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Dynamics and Factors of Innovation Gap Between the European Union and China

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Abstract

The article focuses on the problem of innovation gap in the world economy, as there are in general countries with developed national innovation systems, playing the role of technology leaders, and those with developing innovation systems, acting as innovation followers. Western European economies belong usually to the first group whereas China is traditionally classified in the second group; however, the analysis conducted in this study reveals a continuous catch-up process of this country towards the European Union in terms of the level of innovativeness of the economy. The purpose of this paper is to measure the dynamics of innovation gap between China and the EU average, and to identify the determinants of its evolution. Although for most of the analyzed indicators related to innovation, China's performance is much below the EU average, the growth rates for Chinese economy in 2008–2018 have been higher than these of the EU, indicating convergence process. The key to development success in China lies in closing the technological gap by importing existing technology, and strengthening internal capabilities to utilize and improve on those technologies. Different reasons for China's economy improvement in terms of innovativeness are analyzed, including external factors (e.g., foreign direct investments, which are concentrated mostly in eastern provinces, and associated technology transfer) and internal aspects (like science, technology and innovation policy, investment in research and development, and emergence of innovative regional clusters). The conclusion is that dynamic processes of increasing innovative potential of China provide with a solid fundamental for further convergence and diminishing innovation gap between this country and the European Union.

Keywords Innovativeness · Innovation gap · Technology transfer · Clusters · Research and development · China · Innovation divide

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Introduction

The research problem that is receiving an increasing interest in international economics is structural changes taking place in the world economy, especially the shift of manufacturing activity, including high and medium-high technology industries, to emerging countries, mainly China. Whereas traditionally, research and development (R&D)-led technological progress was concentrated in developed countries, which generated most of the innovation (Furman and Hayes 2004; Dosi et al. 2006), nowadays we witness the emergence of innovation hubs in developing economies, out of which China is making a considerable progress in innovation performance. A significant change in the geography of innovation poses a challenge for developed countries, like the Western European economies, which are being at risk of losing their knowledge-related sources of competitive advantage. This calls to provide new insights into innovation policy that the European Union (EU) should take in order to maintain its position as one of the most innovative group of countries in the world economy. This research concentrates on the scientific problem of convergence in innovation performance between China and the EU. The key objectives of this paper are to measure the dynamics of innovation gap between China and the EU average and to identify the determinants of its evolution. The research questions are as follows:

1) What is the level of innovation gap between China and the EU, and how it has been evolving in the period under analysis?
2) Is innovation gap between China and the European Union persistent or do they diminish in the long run?
3) What are the determinants of innovation performance of Chinese and European economy, including internal (e.g., investment in Research and Development (R&D) or emergence of innovative regional clusters), and external (e.g., international technology transfer through foreign direct investments (FDI)) factors?

The timeframe of the research in this project covers the period since 2008, i.e., the beginning of the world's financial crises. The observations on the structural changes in the world innovation system and the need to search for the answers to the presented above research questions and problems lead to the formulation of the following hypotheses for this study: the European Union has an innovation lead over China, but the innovation gap between these two economies has been diminishing since 2008. Among different factors determining fast improvement in innovation performance of Chinese economy, there are science, technology, and innovation (STI) policy, emergence of dynamic innovative clusters, huge investments in R&D, human capital development, and international technology transfer through FDI.

Theoretical part of the study is based on critical literature review in the area of innovation gap, convergence in innovation performance, measuring the level of innovativeness of the economy, determinants of innovativeness, and innovation systems, including clusters. Empirical part of research includes statistical analysis of the level of innovativeness of analyzed economies, and measuring innovation gaps and convergence/divergence processes, both for innovation capabilities (input indicators, connected with, e.g., R&D expenditures or human capital development) and for innovation position (output indicators).

Definition of Innovation, and Problems Related to Measuring Innovativeness

Recent studies on the drivers of economic growth have demonstrated the significant role of innovation (Mtar and Belazreg 2020). An innovation is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process) (OECD/Eurostat 2018, p. 32). A common feature of all kinds of innovation is that they have been implemented. By definition, all innovations contain a degree of novelty. There are three levels of the novelty of innovations: new to the firm, new to the market, and new to the world. It means that not all innovations in a specific economy must result from its own R&D—they may be transferred from abroad, and implemented in a specific domestic or regional context. This is an important characteristic of innovation for countries with developing innovation systems relying primarily on external technology, like China. When comparing different economies in the world economy with respect to innovativeness, one cannot forget about the relatively new phenomenon in global economy that is globalization of innovative activities, referred to as the techno-globalism. It includes activities aimed at creating of new ideas, their application, and international diffusion.

Innovations are typically considered an element of characteristics of an enterprise. It is possible, however, to perceive innovativeness from the macroeconomic perspective. Innovativeness of economy is usually defined as "the ability of a given economy to create innovation, where *ex ante* is the potential to create innovations and *ex post* is the total effect of innovative activities of enterprises functioning in the economy in a given period of time." (Weresa 2002, p. 14). The implications of this definition are the two concepts: "innovative ability" and "innovative position." The first term denotes the extent to which a given country is capable of creating and commercializing new ideas, while innovative position means the effect of the creativity of a nation combined with financial resources in a given economic and institutional environment (Weresa 2012, p. 32). The prevailing opinion in the economic literature is that the innovativeness of economies is an evolving process, where the ability to create and introduce changes is the function of knowledge and experiences gained before (Soete 1981; Weresa 2002, 2012).

The analysis of the innovative ability and innovative position may be connected by examining the relationship between these two elements to assess the effectiveness of the innovation system, which denotes how effectually a country transforms inputs into results (e.g., Dutta et al. 2018; Nasierowski 2019).

Due to the complicated nature of innovativeness, the measurement approaches and methodologies presented in the theory and applied in practice constantly evolve. As no single universal method to measure that phenomenon has been established, a number of various approaches are used for this purpose. Both the theoretical models and the methods for developing internationally comparable indexes to measure innovativeness point out the need for multifaceted measurement of innovativeness (Kowalski and Michorowska 2014). For that reason, the set of selected indicators that allow for international comparisons between Europe and China should include those, which refer to innovation ability, and innovation position of an economy.

One of the most popular methodology for measuring innovativeness at the country level was developed in annually published report European Innovation Scoreboard

(Hollanders et al. 2019), in which Summary Innovation Index (SII) is developed. This is an example of composite indicator approach, which role has been significantly enhanced in recent years as the single indicator approach (e.g., R&D expenditures, number of patents) has been found to offer only a limited view of such a broad and complex concept such as innovation (Carayannis and Provance 2008; Tidd and Bessant 2018; Carayannis et al. 2016; 2018). SII reflects the distinction between innovative ability and innovation position of an economy, grouping indicators in the following sets:

1) Framework conditions, which capture the main drivers of innovation performance external to the firm, including the dimensions related to, e.g., human resources or attractive research systems
2) Investments, which capture investments in research and development (R&D) made in both the public and business sector
3) Innovation activities, which capture different aspects of innovation in the business sector, including different forms of Intellectual Property Rights (IPR)
4) Impacts, which capture the effects of firms' innovation activities, for example, sales impacts measures

For measuring innovativeness of the EU countries, a total of 27 indicators are used to calculate SII. However, for non-European countries, like China, data availability is more limited, so a more restricted set of 13 indicators has been constructed for the international comparisons, as presented in Table 1 in the empirical part of this study.

Literature Review on Innovation Gap in the World Economy

Theoretical background for this paper is formed by different studies on technological gap in the world economy (e.g., Posner 1961; Krugman 1979; Dollar 1986) and recently in the Central European countries (e.g., Kubielas 2016; Jian et al. 2015). It should be stated that innovation gap is a broader concept, encompassing also non-technological innovation, such as process, and organizational or social innovation. An important research challenge is to connect the topic of dynamics and determinants of innovation gap with the concept of innovation systems, which underlines the role of the organizational and institutional arrangements, such as the public policies (in particular STI policy), scientific units, and innovative enterprises, which are considered the most essential agents within national innovation systems (Lundvall 1992, 2007; Meuer et al. 2015; Rosenbusch et al. 2019). Similarly, there was a wide range of research on convergence process in the world economy, but usually they focus on income levels, especially GDP per capita. There is a strong need to explore determining factors, which impact convergence/divergence processes in innovativeness between different economies. Especially important is the analysis of the mechanism for closing innovation gap between countries with developed innovation systems, and countries with developing innovation systems, like China.

From a theoretical standpoint, technological differences across countries open the possibility for countries with low innovation profile to catch-up the rest of the countries by means of imitating more productive technologies applied in leader countries, as imitation is seen as a less expensive process than innovation (Altuzarra 2010). The

Table 1 China's innovation performance in selected indicators relative to the European Union

	Short name for indicator	Full name of an indicator	Relative performance	Difference in performance growth 2011–2018
Framework conditions	Doctorate graduates	New doctorate graduates (ISCED 8) per 1000 population aged 25–34	11.0	− 2.0%
	Tertiary education	Percentage population aged 25–34 having completed tertiary education	40.4	5.1%
	International co-publications	International scientific co-publications per million population	43.0	7.0%
	Most cited publications	Scientific publications among the top 10% most cited publications worldwide as % of total scientific publications of the country	79.6	17.2%
Investment	Public R&D	R&D expenditure in the public sector (percentage of GDP)	72.6	9.7%
	Business R&D	R&D expenditure in the business sector (percentage of GDP)	126.7	11.8%
Innovation activities	Public-private co-publications	Public-private co-publications per million population	106.5	− 10.4%
	Private co-funding of public R&D expenditures	Private co-funding of public R&D expenditures (percentage of GDP)	5.4	− 3.1%
	PCT patent applications	PCT patents applications per billion GDP (PPP USD)	91.7	24.8%
	Trademark applications	Trademark applications per billion GDP (in PPS)	296.6	62.3%
	Design applications	Design applications per billion GDP (in PPS)	202.6	− 10.0%
Impacts	Med&high tech product exports	Exports of medium and high technology products as a share of total product exports	91.9	− 4.6%
	Knowledge-intensive services exports	Knowledge-intensive services exports as percentage of total services exports	72.4	−19.4%

Source: based on data from European Innovation Scoreboard 2019 (Hollanders et al. 2019)

general tendency is that FDI technological spillover effects are stronger in Chinese regions where FDI inflow is spatially more concentrated (Cheung and Lin 2004), which shows the emerging high-technology clusters. This broadens the research area in this study with mesoeconomic dimension. Despite recent developments in information and communications technologies (ICT), which has rendered the "world flat" (Friedman 2005), many studies emphasize the role of geographical proximity as a key factor in the innovation process (e.g., Cooke et al. 2004; Balland et al. 2015; Chandrashekar and Bala Subrahmanya 2019). Although originally the concept of clusters, defined as "geographic concentrations of interconnected companies, suppliers, service providers, firms in related industries, and associated institutions (e.g., universities, standards agencies, and trade associations) in particular fields that compete but also cooperate" (Porter 1998), was used in order to explain business success of regional economies, they are now recognized as an important element of innovation systems, as they are grouping business and scientific units, facilitating knowledge flows, technology transfer, learning processes, and diffusion of innovation (Audretsch and Feldman 2004). Cluster structures are characterized by cooperation and geographical and sectoral concentration, which means that they constitute a joint element of regional (Cooke 2001) and sectoral (Malerba 2002) systems of innovation (Kowalski 2016). It is important to connect the topic of innovation gap in the world economy by extending cross-country analysis with mesoeconomic dimension (regional level), especially taking into account the emergence of innovative clusters and the polarization of innovation activity in China. It is connected with observation on dynamic emergence of clusters in China, especially centered in special economic zones (Zeng 2012), and this process is accompanied by intense increases in regional disparities in this country (Chen et al. 2014; Guo 2019).

Innovation Gap Between the EU and China

The European Union is facing increasing competition pressure from emerging economies, like China. The sources of competitive advantage of the developed countries in the last decades are connected with such factors, like knowledge and innovation as the USA, Japan, and Western Europe have been playing the role of technological leaders in the world economy. At the same time, the main source of competitive advantage of emerging countries have been cheap resources, with the most notable example of China and its huge reservoir of low-cost labor force, which led to specialization in labor-intensive industries. However, together with rapid structural changes in contemporary world economy, this traditional international division of labor has been going through profound transformation, with the spatial shift of manufacturing industries, including high and medium-high technology sectors, to developing countries (Ebenstein et al. 2015). This process is connected with intense international technology transfer and increasing innovative capacities of emerging economies, with the most notable example of China. Although the European Union remains well ahead of the BRIC (Brazil, Russia, India, and China) countries in terms of innovation performance, China is rapidly closing the gap (Tubbs 2010).

According to the European Innovation Scoreboard 2019 (Hollanders et al. 2019), the European Union has a performance lead (measured by SII) over China, but this lead has

been decreasing strongly in 2008–18, as presented in Fig. 1. In addition, in order to analyse the variability of analysed phenomena in time, dynamic index with variable base ($I_{i/i-1}$) and dynamic index with fixed base ($I_{i/2008}$) were calculated according to the following formula (after Anghelache and Manole 2012):

$$I_{i/i-1} = (SII_i/SII_{i-1})*100\%$$

$$I_{i/f} = (SII_i/SII_{2008})*100\%$$

Own Calculations Based on Data from European Innovation Scoreboard

In the above figure, scores are calculated by dividing the innovation index of China by that of the European Union, and expressed in percentage. The analysis shows that innovativeness of Chinese economy measured by this index has been improving, from 69% of the EU average in 2008 to 76% of the EU average in 2018. We can also observe increasing average values of dynamic indexes, calculated both with variable base and fixed base, indicating China's long-term catch-up process towards the EU in terms of innovation performance.

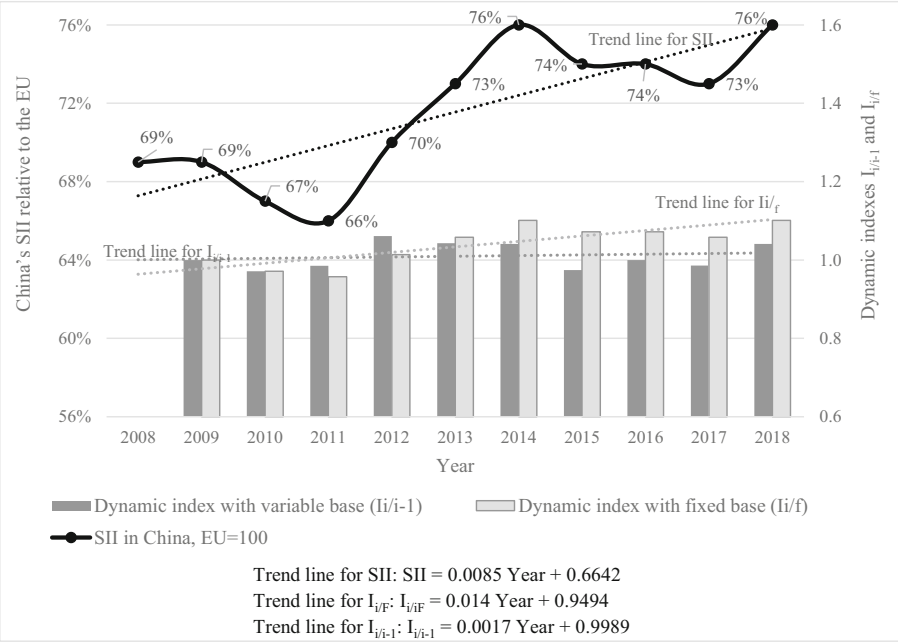

Fig. 1 China's innovation performance relative to the European Union

As it was mentioned in one of the previous sections of this study, data availability for China is more limited than for the European countries. Hence, a more restricted set of 13 indicators is used to conduct detailed analysis of Chinese innovation performance, as presented in Table 1. Performance scores equal 100 * China's indicator value divided by those of the EU. Growth differences are calculated by subtracting EU growth rates from those of China.

Analyzing particular indicators connected with innovativeness, it is observed that in most of them (9 out of 13), China has lower position then the EU average. At the same time, this country obtains higher growth rates for 7 out of 13 indicators, proving that it is converging to the EU in terms of innovation performance. In particular, relative strengths of China are in trademark and design applications, and business R&D expenditure.

Factors Affecting China's Convergence Towards Innovation Leaders

The observation on diminishing innovation gap between China and more innovative economies, including the European Union, may be mostly explained by factors which influence Chinese innovation performance, which are the subject of analysis in this section. In the past, China was mostly dependent on technology transfer from other economies. It is viewed as a country with developing innovation systems, focused not on creation of new, innovative solution, but rather their absorption from abroad and dissemination among domestic actors. However, with its massive investment in R&D in recent years, China is generally believed to be getting out from the stage of little in-house R&D. It is building up more R&D capability quickly, and is gradually becoming globally competitive with its own technology (Zhao 2015). However, the reason for China's transformation from imitator to innovator goes beyond R&D sector and lies in the interplay between industry, academic institutions, and government, as explained by the helix models (Carayannis and Campbell 2009; Carayannis et al. 2019). Parallel with investment in indigenous innovation, foreign technology transfer occurs, developing the absorptive capacity of Chinese firms and enabling them to make use of the foreign technology fully. Hence, there is synergy between external technology absorption and strengthening in-house R&D capability, helping China to move away from being an imitative latecomer to technology towards to being an innovation-driven economy (Fu et al. 2016).

One of the key factors stimulating innovation performance of the economy is Chinese STI policy. The strategic solution is provided by the Medium- and Long-Term S&T Development Plan 2006–2020, and in the short term by 13th Five-Year Plan (2016–2020), which followed the 12th Five-Year-Plan for Science and Technology Development 2011–2015. Among the most important strategic priorities, there are transforming China into an innovative society, promoting indigenous innovation, and contribution of science and technology sector to solve grand challenges in environment, energy, agriculture, and employment. At the operational level, the major funding agencies in Chinese innovation system are the Ministry of Science and Technology (MoST), the National Natural Science Foundation of China (NSFC), and the China Scholarship Council (CSC) affiliated to the Ministry of Education (MoE). In addition, the Chinese Academy of Sciences (CAS) runs programs supporting the researchers in R&D activities, with strong focus on engaging them into international cooperation.

Similarly to the European Union, an important role in China is played by innovation policy run at the regional level. In general, provinces and municipalities enjoy a high degree of autonomy in this area, and sub-national governments contribute a significant part of the total public investment in R&D. Strong concentration of investment in research in the east of China is observed, and there are also significant regional agencies providing science and technology funds, like Beijing Municipal Commission of Science and Technology (BMCST), Science and Technology Commission of Shanghai Municipality (STCSM), or Guangdong Provincial Department of Science & Technology (GPDST). It is worth to note that one of the key priorities in the activities of these agencies is to promote international scientific collaboration.

The study conducted by Guo et al. (2016) on one of the Chinese innovation policy instruments, Innovation Fund for Small and Medium Technology-based Firms (Innofund), proved that supported companies generate significantly higher technological and commercialized innovation outputs compared with their non-assisted counterparts and the same enterprises before winning the grant. Innofund is the largest government R&D programs that support R&D activities of small- and medium-sized enterprises in China. The results of the research also showed that the changes in the governance of this instrument in 2005 from a centralized to a decentralized one have positively influenced the effectiveness of the whole program. Lu (2016), analyzing China's design and innovation policy, recommends to provide national level funding for cutting-edge, universal technology research, and development from the one hand, and to offer local government support for information services, big data and cloud computing research, as well as local provision of engineering technology centers. Study by Rodríguez-Pose and Zhang (2020) demonstrates that government institutional quality matters for innovation. However, they reveal weak institutions for innovation in some of Chinese cities, finding that improving the rule of law, government quality and overall regulation, as well as fighting corruption can unleash a significant innovation potential that, otherwise, may remain untapped.

The study of Howell (2016) reveals that an important factor affecting firms' innovation activities in China is access to financial capital, which may be increased by a reduction in private enterprises corporate tax rate. In a long run, the market failure connected with underinvestment in private sector reduces the innovation success for more R&D intensive enterprises, reducing new product and process sales. Another important factor affecting Chinese innovation performance is inward foreign direct investments (FDI), which bring technology spillovers. There are many empirical studies on technological spillovers from FDI in China, but they generally show inconclusive results (e.g., Findlay 1978; Lipsey 2002; Saggi 2002; Qiu et al. 2009; Xu and Yu 2012; Lin and Kwan 2013; Long et al. 2014; Zhang and Gallagher 2016; Delis and Kyrkilis 2017; Dong et al. 2019). An important observation is that the FDI technological spillover effects in China are different in different regions (Song et al. 2015). The research conducted by Wang et al. (2016) shows that technological spillovers from FDI are important for China, but they are both regionally skewed and unevenly distributed. Results indicate that that industrial specialization diminishes the positive effects of FDI while a more diversified industrial structure increases spillovers from inward FDI.

Taking into account regional perspective is important because of the increasingly recognized importance of proximity in stimulating innovation processes, and an

observed strong geographical polarization of innovation activity at specific regions (Autant-Bernard et al. 2012), the trend which is very visible especially in China (Crescenzi et al. 2012; Zeng et al. 2019). In recent years, industrial clusters have been emerging very rapidly in both number and scale in China, especially in better developed provincial economies in the east along the coast (Kang 2007; Kiminami and Akira 2016; Knorringa and Khalid 2016; Hu et al. 2016; Wei et al. 2016; Wu et al. 2019). An example is Zhejiang province, one of the most prosperous coastal regions in China, including capital-intensive industries (Guo and Guo 2011). As the research of Herrerias and Ordóñez (2014) demonstrated, the growth rate of the stock of physical capital in eastern provinces is twice as high as in the western provinces during the post-reform period (after 1978), and one and a half times higher than in the central regions. However, although megacities, like Beijing and Shanghai, have long captured much of the spotlight as potential investment destinations, the real economic miracle of China occurs behind the scenes in second-tier cities, such as Wuhan, Ningbo, and Dalian, which have become important locations for high-technology clusters, like biotechnology industry (Wang et al. 2015). From this perspective, there is special role of the Belt and Road Initiative (BRI) aiming to connect Asia and Europe, as it may help to develop inland regions, with focus on the city clusters along the middle reaches of the Yangtze River, especially around Chengdu and Chongqing, which may become an important pivot for opening up the western region (Kowalski 2019). This is also connected with relative strong autonomy of the Chinese provinces as local governments in this country are more powerful than their counterparts in other federal states, and they play a much more central role in local economies than their peers elsewhere (Combes et al. 2019). In addition, cross-regional collaboration and interactions among firms provide local companies with the opportunities to improve innovation capacities and techniques, thereby contributing to cluster development (Ai and Wu 2017).

Although there are some empirical studies showing positive impact of clusters on innovativeness of Chinese companies (e.g. Liu 2011), the research on innovation clusters in China is still in the stage of exploration (Shi and Zhu 2013). The analysis of clusters in textile and clothing industry, with use of New Institutional Economics Approach (NIE), illustrated the interaction between institutional change leading to the development and upgrading of clusters and the industrial development of China in transition (Chen 2015). The study conducted by Fri et al. (2013) demonstrated that multinational corporations are investing in Chinese regions where related industries are clustered, both those that are vertically and horizontally integrated. On the basis of the analyses of Beijing, Hebei, Shanghai, Jiangsu, Chongqing and Sichuan clusters, these economists stated that the phases of cluster development in China are related to the level of innovation in a cluster, measured by the number of patents. Another study conducted by O'Connor and Gu (2014) showed the importance of creative industry clusters in China, helping to develop creative class (Florida 2014) and leading to a convergence of culture with advanced technology.

Another important driver of increasing Chinese innovation potential is strengthening its science base through developing large research infrastructures. They constitute an important part of the national innovation system in China, with strong investments of the government (Chen 2011). These types of infrastructures are characterized by a policy of open access based on scientific merit, and especially in China, many of them have been organized to host foreigner researchers and experiments of international

collaborations (Marcelli 2014). Developing research infrastructures is a great contribution to increase R&D base in the economy and increases innovative ability of the country. This process is fueled by the Knowledge Innovation Program (KIP) in the Chinese Academy of Sciences (CAS), which is a giant program aiming to narrow science and innovation gap with leading countries (Xielin and Tingting 2010). China's innovation policy has led to a situation, in which Chinese companies increasingly compete in quality. Created innovation potential and extensive activities aimed at enhancing the international competitiveness of the economy form the basis for an increase in export and both inflows and outflows of foreign investment.

Further focus on innovation is an important factor of international competitiveness for countries like China, which risks falling into the middle-income trap. This refers to a situation when a middle-income country is failing the transition to a high-income economy. It faces the risk of stagnation as it can neither compete with low-income economies any more due to rising labor costs nor with a high-income country on cutting edge technology (Ren and Shen 2013). The key to escape from the middle-income trap seems to lay in strengthening the innovation capabilities of the country (Kang et al. 2015), which will help to switch from the growth model based on technology imitation to innovation-driven stage (Eichengreen et al. 2012). However, according to Fu et al. (2016), China could still end up in the middle-income trap, unless it undertakes a series of critical reforms in its innovation regime in order to keep moving up growth trajectories that are increasingly skill intensive and technology intensive. Fung et al. (2016) notice the importance of internet-related sector in the development of Chinese economy. They treat internet-driven economy as a radical, systemic technological change with substantial implication for China's nature of growth, as it can boost productivity and may even propel this country into a high-income economy. The potential of ICT in promoting economic growth was also mentioned by Kumar et al. (2019), as ICT supports TFP through multiple channels and is a precursor for future innovation.

Conclusions

This paper focuses on the problem of innovation gap in the world economy, as there are in general two main types of countries: these representing developed innovation systems, playing the role of technology leaders, and those with developing innovations systems, acting as technology takers and innovation followers. China is traditionally classified in the second group; however, the analysis conducted in this study reveals a continuous catch-up process of this country towards the European Union in terms of the innovativeness of economy. Although for most of the analyzed indicators related to innovation China's performance is lower than the EU average, the growth rates have been higher than that of the EU. This is reflected in growing summery index showing that overall innovativeness of Chinese economy has been improving, from 69% of the EU average in 2008 to 76% of the EU average in 2018. This may be concluded that although there is still significant innovation gap between analyzed economies, China is relatively quickly converging towards Europe.

There are different factors for China's economy improvement in terms of innovation. Among the key factors identified in this study, there are inward foreign direct investments,

and associated technology transfer. An important observation is that FDI inflows and related technological spillover effects are geographically unevenly distributed, and usually concentrated in high-technology clusters emerging mostly in eastern provincial economies, for example, Zhejiang, one of the most prosperous coastal regions in China. There are not only megacities, such as Beijing and Shanghai, serving as potential investment destinations, but also second-tier cities, like Chongqing, Wuhan, Ningbo, and Dalian, which have become important locations for clusters in high-technology industries in recent years. It must be noted that FDI and related technological spillovers would not influence domestic innovative ability without corresponding investments in developing indigenous innovation, and stimulating absorptive capacity of local enterprises. In this respect, China develops active science, innovation, and technology (STI) policy and gradually increases its spending on research and development (R&D). It can be observed, for example, in strengthening science base through developing large research infrastructures, which constitute an important part of national innovation system. All abovementioned factors contribute to the fact that China is increasing its R&D capability, with firm opportunities to move away from technology taker to technology maker position, and to become globally competitive with its own technology.

The conducted analysis provides the background to understand the significance of explaining the processes of structural changes in the world economy, especially in reducing the EU innovation lead over developing countries, which has constituted key competitive advantage of the Western European economy in the last decades. The process of China's catching-up with world's innovation leaders brings both challenges and opportunities for Europe. The main threat is that China has entered higher value-added segments of global production, increasing competitive pressure on European economy. The opportunity comes from expanding the boundaries of global knowledge thanks to the new technology generated by R&D investments in China. The research brings also some conclusions for countries with developing innovation systems, for example, from Central and Eastern Europe, which are trying to build knowledge-based economy and catch-up with innovation leaders in Europe. The key to development success in these countries lies in closing the technological gap by absorption of external technology, and creating the internal capabilities to utilize and improve on those technologies. This requires strong investment in R&D from public sources (e.g., in developing research infrastructures), and even more R&D expenditure in the business sector, as private R&D spending is more effective in terms of commercialization of research results, which is critical for the innovativeness of the economy.

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