicate that information and communication factors, as well as network factors, have the greatest influence; they are followed by social factors. This confirms the assumption that in the modern information era, domestic factors have a smaller impact on the development of entrepreneurship, and the availability of global information resources is crucial. Social factors are also important. This is due to the nature of entrepreneurial activity related to the provision of life necessities. The structure of companies, groups and societies is becoming more flexible in terms of their processes and standards.

5. Discussion

The truth is that the basis of the competitiveness moved from between countries to between companies

and their supply chains, and nowadays, between global supply networks and their local components in the industrial clusters. Adaptive opportunities and cluster evolution should be studied based on their interaction taking into account the development of industry, technology and institutions, as well as heterogeneous activities of firms. The article [4] examines the processes of cluster destruction. The conclusions made in the article are based on a detailed study of the wireless communications cluster in Denmark. A high-tech cluster emerged in the 1980s and rapidly grew during the 1990s; however, in 2004 it started to decline. There were three periods of destruction: the first occurred in the 1980s, the second - in the early 2000s and the third - in 2009.

The connection between the innovative urban agglomeration and the industrial cluster is characterized by mutual promotion and coordinated development in a particular region. The article [6] evaluates innovative urban agglomerations, industrial clusters and industrial parks. An important criterion for assessing industrial clusters is a high degree of internal interconnection between regional economic and social relations. Collectively, innovative urban agglomerations, industrial clusters and industrial parks are subject to the laws of symbiosis, interaction, competition and cooperation, as well as innovation multiplication. The development of a regional entrepreneurial ecosystem and an institutional culture that will foster innovation is important for those regions where industrial clusters do not have local advantages [6].

The formation of sectoral clusters is an important element of competitiveness. Sectoral clusters are created when competitive advantages stimulate the growth, movement or development of similar industries in the region. In turn, sectoral clusters enhance competitiveness by increasing productivity, stimulating new innovative partnerships among competitors and providing opportunities for entrepreneurial activities.

According to many authors, the introduction and development of modern ICT solutions are one of the key factors of the digital economy development [13, 23, 24]. It is significant investments in the ICT sector and the development of the IT sector that can contribute to creating a strong economy based on knowledge, information and blockchain technologies. The European Union is dealing with fundamental issues related to its future development. The key issue is the role of European integration in increasing the competitiveness and prosperity of Europe [23]. The new model aimed at increasing the competitiveness of Europe is determined by the opportunities brought about by digitalization and, as the study shows, is an important component of the competitiveness strategy in the modern world.

The diagnostic analysis of external factors affecting innovative development shows the importance of the information and communication

sector, modern digital and blockchain technologies. This is also confirmed by the results presented, for example, in [24, 25]. In particular, the authors of [25] conduct research on digital shadow economy. Transition to an innovative economy is the main direction of economic development in modern conditions. However, the large size of the shadow sector affects investment decision-making. As a result, the level of investment and the investment attractiveness of the country are reduced. This eliminates conditions for the development of entrepreneurship.

6. Conclusions

In the modern world, a large number of heterogeneous enterprises gather in a certain geographical location and form an entrepreneurial ecosystem. Therefore, external competence building through supply chain integration as seamless flows of resource coalitions is essential for enhanced competitive performance. In the absence of public investment, private enterprises with clearly defined property rights can spontaneously form a network of mutual competition and cooperation, which affects the level of development of industrial areas and industrial clusters in different regions. Clusters can combine different types of enterprises: industrial enterprises, service providers, end-product manufacturers, as well as enterprises that implement individual stages of production or sales.

Clusters are the geographical concentration of interconnected companies and institutions in a particular area. SCM often combine many related industries. For example, they are suppliers of specialized resources, such as components, equipment and services, and suppliers of infrastructure. Many clusters include state and other institutions such as universities, standards developing organizations, think tanks, institutes for vocational training and trade associations that provide specialized training, education, information, research, and technical support.

Investments in digital infrastructure and an effective digital economy are currently considered the main condition for maintaining and developing international competitiveness. The digital economy development can support the process of convergence and bridging the development gap between regions. In this context, the results of the comparative analysis that we conducted confirm the hypothesis about the key role of the digital economy transformation in the modern world.

Industrial clusters are developed based on the interaction of environmental factors, demand conditions, production factors, and auxiliary industries. However, their competitiveness and sustainable functioning depend on innovation, especially on the degree of integration into digitalization processes and compliance with the requirements of the Fourth Industrial Revolution. A developed innovation ecosystem will allow overcoming technological lag in production and transferring to a knowledge economy.

In conditions of a market economy and global competition, the reengineering of innovative corporations will be a determining factor in the competition, providing conditions for sustainable development and increased competitiveness. Based on the study, further developments will be focused on the formation of applied programs to increase the degree of adaptability of corporations to changing environmental conditions.

For successful management of innovation, a prerequisite is the formation and use of a holistic organizational and economic management mechanism, which would provide for a clear ordering of its elements and the effectiveness of their interactions. Therefore, the corporate research institute of Kazakhmys Corporation in cooperation with the International Innovation and Production Consortium "R&IID" will become a practical base for further developments. The latter are full-fledged elements of the industrial and innovative infrastructure of the Eurasian region.

Future development applications will focus on:
- integration of innovation in Eurasia;
- creating a synergistic effect and diffusion of the transfer of innovations between Eurasian clusters, accelerating their technological modernization;
- increasing the competitiveness and sustainable development of research base corporations;
- creation of a mechanism for training and retraining of personnel on the basis of public-private partnerships, where innovative clusters are actively involved.

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494

Int. J Sup. Chain. Mgt   Vol. 9, No. 5, October 2020

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