# CHARLES UNIVERSITY

FACULTY OF SOCIAL SCIENCES

Institute of Economic Studies


# Bachelor thesis


**2019** **Pavel Zacharuk**

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# Border Effect and Openness of Chinese Economy

*Bachelor thesis*


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## Abstract

The ratio of China's aggregate exports and aggregate imports to GDP has been decreasing in recent years, which seems to contradict many claims about China striving for increased openness about their economy. Our hypothesis is that the decrease might be connected with the development of GVCs and asymmetric improvement of transportation in China, driven by evolution of infrastructure. We have used simplified regionalization methods and regional input-output analysis in order to identify trend of interregional trade. The results show increase in interregional trade which does not refute this hypothesis.

## Abstrakt

Podíl celkového Čínského exportu a importu na HDP v posledních letech klesá, což se zdá v rozporu s četnými tvrzeními o Číně usilující po vyšší otevřenosti jejich ekonomiky. Naše hypotéza je, že pokles může souviset s vývojem GVCs a asymetrickým zlepšení dopravy v Číně, způsobenou evolucí v infrastruktuře. Použili jsme zjednodušené metody regionalizace a regionální input-output analýzu, abychom identifikovali trend v meziregionálním obchodu. Výsledky ukazují nárust meziregionálního obchodu, což není v rozporu s touto hypotézou.

## Keywords

Input-Output tables, regionalization, location quotients, border effect, home bias, Input-Output analysis, hybrid methods

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## Klíčová slova

Input-Output tabulky, regionalizace, lokační kvocienty, border effect, home bias, Input-Output analýza, hybridní metoda

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**Range of thesis:** 55,588 symbols, 49 pages

## Declaration of Authorship

1. The author hereby declares that he compiled this thesis independently, using only the listed resources and literature.

2. The author hereby declares that all the sources and literature used have been properly cited.

3. The author hereby declares that the thesis has not been used to obtain a different or the same degree.

Prague 10.5.2019 **Pavel Zacharuk**

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*Notes: Please enter the information from the proposal to the Student Information System (SIS) and submit the proposal signed by yourself and by the supervisor to the Academic Director ("garant") of the undergraduate program.*

**Proposed Topic:**

Border Effect and Openness of Chinese Economy

**Preliminary scope of work:**

The ratio of China's aggregate exports and aggregate imports to GDP has been decreasing in recent years, which seems to contradict many claims about China striving for increased openness about their economy. There can be multiple explanations, such as: increasing protectionism, internal rebalancing or "asymmetric effects of infrastructure improvements". Therefore, this hypothesis is looked at, which includes an increased role of the "border effect", probably caused by substantial improvement of the transportation infrastructure within China.

***Research question and motivation***

Is China closing its economy? Does China have much more interprovincial trade than international trade? Why is that? Can we still witness a tendency to regional self-sufficiency?

China is one of the biggest trading exporters, which makes China essential for many countries. We can witness the long time decrease in the share of external trade on China's GDP. The tendency to close an economy and become self-sufficient might be crucial for dozens of their trading partners.

***Contribution***

Literature on border effects has developed since 1995 and the analysis of border effect has been developing for a long time. I will study the topic with newer (more recent) data. The results can be then used to predict what might happen to the Chinese international market also to observe the trend of China's trading.

***Methodology***

I am going to use Input-Output tables, where I can find all trading volumes of each country, including interprovincial trade. Geodistances of capital cities from other countries will also be used. Nevertheless, I am going to use dummy variable 1 for international observation and 0 otherwise. The main econometric model will be based on the traditional Gravity model framework. Authors such as Poncet Sandra, have used Input-Output (I-O) tables of provinces or, if I-O tables were not available, they used provincial import and export data from the Ministry of Foreign Trade (MOFTEC). Data since approximately year 1995 will be used.

***Outline***

Introduction
History of China's international trade
The model
Conclusion

**List of academic literature:**

***Bibliography***

List the most important related papers (specify at least five references).

1) PONCET, Sandra. (2005). Measuring Chinese Domestic and International Integration. China Economic Review. 14. 1-21. doi: 10.1016/S1043-951X(02)00083-4.
2) Toshihiro, Okubo. (2004). The Border Effect in the Japanese Market: A Gravity Model Analysis. Journal of the Japanese and International Economies. 18. 1-11. doi: 10.1016/S0889-1583(03)00047-9.
3) A Practical Guide to Trade Policy Analysis WTO/UN 2012 ISBN-13: 978-92-1-112855-0 e-ISBN-13: 978-92-1-055690-3 UN publication Sales No.: E.12.II.D.12 (232 pages)
4) Openness, Economic Growth and Regional Disparities: The Case of China, Yanqing Jiang , Springer Science & Business Media, 2013, ISBN: 3642406661 , 9783642406669
5) Input-Output Analysis: Foundations and Extensions, Ronald E. Miller, Peter D. Blair, Cambridge University Press, 2009, ISBN: 1139477595, 9781139477598

# Contents

# 1. Introduction

The ratio of China's aggregate exports and aggregate imports to GDP has been decreasing in recent years (see **Figure 1**), which seems to contradict many claims about China striving for increased openness about their economy. There can be multiple explanations, such as: increasing protectionism, internal rebalancing or "asymmetric effects of infrastructure improvements". Therefore, this hypothesis is looked at, which includes an increased role of the "border effect", probably caused by substantial improvement of the transportation infrastructure within China. China is one of the biggest trading exporters, which makes China essential for many countries. We can witness the long time decrease in the share of external trade on China's GDP. The tendency to close an economy and become self-sufficient might be crucial for dozens of their trading partners.

Literature on border effects has developed since 1995 and the analysis of border effect has been developing for a long time. I will study the topic with newer (more recent) data. The results can be then used to predict what might happen to the pattern of China's interaction with the world economy as well as to observe the trend of China's trading.

I am going to use Input-Output (IO) tables, where I can find all trade flows between different sectors. Data since year 1998 are used. Three types of panel data are going to be used, first IO tables for years 1998-2011, second provincial employment in each sector for years 1998-2011 and last but not least provincial GDP data. Whole IO analysis is mainly based on these three datasets.

Sadly, we were unable to find any inter-provincial input-output tables, we were just able to find national and domestic IO tables. Because of financial reasons as well as time deadline, we have decided to not use survey methods. We also did not want to work with purely non-survey methods, as it was tested in the past and the results were not the most reliable, in order to have very precise results from non-survey methods, we'd need a lot of other information about trade in the country, which in China's case is not very likely, because of political and other reasons. Hence, we have decided to use hybrid method. In order to establish provincial IO tables, we will be employing the GRIT (*Generation of Regional Input-Output Tables*) technique. The hybrid GRIT technique was selected to construct regional IO tables, due to its wide applicability and ability to construct a regional non-survey table with relative ease.

In order to identify the important sectors for the four provincial economies IO linkage coefficients are used, by employing the constructed provincial IO tables. We will use Rasmussen and Hirschman backward linkages.

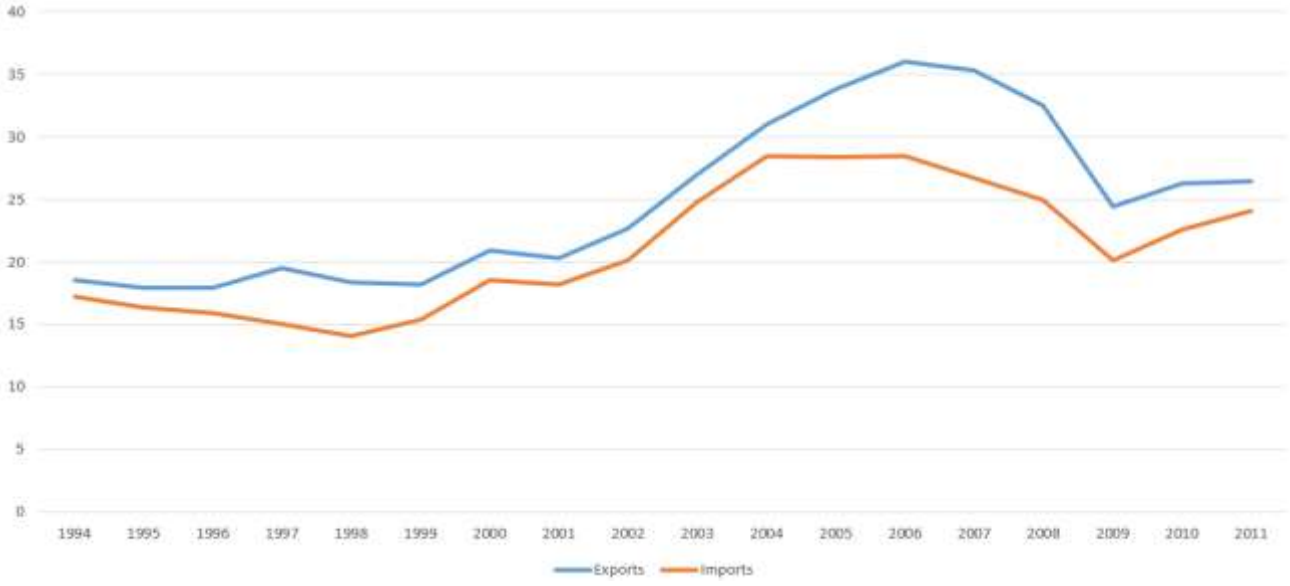
In the first section we will introduce a little bit of background behind Chinese history of economic growth from poor country to one of the most powerful countries in the world and also about interprovincial trade development.

In the second section we will be talking about the background of Input-Output analysis and about the potential trouble of "border effect", connected with higher trade within one country, then we will introduce possible reason behind the "border effect" and higher ratio of China's aggregate exports and aggregate imports on GDP in specific years and why it could be decreasing now.

In third section we will introduce methods for regionalization of IO tables, IO analysis and analyze results of these models. We are aware of imperfections in these models and that our numbers are just approximations, however we would need much more detailed and precise data for more precise and thorough analysis. We have also contacted few of the researchers who were working with Chinese provincial IO tables in the past and few professors from universities in China, yet we were only able to get provincial IO table for year 2012 at the last minute. Because of deadline and fact that we'd ideally need more years than just one, we have decided not to broaden our estimations until year 2012.

In last section we sum up the results from third section and introduce potential reasoning behind our results, look if it proves our hypothesis and introduce possible further use of this paper.

**Figure 1**: Share of imports and exports on GDP (in percentage)




Source: OECD National Accounts Statistics: National Accounts at a Glance, *https://data.oecd.org/trade/trade-in-goods-and-services.htm*

# 2 History of China's Economy and International trade

China rose tremendously in last four decades, rising from a poor developing country to a major economic power. Starting 1979 (when economic reforms began) to 2017, China's real gross domestic product (GDP) increased at an average annual rate of roughly 10%. According to the World Bank, China has "experienced the fastest sustained expansion by a major economy in history—and has lifted more than 800 million people out of poverty." (World Bank, 2017) China has turned up as one of the major global economic power. As an illustration, China is ranked as first in terms of economic size on a purchasing power parity (PPP) basis, value-added manufacturing, holder of foreign exchange reserves and merchandise trade.

Preceding 1979, China, under the command of Chairman Mao Zedong, upheld a centrally planned, or command, economy. A large percentage of the country's economic output was conducted and controlled by the state, which set production goals, regulated prices and allocated resources throughout most of the economy. During the 1950s, all of China's individual household farms were collectivized into large communes. In order to encourage swift industrialization, the central government engaged in large-scale investments in physical and human capital during 1960s and 1970s. Subsequently, by 1978 practically three fourths of industrial production were produced by centrally organized, state-owned enterprises (SOEs), in line with centrally planned output targets. There was almost no private enterprises nor foreign-invested companies, they were generally prohibited. Goal of the Chinese central government was to make China's economy nearly self-sufficient. In most cases, foreign trade was solely limited to accessing those goods, which could not be made, grown or obtained in any other way in China. Such policies created deformity in the economy. Considering that most aspects of the economy were managed and run by central government, there were no market mechanisms to efficiently allocate resources, hence there were little incentives for companies, workers and also farmers to become more productive or be troubled with the quality of what they produced, after all they were first and foremost focused on production goals set by the government. In addition to this there were specific events, with much more acute and disastrous effects: Great Leap Forward (1958-1961), the Cultural Revolution from mid 1960s.

A transformation of society was planned in which the masses were to be driving force. The general line of the Party that guided Great Leap Forward was "Going all out, aiming high and achieving greater, faster, better, and more economical results in building socialism". Starting in the spring of 1958, the Great Leap Forward was China's attempt

to copy Soviet-style development. The plan was to reorganize farmers into large-scale communes and mobilizing society to achieve technological revolution in agriculture in order to upswing ahead in production. During the Great Leap, production targets were adjusted upwards many times, until it reached unrealistic targets. Reaching the targets was main priority for the Party, hence heavy industry was given high priority at the expense of agriculture and light industry. Millions of farmers moved into cities to work in factories. Unfortunately, nothing worked as expected. Great Chinese famine of 1958-61, depending on the underlying assumptions and methodologies employed, the excess deaths of this famine are estimated to range from a minimum of 16.5 million to as many as 30 million.[1] With a population of roughly 660 million in 1958, the year marking the origin of this famine, 30 million amounted to a loss of close to 5% of the country's population. Moreover, the loss of lives of this magnitude occurred within an incredibly short period of time; within 2 years the country's death rate was doubled from slightly below 12 per thousand in 1958 to 25 per thousand in 1960, making it "the worst famine in human history".

The motive behind Cultural Revolution and explanation given by the Chinese, if put simply, is grounded in deep fear of the ageing leaders that unless a constant force is made to keep the spark of revolution glowing, the country is in danger of going down to the multiple attractions of "revisionism", which are natural in changing environment. The main protection against letting this happen, is to implant the proper ideological view, because then he will have no incentive to change his proletarian symbol, no matter how his environment changes. The main characters in Cultural Revolution were actually "raised" and reformed by Mao, as he always considered this rather important. Some papers speak of true sons of the proletariat, raised by Mao.[2] The reasons behind this move were not that hard to find, since the unsuccessful move with the Great Leap Forward, the leadership was worried that following stepping back and relaxation, hesitantly accepted as a necessary step in order to repair the damage done by the Great Leap Forward, would, if not controlled, push the country into "revisionism". As soon as the economic situation turned for the better, the Party started to tighten their control. In 1964 Mao complained that most of the associations of literary and art workers and their publications "… had not carried out the policies of the Party and had acted as high and mighty bureaucrats, had not gone to the workers, peasants and soldiers and had not reflected the socialist revolution

[1] Based on data from Peng Xizhe, "Demographic Consequences of the Great Leap Forward in China's Provinces," Population and Development Review 13 (1987): 639–70

[2] Joffe, Ellis. "China in Mid-1966: 'Cultural Revolution' or Struggle for Power?" The China Quarterly, no. 27, 1966, pp. 123–131. JSTOR, www.jstor.org/stable/651479

and construction. In recent years they had even slid to the verge of revisionism. If serious steps were not taken to remold them, they were bound at some future group to become groups like the Hungarian Petofi Club."[3]

It is specifically aimed to prevent such a development that it was decided in September 1965 to launch a ratification campaign against intellectuals. Mao's health state became very bad after that since November 1965, as his long absence from public view began, and ended in May 1966. If the campaign was run as it was originally intended, it could be understood as "cultural revolution". The removal of many officials could be credit to Mao's desire to get rid of anyone in high functionary position, who could be suspected of bourgeois thoughts. Army has played one of the key roles in this revolution, as it was supposed to restore order, effectively transforming China into a military dictatorship, which lasted until about 1971.

Historians believe somewhere between 500 thousand and 2 million people lost their lives as a result of Cultural Revolution.[4]

China's real GDP grew at an average annual rate of 6.7% from 1953 to 1978, as reported by Chinese government statistics, whose accuracy of data has been questioned by many analysts, because Chinese government officials (especially at the subnational levels) had the habit of overstating the production levels for a variety of political reasons. One of which can be, that the central government set too high production goal for some province, but the province had to meet the goal, hence they rather overstated the production. These overstatements later led to differences between sum of all regional outputs and output reported by Chinese government. Economist Angus Maddison puts China's actual average annual real GDP growth during this period at about 4.4%. (2007)

Starting 1979, China launched several economic reforms. The central government initiated price and ownership incentives for farmers, which allowed them to sell some of their crops on the free market. Moreover, four special economic zones along the coast were entrenched by the government, in order to draw attention of foreign investment, boosting exports and importing advanced technology products into China. Following reforms, which occurred in stages, were mainly meant to decentralize economic policymaking in several sectors, especially trade. Economic control of various businesses was granted to provincial and local governments, which were generally allowed to operate and compete on free market principles, instead of under the control and instruction of

[3] Joffe, Ellis. "China in Mid-1966: 'Cultural Revolution' or Struggle for Power?" The China Quarterly, no. 27, 1966, pp. 123–131. JSTOR, www.jstor.org/stable/651479

[4] Tom Phillips, The Cultural Revolution: all you need to know about China's political convulsion, The Guardian briefing China, May 11, 2016

state planning. Further, citizens were emboldened to start their own businesses. More coastal regions and cities were formed into open cities and development zones, which allowed them to experiment with free-market reforms and offer tax and trade encouragements for foreign investment. In addition, state price regulations on a wide range of products were progressively eliminated. Trade liberalization was as well the crucial key to China's economic success. Cutting out trade barriers motivated larger competition and brought inflows of foreign direct investments (FDI). As mentioned before, China has implemented reforms progressively, in order to identify which policies produced positive economic outcomes, so they could be implemented in other parts of the country, also policies with negative economic outcomes were identified, from which they could learn, a process Deng Xiaoping reportedly referred to as "crossing the river by touching the stones."

Since introduction of economic reforms, China's economy has grown much faster than during the pre-reform period, and, for the most part, has avoided major economic disturbances. From 1979 to 2016, China's annual real GDP averaged 9.6%, which basically means that on average China has been able to more than double the size of the economy in real terms every eight years. The global economic slowdown, which began in 2008, had a significant impact on the Chinese economy. China's media reported in early 2009 that 20 million migrant workers had returned home after losing their jobs because of the financial crisis and that real GDP growth in the fourth quarter of 2008 had fallen to 6.8% year-on-year. The Chinese government responded by implementing a $586 billion economic stimulus package (approved in November 2008), aimed largely at funding infrastructure and loosening monetary policies to increase bank lending. (Xinhuanet 2009)

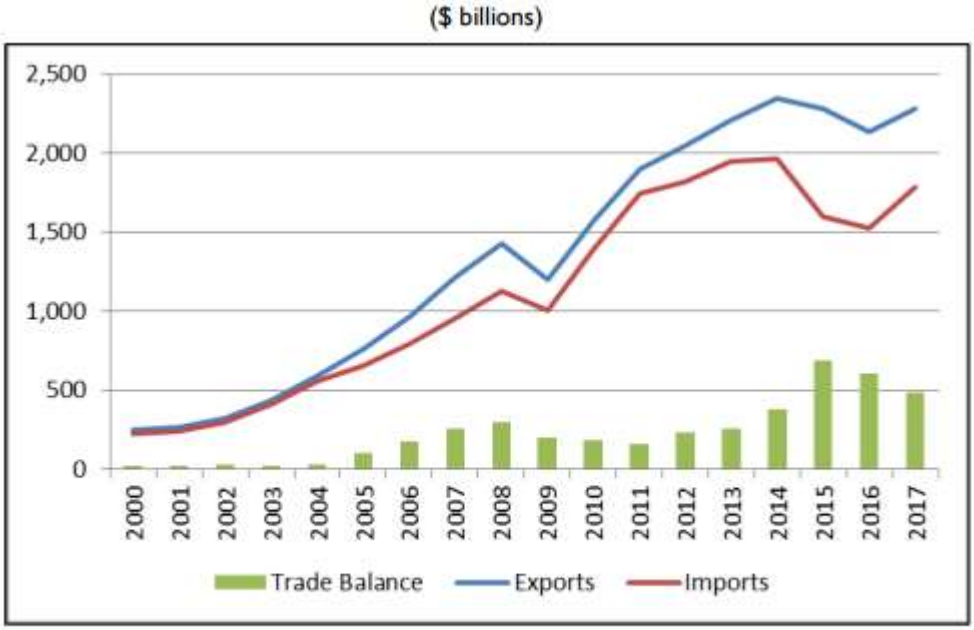
Nowadays the Chinese government views a growing economy as essential to maintaining social stability. Nevertheless, China confronts several significant challenges which could diminish future growth, containing distortive economic policies that have resulted in overreliance on fixed investment and exports for economic growth (rather than on consumer demand), government support for state-owned firms, a weak banking system, widening income gaps, growing pollution, and the relative lack of the rule of law in China[5]. The Chinese government has recognized these issues and has promised to address them by implementing policies to build up the role of the market in the economy, boost innovation, make consumer spending the propulsive force of the economy, expand

[5] Based on research of Morrison, W. M., China's economic rise: History, trends, challenges, and implications for the United States, 2014, Washington, DC: Congressional Research Service

social safety net coverage, encourage the development of less-polluting industries (such as services), and prevent official government corruption. The relative "lack" of the rule of law in China resulted in extensive government corruption, financial speculation and misallocation of investment funds. There have been many cases, when government "connections", not market power, are the core conditions for successful firms in China. It is hard for companies from all over the world to start business in China, because rules and regulations are mostly not compatible or transparent. Hence, contracts are hard to be prescribed and due to the lack of an independent legal system, thoughtful property rights are not protected. Success of implementing such reforms by the Chinese government will most likely be the determiner whether China will continue to maintain relatively rapid economic growth rate, or instead will begin to encounter somewhat lower growth rates.

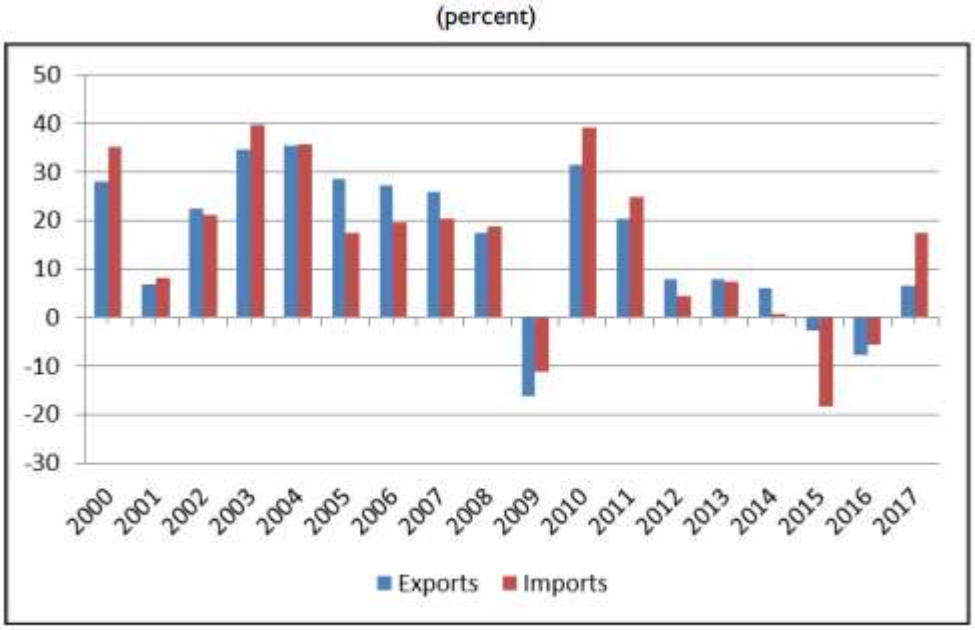
Economic reforms and trade and investment liberalization have helped transform China into a major trading power. Chinese merchandise exports rose from $14 billion in 1979 to $2.3 trillion in 2017, while merchandise imports grew from $18 billion to $1.8 trillion. (See **Figure 2,3** for absolute values, please, see **Appendix 6.1**)

**Figure 2:** China's Merchandise Trade: 2000-2017




**Source:** World Trade Atlas and China's Customs Administration.
**Note:** Data are in U.S. dollars which may be impacted by changes in exchange rates.

**Figure 3**: Annual Change in China's Merchandise Exports and Imports: 2000-17




**Source:** *Global Trade Atlas* and China's Customs Administration.

**Note:** Data are in U.S. dollars which may be impacted by changes in exchange rates as well as commodity prices.

# 3 Literature review

As I've mentioned before, the literature on border effects has developed since 1995, thus there is a big amount of literature about this problem. Let's begin from the scratch and introduce border effect a little bit first.

## 3.1 Border effect

A large body of empirical research finds the existence of a significant "border" effect. McCallum (1995) was the first to estimate this effect. Other research includes that by Wei (1996), Helliwell (1998), and Evans (2002). The most theoretically consistent research on the border effect is Anderson and Van Wincoop (2003), in which they have showed that original, empirical gravity equations did not have any theoretical foundation, by developing their method and application of it, they have solved the famous McCallun border puzzle, they found that national borders reduce trade between industrialized countries by more moderate amounts of 20-50 percent. Obstfeld and Rogoff (2001) declare that the "home bias in consumption" problem, i.e., the border effect problem, is one of the six major puzzles of open economy macroeconomics. According to the typical estimates, regions within countries trade 10 to 20 times more with each other than do regions across countries, relative to what they would trade in the absence of border barriers.

Empirical studies on the size of total home country bias in the goods market are less common because of problems with the availability of regional trade data. First findings of significant "border" effect were in paper by McCallum in (1995), using Canadian province-level data in 1988, he showed that trade between two Canadian provinces is approximately twenty times higher than trade with American states. Later McCallum's findings have been confirmed by extension of sample to cover 1988-1994 by Helliwell in 1996. This result points at potential large degree of home bias among developed countries, since Canada and the United States of America have more in common than most of other countries.

Most common method for estimation of "border" effect is the gravity equation. Gravity equation is one of the most empirically successful in economics. It relates bilateral trade flows to GDP, distance, and other factors that affect trade barriers. Because of the lack of theoretical foundation of empirical gravity equations, there exist two important implications. First, due to omitted variables estimation results are biased. Second, which might be more vital for some estimations, the method can not be used for directing comparative statistics exercises, although in most cases this is the purpose of

estimating gravity equations. In order to run a comparative statistics exercise, for example asking what are the effect of removing some specific trade barriers, one has to be able to solve general equilibrium model before and after the removal of trade barriers.

In this paper we try to locate "border" effect using Input-Output analysis, where we approximate domestic import (inter-provincial), as well as international imports. Then we can compare these two values and see, whether there is any potential "border" effect Domestic trade protectionism across Chinese provinces appears to high and rising even as China has become more integrated with the global economy (Young, 2000; Poncet, 2003)

We believe that membership of China in World Trade Organization (WTO) since 2001 has had an enormous effect on Chinese international trade flow, but also interprovincial, as China had to decrease some of its restrictions on trade flows. Last but not least, membership in WTO has brought increase in liberalization, openness and integration into Global Value Chains with it, which could tremendously affect the trade flows. The interprovincial trade would be more dependent on general level of output and on transportation costs rather than on external tariffs.

## 3.2 Value chains

A value chain describes a set of economic activities needed to bring a product to market, from conceptualization and research and development, through manufacturing, marketing and sales, up to post-consumer recycling. These tasks might be performed within a single company or split between many companies. Over the last two decades, some of the lead firms have internationalized to the stage where global and regional value chains (GVCs), in which activities are divided across multiple national territories, are now common in many parts of the world, at least in some sectors. The less activities are done in single country in order to finish the product, the higher the GVC is. Most concentrated in 'factory Asia' as well as in developed Europe and the United States, GVCs are an important reality for developing countries. (See **Figure 5**) Analytical and policy work is still catching up with this new reality, as it offers several challenges. Firstly, it is important to develop measures of trade in value added, as opposed to measuring trade on a gross shipments basis, so as to emphasize the activity of value addition that is core to the relationships among actors in value chains. Secondly, trade in intermediate tasks rather than final goods is becoming more noticeable in many parts of the world, but realities differ from region to region and from sector to sector, so it is important to reach a precise understanding of the way in which value chains operate internationally.

The main reason behind this relies on the eagerness of big multinational enterprises to lower costs of production, increase efficiency, speed up the production cycle, caused by taking advantage of larger endowments, lower wages and advantageous policies all over the world. Modern transport and communication technology have rapidly expanded global value chains. International trade in goods on a large scale emerged with modern transport in the 19th century. Before invention of fast large volume transport by train, steam ship or truck, each town and region had to produce most of what it consumed. This gave each town and region opportunity to focus on the production of some goods that could be consumed and sold, while buying the rest of products elsewhere. Eventually countries began to specialize labour and trade the goods. Because of fall of transportation costs, trade has constantly increased. (Baldwin, 2012)

This new trend brought enormous increases into international trade, the boost of worldwide exports, complex cross-border flows of goods, people, investments or intangible goods, such as know-how, has been higher than ever before.

Global supply chains do not consist of just simple multiple across-borders transactions, but they rather consist of integrated networks of production operations. Therefore they go hand in hand with transformations in various policy areas and most of the governments in developing countries hanker to promote foreign investment-friendly administrative structure. For example, this happened in the case of China, after tens of years of protectionism, a huge liberalization process started in 1978 and accelerated after its entrance into the World Trade Organization (WTO) in 2001, bringing the country to become one of the most prominent players in the international trade scene.

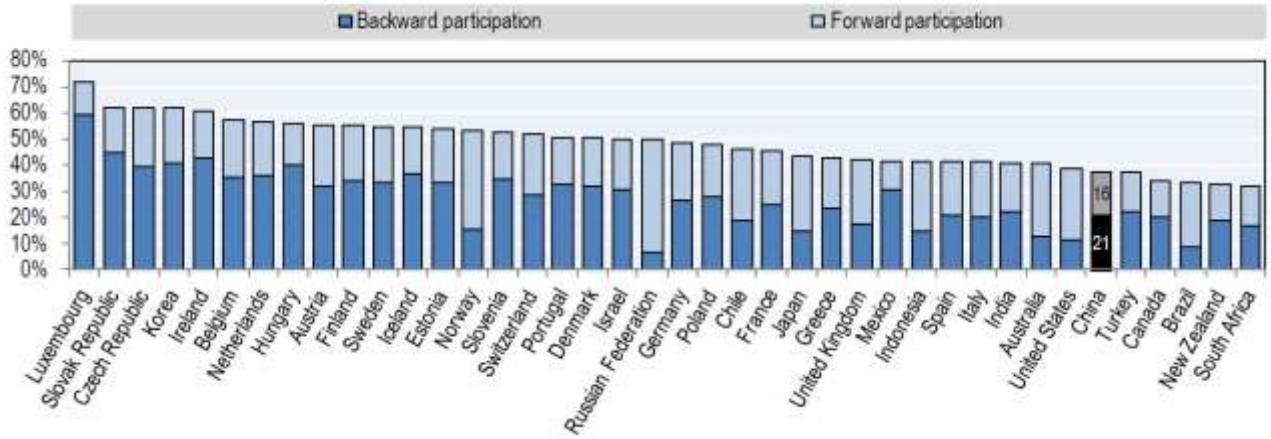
One indicator measuring the participation of countries in GVCs shows what percentage of a country's exports are part of GVCs: either because of upstream links – that is looking back along the value chain and measuring foreign inputs/value added of the country contained in the exports of other countries by looking forward along the value chain. This indicator of GVC participation focuses on intermediates which are produced in one country and then included in another country's exports; it has been introduced by Koopman et al. (2011), Miroudot and De Backer (2013). GVC participation is influenced by the size of the economy, stock of natural resources, distance to world markets, composition of exports (final versus intermediates), etc.

Based on the law of comparative advantage, presented first by David Ricardo in year 1817, and absolute advantage, presented first by Adam Smith, it might be more efficient and mutually beneficial trade for each of the partners of trade, if each of the partners specialize on product in which it has smaller absolute disadvantage or on product

in which it has higher absolute advantage. Traditional theory (Ricardo) was concentrated on analysis of final products, while there are also more recent studies such as Grossman & Rossi-Hansberg, "Trading Tasks: A Simple Theory of Offshoring", 2008, where there are final products replaced by intermediate trade and the use of offshoring in order to efficiently produce final product.[6] If a country has high GVCs it does not mean, that it is pure exporter or importer. It just makes the creation of final product more efficient in cost and potentially better know-how.

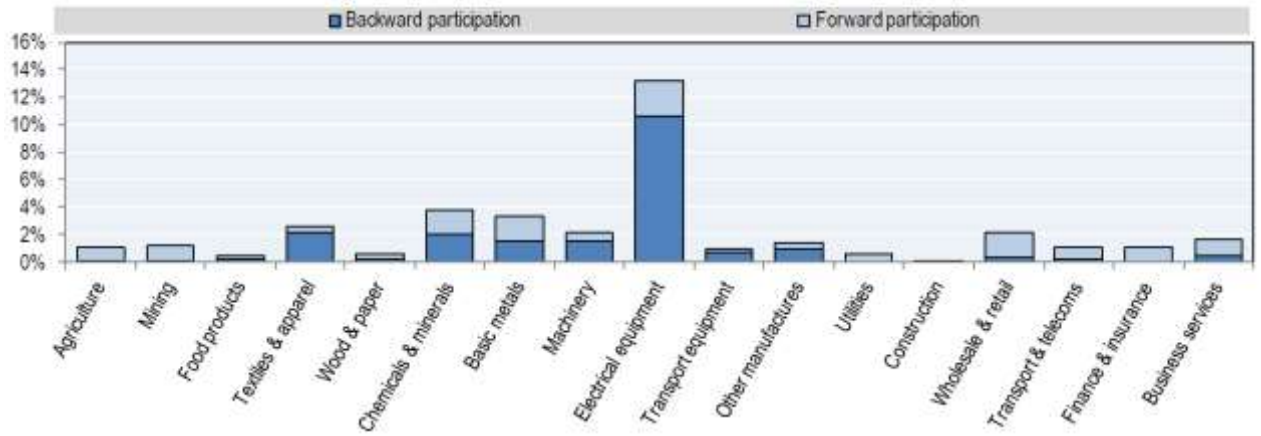
Global supply chains have changed the world. They completely changed development options which poor nations are facing, now they can join supply chains rather than having to invest decades in building their own. Offshoring of labour-intensive manufacturing stages and the attendant international mobility of technology has launched era-defining growth in emerging markets – a change that nourishes and is encouraged by domestic policy reform.

**Figure 4**: GVC participation across countries, 2009




Source: OECD, *http://www.oecd.org/sti/ind/GVCs%20-%20CHINA.pdf*

**Figure 5**: GVC participation by industry, 2009




Source: OECD, *http://www.oecd.org/sti/ind/GVCs%20-%20CHINA.pdf*

[6] For further information about this model, please see Grossman & Rossi-Hansberg, 2008

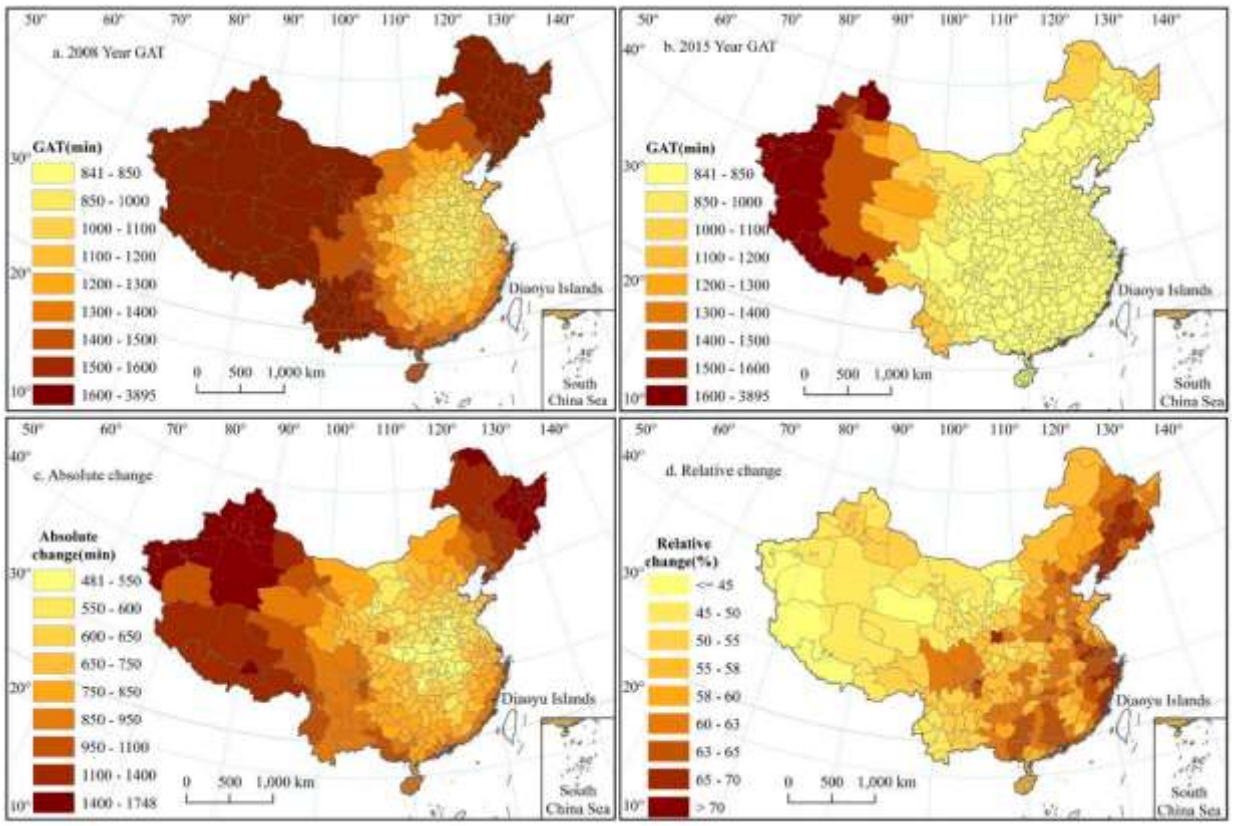
The indicator on the industry level is expressed relative to total country exports (instead of industry exports) in order to take into account the importance of the industry in the total export composition of a country.

Potential reasoning behind so big development of trade in China might be the development of infrastructure, which has been heavily invested to by government in last few decades. There exist many calculation methods, how to measure it, but we will introduce just two methods for measuring of accessibility.

The generalized weighted travel time (GAT) represents integrated time and cost to measure accessibility, where the lower the value, the better the accessibility.

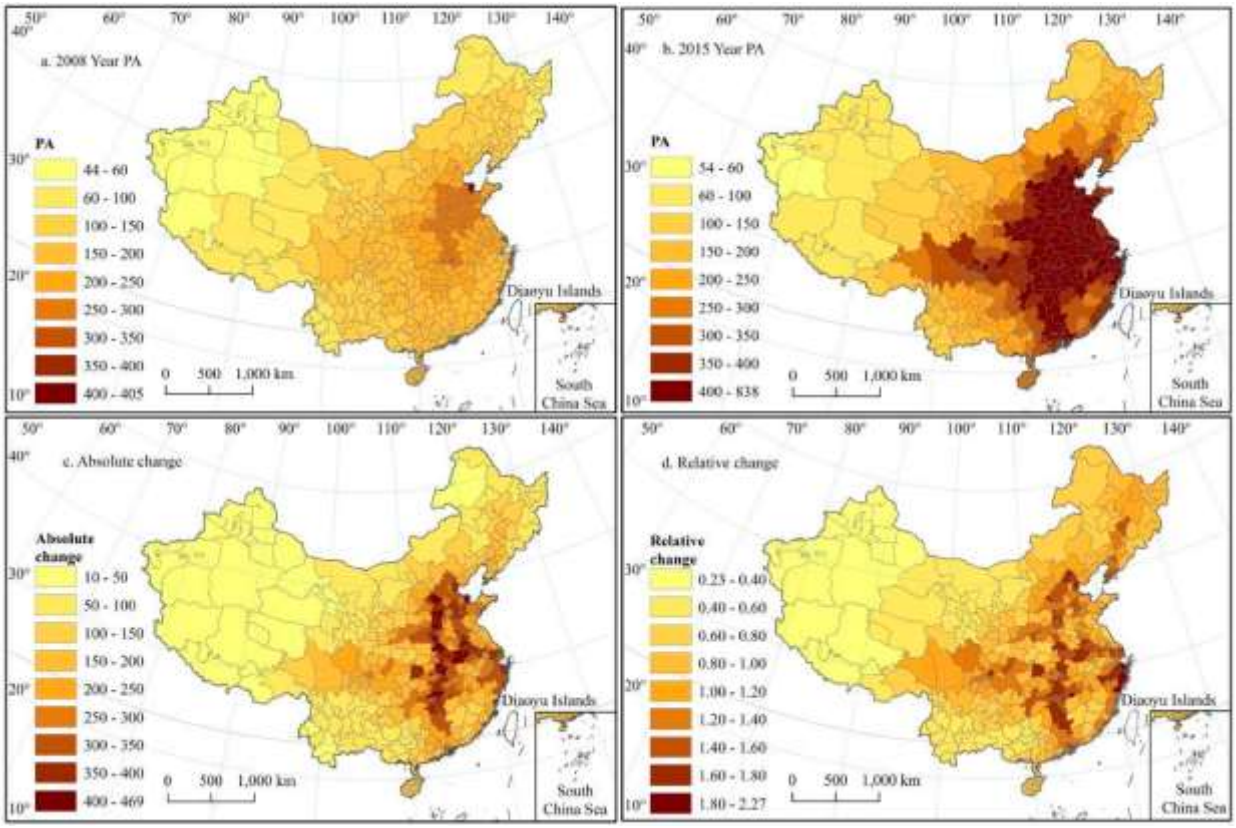
The potential accessibility index (PA) represents the total amount of economic activities in cities and can reflect the strength of interaction among cities and the diffusion capacity.

**Figure 6:** GAT spatial distribution




Source: Jun Yang & Andong Guo & Xueming Li & Tai Huang, **(**2018**)**

**Figure 7:** Spatial distribution map of economic potential




Source: Jun Yang & Andong Guo & Xueming Li & Tai Huang, **(**2018**)**

## 3.3 Input-Output analysis

Input-Output analysis can be traced to the original work of for example Wassily Leontief, older inspiration might have included Quesnay's Tableau économique. Leontief, original study aimed to examine the industrial interdependence in the American economy by implementing a mathematical model within which all economic linkages could be found and estimated. Since Leontief's original work, the IO technique has become one of the most popular inter-industry models. An input-output table reports the "flows of products from each industrial sector considered as a producer to each of the sectors considered as consumers" (Miller and Blair, 1985, p. 2). One of the principal tasks of input-output analysis is to identify the indirect demands concerning the intermediate consumptions necessary to generate the outputs.

According to Miller and Blair (1985), there are two specific characteristics referring to the regional dimension which make evident and necessary the distinction between national and regional input-output models. First, the productive structure of each region is specific, probably being very different from the national one; second, the smaller the focusing economy, the more it depends on the exterior world (this including the other regions of the same country and other countries), making exports and imports to become more important in determining the region's demand and supply.

**Figure 8**: Simplified structure of a national IO table, with total use flows

| Products | 1 ... n | Total Final Demand | Total Demand |
|---|---|---|---|
| 1<br>...<br>n | Total interindustry transactions | | |
| Total Intermediate Consumption | | | |
| Value Added | | | |
| Total Supply of domestic products | | | |
| Imported products | | | |
| Total Supply | | | |

The columns of **Figure 8** provide information on the input composition of the total supply of each product j: this is comprised by the national production and also by imported products.

In general, three approaches have been widely used in estimation of trade flows: survey-based methods; non-survey based methods; and hybrid methods. The survey-based approach provides more precise results. However, survey data is not always

available, especially in the case of inter-regional trade flows within a country due to the significant workload and financial constraints. (Idaha, 2005)

Non-survey techniques applied to national input-output tables can be generally defined as a set of procedures that aim to fill the components of a regional table on the basis of values comprised in a similarly structured national table (Jensen, 1990). Simplified non-survey methods such as gravity models, entropy models, neural network models and behaviour-based models are used in the estimation of transactions between regions (Sargento et al., 2012).

Because non-survey estimates are generally too unreliable and construction methods based on surveys among companies are generally too costly, hybrid methods that combine non-survey approaches with 'superior' survey-based data have become the mainstream. A general finding in the literature is that additional superior data for certain coefficients of the target table may tremendously improve the quality of the estimated IO tables. Hybrid method combines the precision of survey-based method and the convenience of non-survey method, benefiting from the advantages of both of these methods.

There is one crucial limitation of plentiful dataset of Chinese provincial IO tables, which is also reason why only few studies have been published with application of such tables. That is, the data have not been published, mainly due to administrative and financial issues at the provincial level. Although the National Bureau of Statistics (NBS) requires the provincial statistical bureaus to gather the regional tables, the NBS cannot distribute them freely.

We have used data from OECD national, domestic and import IO tables since year 1998 until year 2011, because of confidentiality-related reasons, China has not published regional IO tables between these years, therefore we had to estimate the provincial IO tables by hybrid methods. We have used GRIT (*Generation of Regional Input-Output Tables*) technique with use of provincial industrial employment data, which is publicly available on Chinese statistical servers. We aimed only on 4 provinces (namely: Guangdong, Jiangsu, Gansu and Qinghai), they were chosen based on their geolocation and GDP per capita. We chose few provinces with lower provincial GDP per capita than national GDP per capita and also, we chose provinces, which are on shore, in the center of China and in west-north edge of China. We chose these indexes, to find out if location of province does influence volume of interprovincial trade and international trade.

Because of different level of detail of industrial sectors in China, we had to aggregate the sectors in IO tables from 34 to 9 and in Chinese provincial industrial

employment tables from 19 to 9. The aggregation was done based on ISIC of All Economic Activities, Rev.3 by United Nations.

**Figure 9**: *Classification of IO tables*

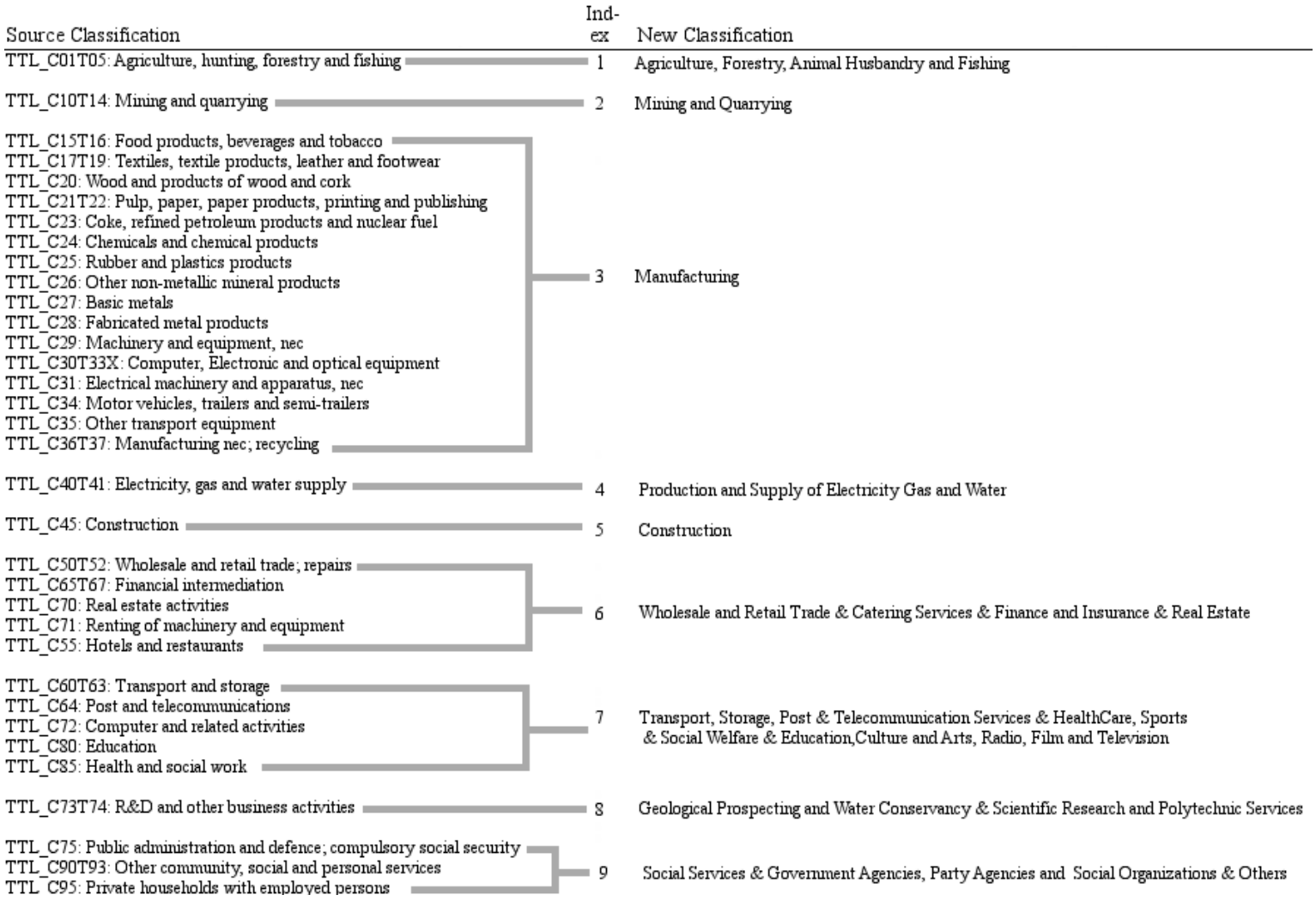
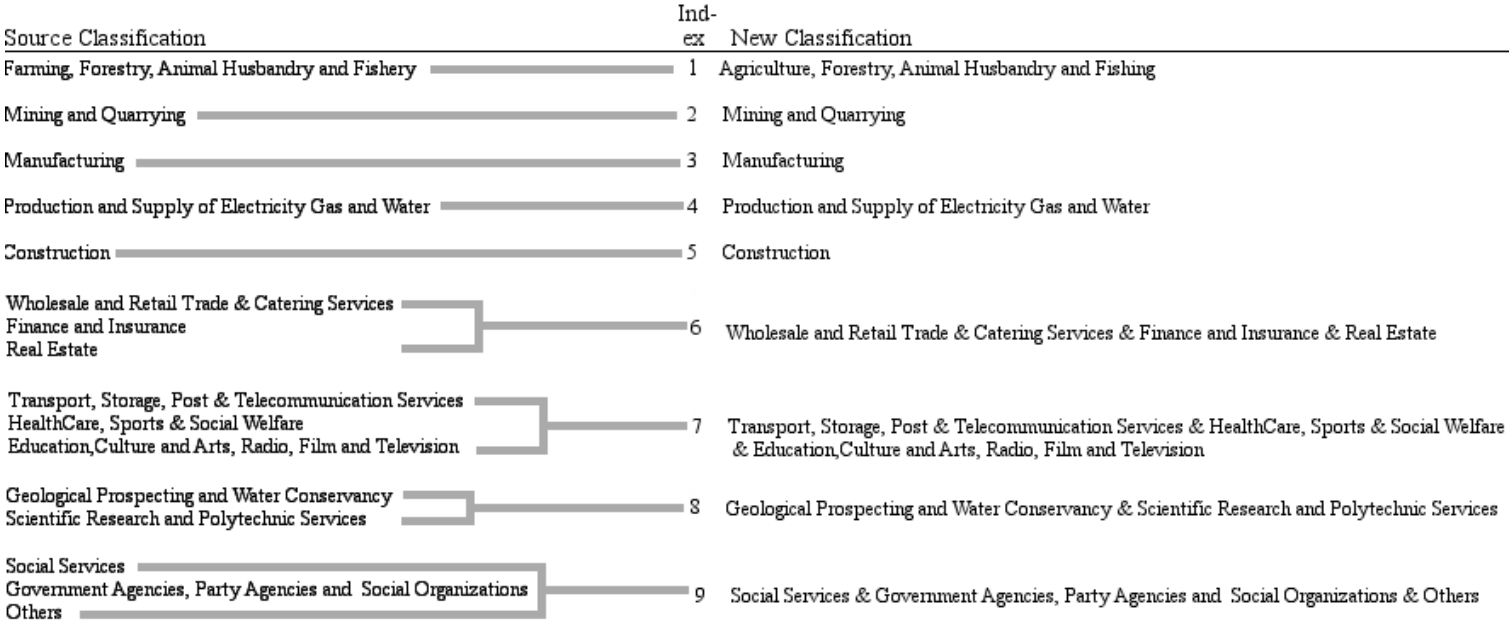
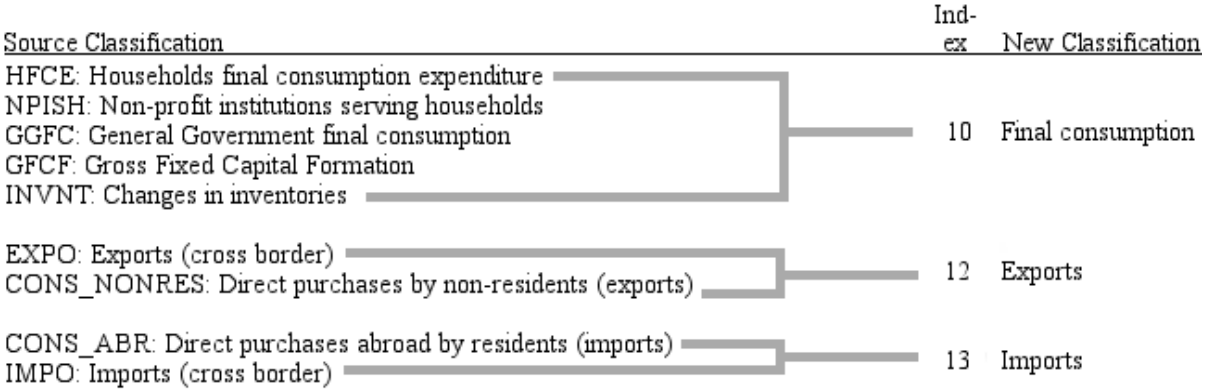



**Figure 10**: Classification of provincial industrial employment table



We have used the most trivial GRIT technique for approximation of provincial IO tables, the technique is called Simple Location Quotient (SLQ), for further description, please see "The model" part. This technique can be only used for "Total interindustry transactions", see **Figure 8**. In order to localize interprovincial trade, we had to approximate total final numbers. In our case we simplified classification for this again, see **Figure 11**.

**Figure 11**: Classification of final numbers in IO table




In order to calculate interprovincial trade out of these 3 sectors: Final Consumption, Exports and Imports, we calculated potential final consumption of each province in each sector. For this calculation we used the simplest logic, we multiplied Final Consumption by percentage, which the province's GDP creates out of national GDP. By this multiplication we find potential Final Consumption of people from that province. There are many more aspects we should consider, such as big gaps between social classes, transportation costs, cost of arbitrage or non-transparent prices. All of these aspects could lead to non-homothetic preferences, although we are aware of these aspects, we assume that we have homothetic preferences between Chinese provinces, which is one of the assumptions of our analysis. We have tried using different indexes for calculation of Final Consumption, but we obtained best results by using GDP data. There are very big differences between provincial GDP per capita (see **Figure 12**).

**Figure 12**: GDP per capita

Per Capita Gross Regional Product (yuan/person)

| Province \ Year | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Guangdong | 10,819 | 11,415 | 12,736 | 13,849 | 15,361 | 17,795 | 20,870 | 24,435 | 28,077 | 33,272 | 37,638 | 39,436 | 44,736 | 50,807 |
| Jiangsu | 10,049 | 10,695 | 11,765 | 12,882 | 14,396 | 16,830 | 20,223 | 24,560 | 28,685 | 33,837 | 40,014 | 44,253 | 52,840 | 62,290 |
| Qinghai | 4,426 | 4,728 | 5,138 | 5,774 | 6,478 | 7,346 | 8,693 | 10,045 | 11,753 | 14,507 | 18,421 | 19,454 | 24,115 | 29,522 |
| Gansu | 3,541 | 3,778 | 4,129 | 4,386 | 4,768 | 5,429 | 6,566 | 7,477 | 8,749 | 10,614 | 12,421 | 13,269 | 16,113 | 19,595 |

Source: National Bureau of Statistics of China (http://data.stats.gov.cn/english/easyquery.htm?cn=E0103)

Then we approximate potential interprovincial imports, by multiplying Final Consumption with approximated regional A matrix of given province in each sector. We cannot forget about a long-lasting problem of Chinese effectivity/efficiency of employees/employment in each province. Some provinces have so called zombie enterprises, which are companies, that do not have high output, but have high employment, therefore total employment in this province will be very high, but the output of this province might be very low. The potential output of province with zombie enterprises might be overestimated. **Figure 13** shows how labour force usage and requirements in agriculture has been dissimilar in China. Zombie companies, heavily indebted companies that have no meaningful operations, are supported by government in poor provinces. China's government is afraid of potential high unemployment in this province, therefore they rather decide to give the company either loans or some subsidies, to prevent the unwanted high unemployment. These zombie companies use their labour very inefficiently.

**Figure 13**: Labour Force Requirements Estimates and Agricultural Labour Force Surplus, 1985-2000 (mn days, mn workers)

| | Number of required working days | Agric. workers required | Agric. workers available | Agric. labour usage rate (%) | Agric. labour surplus |
|---|---|---|---|---|---|
| 1985 | 58,485 | 208.87 | 303.52 | 69 | 94.65 |
| 1986 | 60,487 | 216.03 | 304.68 | 71 | 88.65 |
| 1987 | 61,086 | 218.16 | 308.70 | 71 | 90.54 |
| 1988 | 65,243 | 233.01 | 314.56 | 74 | 81.55 |
| 1989 | 62,076 | 221.70 | 324.41 | 68 | 102.71 |
| 1990 | 64,824 | 231.52 | 333.36 | 69 | 101.84 |
| 1991 | 60,053 | 214.47 | 341.86 | 63 | 127.39 |
| 1992 | 62,402 | 222.86 | 340.37 | 65 | 117.51 |
| 1993 | 67,463 | 240.94 | 332.58 | 72 | 91.64 |
| 1994 | 67,001 | 239.29 | 326.90 | 73 | 87.61 |
| 1995 | 66,508 | 237.53 | 323.35 | 73 | 85.82 |
| 1996 | 63,245 | 225.87 | 322.60 | 70 | 96.73 |
| 1997 | 62,693 | 223.90 | 324.35 | 69 | 100.45 |
| 1998 | 55,492 | 198.19 | 326.26 | 61 | 128.07 |
| 1999 | 53,428 | 190.81 | 329.12 | 58 | 138.31 |
| 2000 | 53,443 | 190.87 | 327.98 | 58 | 137.11 |

**Notes**

1. The number of required working days in agriculture comprises all vegetal (grains, cotton, oleaginous plants, textile fibres, sugar, tobacco, tea, fruits and vegetables) and animal productions (cattles, pigs, muttons, poultries). Forestry and aquaculture activities are not included because of a lack of consistency of the ratios during the period.
2. The number of required working days = sowed surface x number of working days per unit (for each vegetal production) + livestock x number of working days per unit (for each animal production).

Source: Claude Aubert and Li Xiande (2002)

# 4 The model

As mentioned in Section 1, we had to regionalize national IO tables, by using provincial employment industrial employment data. We will be using programming language Python for all calculations of outputs, further analysis of outputs was done in Microsoft Office Excel.

## 4.1 Regionalization of IO tables

At the beginning we had to create national IO tables with more general industry classification, we had to sum all the industry outputs from specific industry classification into more general classification, e.g. TTL_C75, TTL_C90T93, TTL_C95 into one "Social Services & Government Agencies, Party Agencies and Social Organizations & Others". (for more information follow **Figure 9**) Same applies for employment table.

Then we created matrix A by dividing every industry's output of national IO table by its total output: $a_{ij} = {}^{x_{ij}}/_{X_j}$, where $X_j$ = total output of sector j, $a_{ij}$ are values of A matrix, $x_{ij}$ are values of X matrix (X matrix is "Total interindustry transactions" in **Figure 8**). A is so called matrix of technical coefficients, while $a_{ij}$ are also known as technical coefficients.

Next step is to find location quotients, we start off with Simple Location Quotient (SLQ), generally it is a statistical indicator that shows the degree with which two quantitative characteristics (e.g. gross output) are distributed between a region and the country (Hoover, 1975). $a_{ij}^N = a_{ij}^R + m_{ij}^R$ where, $a_{ij}^N$ and $a_{ij}^R$ are the national and regional coefficients respectively, indicating the direct requirements for inputs of sector j from sector i and $m_{ij}^R$ is regional imports coefficient of the product of sector i that is required by sector j.

$SLQ_i = \frac{X_i^R / \sum_{i=1}^{n} X_i^R}{X_i^N / \sum_{i=1}^{n} X_i^N}$ , where $SLQ_i$ is the simple location quotient of sector *i*; $X_i^R$, $X_i^N$ is the total gross output of the sector *i* in the region and the country respectively, *i= 1,.2, ..., n* are the sectors of the model, in our case $n = 9$. SLQs are applied to the selling sectors (all elements across a row).

An important shortcoming in the application of the SLQ is the assumption that the national and the regional demand patterns are similar, which is not so realistic. As Flegg et al. (1995) argue, by using the SLQ (and multiplying the whole row of a sector by the same SLQ) is presupposed that the discrepancy between the national and regional coefficients is the same regardless of the sectors to which producing (selling) sectors are

selling their output. The above assumption does not take into account the relative size of the selling sector, providing inputs, and the sector purchasing them.

The cross-industry location quotient (CILQ) proposed to take into account the above-mentioned lack and the relative importance of each sector intermediate sales.

$$CILQ_{ij} = \frac{X_i^R / X_i^N}{X_j^R / X_j^N} = \frac{SLQ_i}{SLQ_j}$$

where $CILQ_{ij}$ is the cross-industry location quotient between sectors $i$ and $j$.

- A CILQ greater to unity ($CILQij > 1$) means that the regional selling sector can supply all the requirements of the regional purchasing sector. The selling sector has a greater share in sectoral national output (or employment) than the purchasing sector. Hence the regional coefficient and the regional imports coefficient are identical $\left(a_{ij}^R = a_{ij}^N\right)$ with the national ones, no adjustment needed. Meaning that we have to replace $CILQij > 1$ with only 1, because adjustment is not needed.
- No adjustment is needed also, when $CILQ_{ij}=1$ indicating that regional employment in both sectors have the same share of each sector's national employment.
- If CILQ is less than one (CILQ<1) then the regional technical coefficient is replaced (adjusted downward) with the product of the national coefficient and the computed CILQ,$\left(a_{ij}^R = CILQ_{ij} * a_{ij}^N\right)$, while the remaining quantity $(a_{ij} * (1 - CILQ_{ij}))$ is added to the imports coefficients. In this case it is assumed that regional production is insufficient to meet regional demand and imports are required. That is, the supplying sector is relatively small regionally compared to the purchasing sector.

**Figure 15**: *Example of CILQ table for Qinghai province, year 2003:*

| Sector Index | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 0.83 | 1 | 1.00 | 1 | 0.604 | 0.84 |
| 2 | 0.82 | 1 | 1 | 0.68 | 1 | 1.00 | 0.87 | 0.495 | 0.69 |
| 3 | 0.48 | 0.59 | 1 | 0.40 | 0.66 | 0.79 | 0.51 | 0.29 | 0.40 |
| 4 | 1 | 1 | 1 | 1 | 1 | 1.00 | 1 | 0.7268 | 1 |
| 5 | 0.73 | 0.89 | 1 | 0.61 | 1 | 1.00 | 0.78 | 0.4426 | 0.62 |
| 6 | 0.6055 | 0.7387 | 1 | 0.5032 | 0.8263 | 1 | 0.6461 | 0.3657 | 0.5098 |
| 7 | 0.94 | 1 | 1 | 0.78 | 1 | 1.00 | 1 | 0.566 | 0.79 |
| 8 | 1.00 | 1.00 | 1 | 1.00 | 1.00 | 1.00 | 1.00 | 1 | 1.00 |
| 9 | 1 | 1 | 1 | 0.99 | 1 | 1.00 | 1 | 0.7173 | 1 |

To finish off the computation of complete regional input-output tables, we had to use the weighted data for the provinces, which we are interested in, $w_i = E_i^R / \sum_{i=1}^{9} E_i^R$, we have to weight our regional A matrices by this weight. $A_R = CILQ \cdot A_N$ is regional A matrix, where $A_N$ is national A matrix. $A_R^w = A_R \cdot w$, where $w$ is 9x9 diagonal matrix of weights $w_i, A_R$ and $A_R^w$ are regional A matrix and weighted regional A matrix, respectively. If the computed SLQ for any given sector is higher than one, then we can assume that that sector is well represented in the region and thus we can use the sectoral employment ratios to approximate regional sectoral output. Otherwise if the computed SLQ is less than one for any given sector, then the economic activity of that sector in the region is very low and thus its sectoral output should be adjusted for that. We do have SLQ higher that one, therefore we just replace *SLQij* > 1 by 1 and continue.

We can now compute regional sectoral output vector as:

$$X_R = (\widehat{E_R} \cdot \widehat{E_N^{-1}}) \cdot \widehat{SLQ} \cdot X_N$$

where, $X_N$ and $X_R$ are the national and regional sectoral output, respectively, $\widehat{E_R}$ and $\widehat{E_N^{-1}}$ are the diagonal matrices of the national and regional sectoral employment, respectively, $\widehat{SLQ}$ is the diagonal matrix of the simple location quotients, computed above.

Once the regional sectoral output is computed, we can now estimate the regional transaction matrix:

$$Z_R = A_R^w \cdot \widehat{X_R}$$

where, $Z_R$ is the regional transactions matrix, $A_R^w$ is weighted regional A matrix and $\widehat{X_R}$, is diagonal matrix of the regional sectoral output, computed above.

Now we identify the important sectors for the four regional economies I-O by using Rasmussen and Hirschman backward linkages. There are more types of linkages, so called multipliers, we will use Output Multipliers. It is the most known linkage coefficient. It measures overall increase in the economy's output needed in order to compensate a unit increase in final demand of sector i, which we are interested in. This shows the level of interdependence of sector i with all the other local sectors.

$OM_j = \sum_{i=1}^{n} b_{ij}$where, OMj is the output multiplier of sector j, and $b_{ij}$ are the elements of the Leontief inverse matrix $(I-A)^{-1}=B$; a Leontief coefficient identifies the direct and indirect (interindustry) effects on the demand for the output of industry i as a result of changes in the demand (and thereby the input requirements) of industry j.

The higher Output Multiplier is, the more important it is for the provincial economy.

**Figure 14**: *Example of Output Multipliers matrix $OM_j$ for year 2011*

| Sector Index | $OM_j$ |
|---|---|
| 1 | 1.707264 |
| 2 | 2.081933 |
| 3 | 7.570404 |
| 4 | 1.955634 |
| 5 | 1.066636 |
| 6 | 2.965884 |
| 7 | 2.054052 |
| 8 | 1.090223 |
| 9 | 1.227715 |

| Legend: | |
|---|---|
| 1 | Agriculture |
| 2 | Mining and Quarrying |
| 3 | Manufacturing |
| 4 | Elictricity, Gas and Water |
| 5 | Construction |
| 6 | Finance, Real Estate |
| 7 | Healthcare, Transport, Culture |
| 8 | Scientific Research |
| 9 | Social Services, Others |

## 4.2 IO analysis

Our first goal was to estimate the border effect. For this we used two methods:

1. We want to localize interprovincial trade, which we believe can be done with the use of share of provincial employment on national employment. We now count employment share $E_i^S$ using employments in each province for each sector and divide it by total employment in whole China in each sector.

$$E_i^S = \frac{X_i^P}{X_i^N}$$

Where $X_i^P$ is provincial employment in sector i and $X_i^N$ is national employment in sector i, where $i = 1,2, \dots, 9$. Then we multiply final consumption (FC), imports (I) and exports (EX) from domestic IO table by $E_i^S$. We also count share of provincial GDP on sum of all provincial GDP.

$$GDP_i^{share} = \frac{GDP_i^P}{\sum_{i=1}^{n} GDP_i^P}$$

Where $GDP_i^P$ is provincial GDP of province i and i goes from 1 to n, where n is number of all provinces. Then we multiply final consumption from domestic IO table by $GDP_i^{share}$ for each province.

By deducting final consumption (FC) multiplied by $E_i^S$ and FC multiplied by $GDP_i^{share}$ we find potential interprovincial trade (IT, import in – and export in +).

$$IT_i^{Province} = FC_i \cdot E_i^S \; - \; FC_i \cdot GDP_i^{share}$$

Where $i = 1,2, \dots, 9$ is the sector.

Because FC has only final numbers and does not include intermediate trade, meaning there might have been trade with intermediate products in order to get final

product and also because $IT_i^{Province}$ of each province contains only final number of interprovincial trade, meaning it is not looking at total number of imports and exports and we cannot analyze the trend of these total numbers. Thus, we have decided to choose different method, where we could potentially analyze total interprovincial import and export numbers, mentioned above.

2. We have estimated regional A matrices, $A^R$, which as mentioned above are so called matrices of input-output coefficients, and $a_{ij}^R$, elements of $A^R$ matrix are taken as input-output coefficients, which show how big percentage can be supplied from province's resources. There are 4 regional matrices for each year, hence 56 regional matrices of technical coefficients. We have calculated them by multiplication with regional CILQs of each province in each year, but as we know, we have removed CILQs > 1. CILQs are calculated based on the shares of employment in sectors of the province on national employments in the same sectors. Hence it then estimates quotient of output which could be possibly produced, based on the employment in this region. This assumes that the employment in each region is almost identically efficient at producing the products. However, we are aware that this might not be true (see end of section 3.3 and **Figure 13** for explanation), but we think that this effect is not going to have very strong impact, therefore we keep working with this assumption. There might be possible overproduction, if the CILQ is bigger than one, however even underproduction, if the CILQ is lower than one. Hence, in that case such province has to import this product in order to meet their consumption. The origin of this must be from outside of the province. We have decided to use this information to localize import of provinces, based on domestic IO tables. This means that the estimated import in the end has to be from inside of China, so from other provinces. Sadly, we won't be able to track value of imports from different provinces (places of origin) into our analyzed province. Meaning that if we analyze for example Gansu, we will receive total import number from all other Chinese provinces into Gansu, and we will not be able to find how much of that import was from for example Guangdong or Qinghai province.

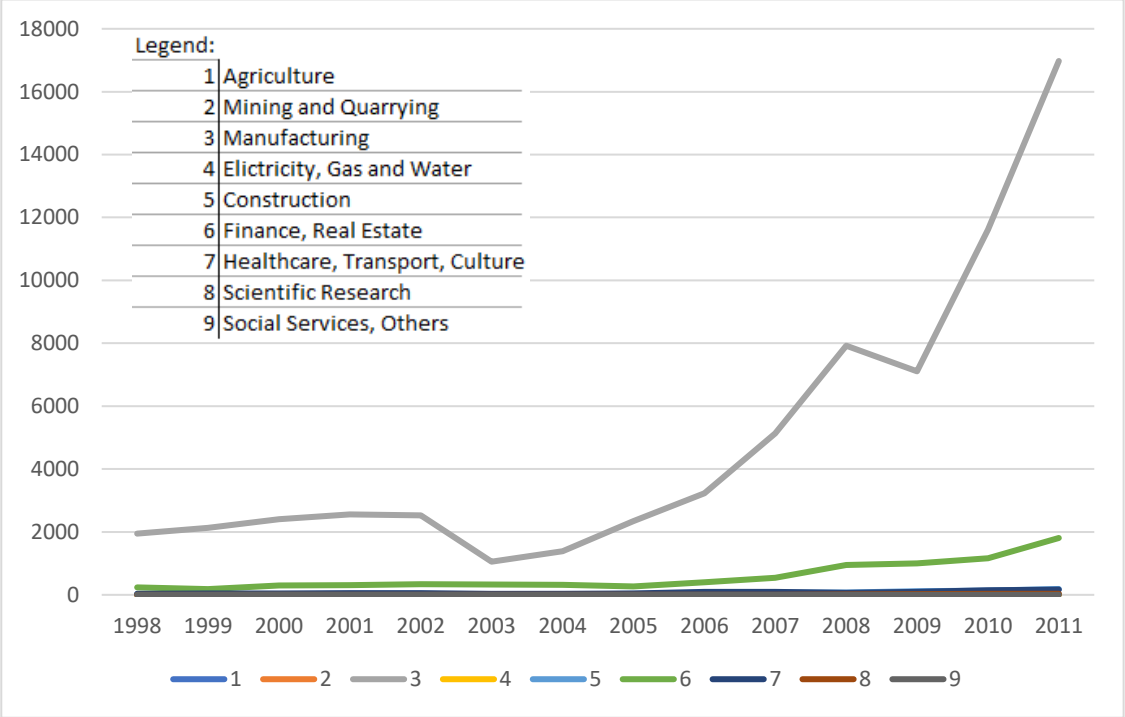
We have already estimated most of the matrices that we need for this calculation. As we know the regional A matrix is just national A matrix multiplied by CILQ matrix, which estimates the input-output coefficients of sectors on regional level. And as we know that elements of A matrix are calculated as share of elements $x_{ij}$ on total output $X_j$, since our case already implies provincial matrix, then we work with same share in provincial level. If we now deduct $a_{ij}^N - a_{ij}^R$, for $i, j = 1, \dots, 9$ we will receive either 0, or a very low

decimal number, which is the share of total imported goods of this province from other provinces in China. By multiplying this on estimated final consumption $d_i^R = x_{i,j}^N \cdot GDP_i^{share}$, for $i = 1, \dots, 9 \; and \; j = 10$. we will estimate absolute value of total import of intermediate inputs in this sector from all other provinces:

$$IM_i = \sum_{j=1}^{9} (a_{ij}^N - a_{ij}^R) \cdot d_i^R$$

for $i = 1, \dots, 9$.

**Figure 15**: Progress of Gansu Interprovincial Imports (years on x-axis; values in Millions of US Dollars on y-axis; sectors from 1 to 9)




Legend is the same for **Figure 15, 16, 17** and **18**, in order to keep graphs clear and easier to read, we have decided to not put the legend in each of the graphs repeatedly.

**Figure 16**: Progress of Guangdong Interprovincial Imports (years on x-axis; values in Millions of US Dollars on y-axis; sectors from 1 to 9)

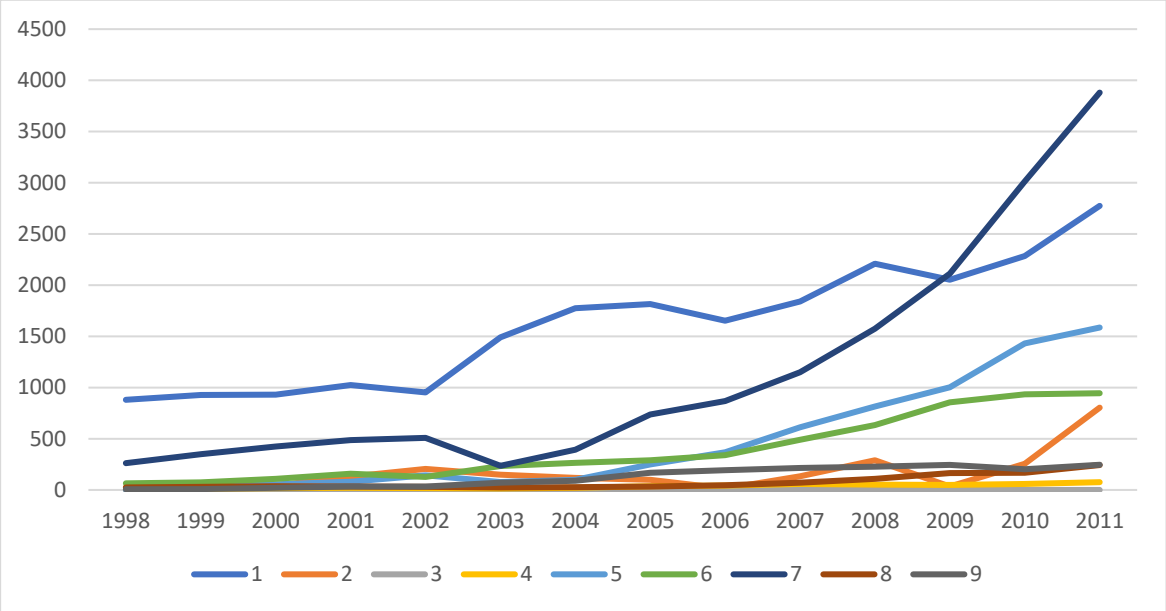



**Figure 17**: Progress of Jiangsu Interprovincial Imports (years on x-axis; values in Millions of US Dollars on y-axis; sectors from 1 to 9)

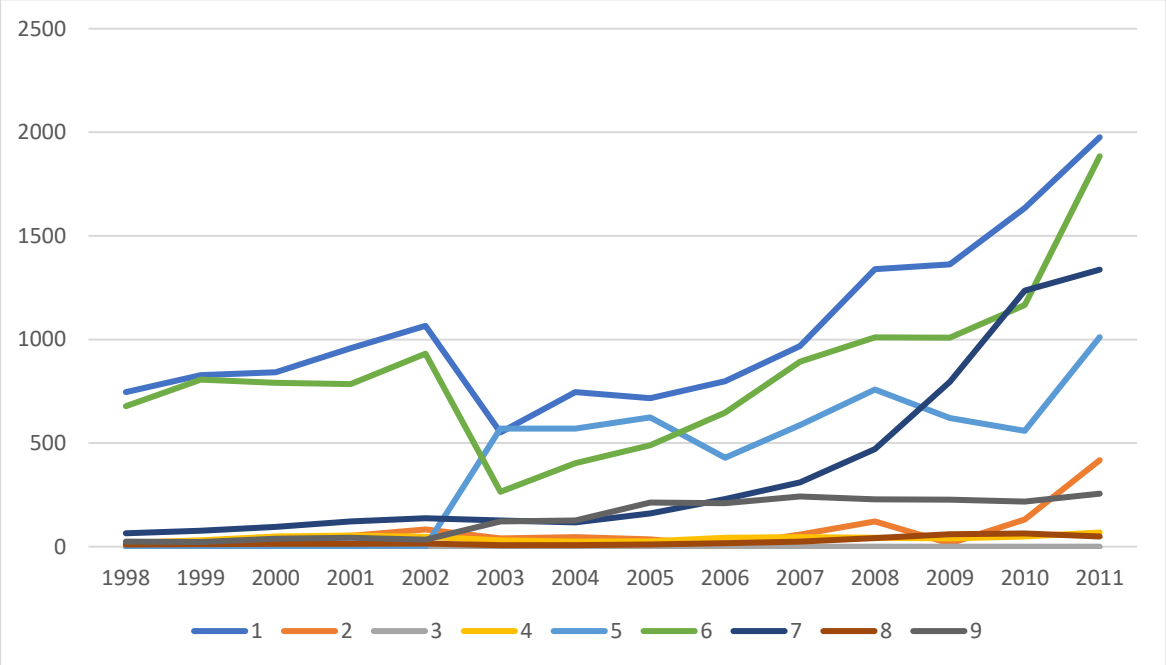
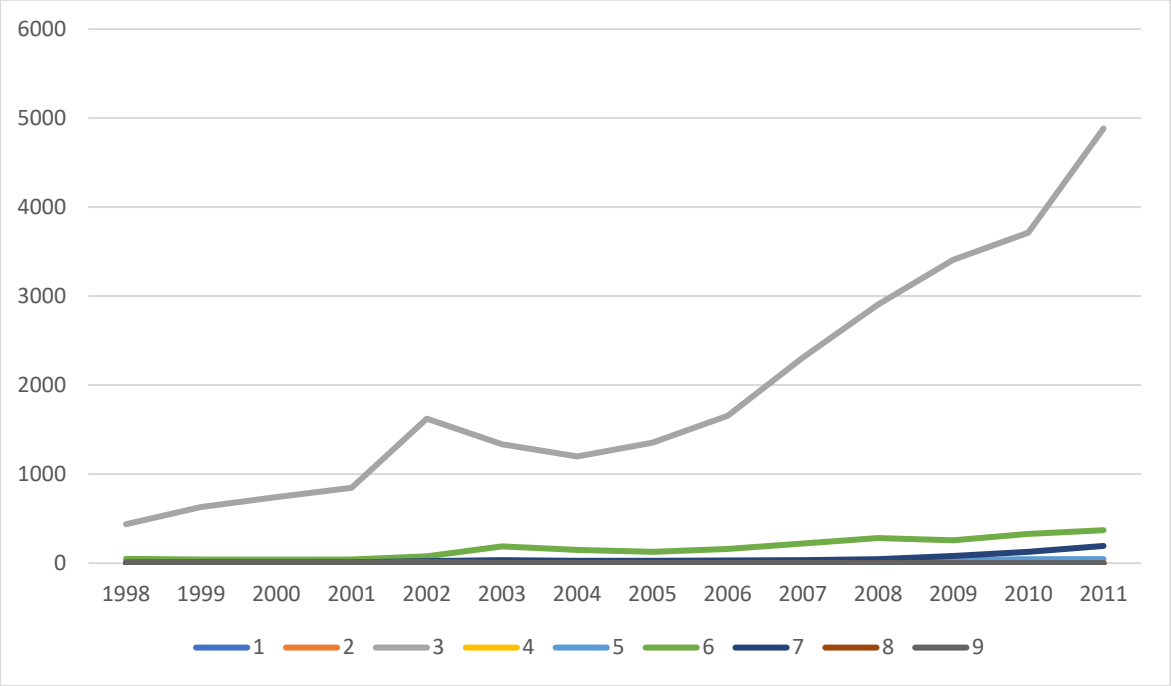


**Figure 18**: Progress of Qinghai Interprovincial Imports (years on x-axis; values in Millions of US Dollars on y-axis; sectors from 1 to 9)




Now we had to estimate the development of non-domestic imports of goods. In order to do so, we estimated output of each province in each sector by multiplying provincial Leontief inverse matrix $(I - A^R)^{-1}$ by estimated final consumption $d_i^R = x_{i,j}^N \cdot GDP_i^{share}$ for i = 1, … ,9 and j = 10. These numbers are based on GDP share in this province, therefore we receive potential final consumption based on average living standard in each province. $A^R$ is provincial A matrix, calculated above.

$a_{i,j}^R$ are elements of provincial A matrix. By inversion we receive Leontief coefficients for each province in each year. By multiplying this in each province by estimated final consumption in each year, for $i = 1, \dots, 9$,

$$o_i^R = (I - A^R)^{-1} * d_i^R$$

we receive estimated output of each province in each sector.

At this stage we have decided to use Import IO table (IIO), accessible on OECD.Stat website. We decided to concentrate only on imports, because export would mean import but just in other way, so for this section we "ignore" exports, but we are aware of it. In order to estimate total extra out of China import (we don't know from which country it comes) of each province in each of our sectors, we have to regionalize IIO. We run it through same GRIT technique, let's call this new regional IIO $M^R$, for each province and year $M^R$ varies. We want to receive index which indicates how many percent does extra import create out of whole output. In order to reach this ratio, we had to divide imports of each sector by total output of that sector in the province. To find total output

we ran regionalization on every domestic IO table and then we calculated total output, by adding up all columns for each sector, including the final demand columns, for $i = 1, \dots, 9$

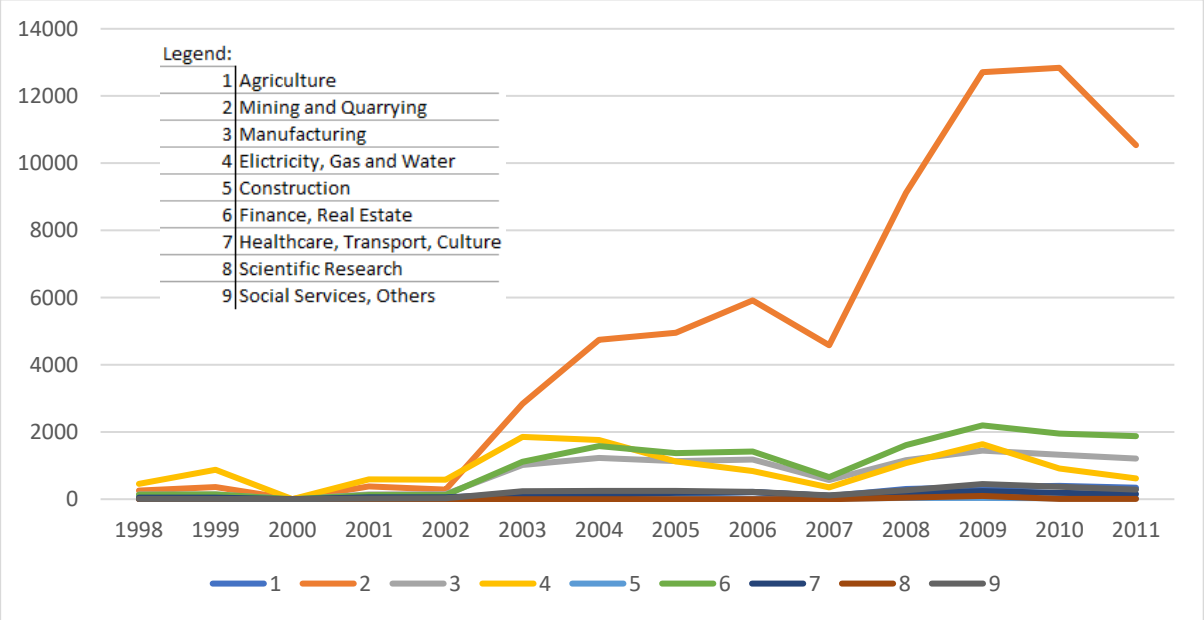
$$total\ output\ = \sum_{j=1}^{13} x_{i,j}^{R}$$

After successful regionalization of IIO we multiply share of import transactions $M^R$ on total domestic output in this province by vector $o_i^R$,

$$EM^R\ = \frac{m_{i,j}^R}{total\ output} \cdot o_i^R$$

where $EM^R$ are Extra China Imports of each province and $m_{i,j}^R$ are elements of matrix $M^R$, for $i, j\ =\ 1, \dots, 9$.

**Figure 19:** Progress of Gansu Extra China Imports (years on x-axis; values in Millions of US Dollars on y-axis; sectors from 1 to 9)




Legend is the same for **Figure 19, 20, 21** and **22**, in order to keep graphs clear and easier to read, we have decided to not put the legend in each of the graphs repeatedly.

**Figure 20:** Progress of Guangdong Extra China Imports (years on x-axis; values in Millions of US Dollars on y-axis; sectors from 1 to 9)

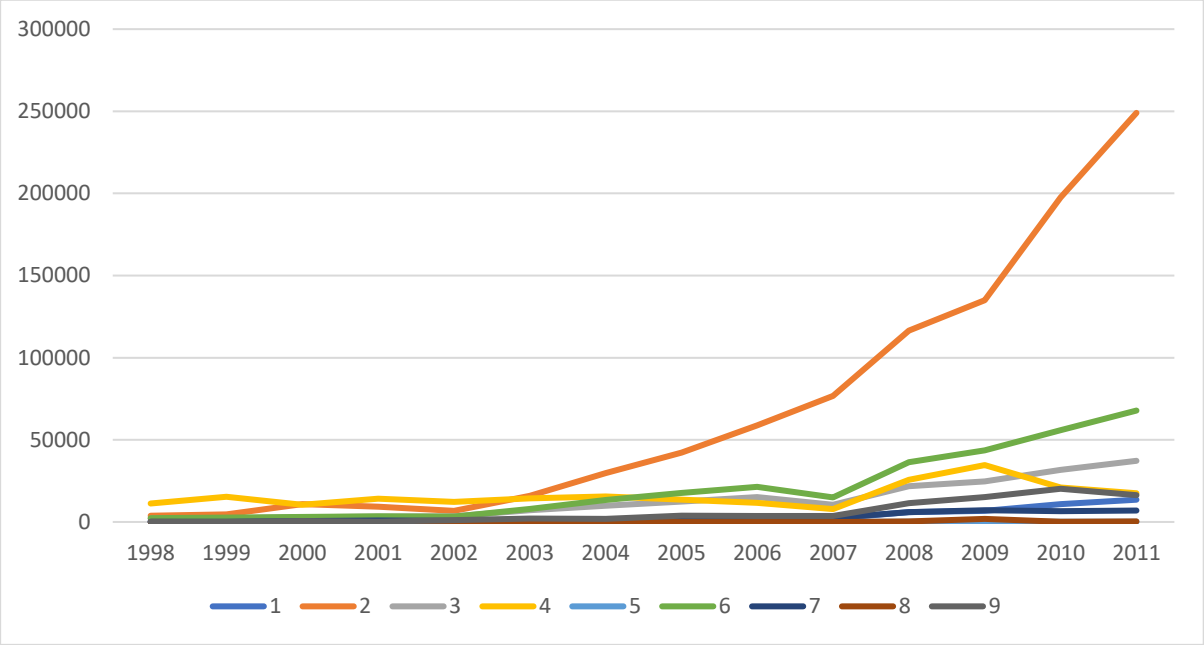



**Figure 21:** Progress of Jiangsu Extra Imports (years on x-axis; values in Millions of US Dollars on y-axis; sectors from 1 to 9)

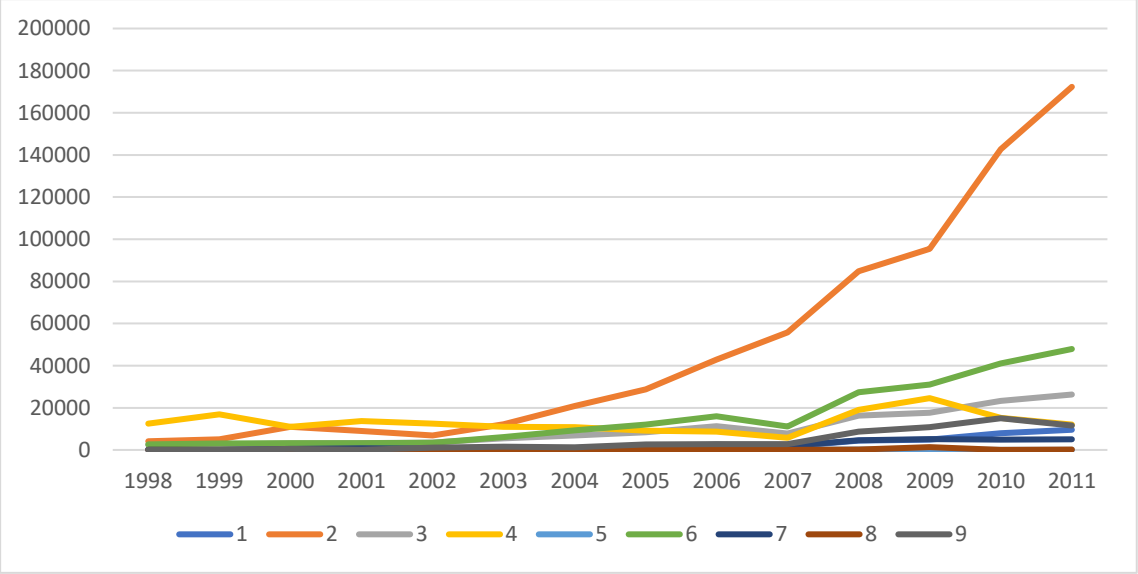
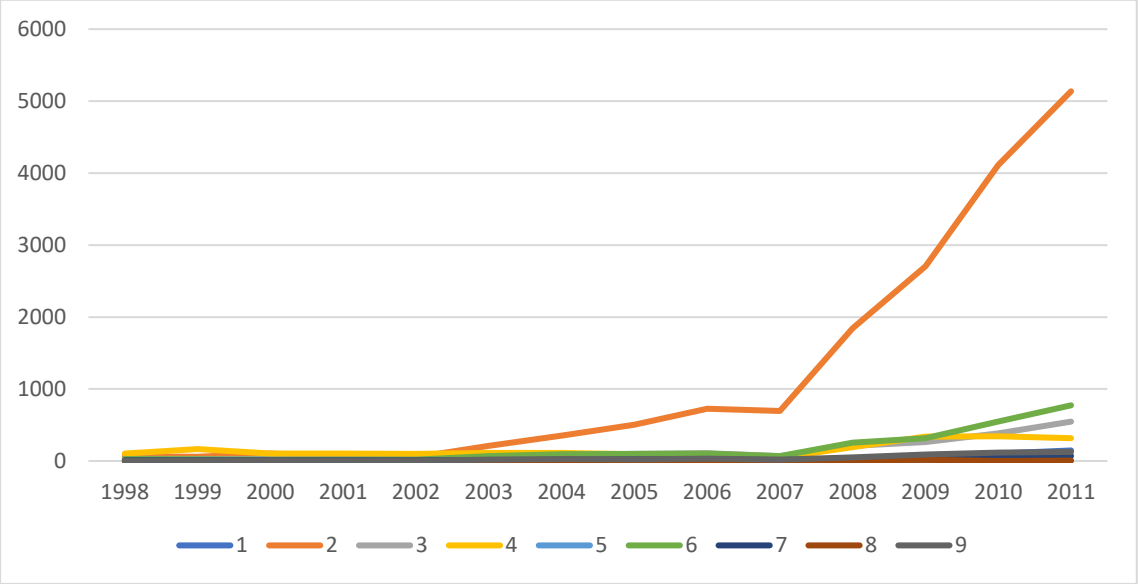


**Figure 22:** Progress of Qinghai Extra Imports (years on x-axis; values in Millions of US Dollars on y-axis; sectors from 1 to 9)



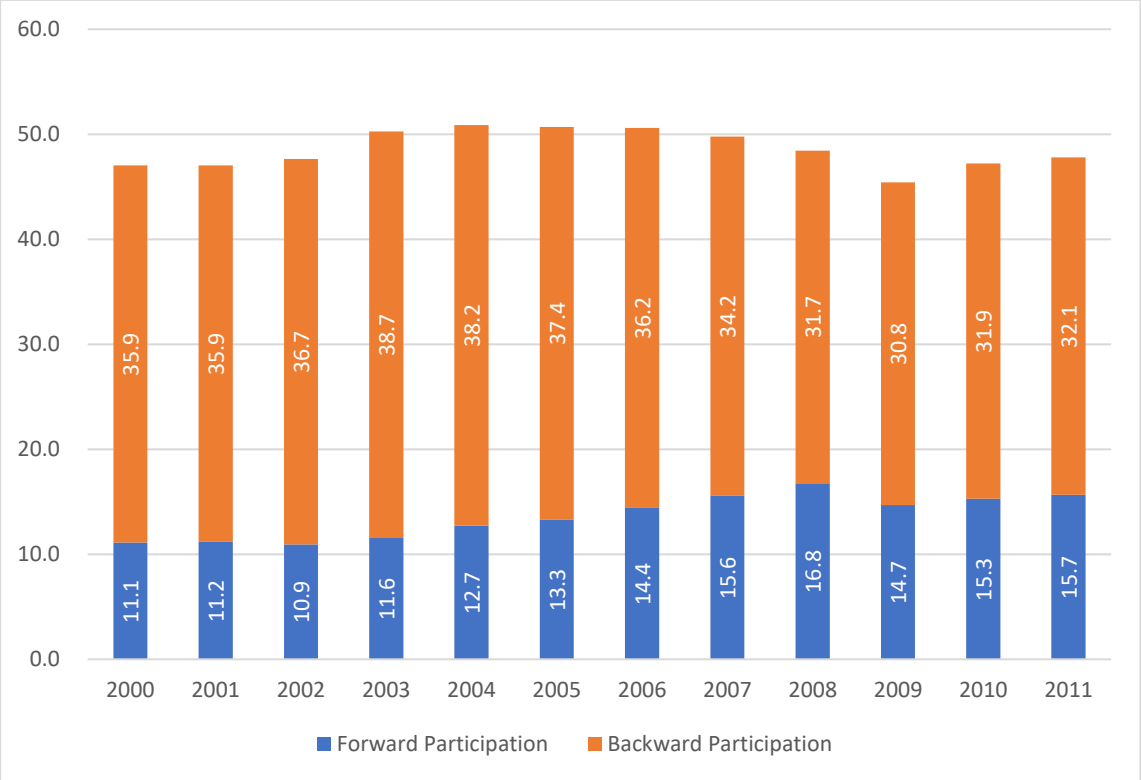

We can clearly see the trend of increasing interprovincial imports in each of provinces analyzed by us. The trend has fallen in most of the provinces in year 2002. There might be plenty of different reasons for the boom of interprovincial trade, first could be the big and quick development of infrastructure in China, we can witness one of the biggest development in China's infrastructure in last 15 years, such as high-speed railways, or the expansion of its road system, highway network (including expressway and class 1, class 2 and class 3 highways) is targeted to reach 3 million km by 2020, up from about 2 million km in 2008.[7] Second reason could be entrance of China to the World Trade Organization in 2001, which decreased import tariff and more companies started to emerge to China's economy, China started importing more goods from world and produce more products at home economy, thus import/export more goods internationally. Many provinces have seen a chance to import cheaper goods since the entrance to World Trade Organization, and decreased import of goods interprovincially, that is the rapid jump of extra imports between years 2002 and 2003, however later we can see that the trend of extra imports stabilizes and the interprovincial trade starts to rise. There is also another steep change, which was caused by outer world, in year 2009, the Global financial crisis (2007-2009)[8]. Provinces which were more concentrated on exports (usually coastal provinces) started to import more goods interprovincially in order to export them to the rest of world. High level of urbanization naturally leads to higher trade in agriculture,

[7] Source: Ministry of Communication "Development Policy on Resource-efficient and Environment Friendly Road and Waterway Transportation", 26 February 2009

[8] Anjan V. Thakor, The Financial Crisis of 2007–2009: Why Did It Happen and What Did We Learn?, The Review of Corporate Finance Studies, Volume 4, Issue 2, September 2015, Pages 155–205, https://doi.org/10.1093/rcfs/cfv001

because the food has to be delivered from agricultural provinces to bigger cities, which consequently might be one of the reasons of constant rise of interprovincial trade in agriculture. Also we can see the trend that the richer provinces (See **Figure 16**), such as Guangdong or Jiangsu, are rather importing agriculture, health care and transport, while they most probably export the manufacturing to poorer regions. There are many more possible reasons, how one could explain the trend.

**Figure 23**: China's participation in GVCs in past years




Source: OECD.Stat, https://stats.oecd.org/index.aspx?queryid=75537#

As one could notice, there is different number between **Figure 23** and **4**, because data has been updated on OECD Stat and data in **Figure 23** are more recent, from December 2016. There is a trend of lowering the participation in Backward Participation GVC, while increasing Forward Participation, which essentially means that less imports are used, while trying to export. This tempts to think, that this is the "closing" economy trend as they try to become more self-sustainable, trade more inside of China, which higher "border" effect. However, the trend is fairly unpredictable in the future, since there have been big investments into infrastructure, such as "One Belt One Road", it might have various results, for example there might be higher trade flow from abroad, because of quick accessibility all over the China and higher interregional trade flows, or the Chinese economy might become more self-sustainable and start closing it's economy and boosting "border effect".

# 4 Conclusion

China has been opening their economy to world at first, but lately there was tendency to close their market, and began being more self-sustainable. We tried to test this statement. Our main indicators were GVCs and interprovincial trade. GVCs are freely available on the internet, however interprovincial trade of China is not. Therefore, we had to estimate interprovincial trade. To do so, we used Input-Output analysis. But in order to have Input-Output analysis on a regional level, we needed the regional Input-Output tables, sadly these tables do not seem to be freely available on Chinese statistical database. Thus, we had to do regionalization of national and domestic Input-Output tables. We have estimated provincial Input Output tables of China, by using Location Quotients techniques. Based on literature, such as Galanopoulos, Konstantinos & Karantininis, Kostas & Mattas, Konstadinos & Karelakis, Christos (2011) or Riccardo Boero, Brian K. Edwards & Michael K. Rivera (2018), we assume, that this technique is quite reliable.

After regionalization of Input-Output tables for years 1998-2011, we were able to locate trend of higher interprovincial trade, which in other words means "border" effect. We tried to look for similar trend in GVCs in order to see some connection between GVCs and interprovincial trade. We can see rapid increase in interprovincial trade and share of export and import on GDP since year 2002, China joined WTO in year 2001 and started opening their market to other countries, which resulted in rapid increase since year 2002, however this trend declined progressively. However interprovincial keeps increasing, which increases gap between interprovincial and international trade, hence increases "border" effect.

In this paper we have introduced and used cheaper way of how to obtain regional Input Output tables, which might be useful for poorer regions, who can not afford to make survey every year. This survey could further broaden into estimation and analysis of interprovincial exports and then with the use of gravity model localize provinces, which trade the most between each other. This paper is also only taking into account 4 regions, which might be too few, hence a study with many more regions might have different results.

We haven't been able to find an analysis, which would be similar to this, but we believe that with the use of more advanced GRIT methodology an analysis like this would be very useful for various studies of Chinese border effect, analysis of interprovincial trade, estimation of regional IO tables with the use of cheaper methods and so on. However, even better data would be required for more advanced GRIT methodology. We believe that in the future such analysis might be possible. For the purposes of further,

better and more advanced analysis the author has made his Python code publicly available, in hope of further improvisation either by him or anyone else, who might be interested in this topic.

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# 6 Appendix

**Appendix 6.1:** China's Global Merchandise Trade: 1979-2017

($ billions)

| Year | Exports | Imports | Trade Balance |
|---|---|---|---|
| 1979 | 13.7 | 15.7 | -2.0 |
| 1980 | 18.1 | 19.5 | -1.4 |
| 1985 | 27.3 | 42.5 | -15.3 |
| 1990 | 62.9 | 53.9 | 9.0 |
| 1995 | 148.8 | 132.1 | 16.7 |
| 2000 | 249.2 | 225.1 | 24.1 |
| 2001 | 266.2 | 243.6 | 22.6 |
| 2002 | 325.6 | 295.2 | 30.4 |
| 2003 | 438.4 | 412.8 | 25.6 |
| 2004 | 593.4 | 561.4 | 32.0 |
| 2005 | 762.0 | 660.1 | 101.9 |
| 2006 | 969.1 | 791.5 | 177.6 |
| 2007 | 1,218.0 | 955.8 | 262.2 |
| 2008 | 1,428.9 | 1,131.5 | 297.4 |
| 2009 | 1,202.0 | 1,003.9 | 198.2 |
| 2010 | 1,578.4 | 1,393.9 | 184.5 |
| 2011 | 1,899.3 | 1,741.4 | 157.9 |
| 2012 | 2,050.1 | 1,817.3 | 232.8 |
| 2013 | 2,210.7 | 1,949.3 | 261.4 |
| 2014 | 2,343.2 | 1,963.1 | 380.1 |
| 2015 | 2,280.5 | 1,601.8 | 678.8 |
| 2016 | 2,135.3 | 1,524.7 | 610.6 |
| 2017 | 2,279.2 | 1,790.0 | 489.2 |

**Source:** Global Trade Atlas and China's Customs Administration.

**Appendix 6.2:** Regionalized Transaction Matrix Z for Guangdong in 2009

| Sector name | Sector Index | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture | 1 | 7.73 | 0.00 | 4512.96 | 0.00 | 5.22 | 42.70 | 45.38 | 3.33 | 3.96 |
| Mining and Quarrying | 2 | 0.01 | 0.07 | 918.77 | 5.70 | 5.39 | 0.31 | 5.75 | 0.21 | 1.00 |
| Manufacturing | 3 | 10.13 | 0.15 | 203617.13 | 48.32 | 1449.73 | 1053.90 | 4932.10 | 223.79 | 619.47 |
| Elictricity, Gas and Water | 4 | 0.40 | 0.05 | 4868.86 | 106.39 | 30.01 | 65.15 | 237.97 | 7.83 | 34.09 |
| Construction | 5 | 0.01 | 0.00 | 43.11 | 0.11 | 24.02 | 35.41 | 95.32 | 2.14 | 26.89 |
| Finance, Real Estate | 6 | 2.68 | 0.06 | 21530.99 | 28.59 | 344.39 | 1108.72 | 2467.45 | 86.47 | 408.09 |
| Healthcare, Transport, Culture | 7 | 1.05 | 0.02 | 6900.20 | 8.72 | 65.73 | 812.92 | 861.42 | 67.76 | 126.59 |
| Scientific Research | 8 | 0.09 | 0.00 | 128.49 | 0.32 | 1.59 | 24.74 | 160.53 | 3.07 | 73.23 |
| Social Services, Others | 9 | 0.28 | 0.01 | 1121.08 | 5.32 | 10.30 | 114.23 | 344.25 | 17.48 | 140.54 |

**Appendix 6.3:** Python code, as well as empirical data needed in order to run the Python code and receive desired outputs, are available on GitHub, https://github.com/PavelZacharuk/Bachelor-Thesis-Pavel-Zacharuk.git