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The Role of "Industry 4.0" in the Modernization of Industrial Production in China

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Abstract In 2010 German government continued with the strategic plan named ''High-Tech Strategy 2020'' with an emphasis on scientific and technological development. Under the title ''Industry 4.0''they are promoting reform and modernization of production in all industry branches by introducing digital technology, which depends on a number of new and innovative technological achievements. Their intention is to integrate production processes at all stages of formation and use of the product with the use and application of ICT and digital technology. The modernization and automation of production processes include advanced sensors and intelligent robots configured independently so as to monitor and participate in the development of products. In addition, technologically advanced countries like USA, UK, Japan, Sweden and others have accepted and introduced digital technology in production processes with the aim of creating intelligent automation, and intelligent factory of the future. China is faced with competition from ASEAN countries and Central Asia, which have cheap labour market. This weakens the export demand from China to the EU and USA, as evidenced by the ''Report on the Global Innovation Index 2015''.In response to the ''Industry 4.0'', the Government of China created the strategy ''Made in China 2025'', which promotes the relationship between information technology and industrial production, introduces the optimization of production processes, increases the ability to innovate in the industry including ICT, industrial and service robots, high technology machine tools, new materials, etc. China is relatively weak compared to the technologically developed countries in the world in regard to innovation and newer technologies, so it focused on industrial modernization in key sectors: telecommunications, production of commercial aircraft and helicopters, agricultural machinery, medical devices, alternative energy, electric vehicles and materials. The implementation of the adopted strategy in China is creating new opportunities for the promotion of successful innovative and creative economy, which enables the transition from ''Great industrial economy'' into ''Powerful industrial economy''.

Keywords Industry 4.0, digital technology, production process, intelligent automation, industrial robot

Introduction

In the recent years the world has witnessed the development and implementation of advanced technologies in production processes, primarily digital technology. Companies that wish to remain on the market must follow the development and conduct the modernization and automation of their production processes in order to be competitive in the global market. Some of the fundamental changes brought by digital technologies are introduction of the internet, including open software platform, open communication, open databases with powerful embedded processors, so that networked production in the industry becomes more flexible and more efficient. These technologies are already partly available to companies due to the declining low cost, waiting to be fully represented in the production processes in the near future. Another reason why companies need to monitor the development and implementation of these technologies is because customers rapidly acquire information through ICT and expand their requirements, so that requested products become more complex and complicated for a production process [1-18]. Companies around the world (and the governments of countries)

are efficiently working on how to implement advanced technology in industry production processes, and thus take advantage of new information and communication technologies (ICT) in order to produce more efficient, more productive and more flexible. The German government marked their strategy of digitizing production process as ‘’Industry 4.0’’, with which they want to maintain its leading position in the production and development of technologies and standards, so that they are first in the export of ready-made solutions. The United States answered to the ‘’Industry 4.0’’ with their own strategy named ‘’Advanced Manufacturing Partnership 2.0’’ where they want to create high quality manufacturing jobs, conduct production renaissance, and link industry to the internet. Japan Government’s answer to ‘’Industry 4.0’’is a strategy called "Revitalization and Robots Strategy" which seeks to increase productivity in the industry by promoting the development and implementation of robotic industry, as well as the revitalization of the digital society and the industrial sector. The Government of China adopted the strategy called ‘’Made in China 2025’’ which aims to transform the country into a leading technological power to 2025, improve global competitiveness through innovation, and explore and apply new business through the adjustment of production. Everyone is continuously and rapidly working on the development of digital technologies, ICT technologies, and sensor technologies and their implementation in all industry branches. Their application in robotic technology will lead to the development of new generation industrial robots which can cooperate with the workers, and are already being implemented in production processes. In this way, companies intend to introduce ‘’intelligent automation’’ in production processes or use ‘’intelligent machines’’ which will be the product of the fourth industrial revolution ‘’Industry 4.0’’, that will lead us to ‘’intelligent factory’’.

The Presence of the Fourth Industrial Revolution “Industry 4.0” in China

Germany announced part of its strategic program “High-Tech Strategy 2020” in Hannover in 2011 under the name ‘’Industry 4.0’’, which even in Germany presents the vision of future intelligent production. With the invention of steam machine in 1784 began the first industrial revolution ‘’Industry 1.0’’, that enabled continuous development of industrial production. The invention of electrical energy in 1870 marked the beginning of the second industrial revolution ‘’Industry 2.0’’, as shown in Figure 2, and the beginning of mass industrial production. In 1968, the development of computers, robots and programmable logic controllers started the third industrial revolution ‘’Industry 3.0’’ that still defines the production process in the industry.

Figure 1: The fourth industrial revolution [1]

The development of digital technology leads to the next step of industrial development, or fourth industrial revolution ‘’Industry 4.0’’, which is characterized by intelligent machines that are interconnected, can communicate to each other, make independent decisions, cooperate with humans, conduct optimization independently, so that production processes become more flexible, transparent and efficient. The development and implementation of digital technology in the industry lead towards rapid development of technological sophistication per exponential function, as indicated in the Figure 2. However, the research of ‘’Deloitte Global Human Capital Trends 2017’’ indicate that business productivity is not following the technological progress. The data from the ‘’US Bureau of Labor Statistics 2017’’ show that business productivity is still low and linear, as shown in Figure 2, regardless of the advancement of new technologies in business environment.

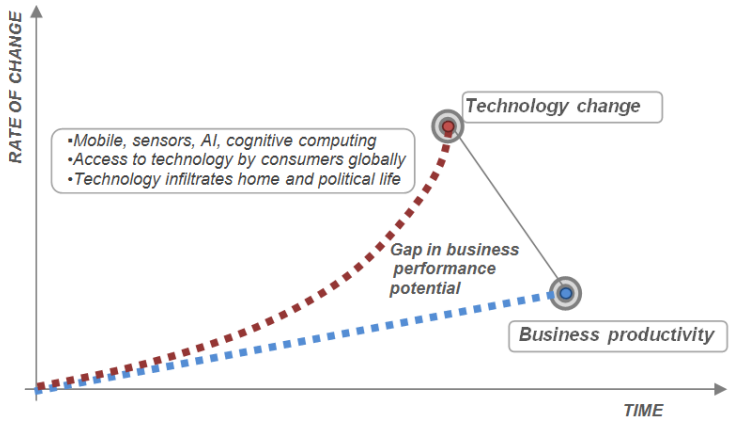


Figure 2: The gap between technological changes and business productivity [2, 4]

The gap between technological changes and business productivity appears due to weak human adjustability, i.e. the uncertainty of how to organize, manage and develop companies, and adjust the workers to new changes. The explanation for this gap is best given in the book *''Thank You for Being Late''*(2016) by Thomas Friedman, who explains the charts of gaps between technology, individuals, companies and public policy, whereas the creator of charts is Eric ''Astro'' Teller, CEO of Alphabet's Google X division, as shown in Figure 3.

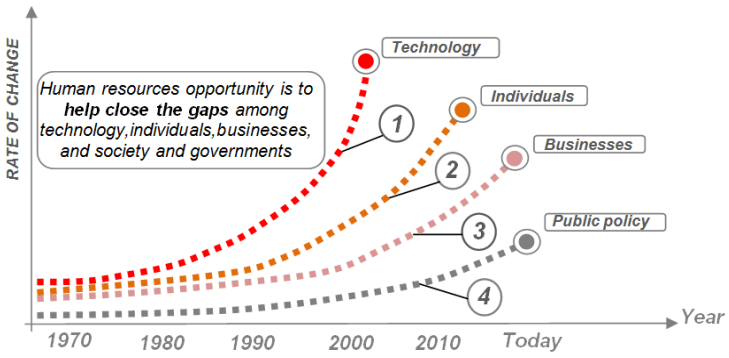


Figure 3: The gap between technological changes, individuals, companies and public policy [2, 4]

Curve 1 illustrates technological changes per exponential function. It is known that every 18-24 months the capabilities of computers are doubled, therefore mobile devices, sensors, artificial intelligence, robotic technology have influence on our lives more than ever. *Curve 2*gives an illustration of adjustability of an individual to the technological changes, and we can conclude that individuals adjust to these changes fast and skillfully, thus adopting technological changes, so that this gap is smaller [2, 4]. *Curve 3*illustrates the adjustment of companies and organizations to technological changes. These changes are far slower in comparison to individuals, even though they have developed planning, organizational structure, business designing, management and setting the objectives, which should be constantly revised. The gap between these three curves is the need for the adjustment of companies and individuals to technological changes, i.e. to change the way of living. Finally, *Curve 4* illustrates the adjustment of public policy to the technological changes. This is the biggest gap that directly influences companies, because it deals with legislation, taxes, education etc. In order to reduce the gap, it is essential to encourage the movements of human capital in the world, i.e. we need to encourage changes in the society [1-4]. In terms of industrial production in China, their government is rapidly conducting digitization and application of information and communication technologies in the production processes even though production in China is on low technological level. The other reason is low labor cost. In

order to decrease the gap between technological changes and public policy, Chinese Government adopted the development strategy named ‘’Made in China 2025’’, that was announced in 2015.

Figure 4: Key industrial sector identified in ‘’Made in China 2025’’

The strategy includes the fourth industrial revolution ‘’Industry 4.0’’ with the purpose of comprehensive upgrade of Chinese production so that the industry can follow the production progress initiators such as Germany, Japan, USA and other technologically developed countries, thus placing themselves above the competition of other developing countries in terms of low labour costs. In terms of strategic objectives of the ‘’Made in China 2025’’ strategy, China focused on ten key industrial sectors, as shown in Figure 4. In order to enable the transfer from *“the biggest production economy”* into the *“the most powerful knowledge economy”* China needs to conduct all reforms so as to modernize its industrial production in all areas, and as we can see ‘’MIC 2025’’ identified ten industrial sectors for sustainable long-term future. Unlike Germany, whose aim is to bring focus of small and medium enterprises to revolutionary technology, China intends to conduct comprehensive upgrade of its industry in all segments (human resources, management, optimization, quality control, etc.). In other words, ‘’MIC 2025’’ presents holistic approach to production, and in order to achieve this China plans to develop and implement 15 innovation production centers up to 2020 and 40 innovation centers up to 2025, the results of which are visible in Figure 5.

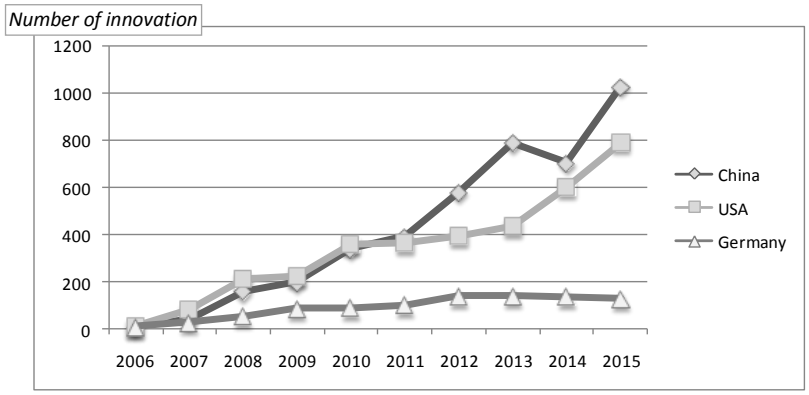


Figure 5: The tendency of innovation in the ‘’Industry 4.0’’ in China, USA and Germany [7]

Since 2006 China has shown the growth of own patents in ‘’Industry 4.0’’ each year, and as of 2011 China holds the leading position ahead of developed countries such as USA and Germany. This brings us to the conclusion that China is placing important role to innovation in advanced technologies. Chinese innovative activities are directed towards industrial robotics, intelligent sensors, as well as wireless sensor networks. Chinese manufacturers show maximum interest in reform and modernization of production processes through the application of digital and other advanced technologies, similarly like they showed interest in modernization and automation of production processes in the automotive industry, as shown in Figure 6.

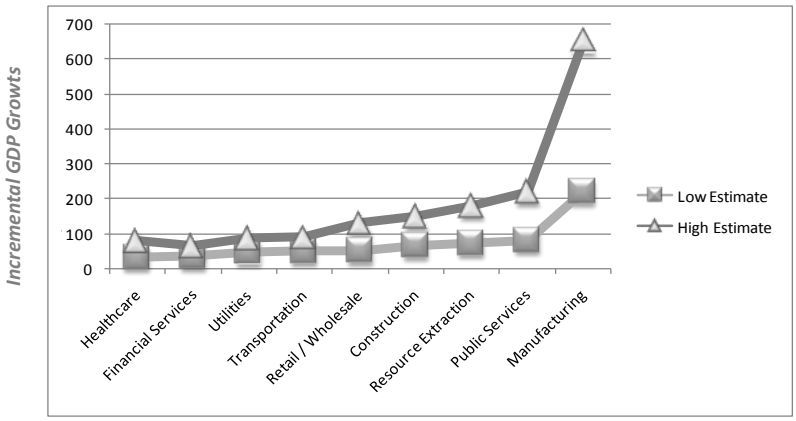
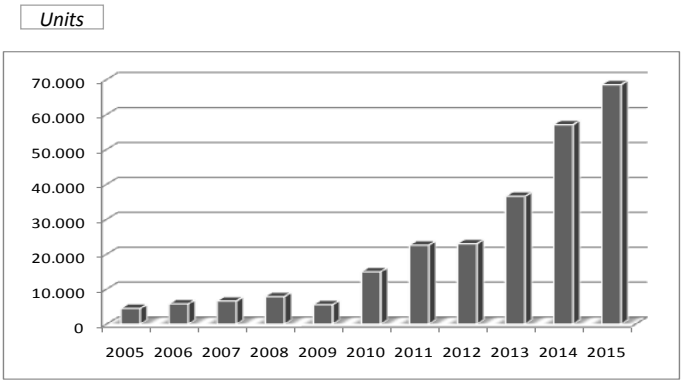
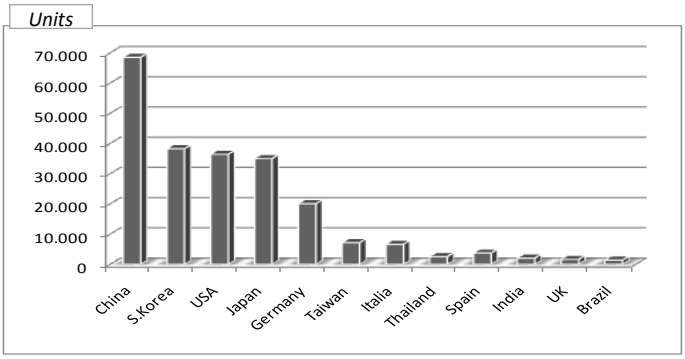


Figure 6: The estimate of influence (high and low) of ICT technology on the industrial growth in China [7]

The chart in Figure 6 shows high and low estimate of influence of ICT technology on the industrial growth in China, based on which we can conclude that the highest incremental growth of GDP due to adoption and use of ICT technology is in the industrial production, including the automotive industry.



a-Application of industrial robots in China



b-Application of industrial robots in top twelve countries in the world

Figure 7: Application of industrial robots in China for the period 2005-2015 and application of industrial robots in top twelve countries in the world in 2015 [15,19-22]

Modernization and Automation of Production Processes in the Industry in China

Chinese strategy named ‘’Made in China 2025’’ is giving positive results, example of which can be observed in the analysis of the application of industrial robots in production processes of the automotive industry. For the analysis of the representation of industrial robots we used statistical data acquired from the International Federation of Robotics (IFR), the UN Economic Commission for Europe (UNECE) and the Organization for Economic Cooperation and Development (OECD) [9-15].The representation of industrial robots in China is shown in the following figures.

The analysis of Figure 7a) gives the conclusion that the tendency of application of industrial robots in China is increasing annually, with abrupt increase in 2012.The representation of industrial robots in China in 2015 reached the value of 69.000 robot units. Figure 7b) shows the tendency of application of industrial robots in top twelve countries in the world in 2015 (of which three are at high technological level): Japan, USA and Germany. Ten years ago, China was in the last place in the representation of industrial robots in production processes, whereas Japan held the first place, followed by USA and Germany. The application of industrial robots changed over the years, so that in the last three years, since 2013, China holds the first place, followed by Korea, USA, Japan and Germany that have lower representation of industrial robots compared to China. In the following period, the tendency of representation of industrial robots in China will continuously grow until 2020 [18,19,20], when estimate of application of 220.000 robot units is predicted. This leads to the conclusion that China will continue the process of automation and modernization of production processes in the industry, which is stated in the strategy ‘’Made in China 2025’’.In regard to technological changes in China, in 2015 Chinese Ministry of Industry and Information Technology and German Federal Ministry for Industry and Energetics (BMWi) signed Memorandum of cooperation of the two countries in the field of ‘’Industry 4.0’’, in this way connecting ‘’Industry 4.0’’with Chinese initiative ‘’Made in China 2025’’, since ‘’Industry 4.0’’ quite fits within Chinese strategy. In this way, they created the stronger innovation partnership between the two countries, as Germany offers the most advanced technology in this area, whereas China wants to prepare and transform its industry for the future. We have to mention that representatives of German automotive industry fear that this cooperation will primarily strengthen Chinese competitiveness in the market, and are questioning if cooperation between Germany and China within ‘’Industry 4.0’’ is a unique opportunity or a mistake. Current representation of industrial robots per 10.000 employees in the industry in China and other countries is given in Figure 8. The representation of industrial robots in China in 2015 was 35, unlike Germany where representation is 301 industrial robots per 10.000 employees in the industry. Chinese average is lower than the world average which is 69 industrial robots.

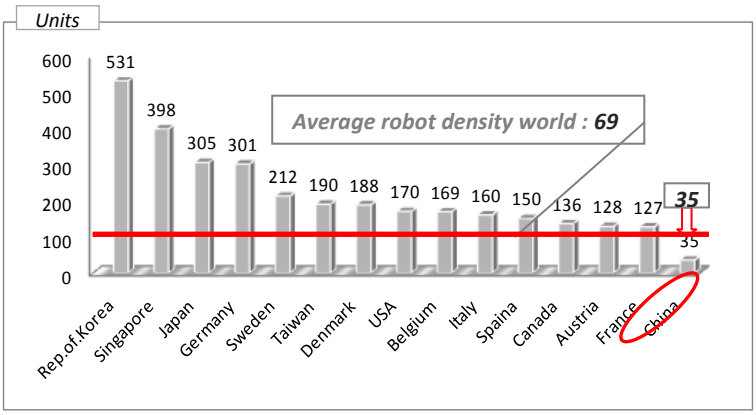


Figure 8: Representation of industrial robots in the world per 10.000 employees in 2015[18]

China is increasing this average each year, and it is expected that in the following years it will be above the world average, which is 69 industrial robots. That these facts are true is confirmed by the growth of vehicle production in China, which has the highest representation of industrial robots.

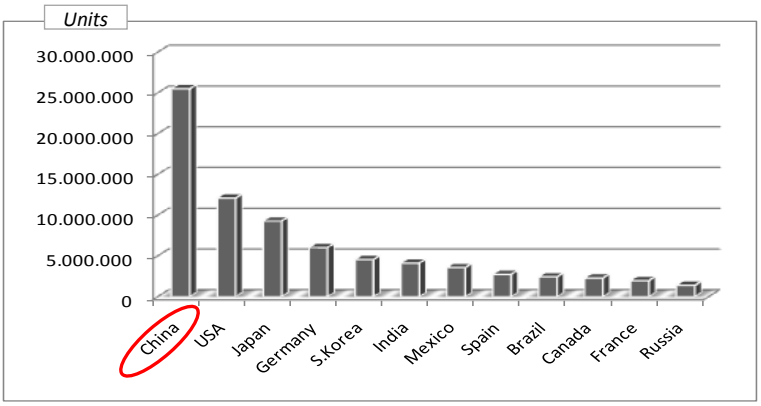


Figure 9: Vehicle production in China and top twelve countries in the world in 2015 [18,23-25]

As is well known, China is continuously increasing vehicle production [23-25] on annual basis, and the reason is the automation and modernization of production processes in the automotive industry through the installation of industrial robots, as shown in Figure 7. In the last few years China isthe first in the world in the vehicle production, so that in 2015 they produced about 26 million vehicle units. This tendency will continue, as indicated by the prediction of the representation of industrial robots in China in the next period [18,19].In regard to the fourth industrial revolution or ‘’Industry 4.0’’, China cooperates with all industrial countries. Together with Germany they are working on standardization, and founded the German-Chinese alliance for vocational training and education, as well as a common framework for an action plan ‘*’Design innovation together*’’. This year China made agreement with Switzerland to strengthen Chinese-Swiss innovative strategic partnership of 2016, which aims to reduce the gap between strategy ‘’Made in China 2025’’ and the Swiss ‘’Industry 4.0’’. In 2017 Chinese President Xi Jinping and French Prime Minister Bernard Cazeneuve welcomed further cooperation and encouraged harmonization of ‘’Made in China 2025’’ with the French strategy ‘’Industry of the future’’. Large companies such as ABB, Cisco, IBM and General Electric are prepared and ready to deliver and equip the Chinese companies with the necessary technology. Chinese companies will become more efficient and produce high quality products, so that they can fill the technological gaps. The Chinese government is effectively protecting domestic companies from foreign competition, especially in the IT sector. If German companies hesitate for too long, they will miss the great opportunities of the ‘’Industry 4.0’’in market China, because the need for German industrial software, cloud computing, sensors and robots is still enormous, as indicated by the Table 1. Table 1 displays the technological gap in different technologies for certain Chinese companies. We can conclude that the company Zhonghanng Dianca has a large gap in sensor technology, while company Shenyang Xinsong has a large gap in robotic technology, etc. Because of the large gap in technology with companies in technologically advanced countries, Chinese companies decided to purchase shares in competitive companies throughout the world.

Table 1: Chinese technological gap in key technologies for ‘’Industry4.0’’ [1]

Technology	**Technology Gap**			**Chinese companies (Examples)**
	Small	**Medium**	**Large**	
Sensor			•	Zhonghang Diance
Industrial Software		•		Yonyou, Shenzhou
Robotics			•	Shenyang Xinsong
RFID		•		Yuanwanggu
Cloud			•	Alibaba

Due to the increasing demand, company ‘’KUKA’’, robot manufacturer, based in Augsburg, Germany, which specializes in high-tech industrial robots, sold 85.7% shares of the company ‘’Midea’’ from China for 4.5 billion euros. Small and medium-sized Chinese companies are far from the advanced capabilities of production. About half of these companies have never invested in automation and information technology, or conducted modernization of production processes [11]. Even vital industries, such as the automotive industry, are far from

international levels of efficiency and productivity. We have to note that this figure in the next decade will change, because Chinese government is taking all steps to ensure that the Chinese industry and its development play an important in the development of the world economy. In other words, their aim is to make China one of the technologically most developed countries in the world by 2025.

Conclusion

The world's fourth industrial revolution in an ongoing process. The implementation of digital technologies is conducted in all segments of society. In technologically developed countries implementations conducted in production processes, with the objective of creating intelligent automation of the production process as a precondition for the creation of complete production process through intelligent factories of the future. The Government of China has adopted an industrial development strategy called ‘‘Made in China 2025’’ and ‘’Internet plus’’ which already produces results, and has become the first country in the world in the application of industrial robots, which in return places the country in the first place in vehicle production in the world, even though modernization and automation of production processes in the automotive industry in China is far from technologically developed countries. However, China recorded growth of industrial automation since 2010 in both domestic and foreign companies, and predictions are that the upward trend will continue in the future. The objective of Chinese Government is to set the standards of intelligent production, expansion of intelligent manufacturing processes and promotion of intelligent transformation in key sectors, both in small and medium-sized companies. In addition, it encourages the acceleration of the integration of industry with education, promotes the key skills and qualities that are adjustable to advanced production industry and establish a high degree of technological production in the industry. It further facilitates access to foreign investment so as to have access to the market, i.e. encourages foreign companies to compete for infrastructural projects through concessions, the purpose of which is to attract more foreign investment, technology, practical management methods and human resources. Many technologically developed countries are present in the implementation of advanced technology in the industry of China, such as France, Switzerland, USA and Germany. China has already shown continuous interest in the first German map for standardization ‘’Industry 4.0’’, so that the standards can be included in the German-Chinese cooperation and potentially expand in China. German industry was quickly established as the partner of China, thus ensuring profits in the growing Chinese market. China is taking all the measures so that its industry is slowly transformed, so as to introduce advanced technologies (digital technology and ICT technologies) and play an important role in the development of the world economy. The aim of the strategy ‘’MIC in 2025’’ is to transform China into technologically developed country in the world by 2025, which would be achieved with this strategy promoted by Chinese politicians.

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