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Diploma Thesis

A Strategic Analysis of China's Shift to an R&D Economy

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Faculty of Economics and Management

DIPLOMA THESIS ASSIGNMENT

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Thesis title

A Strategic Analysis of China's shift to an R&D Economy

Objectives of thesis

The main objective of the thesis is to examine China's economic shift and pronounced growth of R&D expenditure

The partial goals of the thesis are such as following:
- to identify the reasons for China's economic shift
- to analyse and interpret the results obtained
- to process the acquired data using econometric models

Methodology

Further literature review is conducted to facilitate better understanding of the research problem being studied.Methodology of the thesis is based on a general empirical quantitative approach gathered from publicly available data sets. Econometric as well as SWOT analysis will be conducted to evaluate the data acquired.

The proposed extent of the thesis

60 – 80 pages

Keywords

R&D, innovation, clean energy, blue-chip, econometric model.

Recommended information sources

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Declaration

I declare that I have worked on my diploma thesis titled "A Strategic Analysis of China's Shift to an R&D Economy" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the diploma thesis, I declare that the thesis does not break copyrights of any their person.

In Prague on 6.4.2020 _____

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A Strategic Analysis of China's Shift to an R&D Economy

Abstract

In order to understand the reasons for the impressive successes of China’s shift to R&D economy, the thesis discusses the historical, political and cultural overview of Chinese economy, science and technology, the key parameters of China's institutional and political development in the field of science and innovation. Methodology is based on the analysis of the achievements of the PRC, which are compared with the successes of other states. The thesis sheds light on various factors such as reforming higher education, developing technological clusters, effectively using the potential of state-owned enterprises for innovative development, improving the protection of intellectual property rights. The practical part represents a thorough econometric analysis to process the acquired data. Prior assumptions as well as the acquired results are presented. Conclusions based on the interpretation of results are discussed.

Keywords: R&D, innovation, energy, technology, research, development, science, information, data, production

Posun Číny k RD ekonomice - strategická analýza

Abstrakt

K pochopení impozantního čínského přechodu k R&D ekonomice, práce mapuje o historický, politický a kulturní stav čínské ekonomiky, vědy a technologie, což jsou klíčové prvky pro čínský rozvoj v oblasti vědy a inovace. Metodika je založena na analýze úspěchů ČLR, které jsou porovnány s úspěchy jiných států. Práce objasňuje různé faktory jako je forma vysokoškolského vzdělávání, rozvoj technologických odvětvích, efektivní využití potenciálu státních podniků na pro inovativní vývoj a zlepšení ochrany práv duševního vlastnictví. Praktická část představuje důkladnou ekonometrickou analýzu, která zpracovává získaná data. Jsou stanoveny hypotézy a představeny získané výsledky a na závěr probíhá diskuze založená na interpretaci výsledků.

Klíčová slova: R&D, inovace, energie, technologie, výzkum, rozvoj, věda, informace, data, produkce

Table of content

List of pictures

List of tables

1 Introduction

Scientific, technical and innovative development is becoming one of the main factors in the socio-economic growth of modern states. Many countries strive to quickly make up for the lack of innovative potential through the implementation of an effective scientific policy, often based on borrowed practical experience from abroad.

China is one of the most successful examples of institutional and socio-cultural reform aimed at improving the quality of science, technology and market mechanisms that facilitate the rapid commercialization of research and development.

China seeks to get rid of the image of a manufacturer of cheap equipment with low added value. The government has consistently adhered to a policy of supporting technological development in order to create complex technical devices and services in accordance with the global trend of transition to digital technology and Internet connectivity.

In less than 20 years, the PRC will be the first economy in the world, leaving the United States behind. Despite the slowdown in economic growth, China will be able to ensure a sufficient level of economic growth so that the most of its citizens are considered sufficient to classify them as the middle class.

The fact that this will happen is recognized by many experts, but the possible date for China to come first is the subject of serious discussion.

In December 2012, the National Intelligence Council published a report on *Global Trends 2030: Alternative Worlds (34)*, in which the authors predict that between 2022 and 2030 China and the United States will swap places in the list of the largest economies in the world. Also, according to the report, China will retain the first place for a long time, but it is in the early 2030s that its margin from India will begin to decline, because the growth rate of the Indian economy will be much higher than the Chinese.

It goes without saying that Research and Development (R&D) serves as a backbone of innovation. Nowadays, the economic prosperity of the country is highly justified by its ability to leverage R&D. China's made a considerable progress in its R&D economy, expending its R&D expenditure greatly over the past years.

However, it is worth mentioning that China's population is rapidly aging, and this threatens the economy of the country. There is a huge amount of people at the age of 65 years and older. The aging of the population in China is proceeding at a much faster pace than in other countries.

At the same time, in China, the economically active population - people from 15 to 59 years old - is gradually decreasing. And in the coming decades, these two trends will only intensify. The number of elderly people who will have to retire will sharply increase, respectively, there will be fewer citizens of working age who are able to support an aging population. Thus, the aging of China's population may create new problems and put the economy at risk.

China does not keep current statistical records of the population data, published by the National Bureau of Statistics of China. In statistical yearbooks, only general birth and death rates are published but the actual numbers of birth and death are absent.

The current records of population movements are being developed, but China does not want to make this information public. In national statistical publications there is not even a hint of the existence of current population records. (14)

Ideas about human depletion of world resources are an integral part of popular culture, and in some regions of the world, rapid population growth is one of the main causes for concern because it creates serious problems in the areas of land use, labour market and state budgets. But the idea of the population growth reflects only part of the picture. Different forces - aging, migration, urbanization and increased life expectancy form a more diverse and complex world demographic landscape.

Is the aging population a major threat to China's economy? If the population keeps aging and the government doesn't find a quick solution, will the GDP suffer?

2 Objectives and Methodology

2.1 Objectives

The main objective of the thesis is to examine China's economic shift and pronounced growth of R&D expenditure. The thesis has three partial objectives. The first one is to carry out a literature review on the reasons for China’s economic shift. The second one is to analyse and interpret the results obtained and the third one is to process the acquired data using econometric models.

2.2 Methodology

Further literature review is conducted to facilitate better understanding of the research problem being studied. Methodology of the thesis is based on a general empirical quantitative approach gathered from publicly available data sets. Econometric and SWOT analysis will be conducted to evaluate the data acquired. Final conclusions will be constructed with a synthesis of theoretical knowledge and practical outcomes.

3 Literature Review

The development model of the Chinese economy and the role of China in the world have changed a lot over the past decades. The long-term effects of China's increasing global role are valued very differently. The Chinese leadership stresses its commitment to the officially announced peaceful development course, while in many countries the point of view is that China is an expansionist power that seeks to expand its geopolitical influence through the size of its economy and its success. Views on how to perceive the behaviour of China and how to react to it, diverge more and more.

3.1 Overview of Chinese Economy

Since the late 1970s, China has reoriented itself from a closed, centrally planned system to a more market-oriented economy, which is one of the largest in the world. Reforms began with collective agriculture and expanded through gradual price liberalization, financial decentralization, increased autonomy for state-owned enterprises, the creation of a diverse banking system, the development of stock markets, the rapid growth of the private sector, and increased openness to foreign trade and investment (1).

Restructuring of the economy and increased efficiency has contributed to a more than tenfold increase in China's GDP from 1978 to 2010. Measured on the basis of the purchasing power parity of currencies (PPP), this indicator in 2010 became the second largest in the world after the United States, surpassing Japan in 2001. The dollar value of China's agricultural and industrial output already exceeds that of the United States; China is second to the United States in terms of the total value of the services sector it produces (3).

Modern China is a country with one of the most dynamically developing economies in the world. For forty years political reforms have led to a significant success. Currently, the country has entered a period of significant changes in economic policy aimed to change the prevailing growth model (5).

Over the past decades, the country's leadership has paid great attention to the economic growth, and only at the beginning of the XXI century was first formulated the need to find solutions to growing social problems. In 2006 the concept of building a socialist harmonious society was approved, including reducing social differentiation, improving legal systems, development of public services (1).

In recent years, China has renewed its support for state-owned enterprises in sectors that it considers important for "economic security," clearly aiming for leadership in global competition. Recent economic indicators unveiled by China have convinced global analysts that this Asian country has a powerful growth potential and that it is the main engine of the global economy.

The Chinese government is, however, facing many economic difficulties, including:

- a reduction in high domestic savings rates and correspondingly low domestic demand,
- supporting appropriate employment growth for tens of millions of migrants and the creation of new jobs,
- reduction of corruption and other economic crimes,
- and environmental damage and the growth of social inequality, which is related to the rapid transformation of the economy.

The economic development has been much faster in the coastal areas than inland, and about 200 million rural laborers and their children moved to cities to find work. A consequence of the "one child" policy is that China is now one of the fastest growing countries in the world (25).

Environmental degradation, especially air pollution, soil erosion, and the steady drop in the groundwater horizon, especially in the north, is another long-term problem. China continues to lose arable land due to erosion and economic development. The Chinese government is striving to add the ability to generate energy from sources other than coal and oil, focusing on nuclear and alternative energy development (31).

In 2009, the global economic crisis lowered demand for Chinese exports for the first time in many years, but China quickly recovered to an increase of about 10% per year, beating all other major industrialized countries (24).

According to a report released by the State Statistical Office of China, China’s GDP grew 6.3 percent in the first half of 2019, compared to the same period of 2018. These indicators meet the expectations of many and for many others this is an unexpected improvement. (34) Christian Roucher, (3) an economist at the German Institute for Economic Research, rated this growth, which exceeded 6 percent, as "positive," given that it was achieved in the context of *"constant trade friction between the US and China, uncertainty over Brexit and Gulf conflicts"*, which *"could have had a negative effect on the economy."*

Investment strategist E. Rothman noted that despite the growth rate in the areas of production, investment and export, domestic consumption and the services industry, which occupy most of the Chinese economy, remain useful for stabilizing employment. *"In addition,*

the Chinese government is prepared to respond to the economic slowdown and prudently avoid stimulating monetary and fiscal policies". (3)

On the negative side, PRC still faces social problems such as aging population, poverty, as well as extremely high and growing inequality in income. In addition, one of the negative effects of fast industrialization and developed industry, was that country's energy needs were mainly provided by coal, causing environmental degradation. This also resulted in the increase of death rate from diseases caused by air and water pollution.

The government share of health spending is gradually increasing and in 2016 reached 2.9% of GDP (public spending accounts for about 60% of total spending on this scope). In general, the health system is characterized by two main problems; extremely high cost of medical services and low coverage (especially for the rural population) (11).

3.2 The Principals of the Political Economy in China

Presenting a number of large-scale foreign economic initiatives and institutions, Chinese President Xi Jinping has made it clear that the economic development process launched by China aims at achieving prosperity and security both in the region and in the world as a whole.

To adjust their points of view, scientists, politicians, and other practitioners must recognize that they need to go beyond the rigid framework of their specializations - economics, geopolitics, or security. There is a need to look for new ways to understand the growing international influence of China and to establish interaction between the economy and politics in general and economic development and security in particular.

Some scholars, politicians, and organizations (1) have already begun researching the links between economics and politics, as well as the mutual influence of economic development and changes in security. However, much more can and should be done. It is good if such studies become regular, and the participation of politicians and foundations is permanent.

Whether the growth of China's economy and its interdependence with the economies of other countries will lead to an increase in the geopolitical influence of China is one of the most important issues of the 21st century. The answer to it is vital for politicians, scientists, businessmen and many others in China itself and beyond.

The long-term effects of China's increasing global role are valued very differently. The Chinese leadership stresses its commitment to the officially announced peaceful development

course, while in many countries the point of view is that China is an expansionist power that seeks to expand its geopolitical influence through the size of its economy and its successes.

Views on how to perceive the behaviour of China and how to react to it, diverge more and more. They, in essence, reflect two different and in their own way imperfect ideas about how the successes of the Chinese economy inside and beyond affect or may affect China's power and influence in the world. (12)

Most clearly, the difference between these approaches, as well as the likelihood of escalating mounting tensions, can be illustrated by the recent promotion by China of initiatives and organizations formally called to promote the economic development. Large-scale projects to finance and build China's land and sea transport, energy and telecommunications infrastructure - such as **One Belt, One Way Initiative** and **Asian Infrastructure Investment Bank** - have given rise to many speculations and doubts. (30)

Mostly because it is not clear yet, as part of its national strategy, China can use new and existing ties with neighbouring countries and other regions from Africa to Europe to increase its geopolitical influence.

Officially China emphasizes that the participation in new initiatives is beneficial to all countries, while opponents argue that these initiatives will provide China with an additional means of achieving geopolitical goals. This is especially important for neighbouring countries, many of which are seriously concerned about the expansion of China in the South China Sea. However, differences in interpretation of recent Chinese initiatives are just the tip of the iceberg. They reflect much deeper contradictions in China's international economic and political role in the expansion of its geopolitical influence. (6)

The Chinese leadership constantly emphasizes that its priorities are economic development, and traditionally seek to convince neighbours, the United States and its own population, the foreign policy tasks that China sets itself, primarily serve the interests of developing the national economy.

The large-scale initiatives that the President of China Xi Jinping has been putting forward since 2013 are presented as a natural continuation of foreign policy aimed at achieving results that are beneficial to everyone, such as peace and prosperity in the region and around the world. The Chinese paradigm of peaceful development is sharply opposed to the geo-economic paradigm: its many supporters outside China represent this country as a mercantilist power in which a strong, visionary, authoritarian system manipulates the economy as a whole as well as individual economic institutions in order to strengthen its power in China and the world (12).

However, no paradigm fully reflects the changing role of China in the world. Despite the increase in the weight of the national economy and its interdependence with the economies of other countries, China is unlikely to be able to expand its foreign policy and geostrategic influence, as supporters of the geo-economic approach believe. Also, there are no sufficient grounds for claiming that the economic role and ties of China, clearly and consistently, in accordance with the paradigm of peaceful development, contribute to the strengthening of peace and stability. (8)

Each of the systems of representations reflect and form not only a certain way of thinking, but also a special political behaviour. The existence of these paradigms is largely due to the dominance of bureaucratic and academic approaches that separate economics from political and development issues from security issues. The narrow analytical framework and institutional approach gave rise to superficial, and in some places completely misunderstood understanding of how the volume of the Chinese economy, its growth and internationalization are related to the general geopolitical influence of China and its impact on the international security system. (21)

It is necessary to acknowledge the imperfection and limitations of these paradigms and approaches and think about developing a comprehensive method that would focus directly on what political scientist Robert Gilpin called the “dynamic interaction between pursuit of wealth and pursuit of power”. (25) That defines the essence of the evolution of China's role in the international arena.

The key component of the method should be the principle of considering economic development issues in close connection with security problems. Now is the time for this as China is at crossroads. The country is undergoing fundamental changes: it is switching to a new model of economic development, that is, China's relations with the world economy - and with other states as a whole - will be different.

In addition, President Xi Jinping seeks to show that the country's economic growth and security and stability in the region and around the world are directly related. This is the perfect moment to try to figure out what it takes to bring China's political economy to the global level. It is this understanding that underlies further action.

3.2.1 Chinese Economy and Geopolitics

Since the late 1970s, when reforms began, and the policy of openness was proclaimed, until recently, the country's economy grew by an average of 10% per year. After China

entered the World Trade Organization in the early 2000s, its role in the world economy became more significant and noticeable, and as a result, it became the largest participant in international trade. Over the past ten years, China's share of global flows of foreign direct investment and international financing has been growing, mainly through loans and financial assistance to developing countries. (22)

At the same time, the question of how the pursuit of wealth in China correlates with the desire for power in the international arena causes more disagreement and debate. It is still not entirely clear whether the expansion of China's international economic relations is affected by its power and influence in the world.

With the launch of such large-scale projects as **"One Belt - One Way"** and the **Asian Infrastructure Investment Bank**, not to mention the general activation of Chinese economic diplomacy, the determination of the relationship between the economic and political aspects of China's foreign policy, is increasingly relevant.

3.3 Economic Indicators

The fact that the current model of development of the Chinese economy is becoming obsolete is not only confirmed by authoritative experts, but also the country's leaders themselves. The existing scheme, based on continuous reform, cheap labour, and constant influx of foreign investment and export earnings, is getting worse. (26)

This is due to the drop of demand in the world market and the fact that each of the components of the "Chinese economic miracle", are at the stage of the obvious decline. In the next 20 years, China will need to restructure its existing development strategy, especially in transforming the functions of government bodies, revising the relationship between government and the market, as well as between enterprise and society "(30).

If we imagine that all actions of PRC leadership are implemented in a timely manner, and the recommendations of the World Bank and other authoritative organizations are thoroughly implemented, then China's economic model of 2033 will look as follows:

- **In the business sector**, barriers to entry and exit for private companies will be reduced, and the competitiveness of state-owned enterprises will be greatly enhanced. By 2030, the share of the service sector in the country's GDP will have grown from 43 to 60-65%, while the share of raw materials industry will have declined from 10.2 to 5.1%, and the processing industry - from 46.9 to 32.6%.

- **In the financial sector**, the banking system will be commercialized, and thus interest rates will be set based on market requirements, and not directed from above.
- **As for the labour market**, China will be able to move freely around the world in 20 years, responding to market demands. The workforce will receive a decent salary and have a full package of social guarantees operating absolutely anywhere in this rich and successful country. More than half of working citizens will be involved in the service sector (51.8%), and the raw materials industry leading in the number of employees will only be 16.6% of the total labour force in 2030.
- **The rights of the rural population** will be protected at all levels, farmers will be free to buy and sell land. Efficiency of land use will increase, agriculture will be based on scientific research.
- **The personal well-being of Chinese citizens** will grow by almost 4 times. In 2030 China will have been the largest consumer market in the world for more than 10 years, and its volume will be 1.75–2 times the size of the US market. Chinese authors predict that by 2030, domestic consumption in China will be $ 48.5 trillion, if calculated at the current exchange rate, and GDP per capita in similar calculation systems will be $ 46.7 thousand.
- In this consumer society, **the number of cars per thousand people** will increase from 40 to 310 in 2035, exceeding the figure of 400 million in the country. (31)

The Chinese economy looks like this in the eyes of Chinese experts, however, more independent studies contain much less optimistic forecasts and much more subjunctive moods.

However, if the Chinese government starts reforms in the next two to three years, if it can overcome the conservative sentiment, if it takes the risks associated with liberalizing the economy, etc., then perhaps the picture presented in 20 years will become a reality.

The increasing geopolitical significance of China and its role in the world economy is divided by observers into two camps: (28)

- the first believe that the rise of this country contributes to general prosperity and peace
- the second state that China is an aggressive power practicing economic mercantilism

Both points of view are based on the oversimplified view of the political economy of China's international relations. This is the consequence of the lack of new interdisciplinary

approaches both in research and in practical politics - all that could help explain the economic and geopolitical aspects of the rise of China are related. An analysis of the errors of both positions is the first step towards a better understanding of what is happening in China and constructive cooperation with this country.

3.3.1 GDP

In Mainland China with a population of 1.4 billion, the total economy has exceeded to 99 trillion yuan and the per capita GDP has reached 10 thousand dollars for the first time in 2019. This is a new historical indicator of China's wealth, which demonstrates an increase in the level of integrated power and the standard of living. (33) In 2019, the real disposable per capita income in the country reached 30 733 yuan, which is 2505 yuan more compared to that of 2018, for the first time exceeding the threshold of 30 thousand yuan. (34)

Particular attention should be paid to the actual growth in disposable income per capita of the villagers, which amounted to 6.2%, which is 1.2 percentage points higher income in cities. (30) The increase in income of the country's inhabitants has become a sustainable driving factor for economic growth. In the past few years, despite the slowdown in globalization, the escalation of trade friction, and the growth of unstable and uncertain factors in the external environment, the PRC continues to maintain a stable growth rate. The reason is the increasing volume of consumption, which is China's greatest confidence in changing environmental conditions.

From the current point of view, China's export space is limited, the source of stable economic growth is located domestically. To strengthen the fundamental role of consumption, it is first necessary to guarantee a steady increase in income. In order to guarantee stable income growth, efforts must be made in two directions: on the one hand, economic development should be supported, and on the other, it is necessary to continue to improve the system of income distribution, which will help increase the consumer abilities of the population. In addition, it is necessary to increase the wages of residents of a low-income country, to expand the middle-income group (31).

3.3.2 Chinese Yuan

The Chinese national currency will become international, although not global, in the early 2030s. With a high degree of probability, having entered the number of world reserve currencies, the yuan is unlikely to be able to take the palm from the dollar (31).

The fact that China will also be the first place in the list of the largest economies in the world, however, does not guarantee the same success with its national currency - the renminbi (RMB). Nevertheless, it is obvious that in 20 years, under favourable conditions, the internationalization of the Chinese currency will take place. (31)

In any case, the prospects are quite good, because the scale of distribution of renminbi is already large and in the early 2030s it will obviously be much larger. The only doubt is stability and liquidity, but this is already a matter of changing the domestic monetary policy of the Chinese leadership.

So far, the scale of the Chinese debt bond exchange and the volume of transactions resulting in it remains small. Although today the yuan is actively strengthening its influence on the world stage. In early February, Hang Seng Bank launched the world's first RMB Gold Exchange Fund (ETF) on the Hong Kong Stock Exchange. Also, in the beginning of the year, Japan and China agreed to increase the turnover of renminbi - now Japanese companies will be allowed to issue RMB bonds in China. (29)

In addition, the prospects for reforms in the economic, political and social spheres are not completely clear, which casts doubt on the stable and even development of China in the coming decades. The shift would undoubtedly be the devaluation of the renminbi, but this decision has not yet been made. On the other hand, putting forward the experimental calculation of RMB for direct investment allows the currency to move synchronously towards the goal of internationalization at two levels - trade and capital. (29)

Although the Central Bank of China has not yet made official plans for the internationalization of the renminbi, it is expected that this will take about two decades. Beijing experts are also talking about three to four five-year periods needed to internationalize the Chinese currency, however, the full globalization of the renminbi is out of the question. Even if the yuan gains the necessary points for stability and liquidity, its widespread distribution will be limited to the Asia-Pacific region. Already, seven East Asian currencies are watching the yuan more closely than the dollar. When the dollar moves 1%, East Asian currencies move in the same direction by an average of 0.38%. When the yuan positions change, they shift by 0.53%. (28)

So far, we can safely assume: even if the yuan does not replace the dollar in the position of the world reserve currency, its value in 20 years will be comparable to the position of the pound, euro or yen. On the other hand, there are more optimistic forecasts. According to a new study by Arvind Subramanian and Martin Kessler of the Peterson Institute for International Economics in Washington, the currency of China will continue to grow as the Chinese economy and trading activities expand. Thanks to only two of these factors, according to the authors, the Chinese currency should defeat the dollar in the struggle for the title of the leading currency somewhere in 2035 (31).

3.3.3 Geo-economics

Some specialists from American and European think tanks and geopolitical experts use the term “geo-economics” to describe China's allegedly long-standing predisposition to use the approaches of realism and commercialism in building relations between the state and the economy, as well as in building foreign economic policy.

Those who hold a geo-economic view of China's foreign policy usually focus on the use of economic policy instruments by the Chinese authorities to achieve more general foreign or geostrategic goals. This approach is clearly demonstrated by the work of the Indian foreign affairs specialist Brahma Cellani (10). All major projects, from the “One Belt - One Way” initiative to the establishment of the Asian Infrastructure Investment Bank in Beijing, are slowly but surely bringing China closer to its strategic goal - building China-centric Asia.

According to some analysts who share the principles of the geo-economic paradigm, if China's strategy is not balanced by adequate measures, it will strengthen its dominant position in the region and in a large part of the Third World. Ultimately, the logic of the geo-economic approach leads to the conclusion that the economic, political and strategic influence of the United States and its European allies is nearing, with the subsequent collapse of the liberal world order. (17)

However, if we look closely at some arguments of the geo-economic approach, we will find contradictory and simply unexpected consequences of deepening the interdependence of the Chinese and global economies. The increasing attention to China's geo-economics from mainly American and European researchers and institutions reflects the growing interest in other parts of the world and sometimes the concern that economic interdependence with China is creating new models of economic and political influence.

The official reaction of China to the concerns of other countries is based on the logic of peaceful development paradigm for all. In official diplomacy and foreign policy rhetoric, the paradigm of peaceful development described and legitimized China's commitment to a model of global economic development that helps to strengthen peace and stability on Earth (8). Xi Jinping did not just abandon the basic political and economic principles of the paradigm of peaceful development, but also constantly emphasizes its central role. The promotion of new foreign economic initiatives is consistent with the logic of the paradigm and extends it to new directions.

China presents “One Belt, One Way” and the Asian Infrastructure Investment Bank primarily as an economic development initiative designed to connect it with neighbouring and distant countries through financing and construction of transport infrastructure and other projects that boost international ties. Therefore, by promoting these initiatives, Chinese authorities, scientists and analysts are trying to focus on the role of China as a driving force for economic development in the region and around the world. (12)

Despite discussions and debates on the problems that arise as China's wealth and its interdependence with the global economy grow, Chinese leaders continue to come up with large-scale economic development initiatives. Some Chinese analysts even suggest that large-scale Chinese projects, primarily peacekeeping missions in Africa, have a conceptual framework - a complete theory of peaceful development. After the resonant statements of Xi Jinping on regional and international development as a guarantee of security around the world, the number of supporters of this point of view will, undoubtedly, increase. (6)

3.3.4 Macroeconomic Indicators

In less than 20 years, the PRC will be the first economy in the world, leaving the United States behind. Despite the slowdown in economic growth, China will be able to ensure a sufficient level of economic growth so that the most of its citizens are considered sufficient to classify them as the middle class (31). The fact that this will happen is recognized by many experts, but the possible date for China to come first is the subject of serious discussion. (6)

In December 2012, the National Intelligence Council published a report (34), Global Trends 2030: Alternative Worlds, in which the authors predict that between 2022 and 2030 China and the United States will swap places in the list of the largest economies in the world. Also, according to the report, China will retain the first place for a long time, but it is in the

early 2030s that its margin from India will begin to decline, because the growth rate of the Indian economy will be much higher than the Chinese.

PwC predicts (39) China's earlier position in the first place in the global economic race, predicting that the US will move to the second place after China in terms of GDP, when calculating GDP at purchasing power parity. If we measure GDP at nominal value, then the change in economic leader (from the US to China) will occur in 2027. According to PwC experts (39), China's GDP at purchasing power parity in 2030 will be $ 30.6 trillion. This is followed by the United States with an expected $ 23.4 trillion of GDP, India ($ 13.7 trillion), Japan ($ 5.8 trillion) and Russia ($ 5.3 trillion).

At the same time, Nobel Laureate Robert Vogel, predicting an increase in China's share of world GDP to 40% by 2040 ($ 123 trillion GDP in PPP), calculating on a figure of exactly 8-10%, indicated that it was based on the growth rate of real capital - human and physical, and not at the price level (33).

However, the share in the world GDP is only one of the angles, which prospects for the Chinese economy for the next 20 years are examined. The same Global Trends 2030 report predicts (34) that in two decades, most Chinese people will be middle-income people.

The Royal Bank of Canada report, "The Impact of the World on China," predicts that 2030 China will join a number of high-income countries, and 2025 China's prosperity will increase by 4 times (22).

The United Nations Demographic Department and Goldman Sachs published a joint report in the fall of 2011, according to which it is estimated that the number of middle-class people in China will reach 1.4 billion by 2030. The report notes that “according to the criteria for classifying the middle class as established by the World Bank, over the next 20 years, the entire population of China will be classified as the middle class” (14).

3.4 R&D Economy

As technology keeps improving productivity, it serves as a step-stone to drive economic growth. However, the most challenging task on the road to an R&D Economy is the transition to innovation that is impossible without the investment in human capital. The introduction of advanced research and development, which helps to increase the pace of development of the high-tech sector of the economy, the transition from uncontrolled

economic growth to sustainable development is desired by each and every economy, nowadays.

It has been established that the main sources of economic growth and improving people's well-being are increasingly shifting to accumulated advanced scientific knowledge and information resources, the main component of which is a person with his mind and scientific ideas. The quality of human capital can be compared with economic growth, therefore, investment in human capital will contribute to economic growth. Thus, modern society creates the necessary conditions for economic growth through high labour productivity, technical re-equipment of production, as well as, the development of modern means of communication (27).

China has long been known as a low-cost manufacturer, thus its shift to a research driven economy is not an easy transition. Many researchers attribute China's significant economic growth to factors such as: cheap labour, relatively soft legislation (especially in terms of labour and environmental protection), and the accumulation of large investments. Some researchers note that in the formation of the modern model of China's development and the rapid pace of its economic development, scientific and technological achievements play an important role. (3)

China has become visible in the international scientific arena relatively recently. Although the first modern universities appeared in China at the turn of the 19th – 20th centuries, the country has not yet raised a single Nobel scientist, if we do not consider writers and physicists who have built their entire scientific career in the West. Nevertheless, the Chinese state pays rather serious attention to the development of the scientific and technical sphere, especially in recent years (13).

In China, the state plays a critical role in key social processes. Science is no exception. The latest five-year development plan for the country's fundamental science emphasizes “freedom of scientific research,” but this search must be combined with specific goals, which, of course, are established by the state.

Today, China has several national and regional programs aimed at supporting research and the commercialization of R&D. The state allocates about 2% of GDP for these purposes. The most famous companies in China today - ZTE, Huawei and Lenovo - have developed thanks to government programs. It is noteworthy that most of the scientific publications and developments fall on the share of universities, and not the Chinese Academy of Sciences. (5)

Aiming for economic modernization, Chinese universities have focused on engineering, economics, and technology, as well as computer technology and industry.

Education in China is considered one of the fastest growing areas. The literacy of the population is growing, the qualifications of staff are being raised, many articles are published in collaboration with foreign scientists. In the past decade, China has made a big leap forward in the field of science. Serious success stories are noted in the entire system of science in China: at universities, research institutes and enterprises.

Putting the emphasis on innovation has allowed China to move from an extensive to an intensive path of development. Some authors believe that "late" industrialization gives China an advantage, which is manifested in the possibility of the quick and much cheaper implementation of innovation from developed countries by importing their technologies and their own R&D. Nevertheless, state policy in this area is aimed at stimulating their own innovations in the form of tax deductions for R&D expenses, tax free holidays for companies working in the field of electronics and software. A number of laws on venture financing were also adopted, and the Association of Venture Companies was created. (2)

Innovation funding is provided by the federal government and local governments. There is also a public procurement system, according to which the state should allocate a certain part of the costs of products only to innovative Chinese enterprises. Within the framework of the established Innovation Fund for Small Business Support, subsidy and concessional financing schemes are applied. (2)

Thus, describing the innovative model of the PRC, the following specific features can be noted:

- the orientation towards integration into the global innovation sphere,
- the priority of state policy in the field of science and education, the creation of favourable institutional conditions for innovative business,
- the influence of the mechanisms of the Communist Party in the form of developing medium-term and long-term plans in this area (the so-called five-year plans),
- and a hierarchical management system. Each province has its own commission on science and new technologies. Local governments are authorized to adjust state policy to the specific social, economic and geographical conditions of the region.

Despite certain achievements, in the future China will still have to solve problems such as: (2)

- distrust of foreign partners due to the reputation of "a country of fakes",
- obstacles associated with the significant presence of state ownership in the financial sector,

- problems associated with the underdeveloped venture capital market, which is mainly concentrated in the hands of state funds. Private and foreign venture capital investments are currently relatively insignificant due to the unclear legal situation and market opacity.

Although the PRC innovation system has inherited many characteristics of the Soviet scientific system, which was not sufficiently adapted to the tasks of a market economy, large-scale reform of higher education, support for technological enterprises and special development zones and clusters allowed China to become one of the main economic and scientific powers of our time (26).

Currently, China has one of the largest research facilities in the world, which has grown rapidly over the past decade. According to many quantitative and qualitative parameters of research, the country is among top five world leaders. One of the main reasons for the rapid development of science are large-scale financial contributions. They became possible both due to a significant increase in budget spending, and thanks to the activity of the industrial sector.

The management of science in China is confined to the Ministry of Science and Technology (separated from the Ministry of Education), however, key program documents in the state are discussed collectively. The main goal of the current structural reform of science in China is the transformation of enterprises into the main subjects of research. The government is betting on accelerated commercialization of scientific achievements and the leading role of the market in determining the importance of scientific research. An important area of reform is improving the quality of science management and the effectiveness of research.

3.4.1 China’s Aging Population

China’s population is rapidly aging, and this threatens the economy of the country. There is a huge amount of people at the age of 65 years and older. The aging of the population in China is proceeding at a much faster pace than in other countries.

David I. Bloom, professor of economics and demography at Harvard University, offers various options for managing the population growth process, which he calls "the most significant demographic transformation in the history of mankind.” (5)

According to the GSU, at the end of 2018, the total population of China was about 1 billion 395 million people, which indicates a net increase of 5.3 million people compared to the end of 2017. The annual population growth was 15.23 million people, which is 2 million less than in 2017. The birth rate was 10.94 ppm, which is 1.49 ppm less than the corresponding figure for 2017. (13)

The head of the department of population and employment of GSU Li Sizhu said that in 2018 the number of people born in China decreased by 2 million people compared with the previous year. This was mainly influenced by two factors: first, the number of women of childbearing age continued to decline; secondly, the birth rate decreased slightly compared with the previous year. In 2016 and 2017, the “one family - two children” policy began to be implemented centrally, and in 2018 the effect of the new policy weakened, the trend towards the birth of the second child levelled, as a result of which the overall birth rate of the second child decreased in 2018, which led to decrease in the general level of birth rate in comparison with the previous year. (33)

Li Siju added that the “one family - two children” policy played a positive role in raising the birth rate, the number of second born children greatly mitigated the decline in the birth rate due to the “one child” principle, which helps to improve the age structure of the population and promotes balanced development. However, despite the fact that the working-age population in China has declined, and the aging population has increased, the labour force is still abundant, the potential is very large. (32)

Despite the aging population the People's Republic of China (PRC) is a large and economically strong state in East Asia.

3.4.2 Energy Sector of China

Energy consumption is a prerequisite for the existence of mankind, the presence of an ongoing and improving living conditions. The history of civilization is the history of the application of all new methods of energy conversion, the development of its new sources and, as a consequence, the increase in energy consumption.

In the modern world, energy is the basis for the development of basic industries that determine the progress of social production. In all industrialized countries, the pace of energy development has outpaced the pace of development of other industries. At the same time, energy is one of the sources of adverse effects on the environment and humans. It affects the

atmosphere; oxygen consumption, emissions of gases, moisture etc, the hydrosphere; water consumption, the creation of artificial reservoirs, discharges of polluted and heated water, liquid waste, and the lithosphere; consumption of fossil fuels, landscape changes and toxic emissions.

Despite the noted factors of the negative impact of energy on the environment, the increase in energy consumption did not cause much concern among the general public. This continued until the mid-70s, when specialists found themselves in the hands of numerous data; indicating strong anthropogenic pressure on the climate system, which poses a threat of global catastrophe with an uncontrolled increase in energy consumption. Since then, no other scientific problem has attracted such close attention as the problem of real, and especially upcoming, climate change.

When it comes to China, the country is responsible for a huge amount of pollution caused by the increased energy consumption. The excessive dependence of China's national economy on coal is accompanied by an unprecedented level of environmental pollution.

Rapid economic development in the past two decades has turned China into one of the world's largest energy consumers. PRC economy has entered a new development period characterized by trends such as accelerated development of heavy industry, raising the level of urbanization, accelerating Global production.

Nowadays, in the energy sector, the Chinese government aims to promote market pricing systems, measures to increase energy efficiency and competition between energy companies, and to increase investment in renewable energy. Considering renewable sources as one of the options for diversifying energy sources, reducing the country's dependence on coal and improving the environmental situation, the Chinese government actively supports and develops programs aimed at supporting the renewable energy industry in China (31).

The development of Chinese economy is based on five-year plans. It seems necessary to note the fact that the main energy goals of the current five-year plan are to increase consumption from renewable energy sources to 15% and to reduce carbon dioxide emissions by 40-45% by 2020 in order to reduce the country's dependence on coal supplies improving the environmental situation. As a result of the implementation of the state policy on the development of renewable energy sources, China has achieved certain results in the development of wind, solar, hydropower and energy processing waste (31).

The total installed capacity of renewable energy facilities in China was 148,543 MW in 2007, 236,473 MW in 2010 and 545,916 MW in 2016, in accordance with the statistical report released by IRENA in 2017. (6) By the end of 2018, the capacity of renewable energy

in China increased by 12% from the previous year to 728 GW (including hydropower and biomass- based power plants), according to the National Energy Administration. (2)

The share of renewable energy in the total energy portfolio of the country increased in 2018 to 38.3% - by 1.7 percentage points more compared to the end of 2017 and by 7 percentage points more than at the end of 2015. (2)

A very large amount of energy in China continues to be generated using coal-fired thermal power plants, which has a terrible effect on the environment and the state of the atmosphere in the country. At the end of 2015, the country refused to develop new deposits and decided to gradually reduce the share of coal capacity in the energy portfolio from the current 64.4%. In early 2017, the Chinese government cancelled the planned construction of more than 100 coal generation facilities. (32)

In accordance with the long-term forecast up to 2040 from analytical company Bloomberg New Energy Finance (BNEF), due to the slowdown of China's economy and its rapid reorientation to renewable energy sources, the amount of energy generated by coal generation facilities will decrease in the country in the next ten years by about 20%. (13)

In June 2014, at the sixth Central Conference of Financial Leaders, President Xi Jinping put forward five strategies for the development of energy and the consumption revolution in China: (30)

- further reforming energy consumption and controlling unreasonable energy consumption,
- diversification of the energy supply system,
- improving power generation technologies and increasing industrial production,
- development of energy structure, reform of legislation for the speedy energy development,
- tighter and fruitful international cooperation and implementation of the concept of energy security.

In addition, at the 13th National Energy Planning Conference, it was particularly noted that the state should focus its attention on the development of renewable energy sources, primarily wind generation and solar energy.

By 2040, China will continue to remain a leader in the field of investment in the development of renewable energy, with a share of 28% of the global total, in accordance with an estimate published by BNEF in the 2017 New Energy Outlook 2017 report. (13)

In 2015, China intended to increase the amount of solar energy assets to 150 GW by 2020, according to the renewable energy department of the National Energy Administration

(NEA). However, in November 2016, NEA reduced the forecast by 27% to 110 GW due to the fact that the country's power grids are not able to cope with the rate of growth of renewable energy and require immediate modernization. (2)

In 2018, the country was connected to a total network of 20.59 GW of wind power, according to the National Energy Administration. Almost all equipment for projects in the country is supplied by local manufacturers (mainly Goldwind, Guodian United Power, Envision and Ming Yang). (13)

China intended to increase the amount of wind energy assets to 250 GW by 2020, according to the renewable energy department of the National Energy Administration (NEA). However, in November 2016, NEA lowered the forecast by 16% to 210 GW due to the fact that the country's power grids do not cope with the rate of growth of renewable energy sources and require immediate modernization. In 2018, hydropower capacity commissioning in China amounted to 8.54 GW, mainly in the south-west of the country, increasing the total portfolio of hydropower resources to 352 GW. according to the National Energy Administration (13).

3.5. Chinese Coronavirus Threatening the Global Economic Outlook

Given all the indicators China remains one of the top markets in the world, however how resilient the economy really is, when it comes to unstable and unpredicted situations? An outbreak of pneumonia in the PRC caused by the Covid-19 coronavirus has had a major impact on Chinese exports and global supply chain, which jeopardizes the prospects for the global economy.

While some companies return to work after a few weeks of shutdown, others delay the resumption of operations in China. Consumers avoid visiting shops and restaurants, and transport in many regions of the country is interrupted. *"The coronavirus epidemic, or rather, the actions of the PRC authorities to curb its spread, pose the greatest threat to global economic growth in the short term,"* said Neil Shearing (37), chief economist at Capital Economics.

The consequences of Covid-19 for the global economy are likely to be more significant than in the case of SARS, which broke out in China in 2002, since the Chinese economy has quadrupled since then and its relationship with the economies of other regions has significantly increased (38).

Conclusions about the scale of the negative consequences for the economy can already be drawn considering the measures taken by the country's authorities to limit the spread of coronavirus. Wuhan, the epicentre of the epidemic, as well as a number of other cities, are quarantined and it will take months to fully evaluate the amount of the damage down to Chinese as well as global economy. (37)

Despite all these, Chinese President Xi Jinping and other Chinese statesmen are optimistic about the country's economic outlook in 2020, despite the epidemic, but market analysts do not share their confidence, worsening economic forecasts. The optimism of the authorities of the PRC can be traced in Chinese media. With the epidemic almost behind, it the economy shall recover next. The effects of the coronavirus on the PRC economy will be temporary and will not prevent China from achieving the goal of doubling the volume of GDP and per capita income (38).

3.6. Overview of Studies on China's R&D Shift

Several studies have been done on the shift of Chinese economy to research, development and innovation. Scopes of the studies are slightly different however, many of them attempt to examine the shit to R&D over a given period of time, challenges as well as outcomes are indicated after calculations of selected data sets that mostly cover factors such as; FDI, GDP and R&D expenditure, represented as a share of total GDP.

According to one of the studies (41), the shift pauses a challenge for local multinational corporations to adjust the workforce to design thinking and innovation. The study has examined closely the operation of 3 large multinational corporations in China; Fujitsu, Motorola and Nokia. The way those companies manage R&D operations in China has been closely monitored.

The study has found out that many of the R&D centres initially seemed to deal with plain research rather than actual production and product generation. The study indicates that the increased findings from the governments as well as FDI have, in fact, opened up opportunities for China to transform to an emerging market that initiates the production of actual high-quality products, breaking the hypothesis of China being "the country of fakes".

The study period has been selected over the years of 1996-2004, that seemed to notice high potential and growth of investments. The theoretical background of the study covers a research on various R&D activities worldwide and a comparative analysis is then conducted

to find similarities/differences between the operation of the above-mentioned corporations in China and worldwide. Short interviews with R&D directors are conducted as part of the study. Company profiles, R&D operations, facilities as well as the economic growth over the years have been considered.

The study has concluded that given the example of three multinational corporations, China is, in fact, a favourable market for such companies to initiate or procced with their R&D operations due to the available low-cost talent educated either oversees or at local educational and research institutions that the Chinese government has been generously investing in over the past decade. The study also indicates that the local market attractiveness is a key factor to drive economic growth.

Another study (42) reveals the nature of public policy in China when it comes to state statistics and issues related to state financing and strategic planning in the scientific and technical sphere. This study conducts a comparative analysis between countries such as USA, China, Japan, Russia and South Korea.

The study analyses several legislative and policy documents of the Chinese authorities, data from the State Statistical Office, the Ministry of Finance of the PRC and UNESCO, as well as the results of research by Chinese and foreign scientists, establishing the features of state financing and strategic planning in the country's scientific and technical sphere.

The study indicates that a distinctive feature of the development and reform of Chinese science over the past decade has been a constant increase in the absolute and relative costs of research. From 2005 to 2015, the share of research and development expenditures in the PRC's GDP grew from 0.9 to 2.1%. According to UNESCO, in recent years, China spends as much on one scientist (more precisely, on one researcher’s stake) as developed countries. In 2015, such costs amounted to 253 thousand US dollars (at purchasing power parity), 2.8 times more than in Russia for instance.

The study results indicate, that currently, China has one of the largest research facilities in the world, which has grown rapidly over the past decade. According to many quantitative and qualitative parameters of the research, the country is in the top five world leaders.

The given studies are in fact insightful and present a solid theoretical background. However, when it comes to the used methodology and calculations, it becomes clear that there is space for further research. One of the reasons behind that is that the available studies that have been conducted do not include data over the past 5 years, while that is the period of time when China saw a drastic raise in R&D expenditure and R&D operations overall. Thus,

neglecting data sets over the past 5-6 years may fail to indicate the true picture of the economic shift.

Thus, we have collected a larger data set and processed it through a detailed econometric analysis. Apart from that we have also carried out a SWOT analysis to provide a more solid background to base our results on.

4 Practical Part

It goes without saying that it is quite challenging to econometrically model PRC economy, given the lack of published data as well as the fact that china is a transitional economy. In the econometric analysis, our hypothesis is presented in the form of assumptions that are backed by the literature review conducted earlier. Our econometric model is derived from an economic one. The model is used for forecasting that plays a pivotal role in policy making.

4. 1 Economic Model and Econometric Model

Assumptions

1. The most significant influence on increase of R&D Expenditure in China is on increase of GDP

   In 3.3.1 we examine the changes of Chinese GDP over the years. Chapter 3.4 then discusses China's efforts on investing into Innovation from a large share of the GDP. In our econometric model, we try to clarify whether GDP is actually the variable that has the most significant influence on R&D expenditure.
2. An increase on GDP will lead to an increase of R&D spending

   As discussed in 3.3.1 over the past years China has seen a major raise of GDP. Our model examines whether this raise can positively increase the R&D expenditure whatsoever.
3. An increase on FDI will lead to a significant increase on R&D development in China

   As discussed in 3.4 Chinse federal government as well as local governments provide innovation funding when it comes to R&D. Furthermore, there exists a procurement system, according to which the state should allocate a certain remuneration to innovative Chinese enterprises.

   The same chapter also discusses the fact that over the years China has acquired the reputation of "a country of fakes", which creates problems when it comes to Foreign Direct Investments. The uncertain legal state hinders private and foreign venture capital investments and as a result they are, currently, relatively insignificant. Our

econometric model examines whether or not the increase of FDI may positively impact the development of R&D in China.

Economic model

R&D expenditure in China has dependency on GDP, electric power consumption and foreign direct investment.

$y1t = f(x2t, x3t, x4t)$

Econometric model

$By1t = \gamma 12\ x2t + \gamma 13\ x3t + \gamma 14\ x4t + u1t$

Our econometric model has been developed from the economic one. Y1t is our endogenous variable, otherwise called “dependent variable”, the value of which is determined by our exogenous/independent variables X2t, X3t and X4t. Variables X2t, X3t and X4t serve as explanatory variables and their values are determined outside the econometric model. We have also added u1t as a random error term. As a rule, the error term is used when there is an uncertainty associated with the function. Our error term helps to quantify the uncertainty.

Declaration of variables

1. Endogenous Variable

Y1t … Gross domestic spending on R&D Total, Million US dollars

2. Exogenous Variables

X1t … Unit vector

X2t … Gross domestic product (GDP) Total, Million US dollars

X3t … Electric power consumption (kWh per capita)

X4t … Foreign direct investment, net inflows (BoP, current US$)

U1t … Random error, ~ nid (0, σ2)

4.1.1 Parameters' Estimation Using OLSM in Gretl

We have then used Gretl (Gnu Regression, Econometrics and Time-series Library) for our econometric analysis. The acquired OLS model is indicated below.

Model 1: OLS, using observations 1994-2018 (T = 25)

Dependent variable: GrossdomesticspendingonRD

Table 1 Parameters' Estimation Using OLSM in Gretl

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	−28217.4	4758.92	−5.929	<0.0001	***
Grossdomestic product GDP	0.0247881	0.00156234	15.87	<0.0001	***
Electric power consumption	−24.6759	10.8881	−2.266	0.0341	**
Foreign direct investment	0.0314658	0.0470471	0.6688	0.5109	

Mean dependent var	168925.2	S.D. dependent var	152686.8
Sum squared resid	1.10e+09	S.E. of regression	7231.789
R-squared	0.998037	Adjusted R-squared	0.997757

Regression model is equal to:

$$Y1 = -28217.4 + 0.0247881\ X2t - 24.6759\ X3t + 0.0314658\ X4t + Ut$$

4.2 Model Verification

Economic verification of the model

$y1t = f(x1t, x2t, x3t, x4t)$

$$Y1 = -28217.4 + 0.0247881\ X2t - 24.6759\ X3t + 0.0314658\ X4t + Ut$$

The estimated parameters show how spending on R&D will change if any/one of the explanatory variables is changed.

Interpretation

- If all values of all independent variables will be equal to zero, then R&D spending will be equal to 28217.4 USD/per capita/year.
- If GDP will increase by one million USD per year, then it will lead to an increase by 0.024 USD/million/year.
- In the scenario when electric power consumption will increase by 1 kWh/capita, then it will result on a decrease of R&D expenditure by 24.67 USD/capita/year.
- If the government increases FDI, then it will lead to an increase of R&D spending by 0.03 million/USD//year in PRC.

Based on the above interpretations we can check our initial assumptions:

1. Our first assumption was that the most significant influence on increase of R&D Expenditure in China is on increase of GDP. This assumption has not been approved. Our model has indicated that, among our variables, the most significant effect on R&D expenditure has electric power consumption.
2. Our second assumption indicated that an increase on GDP will lead to an increase of R&D spending. This assumption has been approved.
3. Our third assumption stating that an increase on FDI will lead to a significant increase on R&D development in China has also been approved.

Statistical verification (statistical significance of parameters; R2)

Significance of parameters

Based on OLS results we can check P-values and make statistical significance of parameters.

	p-value	*Level of significance*	*Result*
Constant	<0.0001	0.05	Parameter Statistically Significant
X2	<0.0001	0.05	Parameter Statistically Significant
X3	0.0341	0.05	Parameter Statistically Significant
X4	0.5109	0.05	Parameter Statistically Insignificant

R-squared for our model is equal to 0.998 or 99.8%. This means that our model explains changes in our dependent variable for 99.8% and the remaining 0.2 % is in combination with the stochastic variables.

Testing of Normality and Heteroscedasticity

Tests for heteroscedasticity and normality of residual are done to test the normality.

Type	Test used
Heteroscedasticity	White's test
Normality	Frequency distribution

Ho: Hypothesis: Normal distribution of random variable, Homoscedasticity
H1: Hypothesis: Not normal distribution of random variable, Heteroscedasticity

Normality

	P-value	Alpha	Result
White test	0.355988	0.05	Ho approved
Normality Test	0.13723	0.05	Ho approved

In both of the scenarios, we have normal distribution of random variable, Homoscedasticity in our simultaneous model.

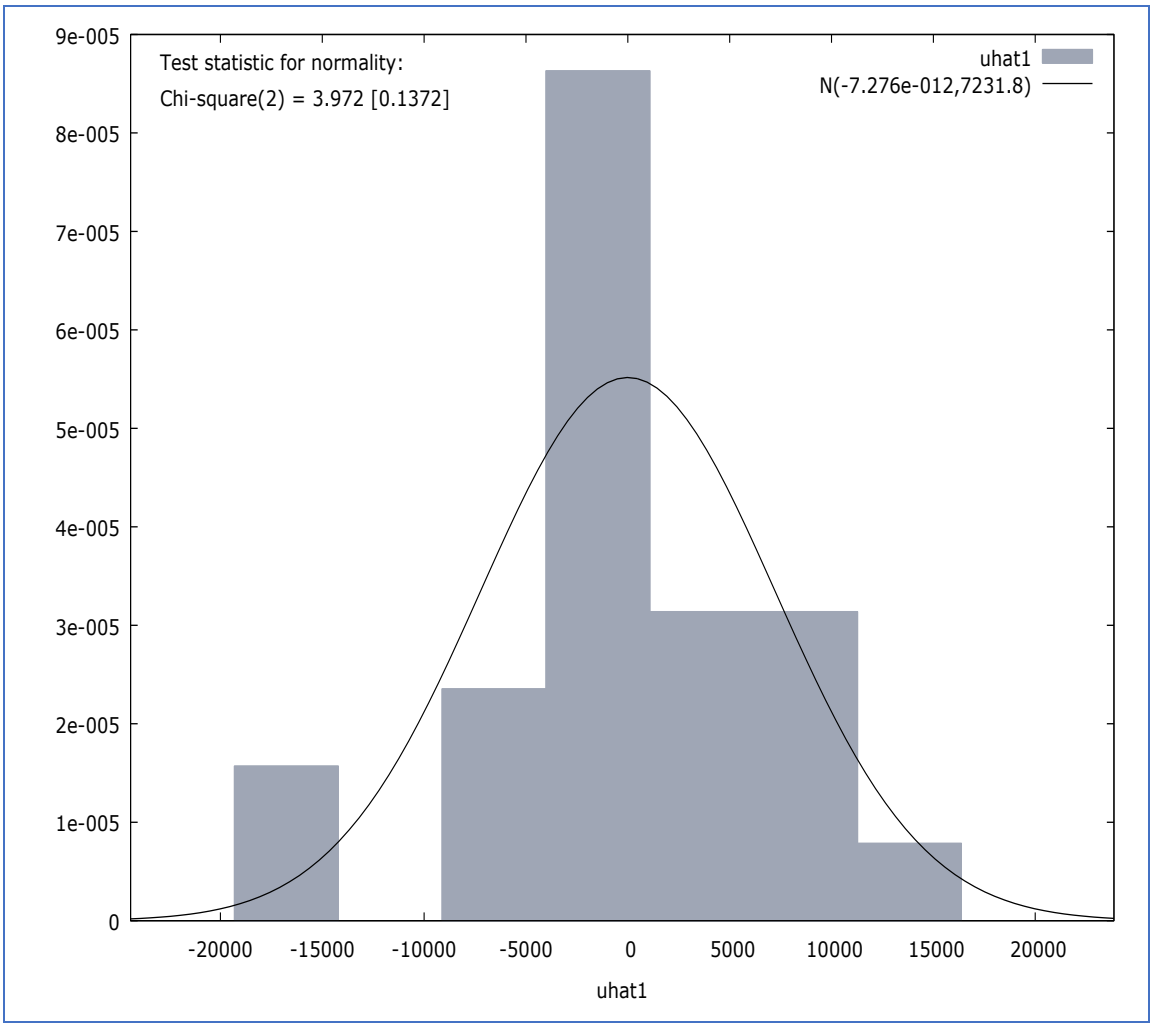

Figure 3 Normality

4.2.1 Model application (coefficients of elasticity, scenarios' simulation)

Coefficient of Elasticity:

Coefficient of elasticity shows the impact of individual variables on the value of dependent variable and it is expressed as a percentage for the certain period. Calculation done with main formula. Please refer to Table 2. For detailed calculations of Elasticity.

$$\frac{\partial Y_{1t}}{\partial X_{1t}} * \frac{X_{1t}}{\hat{Y}}$$

Elasticity calculation for the whole periods can be done based on the above formula.

$$Y1 = -28217.4 + 0.0247881\ X2t - 24.6759\ X3t + 0.0314658\ X4t + Ut$$

Scenarios' simulation and interpretation

Given the model we can infer how much the total R&D spending will change in case GDP increases by 12%.

In case China's GDP increases by 12% then R&D spending will increase by 15.09% (12*1.2581).

How R&D spending will change if electric power consumption will increase by 5% per year?

In the scenario that electric power consumption increases by 5% per year, it will lead to a decrease of R&D to 1.94% (5*- 0.2188).

Let's also interpret the elasticity of FDI. If FDI in China increase by 1% then it will lead to an increase of spending on R&D by 0.017%, which is not a significant increase.

4.3 Simultaneous model

Our simultaneous model represents a set of linear simultaneous equations.

Economic model

1) $Y1t = f(y2t, x_{1t}, x_{2t}, x_{4t}, x_{7t})$

Gross domestic spending on R&D explained by changes on GDP, Foreign Domestic investment and total number of researchers.

2) $Y2t = f(y1t, x_{3t}, x_{5t}, x_{6t})$

Export of goods and services determined by electric power consumption, inflation and number of total population.

Econometric model

$$y_{1t} = \beta_{12}\, y_{2t} + \gamma_{11}\, x_{1t} + \gamma_{12}\, x_{2t} + \gamma_{14} x_{4t} + \gamma_{17} x_{7t} + u_{1t}$$

$$y_{2t} = \beta_{21}\, y_{1t} + \gamma_{11}\, x_{1t} + \gamma_{23}\, x_{3t} + \gamma_{25} x_{5t} + \gamma_{26} x_{6t} + u_{2t}$$

Where:

Y1t … Gross domestic spending on R&D Total, Million US dollars
Y2t … Exports of goods and services (% of GDP)
X1t … Unit vector
X2t … Gross domestic product (GDP) Total, Million US dollars
X3t … Electric power consumption (kWh per capita)
X4t … Foreign direct investment, net inflows (BoP, current US$)
X5t … Inflation, GDP deflator (annual %)
X6t … Population, total
X7t … Researchers Total, Per 1 000 employed
U1t … Random error, ~ nid (0, σ2)
U2t - random error, ~ nid (0, σ2)

Assumptions before analysis

1. An increase of export of goods and services will lead to increase on spending on R&D in China and vice versa

   As discussed in 3.3 by 2030 China aims to get rid of the barriers to entry and exit for private companies and enhance the competitiveness of state-owned enterprises. In our analysis we try to investigate how the easy export of goods and services will impact on R&D expenditure.
2. If the number of researchers will increase it will lead to increase on R&D expenditure

   3.4 discusses, in details, China's efforts to support researchers providing large allocations from the state funding and favourable working conditions. We have tried to analyse how the increase of the amount of research will impact the overall R&D expenditure.
3. An increase in inflation will lead to a decrease of export of goods and services in China

   Our literature review discusses economic indicators in detail, however there is not much date on the impact of increased inflation, which we have tried to calculate.

4.3.1 Model identification

Predetermined variables in the whole model: k = 6 (x1t, x2t x3t, x4t, x5t, x6t)

Endogenous variables in whole model: g = 2 (y1t, y2t)

$y_{1t} = \beta_{12}\, y_{2t} + \gamma_{11}\, x_{1t} + \gamma_{12}\, x_{2t} + \gamma_{14} x_{4t} + \gamma_{17} x_{7t} + u_{1t}$

$y_{2t} = \beta_{21}\, y_{1t} + \gamma_{11}\, x_{1t} + \gamma_{23}\, x_{3t} + \gamma_{25} x_{5t} + \gamma_{26} x_{6t} + u_{2t}$

Identification for next equations: $k^{**} \geq g\Delta - 1$

1st equation $K^{**} = 2 > G\Delta - 1 = 1$ => model **is over identified**

2nd equation $K^{**} = 2 > G\Delta - 1 = 1$ => model **is over identified**

Result -> model is over identified

4.3.2 Parameters' estimation using TSLSM in SW Gretl

Equation 1: y1t= -1.6104- 7.25 y2t + 0.0229 x2t – 0.0213 x4t + 2.7904 x7t u1t

Y1Grossdomesticspendingon = -1.6204 - 7.25*Y2Exportsofgoodsandservic + 0.0229*X2GrossdomesticproductGDP - 0.0213*X4Foreigndirectinvestment - 2.7904*X7ResearchersTotalAPer100

Model 1: TSLS, using observations 1994-2018 (T = 25)
Dependent variable: Y1Grossdomesticspendingon
Instruments: const X2GrossdomesticproductGDP X3Electricpowerconsumption X4Foreigndirectinvestment X5InflationGDPdeflatoran X6Populationtotal X7ResearchersTotalAPer100 Y2Exportsofgoodsandservic

Table 2 Parameters' estimation using TSLSM in SW Gretl

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	−16205.7	5258.83	−3.082	0.0059	***
Y2Exportsofgoodsandservic	−7.25035	263.863	−0.02748	0.9784	
X2GrossdomesticproductGDP	0.0228973	0.000516851	44.30	<0.0001	***
X4Foreigndirectinvestment	−0.0212520	0.0225612	−0.9420	0.3574	
X7ResearchersTotalAPer100	−27949.2	6312.78	−4.427	0.0003	***

Mean dependent var	168925.2	S.D. dependent var	152686.8
Sum squared resid	5.35e+08	S.E. of regression	5171.698
R-squared	0.999044	Adjusted R-squared	0.998853
F(4, 20)	5224.833	P-value(F)	7.01e-30
Log-likelihood	−246.4581	Akaike criterion	502.9162
Schwarz criterion	509.0105	Hannan-Quinn	504.6065
rho	0.378334	Durbin-Watson	0.995716

Sargan over-identification test

Null hypothesis: all instruments are valid

Test statistic: LM = 8.5682

with p-value = P(Chi-square(3) > 8.5682) = 0.0356185

Equation 1	**Parameters**
Constant Term	−16205.7
Y2	−7.25035
γ2	0.0228973
γ4	−0.0212520
γ7	−27949.2

Equation 2: y_{2t}= *-265 – 5.9905 y1 - 0.00233 x3t + 0.646 x5t + 2.3007 x6t + u2t*

^Y2Exportsofgoodsandservic = -265 - 5.9905*Y1Grossdomesticspendingon - 0.00233*X3Electricpowerconsumption + 0.646*X5InflationGDPdeflatoran + 2.3007*X6Populationtotal

Model 2: TSLS, using observations 1994-2018 (T = 25)

Dependent variable: Y2Exportsofgoodsandservic

Instruments: const Y1Grossdomesticspendingon X2GrossdomesticproductGDP X3Electricpowerconsumption X4Foreigndirectinvestment X5InflationGDPdeflatoran X6Populationtotal X7ResearchersTotalAPer100

Table 3 TSLS

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	−264.951	50.4091	−5.256	<0.0001	***
Y1Grossdomesticspendingon	−5.9866705	2.09085e-05	−2.863	0.0096	***
X3Electricpowerconsumption	−0.00233411	0.00336291	−0.6941	0.4956	
X5InflationGDPdeflatoran	0.645843	0.185424	3.483	0.0023	***
X6Populationtotal	2.3037707	4.16482e-08	5.532	<0.0001	***

Mean dependent var	24.42581	S.D. dependent var	5.667794
Sum squared resid	190.6717	S.E. of regression	3.087651
R-squared	0.752687	Adjusted R-squared	0.703224
F(4, 20)	15.21730	P-value(F)	7.30e-06
Log-likelihood	−60.86943	Akaike criterion	131.7389
Schwarz criterion	137.8332	Hannan-Quinn	133.4292
rho	0.611390	Durbin-Watson	0.806696

Sargan over-identification test -

Null hypothesis: all instruments are valid

Test statistic: LM = 6.38321

with p-value = P(Chi-square(3) > 6.38321) = 0.0943839

Equation 2	Parameters
Constant Term	−264.951
Y1	−5.9866705
γ3	−0.00233411
γ5	0.645843
γ6	2.3037707

4.3.3 Model Verification

First equation

$Y1t = f(y2t, x_{1t}, x_{2t}, x_{4t}, x_{7t})$

$y_{1t} = -1.6104 - 7.25\, y_{2t} + 0.0229\, x2t - 0.0213\, x4t + 2.7904\, x7t\, u1t$

Interpretation:

- If export of goods and services will increase by 1% then it will lead to decrease on spending on R&D by 7.25 %
- If GDP will increase by 1 million USD, then it will lead to an increase of spending on R&D for 0.0229 million USD.
- An increase of FDI for 1 million USD will lead to a decrease on R&D spending for 0.0213 million USD.

- If the total number of researchers will increase by 1 unit, it will lead to an increase of R&D expenditure for 2.79 million USD

Second equation

$Y2t = f(y1t, x_{3t}, x_{5t}, x_{6t})$

$y_{2t} = -265 - 5.9905\ y1 - 0.00233\ x3t + 0.646\ x5t + 2.3007\ x6t + u2t$

Interpretation:

- If R&D expenditure increases by 1 million USD, it will lead to a decrease of export of goods and services for 5.99%
- In the scenario when consumption of electric power increases by kWh per capita it will lead to a decrease of export of goods and services.
- If inflation increases by 1%, then export of goods and services will increase by 0.64%
- If the total population of China increases by 1 million, it will lead to the increase of exports of goods and services by 2.3%

Based on the above interpretations we can check our initial assumptions:

1. Our initial assumption that an increase of export of goods and services will lead to an increase of R&D expenditure in China and vice versa, has not been approved. A negative relation has been found. The increase of Y2 will lead to a decrease of Y1.
2. Our second assumption that the increase in the number of researchers, will lead to an increase of R&D expenditure has been approved.
3. Our third assumption that the increase in inflation will lead to a decrease of experts of goods and services in China has not been approved either. A negative relation has been found. The increase of X5 will lead to a decrease of Y2.

Statistical verification (statistical significance of parameters; R2)

First equation

Significance of parameters

Based on TSLS results we can check P-values and make statistical significance of parameters.

Based on the results, we can see that parameters of X2 and X7 are statistically significant.

Model 2: TSLS, using observations 1994-2018 (T = 25)
Dependent variable: Y1Grossdomesticspendingon
Instruments: const X2GrossdomesticproductGDP X3Electricpowerconsumption X4Foreigndirectinvestment X5InflationGDPdeflatoran X6Populationtotal X7ResearchersTotalAPer100 Y2Exportsofgoodsandservic

Table 4 TSLS

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	−16205.7	5258.83	−3.082	0.0059	***
Y2Exportsofgoodsandservic	−7.25035	263.863	−0.02748	0.9784	
X2GrossdomesticproductGDP	0.0228973	0.000516851	44.30	<0.0001	***
X4Foreigndirectinvestment	−0.0212520	0.0225612	−0.9420	0.3574	
X7ResearchersTotalAPer100	−27949.2	6312.78	−4.427	0.0003	***

Sargan over-identification test -
Null hypothesis: all instruments are valid
Test statistic: LM = 8.5682
with p-value = P(Chi-square(3) > 8.5682) = 0.0356185

Testing of Normality and Heteroscedasticity for 1st equation

Type	Test used
Heteroscedasticity	Pesaran-Taylor
Normality	Frequency distribution

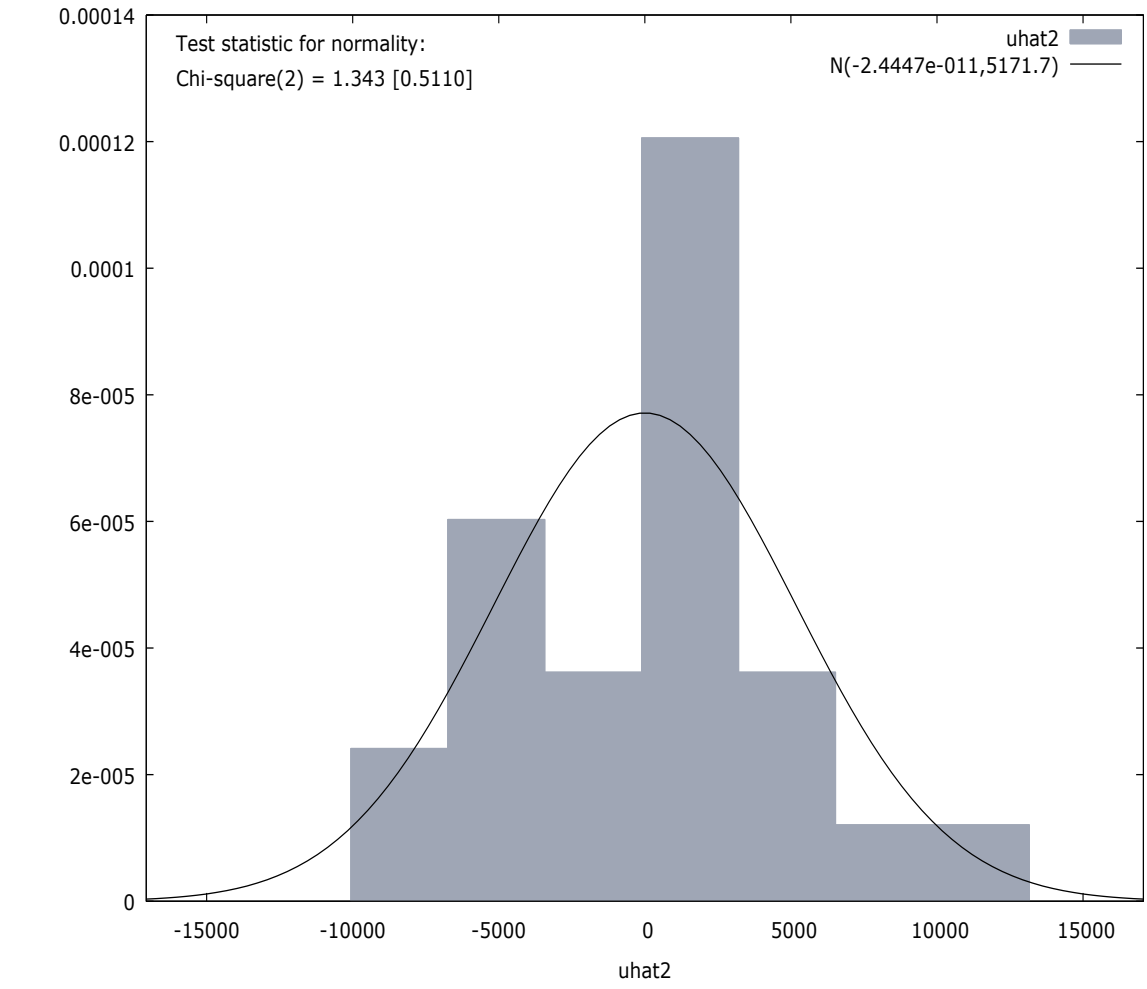

Figure 4 Normality

Ho: Hypothesis: Normal distribution of random variable, Homoscedasticity
H1: Hypothesis: Not normal distribution of random variable, Heteroscedasticity

	P-value	Alpha	Result
Pesaran-Taylor	0.492	0.05	Ho approved
Normality Test	0.551102	0.05	Ho approved

Test for normality of residual

Null hypothesis: error is normally distributed

Test statistic: Chi-square(2) = 7.02559

with p-value = 0.551102

Second equation

Significance of parameters

Based on TSLS results we can check P-values and make statistical significance of parameters. *From our results, we can see that only parameter of Y1, X5, X6 are statistically significant.*

Model 2: TSLS, using observations 1994-2018 (T = 25)

Dependent variable: Y2Exportsofgoodsandservic

Instruments: const Y1Grossdomesticspendingon X2GrossdomesticproductGDP X3Electricpowerconsumption X4Foreigndirectinvestment X5InflationGDPdeflatoran X6Populationtotal X7ResearchersTotalAPer100

Table 5 - TSLS

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	−264.951	50.4091	−5.256	<0.0001	***
Y1Grossdomesticspendingon	−5.98667e-05	2.09085e-05	−2.863	0.0096	***
X3Electricpowerconsumption	−0.00233411	0.00336291	−0.6941	0.4956	
X5InflationGDPdeflatoran	0.645843	0.185424	3.483	0.0023	***
X6Populationtotal	2.30377e-07	4.16482e-08	5.532	<0.0001	***

Mean dependent var	24.42581	S.D. dependent var	5.667794
Sum squared resid	190.6717	S.E. of regression	3.087651
R-squared	0.752687	Adjusted R-squared	0.703224
F(4, 20)	15.21730	P-value(F)	7.30e-06
Log-likelihood	−60.86943	Akaike criterion	131.7389

Schwarz criterion	137.8332	Hannan-Quinn	133.4292
rho	0.611390	Durbin-Watson	0.806696

Sargan over-identification test -
Null hypothesis: all instruments are valid
Test statistic: LM = 6.38321
with p-value = P(Chi-square(3) > 6.38321) = 0.0943839

R-squared for our model is equal to 0.75 or 75,2 %. This means that our model explains changes in our dependent variable for 75,2 % and remaining 24.8% is in combination with stochastic variables.

Testing of Normality and Heteroscedasticity for 2nd equation

Type	Test used
Heteroscedasticity	Pesaran-Taylor
Normality	Frequency distribution

Ho: Hypothesis: Normal distribution of random variable, Homoscedasticity
H1: Hypothesis: Not normal distribution of random variable, Heteroscedasticity

	P-value	Alpha	Result
Pesaran-Taylor	0.0718	0.05	Ho approved
Normality Test	0.27573	0.05	Ho approved

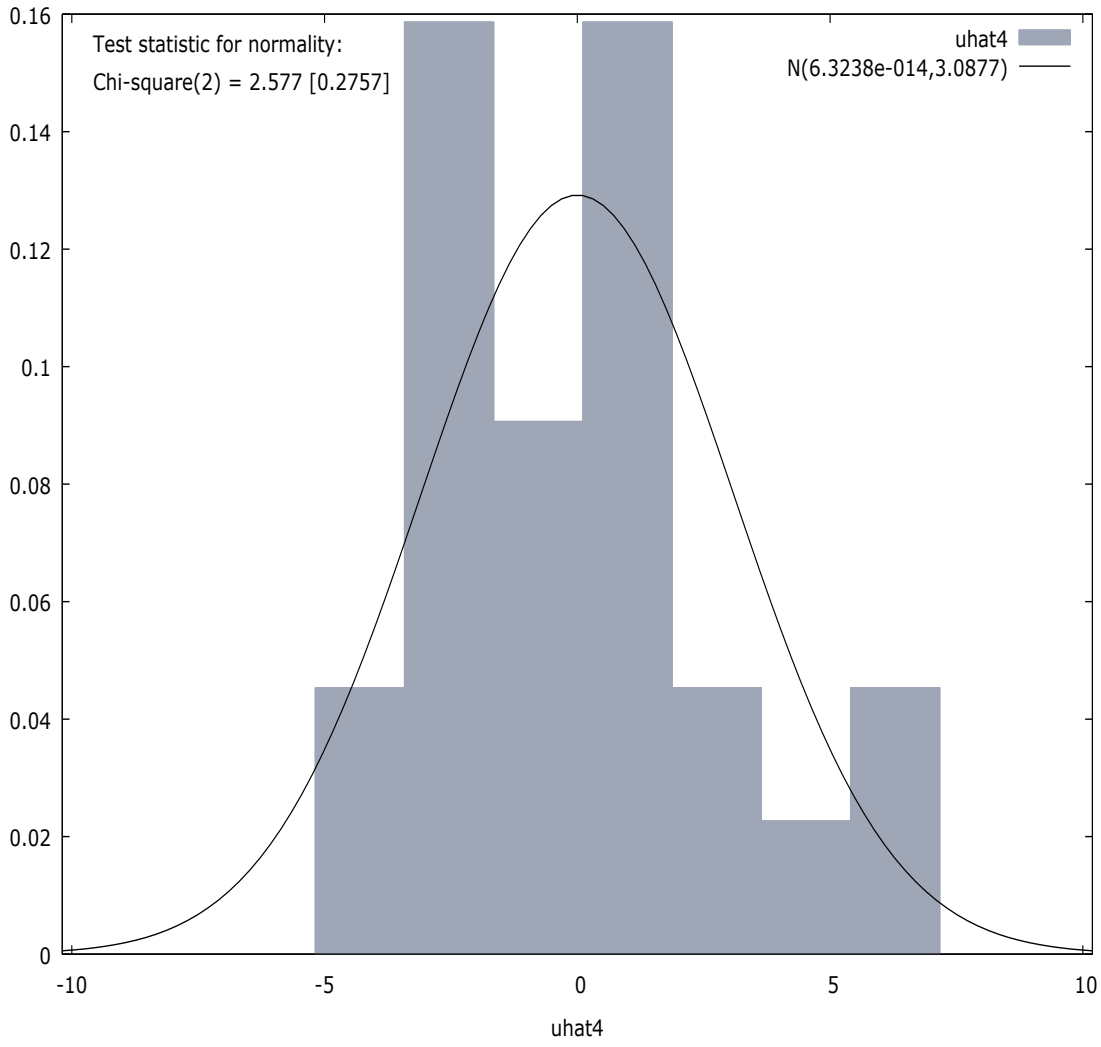

Figure 5 Normality

Pesaran-Taylor test for heteroskedasticity -

Null hypothesis: heteroskedasticity not present

Asymptotic test statistic: z = 0.446029

with p-value = 0.0718

Test for normality of residual -

Null hypothesis: error is normally distributed

Test statistic: Chi-square(2) = 3.18824

with p-value = 0.27573

4.3.4 Matrix B, Γ and matrix M; reduced form of the model and interpretation; explanation of differences between structural and reduced form

Matrixes:

B

1	7.25
5.9905	1

	X1	*X2*	*X3*	*X4*	*X5*	*X6*	*X7*
Γ	1.61104	-0.0229	0	0.0213	0	0	-2.7904
	-265	0	-0.00233	0	-0.646	-2.3007	0

Reduced form:

$$M = -B^{-1} \Gamma$$

M	45.317	-0.001	0.0004	0.001	0.110	0.393	-0.066
	-6.473	0.003	-0.0001	-0.003	-0.015	-0.054	0.394

Structured Form

y1t= -1.6104- 7.25 y2t + 0.0229 x2t – 0.0213 x4t + 2.7904 x7t u1t

y2t= -265 – 5.9905 y1 - 0.00233 x3t + 0.646 x5t + 2.3007 x6t + u2t

The final model in reduced form:

y1t = 45.317 – 0.001 x2t + 0.001 x4t – 0.066 x7t + v1t

y2t = -6.473 – 0.0001 x3t – 0.015 x5t - 0.054 x6t + v2t

The main differences in the models are direct or indirect effects. Structural form of parameters represents direct effects of explanatory endogenous and predetermined on endogenous variables. In reduced form are direct and indirect effects of predetermined variables on an endogenous variable.

4.3.5 Model Application

As an application of the model we have decided to use model elasticity. Elasticity will show us how percentage changes in any of the explanatory variables will lead to percentage change in dependent variable. Calculation was done for the whole period of the time range in our model but for result interpretation we used last year from our table.

Interpretation of the results:

- If the GDP of Chine increases by 1%, it will lead to an increase of spending on R&D by 1.014%
- In the scenario when FDI flow increases by 1%, the spending on R&D will decrease by 0.01%
- If the export of goods changes by 1%, it will lead to a decrease of R&D expenditure by 0.003%
- If the number of researchers increases by 1%, the R&D expenditure will increase by 0.0001%

Interpretation of the results:

- If electric power consumption increases by 1%, it will lead to an increase on export of goods and services by 0.005%
- In the scenario when inflation changes by 1%, export of goods and services will increase by 0.00001%, which is insignificant
- In case the total population increase by 1 percent, it will lead to an increase of export of goods for 1.001%

The majority of our assumptions before the calculations have been approved. However, the econometric analysis has also disproved some of the initial hypothesis. As opposed to other studies that have been conducted initially, during our analysis larger data sets have been

used. All calculations in a form of data sets are available in the appendix of this thesis. Resent data sets have been used for those calculations to provide a more precise overview of the current situation, while other studies have failed to include data sets from the past 5 years.

4.4 SWOT Analysis

Apart from our econometric analysis we have also conducted a SWOT analysis to unveil the potential of Chinese R&D economy. In our SWOT analysis we have closely monitored possible strengths, weakness, opportunities and threats for China to embark upon innovation.

Strengths

Large territory: 9.5 million square kilometres, 15,000 km of the coastline, which makes it possible to use the marine potential, which has not yet been sufficiently disclosed. A large number of non-freezing ports in the Pacific Ocean used as foreign trade ports.

Talented workforce: China has a population of over 1,3 billion inhabitants, that serves as a huge workforce. The large amount of economically active population calls for high tax revenues.

Government: Recent political shifts and reforms have helped to provide a stable space for economic growth. The government has proved to generously support and invest into innovation.

Education: China has recently largely invested into education founding modern universities, laboratories and research institutions that conduct a high-quality research in innovation, robotics and AI.

Economic growth: China's economic growth and a high GDP is a perfect step stone for the development of R&D.

Opportunities

FDI: Recently China has become an attractive location for FDI, given the economic shift as well as the available low-cost workforce.

Improved trade relations: Nowadays, China has improved trade relations with not only neighbouring countries but also rest of the world.

Innovation capacity: The rapid growth of China in the ranking of the Global Innovation Index proves that the country's potential in this area is fully capable of maintaining the high quality of development of the PRC.

Strong financial support for innovation: The volume of investment in science and the number of scientists in China is growing steadily, and Chinese supercomputers and defence projects are breaking records. China is gradually losing its reputation as the country with the lowest cost of production, as now the basis of the state development plan is innovation.

Weaknesses:

Aging population: China’s aging population may pause a threat to the economic growth.

Long decision-making process: While the rest of the world is going ahead with quick decisions to proceed with innovation, Chinese government is known to take a long time to make decisions causing expensive delays in launching a product, thus meeting a higher market competition.

Threats

Epidemics: Due to COVID-19, the economy has suffered greatly. The hospitals are crowded. Thousands of people have died. However, quarantine imposed by the government seems to have worked: it seems that the epidemic is now under control. Due to strict measures, the spread of infection seems to have been prevented. A slow recovery in production and improved economic performance is expected.

Reputation of the “country of fakes”: China has long been seen as a country of fake technologies. This paused a large risk for the country to be taken seriously globally. The government is doing all it can to shed light on problematic issues regarding legal regulations when it comes to the production and distribution of certain technology.

Foreign competition: Major world powers have prepared a number of reasons why, when necessary, it will be possible to impose a ban on the import of Chinese

products: human rights, censorship, democracy, freedom of elections, the environment, strict observance of the Kyoto Protocol, trade unions, working conditions, etc. ., And if an economic, military or other threat arises from China, any of these reasons will be enough to introduce a ban.

5 Results and Discussion

Our research has strongly indicated that China, as the second largest economy in the world today, is one of the drivers of changing the balance of power in the world. The country strives to become a global player in the market of high-tech products, to move from an investment economy to a knowledge economy, to form the largest consumer market in the world and attractive to other major global players. In this chapter, summarise and present our main findings from both theoretical and practical parts of the thesis.

5.1 Outcomes from the Theoretical Part

As a result of this research a connection was established between various factors; the significant influence of political and economic conditions on the determination of scientific and technological priorities was emphasized (chapter 3.1, 3.2 and 3.3). Considering these factors, and a number of critical uncertainties, probable scenarios of China's innovative development have been discussed (chapter 3.4).

Of great fundamental importance are the structural changes taking place in modern China in the national economy associated with the transition from production using low-skilled labour to the growth of the services sector, domestic consumption and the production of high-tech products, as discussed in 3.4. These transformations of the Chinese economy are ongoing, although the question remains open whether China can become a global player in the high-value-added products market.

The Chinese experience of successful innovation development is based on four main factors.

The first of them is to build constructive relations with the West (discussed in 3.3), which will allow to acquire new technologies on its territory for subsequent implementation in Chinese industry and the service sector, and to attract investors who are ready to introduce such technologies at their enterprises in China. The situation in which hundreds of thousands of foreign enterprises constantly bring new technologies to the Chinese economy allows them to upgrade the skills of their Chinese employees, including the ability to innovate in all areas of the country's economy. The design workshops of the largest corporations in the world on

Chinese territory create a very favourable atmosphere for the development of innovation and beyond.

The second is industrial espionage, the scale of which is enormous (discussed in 3.4), but for obvious reasons it is not possible to accurately assess them. In addition to the activities of special services that steal technology around the world and transfer them to Chinese companies for subsequent implementation, almost all Chinese structures with access to the external circuit, from corporations to scientific institutions, are oriented towards industrial espionage.

The third most important factor is the willingness of the government to invest generously in science, discussed in 3.4. Some of the ongoing programs offer generous material incentives to the professors and researchers of Chinese universities for publication in the most prestigious scientific journals in the world. The reward for articles in the most listed magazines can be tens of thousands of dollars per year.

The fourth factor is the creation of various incentives for employees of state and non-governmental organizations to patent their inventions both in China and abroad. This increases the prestige of China in the world and attracts new investors who are no longer looking for cheap labour with a limited level of education, as it was in the first decades of market reforms, but for talented employees who are able to create the latest technologies and products to create efficient export industries.

3.6 presents an overview of 2 similar studies conducted on China's shift to R&D Economy. Both studies use different methods to conduct analysis and present collected results. We have tried to cover any gaps from other studies in our research including larger data sets from recent years that were neglected in other similar studies. We have also used econometric analysis to better process the collected data as opposed to other studies that used interviews or comparative analysis of local R&D firms.

5.2 Outcomes from the Practical Part

As per the practical part of the thesis, in our linear regression model after the estimations, two out of three assumptions have been confirmed. Our verification for the most significant influence on increase on spending for R&D in China is on increase of GDP was not approved.

Our other assumptions stating that the increase on GDP will lead to increase of R&D spending and the increase on FDI will lead to significant increase on R&D development in China have been approved based on estimation results. These results are aligned with the results of other studies that been conducted.

Number of tests allowed determining no autocorrelation, homoscedasticity and normal distribution of random variable in the one - equation model.

The most effect on spending for R&D in one-equation model has been proved for total GDP of China as its elasticity coefficient reached the highest level among the others and it was equal to 1.24% in 2018. Scenario simulations for final years of the observation were chosen and basically were concerned about increase/decrease of any of the independent variables against the dependent variable.

In the second part of the analysis an obvious simultaneous-equation problem was provided, which has been checked by a simultaneity test. With regard to the simultaneous model, the first equation was that total R&D spending is explained by the change of GDP, export of goods and services, foreign direct investments and change on number of researchers in China.

The second equation was about changes on export of goods and services, explained by electric power consumption, change in inflation and population growth per annum. All of the assumptions for the simultaneous model were rejected after parameter estimations in Gretl. Our estimations show that first assumption that the increase on export of goods and services will lead to increase on spending on R&D in China and vice versa was not approved and has negative effect.

However, if the number of researchers will increase it will lead to increase on spending on R&D which was approved by our estimations and increase in inflation will lead to decrease on export of goods and services in China was not approved.

One equation model seems to present a better picture in comparison to simultaneous model since adjusted R-squared is greater and equal to 99% in the one equation model.

Number of tests have been performed and no autocorrelation, homoscedasticity and normal distribution of random variables were detected in simultaneous model for both equations. The scenario simulations were applied to 2018 about how changes on independent variables will influence spending on R&D or changes on export of goods and services.

5.3 COVID – 19 as a Threat to Chinese Economy

Given the recent development of events and the massive spread of COVID – 19 in China followed by the rest of the world, we decided to discuss in 3.5 the possible negative infects of the epidemic on Chinese economy. Given the fact that COVID – 19 is a major threat to Chinese economy as a whole, it would certainly result in a far less generous funding in R&D given the deficiency of government resources.

Even though the Chinese government tries to be optimistic about the impact of the epidemic on Chinese economy, it goes without saying that the coronavirus long term negative impact on the country is inevitable.

Various industries have suffered massive losses with the country being at a lockdown. The tourism industry has been largely affected. In the first quarter of 2019, the income of this sphere only during the New Year holidays amounted to about $ 500 billion compared to almost nothing in 2020.

Undoubtedly, this situation had an impact on retail sales, however, thanks to online sales, it was possible to somewhat compensate for the loss of retail industry.

The loss of manufacturing enterprises is even more worrying. The resumption of work, yet having to pay rentals of premises, wages for employees have created an obvious threat to the cash flow of enterprises. The cash flow in the manufacturing industry is much less than in the catering and tourism industries, and as soon as it breaks, the liquidity crisis can escalate even into the threat of bankruptcy, especially for those manufacturing enterprises that initially had a relatively low rate of return.

COVID – 19 has brought Chinese authorities to a very difficult situation. On the one hand, President Xi Jinping of China requires them to do everything possible to combat the outbreak of coronavirus. However, the ambitious goals of GDP growth are still present, and companies are putting pressure on officials to soften measures to combat the virus, so businesses can resume production.

Xi wants, in spite of everything, to double the size of the Chinese economy. For this to happen, the economy should grow by at least 5.5% in 2020. Many, of course, doubt that this is now possible. Last year, China's economic growth slowed down to 6.1% anyway, which was the worst result since 1990. According to their forecasts, due to the epidemic, the growth may turn out to be zero or even negative in the first quarter of 2020.

Bank of America expects the Chinese economy to slow to near zero in the first quarter, but then accelerate. According to his estimates, China's GDP will grow by 5.2% in 2020, which is 0.4 pp lower than the previous forecast.

China has postponed the publication of official economic data, but many alternative data indicate a significant slowdown in the economy. For example, coal demand from large energy companies over the last weeks was about 40% lower than in the same period in 2019, according to Goldman Sachs. In addition, the demand for steel and the number of transactions in the real estate market fell sharply.

Complicating the situation even more, in many cities the authorities have imposed quarantine and stopped public transport. If office workers can work remotely, factory workers must be physically present at the factory. Only about a third of the 291 million Chinese who left at the end of January to celebrate the New Year according to the lunar calendar to their hometowns and villages, were unable to return to work, the country's Ministry of Transport said.

Nevertheless, the authorities of some cities went to meet the companies and at the end of February began to order charter planes, buses and trains so that people could return to work for free, writes the Financial Times. Many companies offer large bonuses to employees to return to work.

All in all, the effects on the economy can be devastating and China might have to postpone its plans on the high increase of GDP and R&D expenditure for a while until things are back to normal.

There, certainly, isn’t much data available to include in our analysis as the epidemic started at the final stage of our research. However, we decided to include it considering the enormous effect it has on the entire economy.

Further development of events will indicate whether or not our assumptions are correct. This, indeed, opens up opportunities for further research, once China publishes data that illustrate the effects of the epidemic on the economy that can be quantified and passed through another econometric analysis to come up with a more precise idea of how the last quarter of 2019 and 2020 results have suffered from that of 2018.

6 Conclusion

The main goal of the thesis was to analyse China's economic shift and pronounced growth of R&D expenditure, which was successfully achieved by a thorough literature review and a detailed econometric analysis. The literature review unveiled China's powerful growth potential and it being the main engine of the global economy.

The partial goals of this thesis were identifying the reasons for China's economic shift, analysing and interpreting the obtained results and processing them using econometric models.

The literature review has indicated that China's significant economic growth can be attributed to factors such as cheap labour, relatively soft legislation (especially in terms of labour and environmental protection), and the accumulation of large investments.

Aiming for economic modernization, Chinese universities now focus on engineering, economics, and technology, as well as computer technology and industry. Education in China is considered one of the fastest growing areas at the moment. As a result, the literacy of the population is growing, the qualifications of staff are being raised.

Furthermore, China supports research and the commercialization of R&D through several national and regional programs. The state allocates about 2% of GDP for these purposes. The most famous companies in China today - ZTE, Huawei and Lenovo - have developed thanks to government programs. It is noteworthy that most of the scientific publications and developments fall on the share of universities, and not the Chinese Academy of Sciences.

Innovation funding is provided by the federal government and local governments. Putting the emphasis on innovation has allowed China to move from an extensive to an intensive path of development.

However, there are various threats to the shift towards R&D economy as well as the Chinese economy in general. Two major ones were discussed in the thesis.

- China's population is rapidly aging threatening the economy of the country.
- Resent massive spread of COVID – 19 has brought China's economy to a dilemma. It goes without saying that the Chinese government aim to be optimistic about the consequences, the huge loss the economy will suffer in a long run is inevitable.

While aging population of China is not a huge threat to the economy, COVID -19 can have devastating effects. Even though it is too soon to provide the conclusive outcomes of the

epidemic, economic indicators already show a financial loss that may result in limited government resources and less investment in Innovation.

Our thesis has examined in detail not only the historical picture and overview of Chinese economy and it's shift to knowledge economy, but also the most recent data and latest development of events that may play a decisive role in Chinese economy tomorrow.

The thesis can, also, pause questions for further research, the most important of them being the impacts of COVID – 19 on Chinese economy as well as trade and commerce relations with the rest of the world.

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8 Appendix

Table 6 Data set - data table, source, correlation matrix, multicollinearity elimination

	Y1	X2	X3	X4
Year	Gross domestic spending on R&D Total, Million US dollars	Gross domestic product (GDP)Total, Million US dollars	Electric power consumption (kWh per capita)	Foreign direct investment, Million net inflows (BOP, current US$)
1994	17,139.90	1,991,797.78	620.28	35,849.20
1995	17,168.36	2,256,219.80	770.28	40,180.00
1996	18,698.60	2,525,638.01	821.08	44,237.00
1997	23,163.39	2,806,345.47	852.74	43,751.00
1998	25,300.04	3,060,359.02	870.62	38,753.00
1999	31,564.66	3,342,586.29	913.96	42,095.30
2000	40,801.20	3,707,487.59	992.94	47,053.00
2001	46,536.59	4,104,792.56	1,076.55	53,073.62
2002	57,134.82	4,550,443.10	1,194.86	57,900.94
2003	66,584.86	5,100,094.00	1,379.48	68,117.27
2004	79,510.94	5,766,967.36	1,585.84	104,108.69
2005	95,345.55	6,624,265.14	1,782.31	124,082.04
2006	112,455.87	7,692,799.95	2,039.01	156,249.34
2007	128,943.33	9,023,650.35	2,325.93	171,534.65
2008	148,821.06	10,087,286.95	2,446.37	131,057.05
2009	187,453.39	11,119,602.00	2,612.46	243,703.43
2010	213,485.64	12,445,651.09	2,943.59	280,072.22
2011	242,941.38	13,919,132.45	3,298.00	241,213.87
2012	281,426.55	15,301,053.47	3,474.99	290,928.43
2013	316,856.22	16,779,114.38	3,773.41	268,097.18
2014	345,376.16	18,344,523.39	3,927.04	242,489.33
2015	375,751.27	19,820,982.32	3,873.42	174,749.58
2016	411,232.63	21,387,606.58	4,059.12	166,083.76
2017	444,755.12	23,266,768.93	4,244.83	203,492.01
2018	494,683.33	25,361,744.19	4,430.53	272,407.16

Available from: https://data.oecd.org

Table 7 Elasticity Calculation for the period of 1994-2018

Year	Gross domestic spending on R&D Total, Million US dollars	Gross domestic product (GDP)Total, Million US dollars	Electric power consumption (kWh per capita)	Foreign direct investment, Million net inflows (BoP, current US$)
1994	6977.5331	7.0760	-2.1936	0.1617
1995	9966.9398	5.6113	-1.9070	0.1268
1996	15519.4110	4.0340	-1.3055	0.0897
1997	21681.0884	3.2085	-0.9705	0.0635
1998	27379.2161	2.7707	-0.7847	0.0445
1999	33410.6549	2.4799	-0.6750	0.0396
2000	40662.9617	2.2601	-0.6026	0.0364
2001	48637.7938	2.0920	-0.5462	0.0343
2002	56917.1835	1.9818	-0.5180	0.0320
2003	66307.5797	1.9066	-0.5134	0.0323
2004	78878.6277	1.8123	-0.4961	0.0415
2005	95909.7309	1.7121	-0.4586	0.0407
2006	117074.4828	1.6288	-0.4298	0.0420
2007	143464.8859	1.5591	-0.4001	0.0376
2008	165584.7344	1.5101	-0.3646	0.0249
2009	190620.0116	1.4460	-0.3382	0.0402
2010	216463.6088	1.4252	-0.3356	0.0407
2011	243020.2197	1.4198	-0.3349	0.0312
2012	274472.4814	1.3819	-0.3124	0.0334
2013	303028.6834	1.3726	-0.3073	0.0278
2014	337235.2438	1.3484	-0.2873	0.0226
2015	373025.6430	1.3171	-0.2562	0.0147
2016	407004.1908	1.3026	-0.2461	0.0128
2017	450179.7220	1.2811	-0.2327	0.0142
2018	499696.2348	1.2581	-0.2188	0.0172

Available from: https://data.oecd.org

Table 8 Data Set - data table, source, correlation matrix, multicollinearity elimination

Year	Gross domestic spending on R&D Total, Million US dollars	Gross domestic product (GDP)Total, Million US dollars	Electric power consumption (kWh per capita)	Foreign direct investment Million net inflows (BoP, current US$)	Exports of goods and services (% of GDP)	Inflation, GDP deflator (annual %)	Population, total	Researchers Total, Per 1 000 employed
1994	17,139.90	1,991,797.78	620.28	35,849.20	17.95	13.6705391	1204855000	0.818323327
1995	17,168.36	2,256,219.80	770.28	40,180.00	17.92	6.501095946	1217550000	0.766913979
1996	18,698.60	2,525,638.01	821.08	44,237.00	19.49	1.622160415	1230075000	0.794778825
1997	23,163.39	2,806,345.47	852.74	43,751.00	18.34	-0.892589361	1241935000	0.843168147
1998	25,300.04	3,060,359.02	870.62	38,753.00	18.16	-1.268409649	1252735000	0.687316845
1999	31,564.66	3,342,586.29	913.96	42,095.30	20.89	2.06146138	1262645000	0.743900048
2000	40,801.20	3,707,487.59	992.94	47,053.00	20.31	2.043115008	1271850000	0.964225567
2001	46,536.59	4,104,792.56	1,076.55	53,073.62	22.64	0.604850658	1280400000	1.020270066
2002	57,134.82	4,550,443.10	1,194.86	57,900.94	26.98	2.605441209	1288400000	1.106065775
2003	66,584.86	5,100,094.00	1,379.48	68,117.27	31.06	6.954321801	1296075000	1.169181946
2004	79,510.94	5,766,967.36	1,585.84	104,108.69	33.83	3.902639778	1303720000	1.247242271
2005	95,345.55	6,624,265.14	1,782.31	124,082.04	36.04	3.927910852	1311020000	1.498650984
2006	112,455.87	7,692,799.95	2,039.01	156,249.34	35.43	7.749179838	1317885000	1.632153965
2007	128,943.33	9,023,650.35	2,325.93	171,534.65	32.60	7.791801942	1324655000	1.88975319
2008	148,821.06	10,087,286.95	2,446.37	131,057.05	24.75	-0.210533902	1331260000	2.107379175
2009	187,453.39	11,119,602.00	2,612.46	243,703.43	27.19	6.881144874	1337705000	1.519637865
2010	213,485.64	12,445,651.09	2,943.59	280,072.22	26.57	8.07559638	1344130000	1.591013468
2011	242,941.38	13,919,132.45	3,298.00	241,213.87	25.49	2.335120681	1350695000	1.724791939

2012	281,426.55	15,301,053.47	3,474.99	290,928.43	24.60	2.161019142	1357380000	1.830435179
2013	316,856.22	16,779,114.38	3,773.41	268,097.18	23.59	0.791192996	1364270000	1.927900152
2014	345,376.16	18,344,523.39	3,927.04	242,489.33	21.44	0.062699386	1371220000	1.973101757
2015	375,751.27	19,820,982.32	3,873.42	174,749.58	19.75	1.07275629	1378665000	2.090389666
2016	411,232.63	21,387,606.58	4,059.12	166,083.76	19.96	3.884169895	1386395000	2.180554618
2017	444,755.12	23,266,768.93	4,244.83	203,492.01	19.51	2.933332312	1392730000	2.241682338
2018	494,683.33	25,361,744.19	4,430.53	272,407.16	26.12	2.553161002	1405963859	2.313191383

Available from: https://data.oecd.org

Table 9 Data set - data table, source, correlation matrix, multicollinearity elimination

Year	Y1- theoretical	X2-Gross domestic product (GDP)Total, Million US dollars	X4- Foreign direct investment, Million net inflows (BoP, current US$)	Y2- Exports of goods and services (% of GDP)	X7- Researchers Total, Per 1 000 employed
1994	44719.10934	1.019970429	-0.017075205	-0.002910274	0.00005106
1995	50682.18524	1.019439736	-0.016886288	-0.002563897	0.00004222
1996	56754.14425	1.019081711	-0.016602278	-0.002490134	0.00003908
1997	63201.17544	1.016837278	-0.01474492	-0.002104104	0.00003723
1998	69125.41067	1.013841668	-0.011941179	-0.001904937	0.00002775
1999	75497.58406	1.013876497	-0.011876273	-0.002006388	0.00002749
2000	83753.05399	1.013711879	-0.011966476	-0.001758301	0.00003213
2001	92706.34366	1.013951644	-0.012194075	-0.001770908	0.00003071
2002	102777.7225	1.013888462	-0.011999585	-0.001903238	0.00003003
2003	115117.7121	1.014545464	-0.012603603	-0.001956212	0.00002834
2004	129602.6408	1.01898813	-0.017110108	-0.00189245	0.00002685
2005	148794.0419	1.019500981	-0.017762454	-0.001755809	0.00002810
2006	172583.0496	1.020755626	-0.019284112	-0.001488572	0.00002639
2007	202755.1981	1.019167918	-0.018020194	-0.001165789	0.00002601
2008	228032.1894	1.013009925	-0.01224176	-0.000786891	0.00002579
2009	249253.539	1.021605899	-0.020825715	-0.000790736	0.00001701
2010	278850.0814	1.02207397	-0.021393353	-0.000690763	0.00001592
2011	313428.6595	1.01697188	-0.016392424	-0.000589674	0.00001536
2012	344022.5015	1.018520948	-0.018012704	-0.00051841	0.00001485
2013	378363.9639	1.01553466	-0.015092531	-0.00045209	0.00001422
2014	414772.9946	1.012818075	-0.01245265	-0.000374816	0.00001327
2015	450039.3495	1.008579573	-0.008270757	-0.000318199	0.00001296
2016	486098.3494	1.007566043	-0.007277507	-0.000297741	0.00001252
2017	528337.7907	1.008462801	-0.008203804	-0.000267788	0.00001184
2018	574797.1722	1.010415447	-0.01009447	-0.000329406	0.00001123

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Table 10 - Elasticity table for the 1st equestion

Year	Y2-theoretical	X3- Electric power consumption (kWh per capita)	X5- Inflation, GDP deflator (annual %)	X6- Population, total
1994	2771906964	0.000724801	3.18595E-09	1.000037135
1995	2801114175	0.000899626	1.4993E-09	1.00003681
1996	2829921273	0.000958476	3.70299E-10	1.000039676
1997	2857180827	0.000994935	-2.01812E-10	1.000048659
1998	2882015587	0.001015284	-2.84312E-10	1.000052681
1999	2904777998	0.0010653	4.58453E-10	1.000065187
2000	2925900609	0.001156779	4.51093E-10	1.000083627
2001	2945537235	0.001253553	1.32653E-10	1.000094735
2002	2963879348	0.001390617	5.67876E-10	1.000115569
2003	2981480612	0.001604693	1.5068E-09	1.000133873
2004	2998992028	0.001843815	8.40651E-10	1.000158912
2005	3015692280	0.002071216	8.41409E-10	1.000189487
2006	3031384088	0.002368347	1.65138E-09	1.000222318
2007	3046861058	0.002700254	1.65203E-09	1.000253605
2008	3061938099	0.002838665	-4.44179E-11	1.000291248
2009	3076534687	0.003029878	1.44488E-09	1.000365088
2010	3091160739	0.003412221	1.68766E-09	1.00041381
2011	3106088375	0.003821158	4.85655E-10	1.000468632
2012	3121238009	0.004024216	4.47264E-10	1.000540221
2013	3136877589	0.004367628	1.62936E-10	1.000605188
2014	3152696604	0.004543204	1.28474E-11	1.000656343
2015	3169643354	0.00447894	2.18637E-10	1.000710241
2016	3187215215	0.004691347	7.87262E-10	1.000773014
2017	3201589332	0.004903543	5.91872E-10	1.000832267
2018	3231737376	0.005115528	5.10358E-10	1.000917053

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