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Research on correlation effects between Tianjin Port and its inland ports based on modified Gravity model

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DECLARATION

I certify that all the material in this research paper that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this research paper reflect my own personal views, and are not necessarily endorsed by the University.

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Supervised by

Professor Wang Xuefeng(/Associate Professor)

Shanghai Maritime University

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ABSTRACT

Title of research paper: **Research on correlation effects between Tianjin Port and its inland ports based on modified Gravity model**

Degree: **Master of Science in International Transport and Logistics**

This thesis assesses and compares the attractive forces between Tianjin port and its 5 inland ports, namely, Beijing Chaoyang inland port, Hebei Shijiazhuang inland port, Henan Zhengzhou inland port, Ningxia Shizuishan(Luhuinong) inland port, Inner Mongolia Baotou inland port. Under the help of related economic theory, Grey correlation theory and the gravity model as a prototype, this thesis has built a gravity model based attractive force model to monitor the correlation effect between inland ports and coastal ports.

Cooperation mechanism between inland ports and coastal ports and other related economic theories have been discussed to facilitate the construction of attractive force model. Together with the help of information and data from practice and economic theories, this thesis are enabled to justify the results generated by model application. Moreover, some factors which used to highly valued in determining the attractive force are actually turned out not to be true, so these factors have also been further discussed in this thesis. And this thesis put forward some advices that might help Tianjin port and its 5 inland ports to seek improvement and it is also the aim of this thesis that to identify the development in the correlation effect between Tianjin port and its inland port so as to find an effective way to allocate the limited resources to each inland port for a optimal return both economical and environmental.

KEYWORDS: Tianjin port, inland port, attractive force model, correlation effect

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1. Introduction

1.1 Backgrounds of dissertation

Thanks to the further development of global economic integration, the trade volume of China has increased steadily, under which, the port, acting as both hub of international transport and platform of international trade,its role in resource allocation, synthetical logistics is becoming increasingly more important. Back to Eleventh Five-Year Plan, coastal regions had spared no efforts in expanding and building of ports, with the growing number of ports, the ports' hinterland were overlapping with each other, therefore, the competition among ports had become increasingly intense. In order to achieve greater throughput, coastal ports begin to extend their business to hinterlands and port operators were also fighting their way to gain more hinterland as well as source of good. Meantime, the increasing cargo flow and limited port area has pushed container storage capacity and collecting and distributing system under unprecedented pressure as the expanding international trade. Problems like over centralized stations and traffic congestion then followed closely, dropping ports' throughput capability and service level and longer port time had not only cost losses to shipping company but also had restricted the further development of the port.

On the other hand, the growing focus on economic strategy of Midwest provides a better chance for in inland region to develop its economy, foreign trade enterprise want to finish Customs declaration and inspection in local area and carrying the aspiration of developing local economy and opening wider to the outside world, the inland local government long for some way to imitate various functions of coastal ports so as to attract more export-oriented enterprises. Driven by both internal requirement and external environment,inland port, a modern logistic center built in inland place but has almost the identical function with coastal port, appeared on the scene. In general, the birth of inland port has considerably contributed to 3 aspects: firstly, it overcomes the bottle neck for inland region of developing export-oriented economy, as it links inland region with international world and promote local

economy development; secondly, it enhanced the competitiveness of coastal port by offering more source of cargo, as the overlapping traditional hinterland has caused too much competition; thirdly, it will reduce the overall logistics cost by eliminating overlapping process and integrating service, since the overall logistics cost used to count about 18% of China's GDP which doubled the average level of developed countries, while the cost of single function, e.g.storage, transport, labor etc. is cheaper than that in the developed country, which indicates the China was weak in the field of logistic service coordination.

In recent years, joint effort in building inland port by coastal ports and inland regions has become an important way for coastal ports to seize hinterlands and for inland cities to further their opening-up process. Some people called such development as the evolution to the fifth generation of ports, that is forming a hub and spoke system by making a harbour as a hub port and inland ports as its feeder ports to carry out businesses and provide port service to inland area through network system. As a matter of fact, the traditional scale, throughput, price-based competition are shifting to the competition for the control over hinterland and the hub-spoke logistic network.

With regard to the Twelve Five-Year Plan, we are entering into the new stage of developing regional opening-up process, so logistics economy as being one of the powerful driving force in regional development is now an emerging economy and coastal ports and inland ports as the carrier of this economy are gaining growing attention. In March 2006, <Tianjin city master plan (2005-2020)> was deliberated and passed by executive meetings of the State Council, commanding to develop Tianjin into North economic center and international port city, moreover, to make Tianjin the third leading city to bring about a coordinated development of regional economies. Together within the period of Tianjin's Twelfth Five-Year Plan, it is aiming at improving modern logistic system between coastal port and inland port.

The construction and operation of inland ports under such a critical situation, facing the test caused by economy globalization, are calling for more attention than ever to

decide which coastal port it should linked with and to which extend they could coordinate and adding strength to each other so as to achieve synergistic development. And these are the key problem in developing the inland port and also the base point of my research.

1.2 Research Purpose and significance

The aim of this thesis is to analyze correlation effects between developed coastal port and its inland ports by taking Tianjin Port and its inland ports as a typical case to study, as Tianjin is now very likely to be the NO.1 port in Northern China and a flagship of round-the-Bahai economic region which serves as transportation hub for Northern, Northwest and Beijing-Tianjin. Moreover, Tianjin was also the leading character in developing inland ports and has now boasted 23 inland ports so far, so among its large number of inland ports, we would like to explore the develop situation between Tianjin port and its inland ports, and by looking into its each inland port's different characteristics, we will be able to figure out the co-relationship between Tianjin port and its inland ports, after knowing how closely are they being attractive to each other, we could tell whether the interaction between them is good or not comparing to each other and to analyze the reason behind the results thus coming up with reasonable and effective advices for a better synergistic development.

According to the domestic and overseas theoretical and applied research experiences, there is a growing influence casted by inland ports on the coordinated interaction of coastal port development and on promoting the regional economy.

Inland port is the outcome of port and inland's need, and it is growing along side the increasing foreign trade. Medium and big-sized coastal ports have built inland ports by cooperative investment with inland place so as to further extend its economic hinterland into inland area and enhance the relationship with customers in hinterlands. While the coastal port is getting more hinterland resources, the inland regional economy are also being stimulated. By building the inland port, the cargo flow could

be accelerate and the process of containerization could be speeded up, thus improving foreign trade development of the inland region. Consequently, appropriately handling the relationship between coastal ports and its economic hinterland is playing an essential role in promoting the coordinated development of the economies.

And we should notice that a great amount of manpower and resources are needed when building the inland port, blindly building the inland ports would not achieve positive results but even turn into the short board which hinder the sustainable development of coastal port. In short, the fundamental tasks for port operators is to seek a way to coordinate port development and inland port construction, to promote sustainable development of the port through careful and rational plan in the development of inland port.

1.3 The framework and content of the dissertation

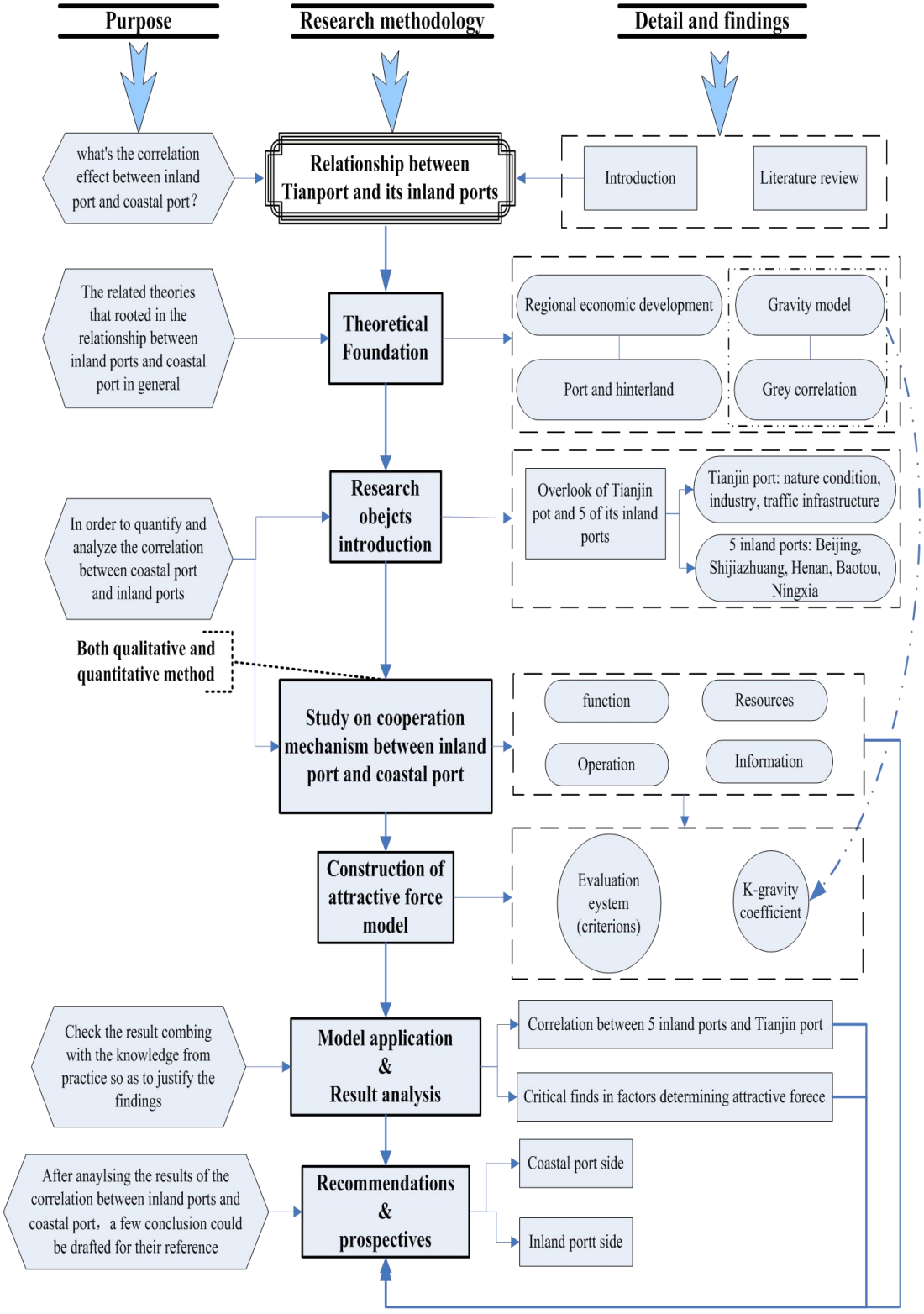

Figure 1.1 Framework of the thesis

The overall framework is displayed in figure1.1, which indicates that this paper will be divided into 6 chapters:

Chapter 1: Introduction of the background of the paper, which provide the reason for the research. After exploring the researches of scholars from domestic and overseas;

Chapter 2: This part serves as the foundation of the whole paper, in the sense of providing both theoretical foundation of economic theory and mathematics model. For the purpose of gaining a overall knowledge of correlation between inland ports and coastal ports so as to pave the road for further research, regional economic development theory and economic theory between port and hinterland are discussed. Moreover, grey theory are discussed in particular for the sake of the model building in the following chapters;

Chapter 3: Introduction of the research object. Give the general idea of the object in the research—Tianjin port and its 5 inland ports(namely, Beijing Chaoyang inland, Hebei Shijiazhuang inland port, Henan Zhengzhou inland port, Ningxia Shizuishan (Luhuinong) inland port, Inner Mongolia Baotou inland port). Analyze Tianjin port with regard to its development situation, natural conditions, primary business as well as traffic conditions. Meanwhile, the development situation and features of the 5 inland ports has also been analyzed respectively;

Chapter 4: This part analyzes the correlation effect between inland ports and coastal port and mainly focuses on 4 kinds of cooperation mechanism between inland ports and coastal port and especially in terms of functional part. Taking the advantage of the detail analysis on the cooperation mechanism, gravity-based attractive force model was built follow. Together with the help of theoretical foundation that formed in chapter 1, the k-gravity coefficient could be successfully quantified;

Chapter 5: The application of attractive force model with more importance being attached to the result analysis. This chapter contains 2 parts, first part is about

justification of the model result by resorting to economic theory, experience and practice, while the later part is more of a conclusion of the model result and upon which this part comes up with the possible solutions for the improvement of the correlation effect between Tianjin port and its 5 inland ports from the 5 inland ports' and Tianjin port's point of view,respectively;

Chapter 6:conclusion of the research. Acknowledgment of the shortage as well as looking forward to the further improvement.

To accomplish my research purpose, the methodology adopted in this thesis are twofold:

1. Combinationof theory with practice:

   Based upon fully understanding of the development pattern in inland port and related economic theories, to collect some worthy researching data from both coastal port and inland port(or its region);

   Supporting model result with proper theory, practice as well as the national or regional policy which directed the development trend.

2. Combination of both qualitative and quantitative methods:

   Combined gravity model with Grey correlation theory in order to quantify a unknown coefficient, and to run the modified gravity model on the data from Tianjin port and its 5 representative and typical inland ports in order to quantify the synergistic relationship between them.

1.4 Literature review

1.4.1 Review of recent research

As competition among coastal ports are getting intensified, the question about how to create a new entity which has the similar function as coastal port in inland area for the purpose of securing more hinterland resources thus increasing the overall competitiveness of the coastal port as well as improving the economic development

in inland region. It is under such development trend that inland port has aroused considerable attention among specialists and scholars, both domestic and aboard.

1.4.1.1 Definition and concept of inland port

The term of inland port has long existed in foreign countries. In 1965, Japanese had already used term inland port, and they had laid their hand on the research of inland port since 1960s and 1970s, but during that time they only considered inland port as a sub-sector of coastal port in inland area in order to gain more cargo and nothing more.[1] European commission began to study inland port in 1990, and they called it "dry port" and defined it as an inland transport station with a direct connection to harbor.[2] Shortly, American Container Association (1992) argued inland port to be an inland container terminal with a long distance to harbor and they thought its main function is providing inland cargo with container loading/discharging service, custom service and short-term storage so as to gain the profit by achieving containerization as well as stimulating the process of containerization in inland area.[3] The scholars of our country only started to notice inland port in the beginning of the 21st century. Inland port was first brought into our sight by Professor Xi Ping(2000) in his research paper on further develop trade in Xian, he believed that the development of inland port met the international trade development of inland areas and followed the development pattern of both international logistics and economic development in inland areas.[4] Later, Xi Ping(2005) improved the idea of inland port by putting forward that inland port could be served as a gateway to international trade for inland

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[1] Lu Shunjian, Dong Yandan, Development of inland port in China, Shipping Management, 2007, Vol. 29, NO.8: 43-52
吕顺坚, 董延丹. 我国无水港的发展, 水运管理, 2007, 29(8): 43-52

[2] Xi Ping. Thoughts on building an international inland port in inland region, Comprehensive Transportation, 2007, NO.2: 45-46
席平. 内陆地区建设国际陆港的思考, 综合运输, 2007,(2): 45-56

[3] P.Leveque, V.Roso. Dry Port concept for seaport inland access with intermodal solutions. Masters thesis, Department of Logistics and Transportation, Chalmers University of Technology, 2002: 40-83

[4] Xi Ping, Yan Guorong, Cao Hong. Establishment of an international port in western China-ideas on "Xian inland port", Tangdu Journal, 2001, Vol 17, NO.4: 12-14
席平, 严国荣, 曹鸿. 建立中国西部国际港口- "西安陆港"的设想.唐都学刊, 2001,17(4):12-14

place which will largely enhance the inland economy development like which were gone through by coastal area.[5] Wang Hongwei, et al(2004) pointed out difference between inland port and container freight station(CFS) helping to solve the vague between these two.

1.4.1.2 The development and function of inland port

Notteboom, Jean P.R(2000) stated that the embryo of inland port was originated form inland CFS, then to multimodal transport station and later through its further development in function and scope of business, it became the inland port with the multifunction of comprehensive trade, logistics, custom service, accounts settlement and etc.[6] Before long, Notteboom, et al(2002) recognized inland logistics cost contributed a lion share in overall logistics cost, so it is recommended that coastal port should devoted more effort in inland cargo operations and logistics integration for a close connection with clients.[7] Arzemskis and Aidas Vasilis (2007), from intermodal prospective, divided the motivation to seek cooperation with port into 8 segments in 5 ways.[8] Zhang Rong and Ai Caijuan (2010) have studied on function and development Strategies of inland port and they took the view that inland port should have the function of intermodal transport, custom clearance, bonded warehouses and value-added supply chain services.[9] Huang Shoaling (2011) by analyzing the recent development of our country's inland ports, he classified the main drivers of inland port are threefold: first, for coastal port to seek more hinterland; second, inland region's will to develop its economy; third, for the need of

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[5] Xi Ping. Turning inland cities into inland port. China Storage and Transport, 2005, NO.5:42-43
席平. 变内地城市为支线陆港. 中国储运, 2005(5) :42-43

[6] Theo E.N., Jean P.R.. Port Regionalization: Towards a New Phase in Port Development. MARIT. POL. MGMT., 2000, Vol32, NO.3: 297-313

[7] Notteboom TE, Winklmans W. Structural changes in logistics: how will port face the challenge. Maritime Policy and Management, 2002, NO.1:71-89

[8] Arzemskis A, Vasiliauskas A V. Research on dry port concept as intermodal node. Transport, 2007, NO.12: 207-213

[9] Zhang Rong, Ai Caijuan. Research on the development strategy and function of inland port. Comprehensive Transportation, 2010, NO.1: 44-47
张戎,艾彩娟. 内陆港功能定位及发展对策研究. 综合运输, 2010(1):44-47.

both port side and inland side. He also highlighted the fact that inland port is the critical part to bridge the gap between inland and international world and to accelerate the development for coastal and inland region regardless of which driving force was.[10] Di Zhiwei (2011) presented a new way of developing inland port by orienting at inland city itself, which theoretical fits our country's actual situation quite well.[11] Nowadays, the existing function of an inland port cannot meet the growing demand of international trade, Kang Shucun (2010) as CEO of www.shippingchina.com defined virtual inland port as the combination of logistics and E-commerce aiming at increasing logistics efficient, reducing logistics cost making a big leap in the development of Chinese logistics industry, moreover he listed in detail 10 advantage for establishment of virtual inland port.[12] Lv Zhifang, Liu Xinyu, Li Hong, et al (2011, 2012) also investigated on the development trend of virtual inland port.[13][14] What's worth noting is that Wei Yongping, et al (2010) used SWOT to analyze the internal and external environment and competitive superiority and inferiority of the development of dry port in Henan Province, the mode of big customs clearance in innovative port is put forward together with the method of "freight trains with five fixed terms", which may improve the efficiency of overall

[10] Huang Shaoqing. China's Modern Dry Port Development and New Customs Clearance Models. Urban Management, 2011: 55-56
黄少卿. 我国现代无水港发展及其新颖的通关模式研究. 交通瞭望, 2011: 55-56

[11] Di Zhiwei. Research on China inland dry ports developing mode and competitiveness evaluation. Master thesis, Dalian: Dalian Maritime University, Transportation Planning and Management, 2011
翟志伟. 我国内陆无水港发展模式及竞争力评价研究. 硕士学位论文, 大连:大连海事大学, 交通运输规划与管理, 2011

[12] Kang Shucun. Develop virtual dry port and reduce logistics costs. World Shipping, 2010, NO.1: 25-27
康树春. 发展虚拟无水港降低物流成本应对危机. 世界海运, 2010(1): 25-27

[13] Lv Zhifang. Development and trend analysis on virtual port in China. World Shipping, 2011, NO.5: 30-40
吕志方. 中国虚拟无水港发展现状及趋势. 世界海运, 2011(5): 30-40

[14] Liu Xinyu, Li Hong, Liu Hongsong, Qiao Junying. Analysis the Development Research of China's "Virtual" Anhydrous Harbor Based on the SWOT. Logistics Engineering and Management, 2012, Vol 34, NO.3: 1-5
刘新雨, 李弘, 刘洪松, 乔俊英. 基于 SWOT 分析的我国虚拟无水港发展研究. 物流工程与管理, 2012, 34(3): 1-5

logistics. Moreover, he also believes it has positive significance for cultivating the port industry and promoting the port and city strategy as well as regional strategy.[15]

1.4.1.3 The location of inland port and its competitiveness

Wang Hongwei (2004) starts from analyzing the shippers' logistics cost and then build the location model of inland port with the help of discrete choices model and also compared it with AHP model.[16] Yang Rui (2006), however, use the DEA to build the location model for inland ports along with AHP-Fuzzy to help ranking the candidate locations.[17] Zhang zhaomin (2007) discuss the principal of siting an inland port to meet the demand of transport volume, overall and regional planning and pursuing economic efficiency. He started from the amount of container generated and transshipment container volume and raised a series of factors contributing to the location of inland port which than be applied on the case study of siting the inland ports for Dalian port thanks to the fuzzy cluster theory.[18] And with the development of international trade, people's begin to focus more on green side of logistics which give birth to location model based on green conception, such as Lv Jing and Chang Zheng (2013), in their research they took environmental factors such as noise, accidents, crowd and emissions into consideration when formulating generalized cost

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[15] Wei Yongping, Ma Jianxiao. SWOT Analysis on Development of Anhydrous Port in China -Taking Henan Province as an Example. Transport Standardization, 2010, NO.11: 176-179
魏永平, 马健霄, 我国无水港发展的 SWOT 分析——以河南省为案例, 交通标准化, 2010(11): 176-179

[16] Wang Hongwei. Construction of"inland port" and application of discrete choices model in siting inland port. Master thesis, Shanghai: Shanghai Maritime University, Transportation Planning and Management, 2004
王红卫. "无水港"的建设和离散选址理论在选址中的应用. 硕士学位论文, 上海:上海海事大,学, 交通运输规划与管理, 2004

[17] Yang Rui. Study on Inland "dry ports" and its location selecting. Master thesis, Shanghai: Shanghai Maritime University, Transportation Planning and Management, 2006
杨睿. 内陆"干港"及其选址研究. 硕士学位论文, 上海:上海海事大学, 交通运输规划与管理, 2006

[18] Zhang zhaomin. Research on location for dry port. Master thesis, Dalian: Dalian Maritime University, Transportation Planning and Management, 2007
张兆民. 干港选址研究. 硕士学位论文, 大连: 大连海事大学, 2007.

function to a build a bi-level programming location model that can satisfy the cost needs of both decision makers and shippers.[19]

With regard to the study on inland ports' competitiveness, Gi-tae Yeo has gone though related researches in recent 30 years and then build a core competency index system for assessing the competitiveness of ports between Korea and China, which contains 7 secondary criteria and 14 tertiary criteria, among which the service level, convenience, obstruction level, logistics cost of ports and economic development level in hinterland are serving as significant reference for future researches on the competitiveness of ports.[20] While, after paying visit to 11 existing international inland ports in Europe, Asia, Africa and etc., he held that there are mainly 6 factors that affected potential development and competitiveness of an international inland port, and there are: land, regulation, infrastructure, service, environment, and other small factors, which also served as an important reference for the late comer.[21] Song Ruiqi (2011) by building the rating system used TOPSIS to rank the competitiveness among several inland ports in Tianjin and proposed some advices according to the ranking result.[22] Soon after Song's work, Wang Jian(2013) build the evaluation criteria upon related inland port theory, and applied them on 5 main inland ports in Tianjin but under the assistance of a more comprehensive model including Entropy Weight Assignment method as well as TOPSIS.[23]

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[19] Lv Jing, Chang Zheng. Location Model and Solution for Inland Ports Based on Green Conception, Journal of Transportation Systems Engineering and Information Technology, 2013, Vol.13, No.2, 21-26
吕靖, 常征, 绿色物流理念下的内陆港选址模型及求解. 交通运输系统工程与信息, 2013,13(2), 21-26

[20] Yeo G-T, Roe M. Evaluating the competitiveness of container ports in Korea and China. Transportation Research Part A, 2008, 42: 910-921.

[21] Roso V, Lumsden. K. A review o f dry ports. Maritime Economics&Logistics, 2010, Vol. 12, NO.2: 196-213

[22] Song Ruiqi. Case study on competitiveness evaluation of inland ports in Tianjin. China Water Transport, 2011, NO.6, 16-17
宋睿琦. 天津无水港竞争力评价研究及实证分析. 中国水运, 2011(6): 16-17

[23] Wang Jian. Research on the construction and development of Tianjin inland ports. Tianjin: Tianjin Polytechnic University, 2013
王建. 天津港腹地内陆无水港建设发展问题研究. 天津:天津工业大学, 硕士学位论文, 2013

1.4.1.4 Relationship between inland port and coastal port

Foreign scholars are head of us for more than a half century, as it is acknowledged that The Value of a Ton of Cargo to the Area Economy(1953) published by Delaware River Port Authority was the first work about the relationship between port economy and regional economy.[24] Zhang Lili (2009) did some quantitative research on the interaction between international shipping center and inland ports upon the theory of synergistic development mechanism between them to see the effect brought about by their interaction.[25] Jiang Weixiang has further explored the interactive development mechanism based on theory of system dynamics.[26] Zheng Haixin proposed 7 levels of the interactive development between coastal ports and inland ports and used BP nerve network model to solve the case after building the corresponding evaluation criteria.[27] Tang Huiliang, et al (2006) analyzed contribution of Shanghai port to regional development by input-output model. Zhang Shuyan[28] and Han Zhaoyan[29], they both took the advantage of Statistics analysis such as Linear Regression to analyze the correlation between port and hinterland, Zhang investigated the correlation between GDP and tertiary industries of 5 coastal cities and their ports'

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[24] Delaware River Port Authority. The Value of a Ton of Cargo to the Area Economy. Philadelphia Port Area, 1953

[25] Zhang Lili. Research on the development of interaction between international shipping center and inland port. Master thesis, Dalian: Dalian Maritime University, 2009
张丽丽. 国际航运中心与内陆港互动发展研究. 硕士学位论文, 大连: 人连海事大学, 2009

[26] Jiang Weixiang. Research on system dynamics of bonded port with inland port interaction development mechanism model. Master thesis, Dalian: Dalian Maritime University, Transportation Planning and Management, 2011
姜伟香. 基于系统动力学的保税港区与内陆港互动发展机理模型研究. 硕士学位论文, 大连:大连海事大学, 2011

[27] Zheng Haixin. Research on Levels Selection Model of Interactive Development. Master thesis, Dalian: Dalian Maritime University, Logistics Engineering and Management, 2011
郑海鑫. 保税港区与内陆港互动发展层次选择研究. 硕士学位论文, 大连: 大连海事大学, 物流工程与管理, 2011

[28] Zhang Shuyan. Analysis of Port logistics' contribution to urban economic growth: case study of selected coastal cities of China. Master thesis, Ocean University of China,International trade,2006
张树艳. 港口物流对城市经济增长贡献分析. 硕士学位论文, 中国海洋大学, 国际贸易学, 2006

[29] Han Zhaoyan. Study on the interaction development of Qingdao Port and the hinterland economy. Master thesis, Dalian: Dalian Maritime University, Transportation Planning and Management, 2006
韩兆艳, 青岛港与腹地经济发展互动研究: 硕士学位论文, 大连: 大连海事大学, 交通运输规划与管理, 2006

throughput thus getting the idea of the correlation effects between port logistic and cities' economic growth, while Han further applied the theory of grey correlation to model the relationship between inland port and coastal port so as to have a more precise view of the coefficient between them. In the book of Dong Qianli, a concept of integrated attractive force was introduced to measure the relationship between inland port and coastal port from the prospective of logistics integration.[30]

1.4.2 Existing problems

Recently, the research on inland port (dry port, international dry port were mainly focused on it theory, concept, development pattern and the location by applying both real case study and theory analysis, and may find a lot of researches about the location problem of an inland port provided with the solution of both quantitative and qualitative which laid a solid foundation for later study. It's also worth noticing that in the study of port competitiveness many scholars have come up with a lot of brilliant ideas in establishing the criteria mechanism as well as choosing the critical criteria under the help of some qualitative and quantitative theory. However, behind the flourish achievement, problems and weakness do and still exist:

1.4.2.1 The overall knowledge of inland port is not that clear

People's minds are different with each other and although foreign country started the study on inland port long before us, they still do not have a universally accepted or general definition on the characteristics of a so called inland port, which, to some extent, may hinder the development of inland ports.

1.4.2.2 The study on inland ports were somehow one-sided not big picture-based

It is often seen in the research paper that the author tended to study the necessity of building the inland ports regardless of whether in the real world there are enough surrounding facilities to support the establishment of inland port. And many researches concerning the location of inland ports often turned a blind eye to the real

[30] Dong Qianli. Logistics integration field: Theory and practice for international inland port. Beijing: Social Sciences Academic Press, 2012.11
董千里, 物流集成场: 国际陆港理论与实践,北京:社会科学文献出版社, 2012.11

need of the coastal port and inland region, as a matter of fact the cost of building a new inland port was hardly appeared in any research paper on siting an inland port, and we both know the initial cost and foreseeable amount of future earning speaks louder than complex model or words. So may be it's time to paying attention to those existing inland ports, and explore their advantages and disadvantages and put forward feasible solution to improve it, after all it is more economically viable to make improvements than doing something from scratch.

1.4.2.3 Inland port tended to be viewed as an individual thing

From both domestic and overseas research, it won't be hard to notice that inland port are always be separately studies, there are not so many paper about the relationship between inland port and costal port(costal) area. But we may encounter some researches on the relationship between inland port and its regional development or the relationship between costal port and its hinterland, and even there do have some paper on the coefficient between coastal port and its inland ports, they are more of qualitative and lack of quantitative study.

In brief, the development of inland ports in our country is still at an elementary stage, being lacked of sound theoretical research, our inland ports' development were blocked by less coordinated planning, mono-styled function, which prevented its function from connecting the inland to the outside world. So it is of great importance to study the bond effect of the inland port, and despite the fact that more and more ports are building or going to build inland ports and the question of how many of the could actually adding profits to each other should be further studied especially in some kind of measurable way.

2. Theoretical Foundations

2.1 Theories of regional economic development

The question about how to make the most of the limited regional resources so as to maximize the output is exactly what the regional economy is all about, and different way of resources allocation has divided the theory into 2 groups, one is

balance-growth theory and the other one being also the start point of my research is unbalance-growth theory.[31]

The unbalance-growth theory believes, limited by numerous factors, a country (or region) during its economic development cannot achieve balanced or all-round development, but to wait for a breakthrough in some favored area first, which then will boost regional development.

As of the main theory rooted in unbalance-growth theory, the growth-pole theory was presented by French economist Fran ois Perroux, and its main concept is: the economic growth are first appeared in some innovative industry and leading sectors instead of simultaneously happened in all places. In another word, growth is first seen in some kind of growth-pole, and bring about different influences to the whole region through diffusion. Later, the concept of geographical space in this theory was further developed by J.B.Boudeville, after analysis on external economy, J.B.Boudeville polished the theory by theoretically adding geography concept. In his mind economy space includes 2-layer relationship, one is between economic variable, and the other is between geographic factors and structures, which highlighted importance of growth-pole in geographic field.

Raised by Polish economists, pole-axis theory is also the extended version of growth-pole theory, it focus not only on the point-growth pole(center of the town or region with comparatively better developed economy) but also lays emphasis on “axises” between those points, which are the traffic arteries. With the growing constructions of traffic arteries like rail, road , waterway, people and goods are moving more frequently between the points, the lowered production and transport cost has made a favorable regional conditions and investment environment. Industries and population moved towards traffic arteries, so the areas connecting by traffic arteries became the economy growth points, and together with the arteries,

[31] Gao Hongshen. Regional economics. 3rd edition. China Renmin University Press, 2010.

they became Economic growth axis. In the development of a country, according to the pole-axis theory, most factors of production will be gathered at “points” and connected by linelike facilities thus becoming the “axis”. This theory views highly of the role transportation plays in the economic growth, and is convinced it has a better effect than simple growth-pole theory could do to regional development.

According to the above 3 theories, regional spatial structure will be first shown in points, with the points growing stronger, some of them will become regional economic centers. After further gathering to a certain scale, these regional economic centers will start to radiate economic energy to its surroundings, and this kind of radiation will be sure to happen alongside traffic arterie, which later will turn the point effect into line effect, moreover, through time, points and lines should expanded into meaningful flat.

In 1966, John. Frishman[32] put forwarded Core and Periphery Theory in *“Regional development policy”* based on his study on the development in Venezuela. He thought the central area and the peripheral area are interactive and mutual-promotive. On one hand, central area are attracting a lot of factors of production such as material, technique social and cultural systems for more innovation. On the other hand, the innovation would kept fanned out, and direct transform of external economic activity, social and cultural structures and settlement type in the peripheral region.

At the expense of the inner areas, the economic reforms shifted the focus away from encouraging full regional development in China to developing only the coastal areas, which traditionally had a relatively well-developed infrastructure and a strong economic base. Since the readily accessible geographic location of the coastal areas promised a much higher rate of return on investments when compared with other parts of China, the central government further established special economic zones,and opened cities and regions along the coasts with the aim of attracting more investments from foreign countries and economies.

[32] Frishman J R.Regional development policy: a case study of Venezuela, Cambridge, Mass: MIT Press, 1966

The 9th Five-Year Plan for National Economic and Social Development of the People's Republic of China[33], "Promote Regional Coordination and Development" was defined as: during the regional national economic development, not only should efficiency operation and appropriate growth rate in regional economic to be secured, but also the economic development in sub-region should be promoted in order to make full utilization of the comparative advantages of the different regions, facilitate reasonable circulation of production elements, deepen regional cooperation, promote development of regions through healthy interaction, and gradually narrow the development gap between different regions.

The unbalance-growth theories are actually the foundation to carry out synergistic development. Coastal areas, which traditionally had a relatively well-developed infrastructure and a strong economic base. Since the readily accessible geographic location of the coastal areas promised a much higher rate of return on investments when compared with other parts of China, coastal areas tended to play the role of growth pole. If inland port and coastal port could from a positive interactive development, it is no doubt that rational labor division and coordinated development between inland and coastal area will be achieved which enhanced process of economic integration.

2.2 Economic theory of port and hinterland

Indulged in the trend of world economic integration, the relationship between the port and the hinterland has become more closer than before. The economic development of port economy in coastal region turned out to be the main driving force for regional economic development. As we know that ports' development need the support from storage, processing , trade, transport , finance and other related services, and in turn its development will largely prompt the development of those industries. What's more, it does not only do good to the economic development in where it is located, but it is also an force that cannot be neglected when speaking of

[33] The 9th Five-Year Plan for National Economic and Social Development of the People's Republic of China, 1996

the economic development of surrounding cities. And of course the development of hinterland economy will serve as a strong support to ports' economic development, ie. Secure cargo sources. So, indeed, it is not only its own port conditions that the development of ports counted on, but it also has a intimate linkage with its economic hinterlands. A hinterland with prosperous economy, advanced integrated transportation network, improved municipal infrastructure and sufficient cargo supply, its coastal port is of a more promising future.

German scholar Gorz (Erich A Kautz)[34] published a "harbor location theory" which was based on relations between the coastal port and the hinterland. Gorz was convinced that hinterland is the primary factor to the development of coastal ports. Optimal location of the coastal port is equals to minimizing the overall cost, in another word, it is constrained by hinterland condition, sea condition, labor cost, capital investment, among which he underlined the factors of hinterland played the decisive role in coastal port siting. He took the view that the scale of hinterland, its size of economy as well as the vitality of its economic development were the main backing force for the coastal port's development, and they are also critical to the structure and vitality of development in contiguous areas between hinterland and coastal port.

So it is undeniable that coastal port and its hinterland are inter-related and inter-dependent. The development of coastal port stimulated the development of its economic hinterland, and it was also benefited through the development of its hinterland's advancement, they viewed each other as the prerequisite of their own existence and development and together they are the harmonious regional combination.

2.3 Theory of Gravity Model

Newton's law of universal gravitation

[34] Erich A.Kautz.Theory of Harbor Location.1934

In 17th century, The law of universal gravitation was discovered by Newton has given an impetus to development of science and many natural science disciplines. According to the law that any two bodies in the universe attract each other with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

Gravity model

Gravity model was developed from Newton's classical mechanics, Tinbergen(1962) and Poyhonen(1963) have applied and further developed it in the field of economics, which then give birth to a relatively complete and simple model-Gravity model. In the model,the individual trade flow has a positive relation with their GDP between 2 economies, and has a negative relation with the distance between them. An important feature of the gravity model is it has a comparatively fixed form, so the model can be applied to a lot of problems by only making appropriate changes in defining the parameters and components in it. Researchers can just start from estimating the parameters of the basic model, and usually the gravity model can be simplified as follow:

$$M_{ij} = KY_iY_j \big/ D_{ij} \tag{2.1}$$

In which, K is a constant, or so called gravity coefficient; Yi and Yj are endogenous variables, which needed to be estimated according to the unique requirement of each research purpose; Dij is the distance or space between object i and object j

J.Q Stewart(1948) and G.K. Zipf(1946), those two, individually and simultaneously, proposed prototype formula of the recent gravity model. Zipf was devoted to the research on the spatial interaction between two cities, in his model he used railway traffic volume, number of telephone calls and number of similar forms of social or economic exchanges.With the development of science, gravity model has become more and more popular in studies in bilateral trade as well as in socioeconomics. Anderson(1979), Tinbergen(1962) and Poyhonen(1963) are the first generation to apply gravity model to anaylze international trade. As for the application in

socioeconomics, W.J.Reilly's retail attraction model(1931) and Converse.P.D's breaking-point formula(1949) was the most popular models known by people, the late comer W.Isard(1965) through emphasizing more on regional population on the basis of Converse.P.D's model and further raised interaction of the region's potentiality has a positive relation with the population, and a negative relation with the distance between two cities. It is also interesting to notice that, the gravity model has also been seen in tourist field, Zipf(1946) and Peter F. Colwell(1982) have proved that there exists a positive relation between logarithm of distance(between two places) and number of travels, which is identical to the basic gravity model.

The application of gravity model and its derivative models can enhance the accurateness in the research on spatial structure and providing relatively reliable grounds in location siting for industry, agriculture, transportation, commercial and residential use, etc. So gravity model was widely applied to Economic geography , urban geography, population geography. Meanwhile, during the analysis of regional urban hierarchy and can have a quantitative understanding of economic relationship between cities as well as defining the boundary of the urban economic domain of attraction, which certainly is of far-reaching significance in dividing economic region as well as the development of regional economy.

2.4 Theory of gray correlation

A device to measure the change in the relationship of the factors between 2 systems over time or other objects is called correlation.

Grey Relational Analysis(GRA) is one of the device to measure the correlation, within GRA, situations with no information is viewed as black, and those with perfect information as white. However, those extreme situations can never be seen in the real world, instead, situations between these extremes, described as gray or fuzzy, are everywhere out there. Therefore, a gray system means only part of the information is known and the rest remains unknown or uncertain. Being neither of the extremes, gray systems will give a variety of available solutions, which may not

be the best, but gray system does provide techniques for determining an appropriate solution for real world problems[35].

The gray relational analysis theory is the most mature and widely used product of gray system theory, which provides a simple scheme to analyze the series relationships of the system behavior even with few information or irregular data. The principle of GRA is through both quantitative analyses and qualitative method to achieve comparison with references or criteria for contrasting. The key of GRA is using quantitative method to make comparison of concerned factors in dynamic development process. During the dynamic development process of the system, if the two factors in two systems follows almost identical trend over time, then they have a higher degree of synchronous change which may lead the conclusion of a high degree of correlation.

Nowadays, there are 5 popular model to analyze the degree of gray relationship, such as mean associative degree's method, Deng's correlation degree's method, Grey slope incidence degree's method and grey relevant degree's method, etc.. In this research, mean associative degree's method was used to help constructing the gravity model. In general there 5 steps to do the Grey relation analysis:
First, collect raw data series, and determine the mother factor X_0, and Sub-factors X_i;
Second,data standardization of both mother factors and sub-factors;
Third, compute Grey relational coefficient;
Forth, compute Grey relational grade;
Fifth, sequencing.

3. Tianjin port and its inland ports

As the topic name indicates, this paper intends to take Tianjin port and its inland ports as an example to study the correlation effects between the costal ports and their inland ports.

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[35] Wikipedia, http://en.wikipedia.org/wiki/gray_relational_analysis; XIAO Xiao-Cong,WANG Xiang-Qun, FU Kai-Yao,ZHAO Yi-Jiang. gray Relational Analysis on Factors of the Quality of Web Service, www.sciencedirect.com, 2012

3.1 Development situation of Tianjin port

3.1.1 Natural conditions

Tianjin Port locates at the cross point of Beijing-Tianjin city band and Bohai Rim economic circle. It is the sea gate of Beijing, the important international trade port in northern China and the linkage to connect Northeast, Central and West Asia. Tianjin Port is the greatest artificial port in the world with -21.0m-water-depth main navigation channel, which entitles the port to cater for 300,000-ton ship with high tide.

Tianjin Port has broad international connection. It has trade relation with more than 500 ports in over 180 countries and regions. Every month there are about 500 scheduled vessels connecting with the main ports in the world. It possesses strong economic radiant power. The hinterland is almost 5 million square kilometers, accounting for 52 percent of total Chinese area. Presently, approximately 70 percent of the cargo throughput and more than 50 percent of the import and export cargo value via the port come from the provinces outside Tianjin[36].

3.1.2 primary Business

Tianjin port is the biggest comprehensive port in Northern China and has already formed its four pillar businesses in terms of container, crude oil and products, ore and coal. Moreover, steel and grain are also it main cargo resources. In fact Tianjin port is China's biggest coke export port and second largest iron ore import port, moreover, it is China's container shipping arterial port and also one of the national oil giant port.

Tianjin Port mainly consists of North Port, South Port, East Port, South Zone of Harbor Economic Area and East Zone of Nangang Port. North Port is mainly engaged in the operation of containers and general cargoes; South Port focuses on dry bulk and liquid bulk cargoes; East Port focuses on container terminal operation and modern services of international shipping, logistics, trade and off-shore finance,

[36] http://www.chinadaily.com.cn/m/tianjinport/2013-03/25/content_16342899.htm

and the urban functions in its eastern side are improving; the main development trend in the South Zone of Harbor Economic Area is heavy equipment manufacturing, new energy, food and light industry; the East Zone of Nangang Port is a new port area for bulk cargo of coal and ore.

3.1.3 Traffic conditions

Rail: Beijing-Harbin Railway, Beijing-Shanghai Railway and Beijing-Tianjin Railway crossed at Tianjin, reaching outward to Beijing-Guangzhou Railway, Beijing-Kowloon Railway, Beijing-Baotou Railway, Shijiazhuang-Chengde Railway, Lunghai Railway, Lanzhou-Xinjiang Railway and etc. so as to connect with the national railway network. With the help of comprehensive railway network, Tianjin can stretch itself toward all directions: North to Beijing, Inner Mongolia and North-East China; South to places in East and South China; West to West and North-West China and then link to Mongolia Russia and European countries.

Highway: A radiant highway network consisting of Jing-Jin-Tang Highway, No.103 Highway, DanLa expressway, Jin-Jin Expressway runs through here, which puts together Beijing, Tianjin and places in Northern China and North-West China. In addition, the government of Tianjin has take action in further developing transportation facilities like airport, port, railway and highway, and the investment for these transport projects or municipal projects will reach 67.8 billion RMB.

Pipe line: Pipe lines in Tianjin port are mainly used for oil-gas product, the existing pipe line are mounted in South Port, there is a pipeline corridor which is capable of catering 45 pipelines has now accomplished 10 trans-Haihe oil-transmitting pipeline. What's more, there are also aviation kerosene pipeline linking direct to Beijing, crude oil and refined oil pipeline linking to Dagang oilfield and Tianjin Petrochemical, respectively. These pipelines can even get in touch with Sinopec crude oil pipeline network under the help of pipelines between Tianjin and Cangzhou.

3.2 Development situation of Tianjin's inland ports

This paper aims to use 5 of Tianjin port's inland ports as the research objects and they are Chaoyang inland port in Beijing, Shijiazhuang inland port in Hebei. Zhengzhou inland port in Henan, Shizuishan(Luhuinong) inland port in Ningxia. The reason why we use only these 5 inland ports to carry out our research is as twofold: one is because most of the inland ports of Tianjin ports are either under construction or just started up, they won't be sufficient data available for us to do the research. While, these 5 inland ports are founded comparatively earlier than the rest and they are also the typical cases among those pioneer inland ports with regard to several aspects. Secondly, since the purpose of this paper is to analyze the correlation between inland ports and costal port so as to redirect each parties's resources into the some investment worthy field to seek a better future for both sides. We just want to take a few inland ports as an demonstration for the application of our gravity based attractive force model.

3.2.1 Beijing

As the pilot for Tianjin's plan of building inland port, Beijing play a quite important role in setting samples for the late coming inland ports. Since 2002, after Port Office of Beijing Municipal Government, Beijing Customs, Beijing Entry-Exit Inspection and Quarantine Bureau, Beijing Inland Port International Logistics Co., Ltd. and their Tianjin counterparts signing the "Beijing Chaoyang Port and Tianjin seaport straight-in Agreement", Beijing Chaoyang port has become the first authorized inland port to interact with non-local coastal port in Beijing and in China as well. The establishment of the direct linkage between Beijing Chaoyang port and Tianjin port has largely increase the throughput in Beijing Chaoyang port, in 2010 its throughput has exceeded 10,0000 TEU, and tariff collected by and for custom has surpassed 10 billion ranking highly among other customs throughout the nation. With the further economic integration in Jing-jin-ji[37] area, a wider radiating, deeper regional

[37] Jing-jin-ji includes Beijing, Tianjin, Tangshan, Shijiazhuang, Chengde, Baoding, Langfang, Zhangjiakou, Qinhuangdao, Cangzhou, Handan, Xingtai and Hengshui. Jing-jin-ji is located in Northeast of Bohai's heartland

cooperating external trade pattern is rising up. Later in March 2010, Beijing Pinggu international inland port, Beijing's second gateway formed to serve as a new platform for Tianjin port to achieve seamless cooperation between coastal port and inland port so as to promoting the export-oriented economic development in both Tianjin and Beijing.

3.2.2 Shijiazhuang

As the capital city of Hebei Province and adjacent to the port of Tianjin Port, Shijiazhuang has an early start in the construction and development of inland port with an undeniable advantage. October 2004, Tianjin and Port Office of Hebei Province, and other port-related authorities signed a "Memorandum of Cooperation between Tianjin and Hebei" with Shijiazhuang inland port being the main cooperation body.

December 2006, a Joint Venture Agreement on "inland port" was signed between Tianjin Port Group and Shijiazhuang inland port company to establish Hebei-Tianjin International Logistics Co., Ltd. to operate the inland port with joint hand. Shijiazhuang inland port was officially opened in April 2007, which marked the realization of a direct connection between Shijiazhuang and Tianjin Port, moreover, allowed Shijiazhuang becomes a "coastal city" in the true sense .

Shijiazhuang Inland Port[38] spreads out in an area of 255,241 square meters with an total constructed gross floor area of 21692.8 square meters and costs a total of RMB 268 million. Facilities include bonded warehouse(5513.6 square meters), CIQ (customs, inspection and quarantine) office building(9585 square meters), break-bulk/consolidation warehouse(4753 square meters), cargo distribution warehouse, container yard (CY), maintenance & repair workshop, dedicated rail platform and MIS. Its designed annual container throughput is 205,000 TEUs. Its

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where has the biggest and most dynamic economy in North China. So it is gaining more and more attention from home and aboard.

[38] SHIJIAZHUANG INLAND PORT.,LTD http://www.sipc.com.cn/

B-bonded logistic center(BLC) equipped with foreign processing zone which will include automotive parts and accessories, medicines, textile, garment, cereal, oil, construction material and etc., thus making Shijiazhuang inland port a function integration of port function, international container intermodal transport , transshipment and 3rd party logistics. Which plays an important role in improving the image of city, widening the potential development space, enhancing its international influence, stimulating the export-oriented economy as well as providing a better investment environment.

3.2.3 Henan

Henan Highway Port[39] was the first inland port in Henan province approved by Henan provincial government and also the main carrier for the cooperation between Tianjin port office and Henan port office. In 2006, a letter of intent on cooperation in Carriage of Goods by Road was signed between Tianjin port office and Henan port office followed by an joint venture agreement between Tianjin Port (Group) Co., Ltd. and Henan Highway Port(Group) Co., Ltd in order to enhance the cooperation in trade between Henan and Tianjin. Later in 2010, Henan inland port has accomplished the construction of Henan Highway Logistics Park, a Large modern logistics park which was complete in function, complete in facilities and a top level in service, whose functions included administrative operations, warehousing, transportation , storage, disassembly , distribution , packaging.

So far, about 330 million RMB investment has been made in Henan Highway Port, who now employing nearly 4,000 people, and has a standard Customs surveillance Warehouse of 4,200 square meters, a 22,000-square meter container yard, a dedicated office space for customs, inspection and quarantine institutions service of 500 square meters, 300,000-square meter warehouses, a 57690-square meter sorting and distribution center, last but not least, it also enjoys special railway lines covering 400

[39] Hennan Highway Port(Group) Co., Ltd http://www.hnhp.com/

meters, 1600 vehicles, 700 logistic operation stations with businesses stretching to Henan, Shanxi, Hubei, Shandong , Hebei, Shanghai, Shanxi, Anhui.

3.2.4 Baotou

In 2007, Baotou inland port, Tianjin port's first modern platform of logistics with the function of custom, port and cargo distribution in Northwest, was put into operation. The accomplishment and operation of Baotou inland port marks the seamless connection and mutual-extension between Baotou inland port and Tianjin port, more importantly, it provides Inner Mongolia Autonomous Region a "west access to the sea" which facilitates the local international trade with convenient custom and comprehensive logistic service, and to some extent, it has also create suitable conditions for Baotou to enter into Bohai-Rim Economic Circle as well as participating in economic globalization and regional economic integration. Since its establishment, Baotou inland port has scored remarkable achievements under the strong support from both sides: containers' volume and turnover has increased a lot inland port were playing an increasing important role in Logistics and foreign trade development in Baotou.

In 2008, Baotou inland port achieved 26,386 tons of total cargo volume, cargo turnover 368,825,211 tonne-kilometers, import and export value of $17 million and operating income of 36 million RMB. Tianjin municipal government has launched a forum on "focus on East port and seek win-win cooperation" at December 11, 2008, during the forum, Baotou International Container Transport Co., Ltd. signed an agreement for entry of inland port with Tianjin Port (Group) Co., Ltd., which marked a big step in the development of Baotou inland port.

A memorandum of cooperation on convenient customs system in 2009 in order to promote the further development of Baotou inland port, which involves export business processes, their own areas of responsibility, contingencyplans. Thanks to such memorandum, registration and application procedures for companies has been greatly saved with the information platform. Meanwhile, it helped the positive

interaction between Tianjin port and Baotou inland port so as to prosper logistics industry in Baotou; and it also does good to foreign trade enterprises in cost cut to enhance competitiveness in foreign trade.

July 2010 and March 2011 witnessed the optimization, reorganization and structural readjustment of Baotou inland port, which paved way for Baotou inland port's promising future. It is noticeable that in the first 7 months in 2011, Baotou inland port has achieved 172 million RMB turnover and total cargo volume of 873 thousand RMB, in which railway transport, land and air transport, land and sea transport accounted for 825thousand tons, 332 thousand tons and 873 thousand tons, respectively. And in order to accelerate the construction of Baotou inland port, Baotou government has made their decision to further expand investment, they plan to invest 1.2 billion RMB for the construction of Baotou International Inland Port Logistics Park, after the completion of which, it is estimated that the total cargo volume could be 4000 thousand tons and the operating income of land transportation, logistics services, related service industries and commodities interflow would reach 2.5 billion RMB.

3.2.5 Ningxia

The idea of building a inland port in Ningxia was first appeared during the consultation between Tianjing port office and Ningxia port office in 2004.Three years later, port office of Ningxia Autonomous Region invited Tianjin port office and Tianjin Port (Group) Co., Ltd. to demonstrating meeting concerning turning Huinong container logistics center into an open-up inland port. Ningxia Luhuinong inland port made its way into reality under the considerable assistance from Yinchuan customs and Ningxia inspection and quarantine administrations. The success establishment of the Ningxia Luhuinong inland port is also the momentous results of realizing the letter of intent on cooperation in inland port construction, Agreement on inter-regional cooperation, collaboration memorandum on facilitating Customs Clearance and etc., which enhanced the ports cooperation and promoted a

coordinated development of the regional economy.

Recently, Huinong inland port is one of Ningxia Hui Autonomous Region's three key construction ports, equipping with customs surveillance zone, container yard, special railway line, inspection and quarantine area, JIU office, living area, custom information system and etc.. Basically, this inland port area could be divided into 3 sectors: one is the railway line which accounted 160 thousand square meters; secondly, the area for container yard as well as dedicated platform for land and railway transport, which amounted 80 thousand square meters; thirdly, a 30-thousand square meter area for administration work. Under the help of railway and highway the inland port could find its way to the sea, so that through sea-train transport or sea-land transport, bulk of industrial products and raw materials could be sent to Brazil, India, Korea, Japan, the United States and other 30 countries and regions. In 2011, in order to further improve the port and logistics park infrastructure and functions, Ningxia Huinong inland port has launched project of inland port logistics park, integrated land logistics market. In addition, it has also formed a Customs surveillance auto fleet. As achieving the full realization of a typical inland custom clearance of "declaration in local area, examine and allow passage at port side", Ningxia Huinong inland port has communicated and promoted their success through the national inland port fair held by Tianjin. By the end of 2011, it has ranked 1 first among the 21 existing inland ports of Tianjin at that time and also the biggest one in terms of the land scale

Exchange

4. Research on correlation effects between inland and coastal port

4.1 Cooperation mechanism between inland port and coastal port

With the development of modern logistics, inland port has become one of the indispensable element in the big picture of logistic activities. At the macroscopic level, the efficiency of international logistic system is not only counted on the efficiency of individual inland ports, coastal port and related transportation channels,

but are largely depended on the cooperation mechanism between each dots such as inland ports and coastal posts. It is impossible to give the full play of inland port without a positive cooperation mechanism between inland ports and coastal ports. Therefore, it is needless to say the importance of analyzing the cooperation mechanism

4.1.1 Function harmonization

In international logistic system, the function of inland ports includes distribution, storage, transshipment, custom clearance, inspection and quarantine and etc., while the function of a coastal port tends to include storage, loading, discharging, physical entry and exit; needless to say the function of transportation channel is to provide a more facilitated passage between inland ports and coastal ports.[40] Only by achieving the harmony among those three can the logistic system as a whole or what we used to called logistics integration exert its full potential.

4.1.1.1 land-water transportation coordination

So called multimodal transportation coordination based upon seamless connection so as to avoid the inefficiency and less efficiency modal shifting, which has a direct connection to the efficiency of the whole logistic system.

4.1.1.2 logistics transitional function of inland port and coastal

The function of coastal port is extended to the inland port. The growing volume of international trade has casted a great pressure on the handling capacity of coastal port, under traditional way the coastal port needs to enlarge itself to meet the increasing need. But, unfortunately, as arised with the port' development, the port city is also growing stronger and stronger together with its industrial land price. Now that limited by the economic infeasibility, part of the container storage and other operation that once belonged to coastal port are now moved to inland port, which

[40] Cai Yufeng, Chen Ning. Synergistic development between dry ports and coastal ports. China Ports, 2009, NO.10: 26-31

means coastal ports could focus more on developing its core function, meanwhile, let inland port gets a share of the coastal ports' function. By such kind of mutual benefit, mutual complementarity and common development, coastal port and inland port will achieve a win-win strategy and not even mention the big progress it has made in the whole logistic system.

4.1.1.3 ports and transportation channel

Inland port plays a significant part in land transportation system in that convenient external passageways are needed, usually taking the form of a close linkage to the passageways. For instance, if a inland port locates at the gateway of a highway, trucks from the inland port can easily get access to the highway and reach the coastal port through highway. With regard to those middle range or distant inland port, since railway transport enjoys a remarkable cost advantage in long distant transportation, if possible a rail should be extended into the inland port or a exclusive station for container to be set up near the inland port to make it possible for containers to be transported to coastal port by railway, which enabled the cargo to be more cost competitive.

Most of the coastal port in China do not have a good connection with railway system, which makes it difficult for the function of container distribution to exert its potential. On the contrary, foreign countries has formed comparatively good land collection and distribution system in terms of easy accesses to road, inland water and railway system after years of development. Countries with a well-developed integrated transport system like America and Canada, they have their inland carriage done by railway, moreover, a lot of transportation system are centralized in coastal port, in which railway system also has a lion share. Tianjin port is one of the a few coastal ports who have a relatively close connection with railway system, up to 2011 Tianjin port has already set up 15 railway lines reaching to its hinterlands, which not that big as that overseas, but quite effective.

It is acknowledged to all that traders are getting more and more interested in transporting their cargo to coastal port by railway, because of its notable cost advantage. Thanks to Wei Y.P et al. who put forwarded the concept of "freight trains with five fixed terms"[41], in which he stated on the base of multimodal transportation we should actively carry out a train as well as ship(inland water way) schedule that has fixed stop, fixed route, fixed price, fixed departure and arrival time and of course with a fixed train or ship(each time), such kind of service will largely reduce the transportation for less-than-carload goods, reduce less efficient transportation and increase the reliability and punctuality at the same time. And it is important to mention that with the sea-rail combined transportation, inland-based companies could enjoy a one-stop service for custom clearance and booking at local place and direct send the cargo to the port without bothering coastal port custom again with the redundant paper work. Likewise, for import cargo, they can be transported straight to the inland destination with custom formality done by local custom once for all.

4.1.1.4 customs in coastal port and inland port

As be mentioned a little above, customs' role in international trade is doubtless of great importance, a certain time and money should and do consumed by its process. However, we should also admit that some of the work is more or less repetitive and even like a money or time drain. In the old days, China's bonded area can only be found in coastal areas, though some inland city did called for bonded logistic platform, while because of the huge distance between inland places and coastal area, customs inspection are highly likely to be out of line with frontier inspection, which at the end resulted in time and money consuming recheck process. The development of inland-based processing trade was disadvantaged by the lacking of favorable custom policy. It is quite comforting that China has already sensed such drawbacks, and are now actively promoting a so called Big Customs Clearance Policy, aiming to

[41] Wei Yongping, Ma Jianxiao. SWOT Analysis on Development of Anhydrous Port in China -Taking Henan Province as an Example. Transport Standardization, 2010, NO.11: 176-179

achieve “declaration in local area, examine and allow passage at port side”, which definitely required cooperation between inland ports and coastal ports. And in these years, port office in Tianjin has made a first try with port office in Shijiazhuang by signing the “Cooperation between inland ports and coastal port on convenient customs clearance MOU” on basis of crystal specifying each parts’ duty and rights.

4.1.2 Operation harmonization

Operation harmonization means to minimize the move between inland port and coastal port in order to save time and expense while still meet the time requirement of shippers. Like 5-fixed term train, if we adjust its schedule to synchronize with ships’, there will be no longer waiting time for cargo to be departure. Such seamless connection will largely shorten the transportation cycle and cut the logistics cost as well.

For most inland ports, they have their businesses in domestic logistics as well as international logistics, if we may properly coordinate these two, we may increase the whole operation efficiency and lower the cost at the same time. As be presented by a lot of scholars, empty container allocation is one of the main courses of the high operation cost in inland ports. In general, empty containers need to be transported from coastal port to inland port to accommodate the inland cargo for export purpose, which will inevitably cause fees for empty container allocation. Nevertheless, what will happen if there exists a mechanism that allows inland shippers to use the container which carried cargo from other other part of the country to inland port after them being discharged. I am fully convinced that to both shippers and inland ports this a future trends.

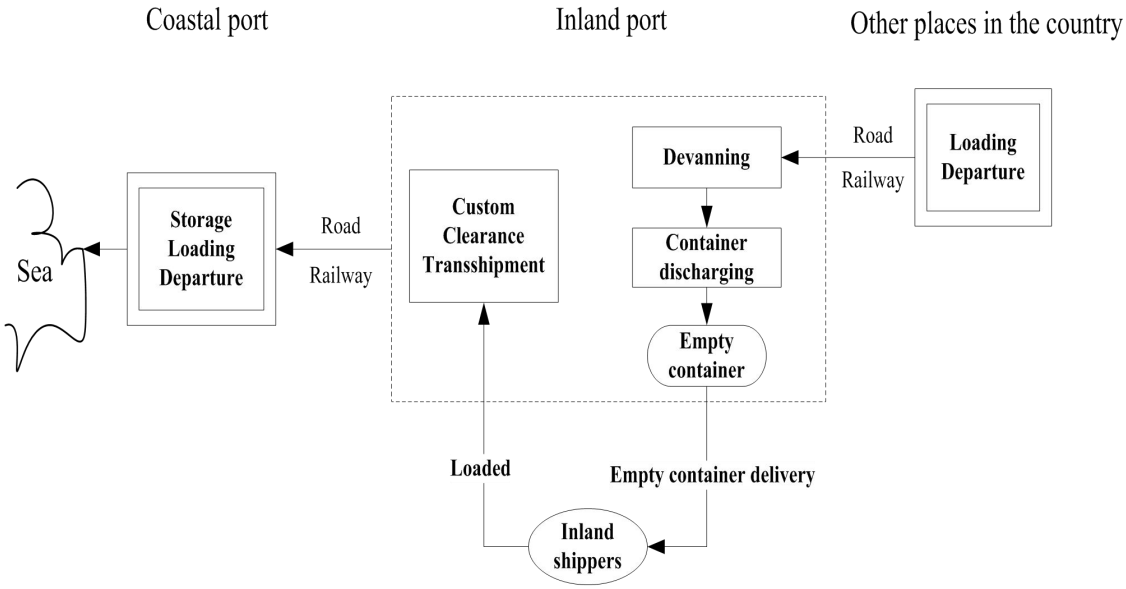

Figure 4.1 operation network

(Source: *Theory and practice for international inland port*[42])

4.1.3 Information harmonization

Frequent and sufficient information flow is the key to a achieve a positive interaction between inland ports and coastal port. A information exchange platform will suit this purpose well, as it can provide coastal port custom, inland port custom, quarantine office, freight forwarders, shippers, shipping companies, logistics providers, Commercial and Industrial departments, Tax Agency, banks, insurance companies and ect. with services as online customs clearance, inspection and quarantine declaration, export tax rebate, data exchange so as to integrate information flow, cargo flow and cash flow properly together and to further achieve inter-departmental, inter-industries inter-regional exchange and share of information as much as possible through information system.

Two custom offices with one at the inland port side, while the other in the coastal port side will result in a couple of overlapping field and some vague area. But if

[42] Dong Qianli. Logistics integration field: Theory and practice for international inland port. Beijing: Social Sciences Academic Press, 2012.11
董千里. 物流集成场: 国际陆港理论与实践. 北京:社会科学文献出版社, 2012.11

information could be shared to its full, shippers may be saved from endlessly going back and forth among coastal port, inland port and customs like a newsboy. As long as a information platform is established, local shipper could effect the shipment at coastal port by showing the -local custom-sealed B/L and do not need to pass the related documents to customs declaration agent, neither do customs declaration agent to do the check and release at coastal port. This information sharing platform has also be referred to "virtual inland port" by some scholars, they put forwarded the idea of integrating logistics with e-commerce so that coastal port could be closely linked with inland port. While although it is still a long way to go to actually form the whole system of "virtual inland port" which required great efforts from a lot of relevant government department, logistics providers and shippers as well, it is for sure the future direction we are pursuing towards.

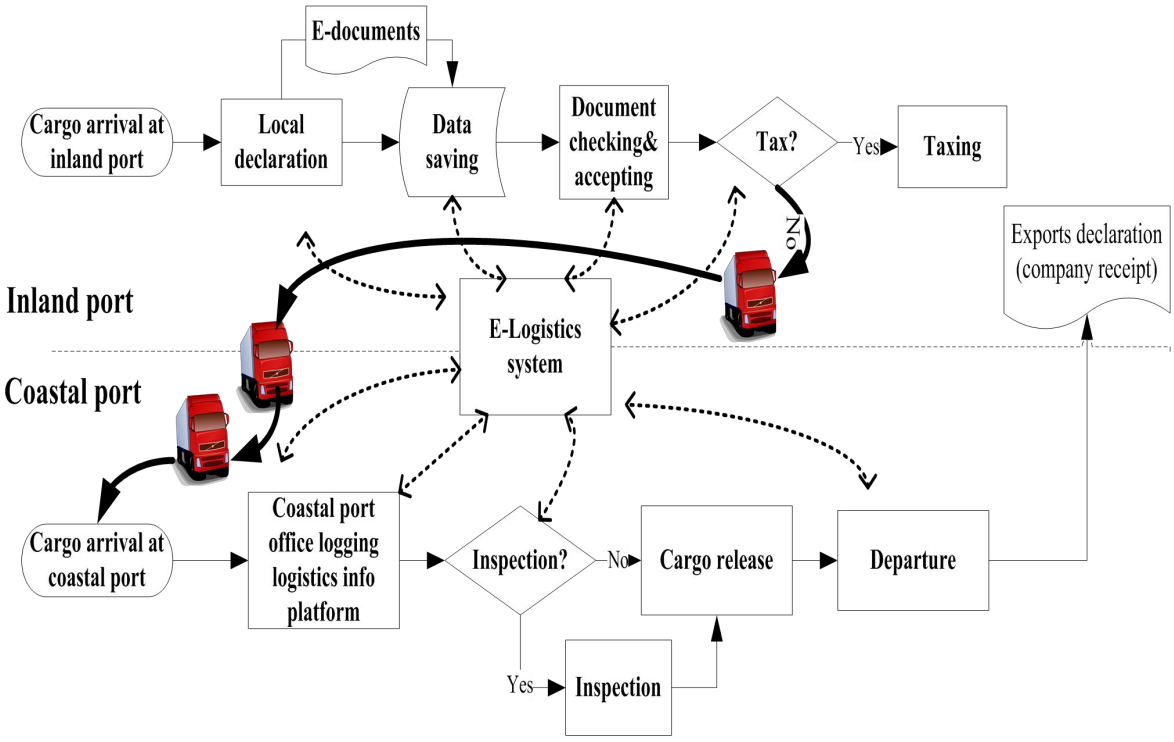

Figure 4.2 E-logistic operation

(Source: *Theory and practice for international inland port*[43])

[43] Dong Qianli. Logistics integration field: Theory and practice for international inland port. Beijing: Social Sciences Academic Press, 2012.11
董千里. 物流集成场: 国际陆港理论与实践. 北京:社会科学文献出版社, 2012.11

4.1.4 Resources sharing and technology upgrading

Inland port, logistics park and bonded port have made it possible for available resources that come from trade, logistics, port, manufacture to be fully integrated. As for different functional parties, they count on different resources. Processing technology, product technology as well as brand innovation depend on a cluster of manufacturers; while, international logistics and social material integration depend mainly on logistics integrator, custom, one-stop commodity inspection, bonded processing. And these functions can be realized simultaneously within one international inland port, because the strategies of each functional parties are in line with each other.

With regard to technology, which is the part involves high end trade facilitators, it mainly affects logistics integration system. For example, the development from "Internet" to "Internet of Things" has brought about a lot changes to logistic activities. To develop processing trade, inland ports should focus beyond pure manufacturing or assembling, they should actively try to occupy the high end in account settling and R&D so as to promote the structural transformation of processing trade.

Inland port may introduce 3rd party clearing center featuring network, off-shore finance and high added value. To simplify procedures, enhance efficiency and reduce cost, a clearing house located at place of 3rd party to deal with the settlement among brand merchants, OEM, parts suppliers and logistics providers and some other parties along the whole supply chain and obsolete the old clearing style of point-to-point settlement between only two parties at one time. As the raw material, parts and products sale all have something to do with duty free, the clearing house are usually established in somewhere with a ease financial policy. Furthermore, every ten billion USD in import and export can generate about 1% tax and every ten billion USD in the account could bring about 0.5% to 1% commission fees for banks.

As for R&D, which is the high level in whole supply chain, we shall admit that for the moment, processing enterprise tend to do the low-end like part assembling with low level of technique skill, low added value, while the core competitiveness still within the hand of foreign companies. With one end in foreign countries and one end in China, new demand for new technology, R&D should always be flexible in order to keep path with brand merchants, OEM, parts suppliers and to solve the problems arising in the process of technology sourcing and technology progress. And this will certainly pave the way for foreign R&D center to move to China, thus with the cluster of these high ended sectors, our processing trade could gently move itself toward high level, and more profit and added value will be sure to follow. And not to mention the possibility of spill-over effect that could enhance China's self-renovation capability.

Actually, the of Chongqing inland port can vividly display the above 2 points. In recent years, Chongqing inland port has formed a pc production scale of 40million sets and intended to expand it scale to 100million sets and become the biggest producer of pc in Asia. The success of processing trade in Chongqing is not based on low land price or tax free or high subsidy, but are grounded in its well connected and integrated processing resources, land resources, logistics resources and channel resources. Moreover, with the help of State administration of Exchange Control, Chongqing inland port has established new set of regulations through reform and innovation according to the particular need of processing trade. Accordingly, together with its big production scale of pc sets and top class financial ecology and business environment in China that Chongqing inland port then successfully convinced HP to move its clearing house from overseas to Chongqing.

4.2 Construction of correlation effects model

4.2.1 Introduction of the invisible gravitation

In the development of inland port, inland ports and coastal ports are always supporting each other and has formed a relationship of mutual attraction, extension

and radiation, which displayed by the logistics network with multipoint-to-multipoint connection between coastal port and its inland ports.

In order to analyze the correlation effect between coastal port and its inland port, it won't be possible if we view them as a single unit individually. In stead they should be analyzed under a more macro level, here we called it logistics integration field, where inland port system and coastal port system are viewed as two main integrators. In the same logistics integration field, it involves several integrators operating simultaneously, inevitably, two integrators are affecting each other in one way or another, so we called the interaction as attractive force or gravity force(in the following we called it attractive force) between 2 integrators.

The attractive force between two integrators are largely caused by each basic units owned by integrators, those mainly refer to 4 types, there are employee, material(facilities), information as well as energy, and they may also be divided into more detailed units.

4.2.2 Adaption of Gravity model

Gravity model derived from Newton's law of universal gravitation, that is any two bodies in the universe attract each other with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them. It has been long, since Newton's law of universal gravitation was first applied to other field of research especially in economic field. Nowadays, it is widely applied by scholars and practicer to study modern economics and management, as economy is so unique that requires us to adjust the formula which need a few variables to be redefined, and that also applies to our research.

Being the door of a country to the outside world, coastal port is quite essential to a country when speaking of international trade. It is estimated that about 80% of international trade was done through sea transportation, which indicates coastal ports plays the role of maintaining a rational connection with inland logistics to ensure the

continuity of foreign trade. The volume of cargo flow is the outcome of mutual-attraction between coastal port and inland port, or to be more specifically between coastal port and inland port including the city where the inland port locates. Inland port and coastal port then formed a logistics integration field with two integrators bonding by mutual-attraction, so according to Newton's law of universal gravitation, the correlation effects model should have the following two elements:

First of all, the quality of resources which can be displayed by the import and export volumes. As for inland port, we may use import and export volume in a certain amount of time of its city's(where the inland ports locates) to demonstrate the quality of its resources, since we are all convinced that a city with a big number of import and export volume is no doubt has a better cargo supply resource than the one with a small number of import and export volume, and the city with a better cargo supply is for sure to have a much stronger attraction to the coastal port. With regard to the resource quality of coastal port, we may also use the import and export volume in a certain amount of time of the port, still the say story, a bigger and busier port are more likely to attract the cargo flow form inland places.

Secondly, the distance between inland port and coastal port. As the matter of fact, one of the core concept of gravity model is distance-decay theory which states that the economic correlation effects between economic phenomenas at two locations decreases as the distance between them increases. Consequently, the attractive force between inland port and coastal also lies in the distance between them.

We use Rcp_i (i=1,2,3...) to demonstrate the total import and export cargo volume of coastal ports during a certain period, while Rip_j (j=1,2,3...) is the the total import and export cargo volume of inland ports during a certain period, Dij is the distance between coastal port i and inland port j. Then we are able to suite these variables into gravity model, in which attractive force A_{ij} (between coastal port i and inland port j) was demonstrated by the ratio of the product of total import and outport cargo

volume of coastal port and inland port to the square of the distance between coastal port i and inland port j, which expressed below:

$$A_{ij} = k_{ij} \cdot \frac{Rcp_i \cdot Rip_j}{D_{ij}^2} (i = 1,2,3\ldots\ldots n;\ j = 1,2,3\ldots\ldots m) \quad (4.1)$$

In which, the place where k_{ij} stands use to be the gravity constant G, but here in the attractive force model, we redefined it as an adjusted parameter named k_{ij} which reflects the correlation between coastal port and inland port caused by factors other than Rcp_i and Rip_j.

4.2.3 Introduction of k-gravity coefficient

As has mentioned above, k_{ij} is the adjusted parameter, or we may officially introduce it as the gravity coefficient which should be modified according to the propose of each model. a few scholar has once argued this k_{ij} should include coastal ports' throughput and the share of foreign trade import and export volume(in terms of money) that inland city has occupied in the figure of coastal port. Those two are fully understandable, as the throughput of a coastal port is definitely an important criterion in measuring the power of a coastal port, while the share of foreign trade import and export volume (in terms of money) can largely explains how important the cargo supply of a inland port is to a coastal port. So I totally agreed that those two should be taken into consider ration when calculating k_{ij}. But the question remains whether it is fairly enough to use only two factor to define k_{ij}, from my point view it is a little bit far fetched and not seemed quite persuasive. So, as far as I am concerned, it may be more proper if we can include more factors, such as regional GDP, regional GDP per capita, Primary Industry output, Secondary industry output, Total social investment in fixed assets, Total Retail Sales of Consumer Goods into the establishment of the gravity coefficient k.

So I decided to improve the gravity model by generating a more comprehensive gravity coefficient k with the help of taking more factors into consideration. The gravity coefficient can be interpreted into the the level of closeness between inland

ports and coastal ports in a complex way. When choosing the factors, I believed it is no need to reinvent wheel, therefore I did some research on the location problem of inland port as well as the study on the evaluating of the competitiveness of inland ports, where a lot of scholars have already make several criterion system for selecting a best location for inland port among a given number of candidates. It is quite enlightening to analyze the evaluating system made by these scholars, apart from the methodologies adopted by them, I rather interested in the basic criteria they had chosen or considered during the whole appraisal process. And I found there are mainly 2 parts to be considered when evaluating the possible connection and interaction between inland port and coastal port.

Firstly, the internal criteria, which includes the performance level of the inland port in terms of its software and hardware. This part is not difficult to understand, as the higher level the infrastructure is, the more chance of success the inland port has. Meanwhile, the service level of logistics providers are of the same significance or maybe even more important than the infrastructure. Lastly, the feedback from shippers. It is interesting to notice that in some paper, some scholars tend to add the administrative ability as one of the ways of evaluation, nevertheless, he then chose to use the "number of universities and colleges in local area", it seemed to me that such kind of figure is too blurry to show the administrative level, and my opinion goes along with other scholars such as Dong Xiaofei[44] et. Al. that administrative ability is more or less reflected by the service level, because the quality of the service is the outcome of its administration.

Secondly, the external criteria including local economic development, local infrastructure, environment of both natural and politic development level of the inland port. Inland port development largely relies on the economic development of the local area, because a solid economic foundation and a well developed infrastructure will no doubt facilitate the establishment and development of a inland

[44] Dong Xiaofei1,Wang Rongcheng1,Han Zenglin2. Study on the Correlation Spatial Evolution of Dalian Port-Liaoning Hinterland System. ,Areal Research and Development.2010.NO.06

port, and in turn a inland port could add the function of international port to the economic city where the inland port lies. The economic development is displayed in the industrial structure as well as logistics need, so whether the inland port can meet the need of industrial structure, product structure. With regard to the political and natural settings, we know that in China, where the government still has a strong voice over the economy life in many ways, whether a policy is supportive or not means life-and-death to a inland port. In addition, those highways and railways spreading like veins throughout the city plays a decisive role in building a positive relationship with a coastal port. A well developed transportation system could ensure a quick delivery with punctuality, reliability, which will no doubt increase the satisfaction of the shipper and in turn gain a closer relationship with coastal port.

Based upon the above mentioning two part, I am able to make the following table:

Table 4.1 Internal and external index of inland port

Level-1	Level-2	Level-3	Index wanted
Internal	Logistic development	Service level of logistics provider	Increased value in transportation industry
	Work efficiency	Satisfaction of clients	Increased value in tertiary industry
	Infrastructure of inland port	Equipment	Total social investment in fixed assets
External	Local economic development	GDP	GDP
		Industrialization level	Total industrial output
		Export	Total volume of imports and exports
	Transportation infrastructure	Railway	Number of railways connected to the coastal port
		Road	Number of highways connected to the coastal port
		Transportation volume	Total volume of cargo
	Laws and policies	Local policy	Number of promotion policies
	land	Price per square	Land price for commercial use

After digging the index according to the previous table, I have encountered a few difficulties as the released information is not sufficient and and some of them are even untraceable. So subject to the real problem that we have confronted, I at end decide to adopt a new criteria system which is based upon the former one but with some adjustments through thorough consideration after resorting to some related papers[45].

Table 4.2 Index selected for model building

Criteria system	Variables	Index available	Criteria system	Variables	Index available
Tianjin Port	X1	Cargo throughput (*10000Tons)	Inland of Tianjin Port	X3	Regional GDP (*1000RMB)
				X4	Regional GDP per capita RMB)
				X5	Primary Industry (*100 million)
				X6	Secondary industry (*100 million)
				X7	Tertiary Industry (*100 million)
				X8	Total Retail Sales of Consumer Good (*10000RMB)
	X2	Container throughput (*10000TEU)		X9	Total volume of cargo (*10000Tons)

[45] Zhang Lianjuan, Zong Peihua. Research on index system of ports' overall competitiveness, Comprehensive Transportation. 2004(6): 42-45.(张联军，宗蓓华.港口综合竞争力评价指标体系研究[J].综合运输，2004（6）：42-45.); Kuang Haibo,Chen Shuwen. The Research on Port Overall Competitiveness Model, Science of Science and Management of S.& T., 2007(10): 157-162.(匡海波，陈树文. 基于熵权 TOPSIS 的港口综合竞争力评价)

				X10	Total social investment in fixed assets (*10000RMB)
				X11	Export (*10000USD)
				X12	Import (*10000USD)
				X13	Highway mileage (km)
				X14	Length of Railways in Operation (km)

4.2.4 Quantify k-gravity coefficient by Grey correlation theory

In order to melt those factors into gravity coefficient k, I resorted to Grey correlation theory. The theory of can help us deals with those factors which are incompletely independent and even with some of them interwinding with each other somehow. By applying the method of Grey correlation, we now are able to get the k-gravity coefficient quantified. (For the calculation detail please see appendix.)

In this paper I mainly use the method of mean associative degree, and all the data used are directly collated from Statistical Yearbook of China(2005-2011) and website of Ministry of Transport of the People's Republic of China and some of the data are derived from the processing of other data.

According to the criteria system in 4.2.3, we now reach the different k for different inland ports of Tianjin port. As 2011 is the latest data among which we are able to lay our hands on, we then choose it to be the benchmark for our research.

Table 4.3 k-gravity coefficient of year 2011(Source: research calculation)

Inland port	k_{2011}
Inner Mongolia-Baotou City	0.689211442

Henan-Zhengzhou City	0.849604651
Hebei-Shijiazhuang	0.59694397
Beijing	0.7568642
Ningxia-Shizuishan City	0.640662039

As a result, here we can get the 5 formulas derived from the gravity model we introduced before.

Table 4.4 Models of each inland ports in 2011(Source: research calculation)

Inland port	k_{2011}	Model
Inner Mongolia-Baotou City	0.699238943	$A = 0.6992 \cdot \frac{Rcp \cdot Rip}{D^2}$
Henan-Zhengzhou City	0.84550641	$A = 0.8455 \cdot \frac{Rcp \cdot Rip}{D^2}$
Beijing	0.760993506	$A = 0.7610 \cdot \frac{Rcp \cdot Rip}{D^2}$
Hebei-Shijiazhuang	0.609943584	$A = 0.6099 \cdot \frac{Rcp \cdot Rip}{D^2}$
Ningxia-Shizuishan City	0.653942204	$A = 0.6540 \cdot \frac{Rcp \cdot Rip}{D^2}$

5. Model application to Tianjin port and its 5 inland ports

5.1 Model application

Since we have already form the 5 formulas for the evaluation of the correlation between inland port and its coastal port, we can enter into the calculation phase.

Table 5.1 Data for model application(Source: Year book of China in 2011 and Google map)

Year: 2011	Total imports and exports of inland ports (*10000USD)	Distance between inland city and Tianjin (Drive:km)	Distance between inland city and Tianjin (Straight-line:km)
Inner Mongolia-Baotou City	1194374.8	807	654

Henan-Zhengzhou City	3264212.4	733.5	577
Beijing	5360358.3	144	114
Hebei-Shijiazhuang	38949480	334.7	267
Ningxia-Shizuishan City	228574.5	1256.5	935
Inland port	**R_{ip}**	**D_1**	**D_2**

And according to the Tianjin statistical yearbook, the total imports and exports of Tianjin port in 2011 is 197249millionUSD, to make it comparable to the above mentioned, that is 197249000(*10000USD).

Table 5.2 Data for model application(Source: research calculation)

Year: 2011	R_{ip}	R_{cp}	D_1	D_2	Attractive force-D_1	Attractive force-D_2
Inner Mongolia-Baotou City	1194374.8	197249000	807	654	252949590.21	385146142.9
Henan-Zhengzhou City	3264212.4	197249000	733.5	577	1011835444.12	1635153388
Beijing	38949480	197249000	144	114	281950221825.09	619127191422
Hebei-Shijiazhuang	5360358.3	197249000	334.7	267	5756875969.53	657330249944
Ningxia-Shizuishan City	228574.5	197249000	1256.5	935	18674843.44	33725526.14

By applying (4.1) we finally get the Attractive force: A-D1 and A-D2, in terms of different distance used respectively.

Table 5.3 Result of model application(Source: research calculation)

Year: 2011	Attractive force-D_1	Attractive force-D_2
Inner Mongolia-Baotou City	252949590.21	385146142.94
Henan-Zhengzhou City	1011835444.12	1635153387.88

Beijing	281950221825.09	449870714047.78
Hebei-Shijiazhuang	5756875969.53	9046399749.32
Ningxia-Shizuishan City	18674843.44	33725526.14

With the help of the figure 5.1, it is easy to tell the regardless of using D_1(drive) or D_2(straightaway distance),which is also true for the whole trend from2005-2011, they share the same trend indicating that we shall use either of the two distance without harming the ranking result of our calculated attractive force. Therefore, to be more practical, we here choose to wash out the straightaway distance as this may not suit the reality of different landscape.

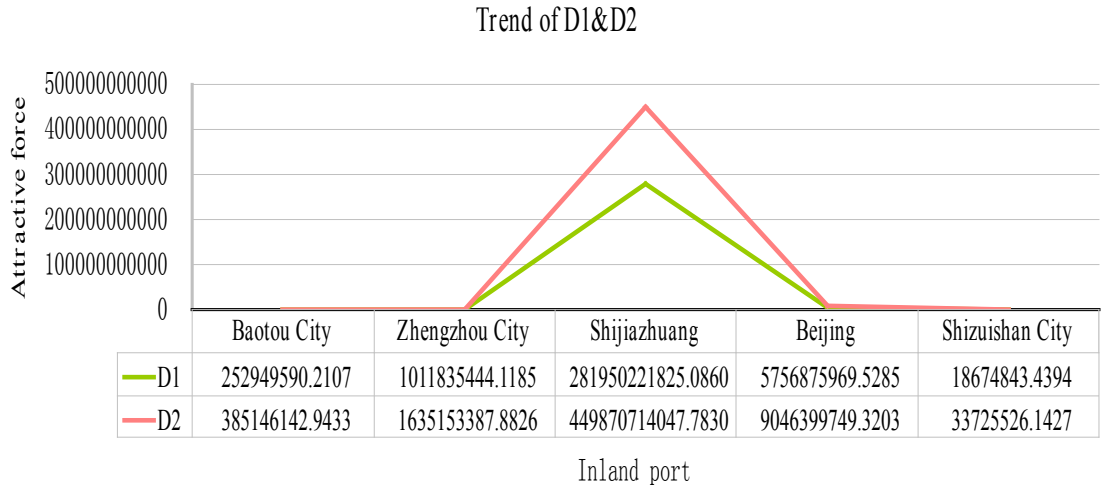

Figure 5.1 Trend of attractive force with regard to D_1 and D_2

(Source: research calculation)

Table 5.4 Ranking of the attractive force in 2011(Source: research calculation)

Rank	Year: 2011	Attractive force
1	**Beijing**	281950221825.0860
2	**Hebei-Shijiazhuang**	5756875969.5285
3	**Henan-Zhengzhou City**	1011835444.1185
4	**Inner Mongolia-Baotou City**	252949590.2107
5	**Ningxia-Shizuishan City**	18674843.4394

5.2 Result analysis

5.2.1 Correlation between Tianjin port and its inland ports

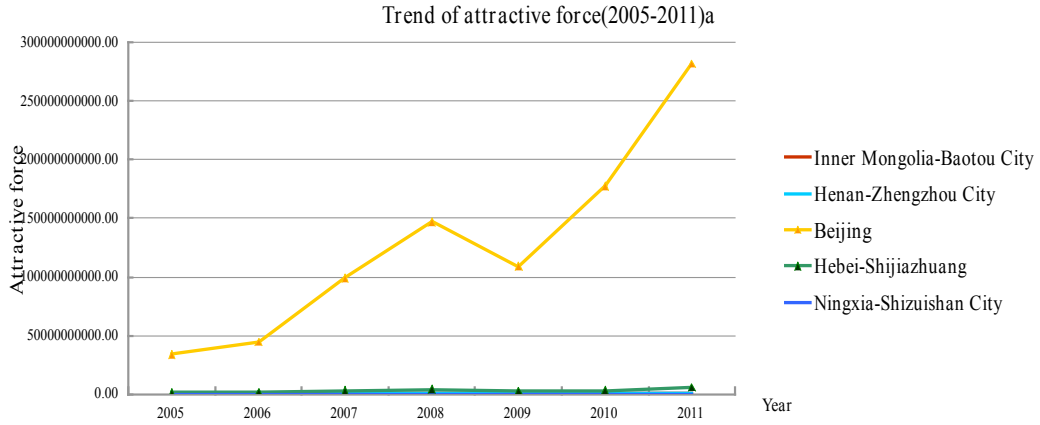

Figure 5.2 Trend for attractive force(2005-2011)a

(Source: research calculation)

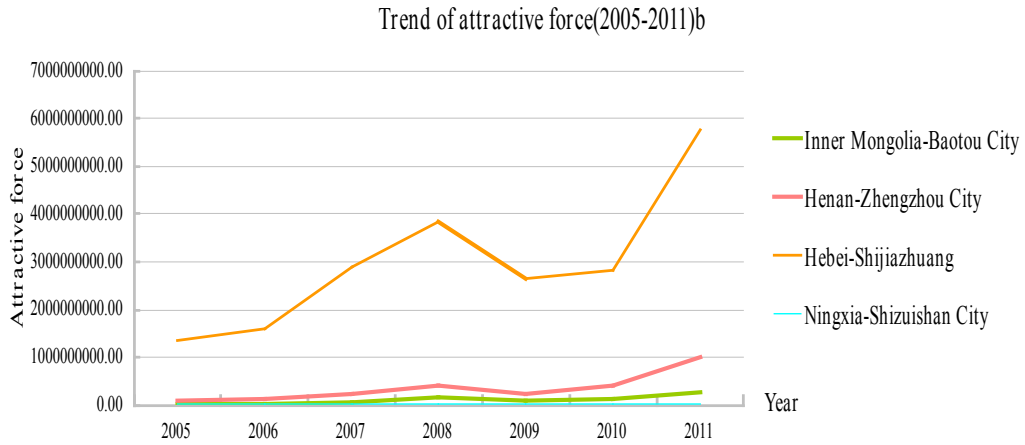

Figure 5.3 Trend for attractive force(2005-2011)b

(Source: research calculation)

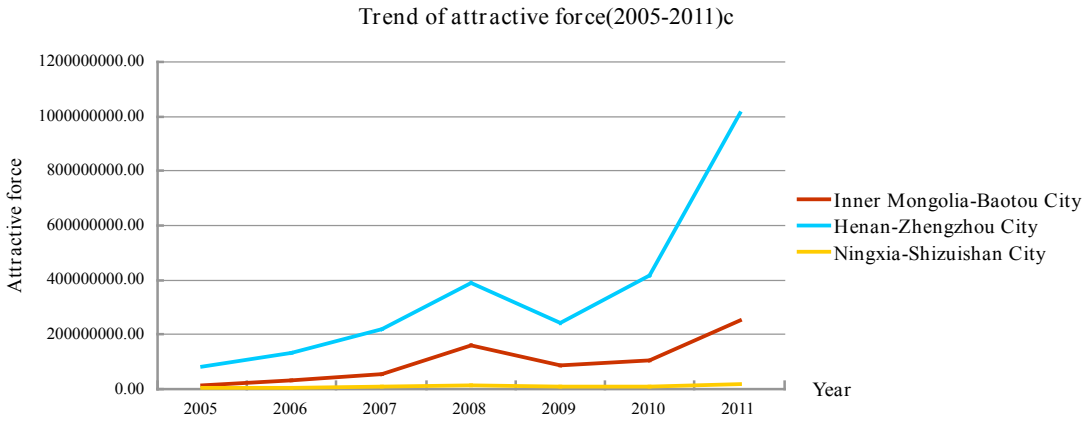

Figure 5.4 Trend for attractive force(2005-2011)c

(Source: research calculation)

In light of the result we have generated, we can see that the 5 inland ports are somehow sharing the similar trend of development, a booming time since 2005 until the figure summited during the period before global economic crisis which happens in 2008. And those figures plummeted from the crisis followed by about 1.5 year clumsy creeping, thereafter, it seems that the trend begin to pick up eventually.

However, with the trends alone can not tell the story, especially, when we look at Ningxia-Shizuishan city, it almost stretches out like a flat line in terms of its development trend, which, at first glance, will be easily regarded as the least vigorous. Together with the growth rate, that what makes us capable to tell what is really behind them. We can probably categorize them into 2 groups as according to the average annual growth rate of their attractive force. The first group is made up by the trend of Inner Mongolia-Baotou City and Henan-Zhengzhou city, because of their comparatively high growth rate(average annual growth rate is no less than 0.5), while, those in the other group are much more lackluster in development(average annual growth rate is lower than 0.5). So, at this moment, if we again look into the figure of Ningxia-Shizuishan city, we will surprisingly find that it is not as morose as we thought before, the real growth of it has been unveiled by the average annual growth rate only under which can we make the trends comparable to each other, we will

know that although in figure 5.3 the condition of Ningxia-Shizuishan city is almost a even line comparing to the trend of Hebei-Shijiazhuang, they now have been moved to the same group as they actually have the equal pace in growth.

Table 5.5 annual growth rate of attractive force in each inland ports(Source: research calculation)

Annual growth rate	2006	2007	2008	2009	2010	2011	Average annual growth rate	Average annual growth rate(with out crisis)
Inner Mongolia-Baotou City	1.0605	0.6895	1.9011	-0.4552	0.2248	1.3646	0.7976	1.0481
Henan-Zhengzhou City	0.6390	0.6810	0.7630	-0.3789	0.7108	1.4383	0.6422	0.8464
Beijing	0.3171	1.2290	0.4855	-0.2590	0.6304	0.5853	0.4980	0.6495
Hebei-Shijiazhuang	0.1859	0.8113	0.3320	-0.3107	0.0608	1.0404	0.3533	0.4861
Ningxia-Shizuishan City	-0.022	0.6988	0.4768	-0.5009	0.3322	0.8203	0.3009	0.4612

5.2.1.1 Group1: Inner Mongolia-Baotou City; Henan-Zhengzhou City Inner Mongolia-Baotou City

Being the primary port of Inner Mongolia, Tianjin has handled 70% of the total imports and exports of the autonomous region every year, Baotou and the cities around it in particular have more than 90% of their import and export cargo taken care via Tianjin port. Before Baotou inland port was built, all the cargo owners have to go all the way to Tianjin to have transit and customs clearance done which has consumed tremendous human and other resources, worse still it has delayed the time for cargo to enter into the market and increased logistic cost. Nevertheless, since the foundation of Baotou inland port, local companies could easily find their way to deal with the custom related procedures and their goods can be loaded onto the ship directly as soon as they get Tianjin port so as to reduce the overall logistics time and increase the business efficiency. According to the statistics from Tianjin port, the operating time of its inland port in West China has been reduced by 3 to 5 days, the overall cost for logistics cut by more than 20%.

From the result that we have generated before, the stunning annual growth rate in the attractive force between Tianjin port and Baotou inland port is not without rhyme or reason, the answer is deeply rooted in the inherent situation of Inner Mongolia. It is because Inner Mongolia is located in the West part of China where there is a huge distance away from the costal area and hard to carry out import and export activities, thus it is not a convenient place in the interest of the companies. 2007 and the years after that have witnessed tremendous changes in Baotou and Inner Mongolia as well, take the very next year as an example, the amount of actual utilized foreign investment in 2008 was 820 million USD, up by 31.5% year on year, the amount of attracted investments from other countries that year was 30.3 billion USD, up by 7.4%. Judge from the whole region, the local government have approved 125 new foreign-funded enterprises with a commitment of 2.984 billion being realized, and thereafter the annual growth rate in foreign investment has steadily expanded by around 20% each year. We may reach to the concept that the inland port has indeed provided Inner Mongolia with a gateway toward the outside world and more comprehensive and complete logistics service, which has largely facilitated the growth of out-bound enterprises as well as the development under the opening-up policy. Ever since the establishment of "gateway" to the international world, foreign investors began to lay their foot on Inner Mongolia and mushroomed all over the area. Moreover, as we all know, high growth rate are often see in the developing area because there is plenty of untapped potential to develop, I believe this also helps to answer why the growth rate in the recent decades are so dramatically among its peers, and we can also foresee the future of Baotou inland port that it will still grow stronger, while with the a gradually slowing-down pace.

Still, we shall notice that the highest average annual growth rate in attractive force that Inner Mongolia now sitting on should give most its credit to the first 2 to 3 years' rocking development in economy. Being one of the places that richest in natural resources, Inner Mongolia benefited from the nation's general environment of developing the economy where give the chance for those places who are rich in

resource to make a fortune out of their resources. Consequently, Inner Mongolia turned its rich natural resources into actual economic advantages. Resources related output has taken a lion share in Inner Mongolia's GDP, which is especially true in Baotou where heavy industry was so booming all the time. And, without doubt, places like Baotou is always the one to lead the economic growth in Inner Mongolia and have driven the economy doubled several times in the last decade. Nonetheless, such kind of growth is not sustainable that is why the years follow had witnessed a slowly decrease in economic progress, and we can reaffirm our former assumption that the if we recalculate the attractive force between Inner Mongolia and Tianjin port a few years later, the out come could be quite different from what we are seeing now and Inner Mongolia is sure to phase out from the top of the list. Because, there is a sign that the local government is trying to turn Inner Mongolia a place relying mainly on exporting primary resource-oriented products into exporting further processed products, it is not the way forward by solely exploiting the natural resources after all.

Henan-Zhengzhou City

With regard to the performance of Zhengzhou inland port in Henan province, we won't find its unexpected because of the unique geographic location of Zhengzhou. And actually at the very beginning and even earlier than Zhengzhou inland port was built, experts and scholars has already estimated the possible out come if an inland port is built. History tells us 1/3 of Henan province's total cargo volume and 35% of total container volume were handled through Tianjin port, which accounted 10% of the entire handling capacity in Tianjin port. Henan,situated in the center of China's railway network, is the place where "3 vertical and 5 horizontal lines" meet with a longest mileage among any other places in China. Henan alone has seen itself undergone profound changes these years with the help of government's support in building Henan into a export-oriented economy which is strong in economic power and industry as well. Henan's GDP has ranked 5th in the last decade preceded only by Guangdong, Shandong, Jiangsu and Zhejiang province, and its GDP per capita also

approaching to China's top 10, and all these have made Henan a emerging economy. It is 2007 the turning point of Henan's industrial development trend, at this particular year the profit generated by industrial enterprises in Henan exceeded that of Zhejiang and became the fouth biggest in China as well as one of the top level in terms of its overall industrial strength.

The '*Restructuring and revitalization plan of logistics industry'* extended by State Council in 2009 has given an impetus to the logistic development in Henan province by specifying on building Zhengzhou into a key nodes in the map of national logistic network and on developing the North and South logistics channel spinning around Zhengzhou and Wuhan in the middle part of China. What's more, provincial Party Committees and provincial government of Hunan in particular have attached great importance to the development of modern logistics, and they have listed the project of Zhengzhou inland port into the local 'the eleventh five-years' plan'. It is recognized that Chinese government really plays a crucial rule from a macroscopic view, which shows a brilliant part of typical Chinese characteristic style of development that at the word of the central government all people relevant would spare no efforts on the project concerned.

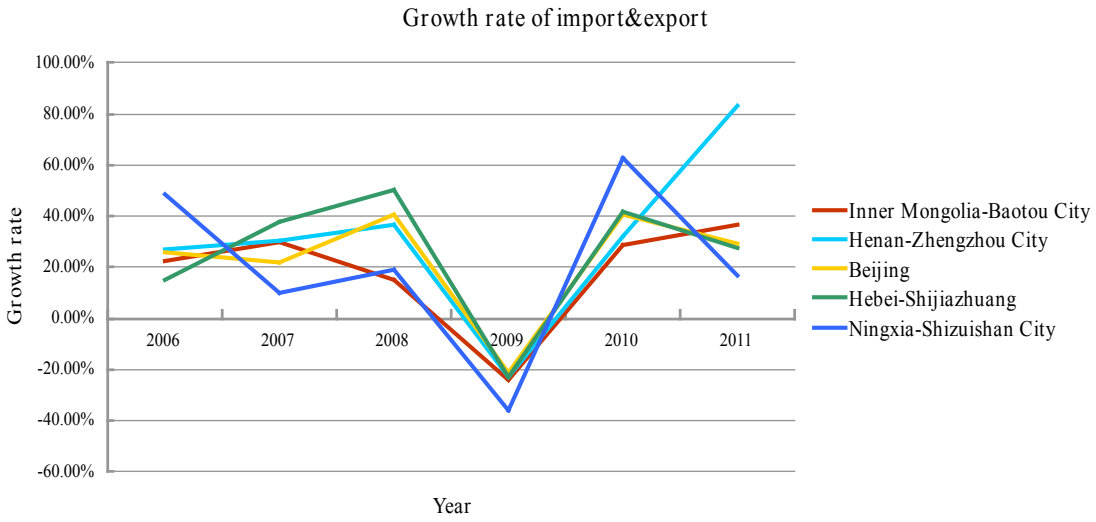

Figure 5.5 Growth rate of import and export

(Source: research calculation)

It is worth mentioning that both two cities share one thing in common that is the growth rate of their import and exports has sustained the up growing trend. As can be deduced from our attractive force model that the larger the trade volume the bigger the attractive force will be. And the reason for the growth in Inner Mongolia can be explained in the following aspects:

Despite the heavy strike on the exports of Cashmere textile, iron and steel, metallurgy, freight vehicles, chemicals and grain, however, pharmaceutical industry and textile and cloth, agricultural products processing industry had not been affected much and the processing industry even witnessed a rapid growth in spite of global recession. From the research, we found that pharmaceutical companies are technique intensive with a high product added value, which enjoyed a great demand from overseas. Therefore, these companies hold a relatively stable source of foreign customers, which helps the local economy overcome part of the overall financial turmoil.

If we look at the import of Inner Mongolia, we can find the top 10 categories of imports: machine tool, electronic appliance, coal, timber, to name just a few, they have sustained a upward trend. Iron, copper concentrates and some mineral sand are indispensable and scarce for China's ever-increasing crave for development, with the pricing lowered because of the crisis, domestic manufacture and traders tended to seize the chance and purchase huge amount. Although the crisis has after all shrunk the domestic needs, under the help of Chinese revival plan in steel industry together with a 4-trillion domestic investment as an incentive to spur the domestic demand, Chinese steel industry was doing better and better, consequently the import of these material are on the increase. While, there are also are some increase in exports which was not expected by domestic companies, for instance, timbers that are usually regarded as bulk commodity import from Russia, but since 2007 Russian government has increased its export tariff by 10% (no less than 6 Euro per cubic meter) and they are going to raise it up by 30% year upon year from that year after. These soaring tariff has direct link to the increasing import price of the total timber import.

5.2.1.2 Group2: Beijing; Hebei-Shijiazhuang; Ningxia-Shizuishan City

1. Beijing

If we just focus on the latest data available(here, data in2011), we now get the ranking of the 5 selected inland ports in respect of their attractive force between themselves and the common coastal port—Tianjin port. It is of overwhelming superiority that Beijing has enjoyed over the other 4. However, it won't be a surprise for us, since we are already aware of its being the first inland port of Tianjin port, it is doubtless that "practice makes perfect", Beijing, through its arduous effort, has established a sound correlation effect between itself and Tianjin port. While, if we go deeper into the overwhelming figure it has, we will notice that it is the big number in total import and exports, that is, large amount of hinterland supply, which made the Attractive force for Beijing so "terrifying". And there's another part that we dare not to miss—due to its huge territory, Beijing boasts 2 inland ports so far, one is the very first Chaoyang inland port and the other is called Pinggu inland port. Consequently, as I am collecting the data, inevitably, the contributions of both inland ports are to be counted in. It sounds a little bit like "cheating" on the other four single inland port, but it is the reality, and the rocketing speed of the two are proved indisputably according to the official statistics recently, which is, in 2013 the two inland ports has handled more than 147000TEU, up by 84.2% year on year and the growth rate has gain the momentum since the new one was gradually opened.

Also, begin with a comparatively big attractive force, Beijing's inland port interaction has always been quite eye-catching judged by its appearance, while we shall notice that Beijing is only the third of the list with regard to the annual growth rate in attractive force among the others, moreover, after the financial crisis, Beijing was the only one in 5 inland ports that has a decreased growth rate in attractive force compared with last year, which arouse the question of why does this happened. The reason behind the relatively sluggish growth is contributable to several reasons. First and the easiest to be deducted is that the effect of the big denominator which will definitely shrink the growth rate when compared to the absolute amount of growth.

Secondly, as we are busy appreciating the numbers grow in cargo handling capacity in Beijing thanks to establishment of the Pinggu inland port, we shall always be aware of the side effect that might come after, for example, the k-gravity coefficient of Beijing inland port are the reflection of the two interwinding inland ports to some extend, and we can tell from the statistics that the k-gravity was slowing down after the introduction of the new one in 2010, which indicates that more inland port in the same place maybe not suit the principle of "one plus one equals two" but less than "two". Because of a certain degree of interference of the two inland ports within one city, and it is just like gradually declining law of marginal effect that we have always heard about in economics class. Thirdly, a relatively well-developed economy as Beijing is, Beijing participated much more in the world economy than those others, accordingly Beijing is more vulnerable against global financial crisis for its big exposure. Beijing is going to need more time to pull itself together, and the longer duration it needed to absorb the turmoil may well explain why the growth rate did not pick up.

2. Hebei-Shijiazhuang

Hebei Shijiazhuang has undergone tremendous development since its initial operation, from 7000 TEU at the beginning to more than 40000 TEU just after several years in 2011, which is about 5 times growth. Inland logistic service have expanded its coverage from Zhijiazhuang to Baoding, Xingtai, Handan, Cangzhou, Hengshui and other regions with Henan province, which has no doubt given a full play to inland port's role of improving the function of regional central cities, and develop the area surround, and also widen the gateway for exports from Henan, by doing which effectively drive the growth of container turnover in Tianjin port. So as in quantity, Hebei Shijiazhuang inland port's attractive force to Tianjin port is second only to Beijing, because the data we used inevitably involves Hebei province as a whole, which means those later comers such as Baoding, Xingtai they had contributed a lot TEU. And since its opening, Zhijiazhuang inland port has extended cooperation with a lot of mainstream shipping companies such as Maersk， COSCO

and China Shipping, and those large international freight forwarder and logistics companies as well as a number of Custom brokers have sprung up in inland port. Meanwhile, a joint venture called Ji-jin(stands for Hebei and Tianjin respectively) international logistic co. Ltd. was created by Shijiazhuang inland port and Tianjin port, which has signed memorandum on Big Customs Clearance Policy in North China, moreover, a online information platform was put into use according to quartet agreement signed with North China Pharmaceutical which has largely facilitated smooth running of the inland port. It won't be surprise to see the big number of the attractive force that Hebei inland port has boasted these years.

However, as for the annual growth rate, again, the same thing that happened to Beijing inland port applies to Hebei Shijiazhuang—it drop from second to almost the bottom of the list and the result is almost identical even if we phase out the influence casted by the financial crisis. So it could be attributed to its big denominator which makes the annual growth rate "smaller", while I also believe there are other reasons.

According to Statistical Yearbook of China, the added value of financial sector in Hebei province in 2011 has increased to 74601 million Yuan from 20910 million Yuan in 2004, averaged at 19.93% on yearly basis. Rapid growth in the development of local financial sector and it has served well in supporting industrial structure adjustment, but, by no means can it be in anywhere close to places like Shanghai or Guangdong in terms of overall competitiveness of financial sector, the contribution that local financial sector has made was far from enough, especially when we are talking about developing the inland port. Actually, the crave for financial support is becoming more and more prominent. As far as we know now, there are only 7 National Commercial Bank, 11 Urban Commercial Banks, 1 trust company, 1 financial leasing companies and 4 finance houses, and there's no financial institutions that has set up branches or sectors specialized in dealing with dry port construction, financial institutions expert in inland port is still a blank field. And then the lack of financial support to Hebei's expanding plan in inland port, which lead a low rate of development speed.

3. Ningxia-Shizuishan City

As can be seen from the table5.5, Ningxia Shizuishan inland port seemed to be quite sluggish with respect of its growth rate of attractive force. But after deducting the year of the financial crisis, the difference between Ningxia Shizuishan inland port does not appeared to as laggingbehind as before. Of course, we can ignore several data which generated by us, especially the overwhelming k-gravity coefficient of Ningxia Shizuishan as well as Shijiazhuang in the first year in the research period, as officially the bond between Shizuishan was established during 2006 to 2007. As a result, the data after the first year could be of more value for reference.

It is understandable that Beijing as a metropolitan exposed itself more to the world economy, but Ningxia as an typical inland province has suffered so much due to the global financial crisis is not making much sense at the first thought. Nonetheless, we find some thing that might help us explain a part of the question. First of all, in 2011, we can see from the energy consumption for unit GDP production for Ningxia was 22.79 tons of standard coal per thousand RMB listing at the top among any other provinces in China and 2.87 times of the average national level or 3.97 times of that of Beijing. Industry in Ningxia are mainly high energy-consuming products, high-energy consuming industry has taken up about 55% of the total industry which has a strong link with coal and electronic industry. Thus, when there is a financial shock, the strong link between them will worse the shock which will definitely hurt the economic growth. Secondly, concentration degree of manufacture industry is comparatively low in Ningxia. The companies are big in number but small in scale, that's why economies of scale is strangled. Scattered small businesses is risk vulnerable for their relatively low accuracy in predicting the varying industry. Thirdly, the economy in Ningxia is mainly driven by the resources it has and it is also resource export-oriented. Those leading products like coal, coke, electricity and metallurgy, they are at the upstream of industry chain and the downstream of the value chain where foreign market take the initiative. As a result, it will be affect more

the external environment, which is the global economic climate. The financial crisis make Ningxia this time cornered for sure.

5.2.2 Critical findings in factors that affecting the correlation between Tianjin port and its inland ports

From table5.5, we can see the k-gravity coefficient for 5 inland ports share some thing in common, that is their k-gravity coefficient goes up at the first and phase and then undergone a period of slow-down or even negative growth, this is mainly because that after year of 2005, or maybe even earlier, due to the increasing competition among coastal ports, a great number of coastal ports began to offer preferential policies or incentives in order to attract more cargo supply. Furthermore, with the gradually improving transportation system in all dimension, it has become much more flexible for most of the inland ports to choose, which as a matter of fact has lead to the diversification of cargo supply flow. Take Beijing, Ningxia and Shijiazhuang as examples, we can find the k-gravity coefficient has been in a upward trend followed by an abatement after early 2007.

During 2005 to 2011, we can tell that the k-gravity of them are around 0.6 to 0.8, which indicates a relatively high correlation, this is expected at the first place because these 5 inland ports were chosen deliberately out of all the 23 inland ports that initiated by Tianjin port. Thus, we may say the attractive force of the 5 inland ports are advancing on a sound basis, even undergone the least prosperous time, the growth rate of attractive forces after are sustained somewhere close to 30%.

5.2.2.1 Ladder effect (radiant effect)in the distribution of attractive force

If we reconsider the result we generated before under the help of a map of Bohai bay area, we are able to find something interesting, that is, the distribution of each inland port's attractive force is closely linked to their geographic location. There is an gradient effect hidden behind what we have found, what has been displayed in figure5.7 should be much more clear for us to identify gradient effect, and that is exactly accords with the theories of regional economic development, which is to say

the as coastal port being the original flame and triggered the flare along the fuse from the near to the distant, this is not only applied to the attractive force but also could be used to explain some part of the changes in k-gravity coefficient.

Figure 5.6 overlook the link between 5 inland ports and Tianjin port

(Source: http://map.baidu.com/)

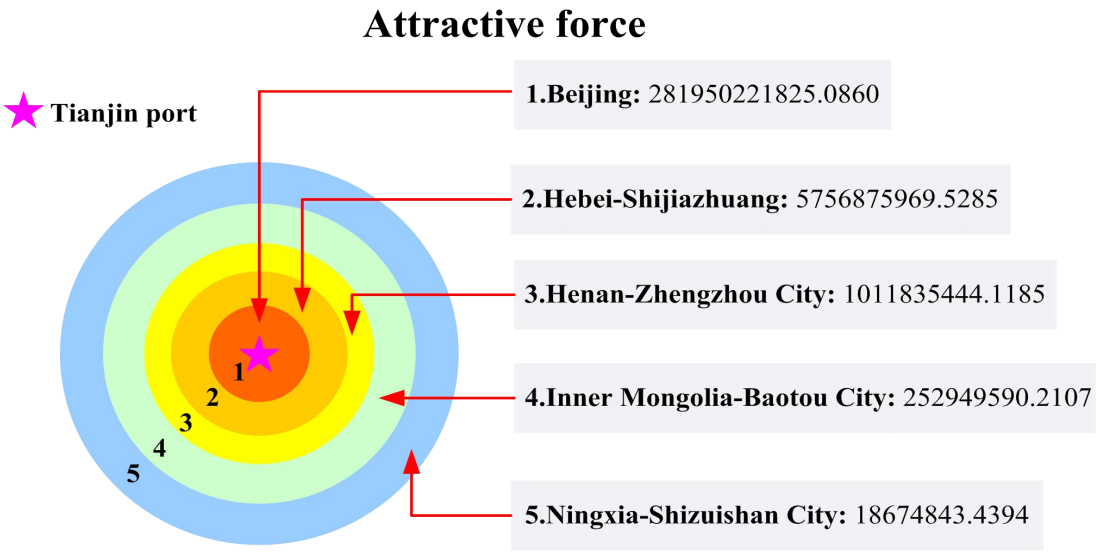

Figure 5.7 ladder effect of attractive force

(Source: research calculation)

And what has lead to the gradient effect of the different attractive forces should be traced back to the following causes:

Transportation-Difference in the accessibility

Transportation network has played an crucial part in the interaction between inland ports coastal port. Here, we will examine accessibility of Tianjin port from its 5 inland ports from two points of view, one is rail way access, the other is highway access.

Table 5.6 Railway(Source: www.checi.cn)

Railway (via train)				
Beijing	**Hebei: Shijiazhuang**	**Henan: Zhengzhou City**	**Inner Mongolia: Baotou City**	**Ningxia: Shizuishan City**
125	21	14	10	0(4)

Table 5.7 Highway(Source: www.checi.cn)

Higway (via express bus)				
Beijing	**Hebei: Shijiazhuang**	**Henan: Zhengzhou City**	**Inner Mongolia: Baotou City**	**Ningxia: Shizuishan City**
27	5	4	1(5)	0(3)

From the above table 5.6 and table 5.7 and experience in practice,the most obvious thing that catch our eye is that there is no direct railway link between Tianjin port and Ningxia Shizuishan inland port, the majority of the cargo gathered in Ningxia are transported by road and other means except for railway, which shows the low level of sea-train transportation, what is even shame is that Ningxia is the most distant from Tianjin compared to other 4 inland ports to. On the contrary, Beijing boast a wide range of transport connection with Tianjin, guess this could give us a hint on the large quantity of cargo that is able to be generated by Beijing inland port to Tianjin port and not to even mention how close the places are geographically speaking.

Although, the situation in Hebei, Henan and Inner Mongolia are not seemed to be

much promising as that of Beijing, actually these 3 are doing not bad, let us use Shijiazhuang as a demonstration of the progress in accessibility the port has made during last decade. Shijiazhuang inland port is on the North of Shi-Cheng (Shijiazhuang-Chengde) railway and have Jing-Guang (Beijing-Guangzhou) railway run through the center of the city. Also in the North part there is an airport 30 miles away from downtown and a number of highways such as national 307 highway, Shi-Huang (Shijiangzhuang-Huangye) highway, Shi-Bao (Shijiazhuang-Baoding) highway, Shi-Tai(Shijiazhuang-Taiyuan) highway and so on. If it is used to be perceived by the majority that before the found of Shijiazhuang inland port, those companies who were based middle South of Henan province and even in its surrounding regions could choose to ship their cargoes directly through coastal ports like Tianjin port and Dalian port, however, in recent years, thanks to the upgrading of the transportation system in Shijiazhuang, companies locates in the North of Anyang in Henan province, in the East of Yangquan in Shangxi province, in the South of Baoding in Hebei province and in the West of Hengshui will probably prefer to ship their cargoes through Shijiazhuang inland port to save the overall cost and certainly not limited to transportation cost.

Moreover, from the table 5.8, which shows the Tianjin port's plan on sea-train transportation, it is clear that Tianjin port has already extend the multimodal transportation to these 3 inland ports especially in terms of see-train transportation. It is worth mentioning that Tianjin is the pioneer in field of sea-train transportation in China by introducing "freight trains with five fixed terms", even through the leading position in recent years are weakening because of the vigorous late comer—Dalian port, Tianjin itself depend a lot on combing railway transport with sea transport. Therefore, we should be convinced that the accessibility of the inland port from Tianjin port really means something to the attractive force.

Table 5.8 Railway type(Source: www.checi.cn)

Name	Type	
	2009-2012	2013-2020

Tianjin-Shijiazhuang	Nonstop	Nonstop
Tianjin-Zhengzhou	Stopover Taiyuan (Drop and Pull Transport)	Nonstop
Tianjin-Hohhot-Baotou	Stopover Hohhot (Drop and Pull Transport)	Nonstop

Leading industry

The other factor that could explain the distribution of attractive forces are the differences that lied in industry structure of the region where 5 inland ports locate.

Table 5.9 main industries in 5 inland ports

Inland port	Main industries
Inner Mongolia-Baotou City	Energy, metallurgy, building materials, chemical industry, machinery manufacturing, agricultural and livestock products and high-tech products
Henan-Zhengzhou City	Clothing, copper, tires, steel, fur products, automotive, ceramics production
Beijing	Manufacturing, information transmission, computer services and software industry, wholesale and retail trade, financial services and real estate
Hebei-Shijiazhuang	Information industry, metallurgy, medicine, building materials, chemicals, machinery, textiles, food
Ningxia-Shizuishan City	Petrochemical, metallurgy, machinery, textile, building materials, pharmaceuticals (agricultural products like halal food and cashmere, textile products, tantalum, niobium, beryllium products, radial tires, activated carbon and bio-medicine)

From the above table5.9 we can see that leading industries in Beijing and Hebei are of much higher level than the other 3 who are mainly depend on primary industry as well as product such as the raw material and textile with only primarily processing. That is why, in terms of money, that Beijing and Hebei contribute more to Tianjin port than the others and also why that in last decades they had always ranked the top with regard to their attractive forces. As from the perspective of the container, general cargo container are used to contain general cargo which mainly refer to

stationery, daily provisions, medicine, chemical products, electronic devices and etc.. Such kind of general container makes up some 75% of the total number of containers, while a small part of the container are of different size and function: dress hanger container are mainly needed when shipping clothes and textile; pen container are used when livestock are to be transported; reefer container are required when shipping those goods who are quite sensitive to the change of temperature; tank container appears when people want some fluid material. As far as we can see from table5.9, a lots kinds of cargoes in Inner Mongolia-Baotou City and Ningxia-Shizuishan City belongs to the area of special container, since the 2 regions are famous for their primary industry together with some pharmaceutical industry as well as mechanism manufacture, and all these put in a demand for more specialized container. As a result, handling capacity of container in these regions are hindered by the "nonstandard" product causing by the typical characteristic of local industrial structure.

In brief, we can jump to the conclusion that it is mainly due to the above mentioned 2 reasons that result in the distribution of attractive forces among 5 inland ports of Tianjin port.

Table 5.10 Correlation between each factor and import and export in Tianjin port in terms of tons(Source: research calculation)

Tons \ Inland port	Inner Mongolia-Baotou City	Henan-Zhengzhou City	Beijing	Hebei-Shijiazhuang	Ningxia-Shizuishan City	Average
Regional GDP(*1000RMB)	0.5767	0.3149	0.0717	0.6157	0.7743	**0.4707**
Regional GDP per capita(RMB)	0.6974	0.4001	0.2176	0.6345	0.5545	**0.5008**
Primary Industry(*100 million)	0.4192	-0.5753	0.4654	-0.0114	0.2499	**0.1095**
Secondary industry(*100 million)	0.3995	0.1732	-0.0676	0.7814	0.7597	**0.4092**

Tertiary Industry(*100 million)	0.4011	0.5058	0.3956	0.0895	-0.1354	**0.2513**
Total Retail Sales of Consumer Goods (*10000RMB)	0.0076	0.4331	-0.5296	0.1320	-0.3341	**-0.0582**
Total volume of cargo (*10000Tons)	0.1493	0.0259	-0.3238	-0.3856	0.2946	**-0.0479**
Total social investment in fixed assets (*10000RMB)	0.3479	-0.1326	-0.3546	-0.3851	-0.2016	**-0.1452**
Export(*10000USD)	0.1939	0.3535	0.1816	0.1163	-0.1362	**0.1418**
Import(*10000USD)	0.3699	0.7442	0.0108	0.3185	-0.6323	**0.1622**
Highway mileage(km)	-0.4869	-0.3232	-0.2523	-0.2320	-0.4013	**-0.3392**
Length of Railways in Operation(km)	-0.2158	0.4703	0.1338	-0.3014	-0.2397	**-0.0306**

Table 5.11 Correlation between each factor and import and export in Tianjin port in terms of TEU(Source: research calculation)

TEU \ Inland port	Inner Mongolia-Baotou City	Henan-Zhengzhou City	Beijing	Hebei-Shijiazhuang	Ningxia-Shizuishan City	Average
Regional GDP(*1000RMB)	0.1383	0.8389	-0.2020	0.6963	0.3286	**0.3600**
Regional GDP per capita(RMB)	-0.0963	0.8373	-0.0163	0.7155	0.3767	**0.3634**
Primary Industry(*100 million)	0.5240	-0.0342	0.5203	0.2492	0.4466	**0.3412**
Secondary industry(*100 million)	0.3461	0.7848	0.5810	0.5911	0.6169	**0.5840**
Tertiary Industry(*100 million)	-0.4466	0.5928	0.6526	0.3531	-0.9030	**0.0498**
Total Retail Sales of Consumer Goods (*10000RMB)	0.2488	-0.0230	0.0989	-0.1539	-0.2317	**-0.0122**

Total volume of cargo (*10000Tons)	0.8462	-0.0595	-0.1512	-0.6187	0.2914	**0.0616**
Total social investment in fixed assets (*10000RMB)	-0.3492	-0.0010	-0.4555	-0.5570	0.0004	**-0.2725**
Export(*10000USD)	0.7298	0.5884	0.9244	0.7630	0.7122	**0.7435**
Import(*10000USD)	0.7638	0.4808	0.7271	0.5173	0.6057	**0.6190**
Highway mileage(km)	0.5152	0.4715	0.4758	0.4803	0.0732	**0.4032**
Length of Railways in Operation(km)	-0.9667	0.6382	0.1227	0.4804	-0.9580	**-0.1367**

The above table5.10 and table5.12 show us that it is always the secondary industry that hold a strong voice in determining the total export and import in a coastal port. It matches China's recent situation, we are country strong in secondary industry and striving to create more opportunities in tertiary industry, and for this moment while we are still moving gradually toward this goal, it is still secondary industry controlling the lifeblood of coastal port's prosperity. In general, we can tell container transportation has become the mainstream in the total cargo transportation, as from the figures the correlation between export and import in TEU is higher than in Tonnage.

Further more

5.2.2.2 Low correlation expressed by Total volume of cargo

"Total volume of cargo" of each inland port does not seems to be capable of explaining the development of Tianjin port. It is less than 0.1 and is about one twelfth of the performance of Export or one tenth of that of Import.

Such phenomenon reveals the fact that in recent years due to the fast development in economy in the inland ports of Tianjin port, there surges a huge demand for container transportation. Nevertheless, with the booming economy the competition among coastal ports over the control over container cargo supply are getting much more intensive. Accordingly, in the context of the ever-improving transportation network, there are a lot alternative coastal port for inland port to choose. Therefore, from the

figure we can see that Tianjin port has somehow lost a lot of goods, it has failed in controlling the cargo supple in its inland port especially the supply from Henan-Zhengzhou, Beijing and Hebei-Shijiazhuang. However, this could be blamed on Tianjin port along as there are two reasons that will inevitably encountered by Tianjin port. Firstly, Tianjin port has it limitation in handling capacity, so that it can not take care of all the cargo supply itself alone,. With the growing trade volume in its more than 20 inland ports, maybe it is possible for Tianjin port to handle the all the volume from its inland ports in the first few year, but it will not be possible to swallow all the cargo flow generated by them, the cargo flow should and must be divided to other coastal port. That's out of the nature. Secondly, we should notice that there are something in common among the three ports (Henan-Zhengzhou,Beijing and Hebei-Shijiazhuang), all of them are located close to the Bohai bay, for their easy access to nearby costal port. Being compared with the other 2 inland ports their switching cost is much lower and as they are exposed to a certain range of choices, they are entitled of more bargaining power, which means they could enjoy more benefit by dealing back and forth among several coastal ports.and that is fair enough to explain the split of the cargo flow from those inland ports.

5.2.2.3 Foreign trade plays a big part(Total Retail Sales of Consumer Goods)

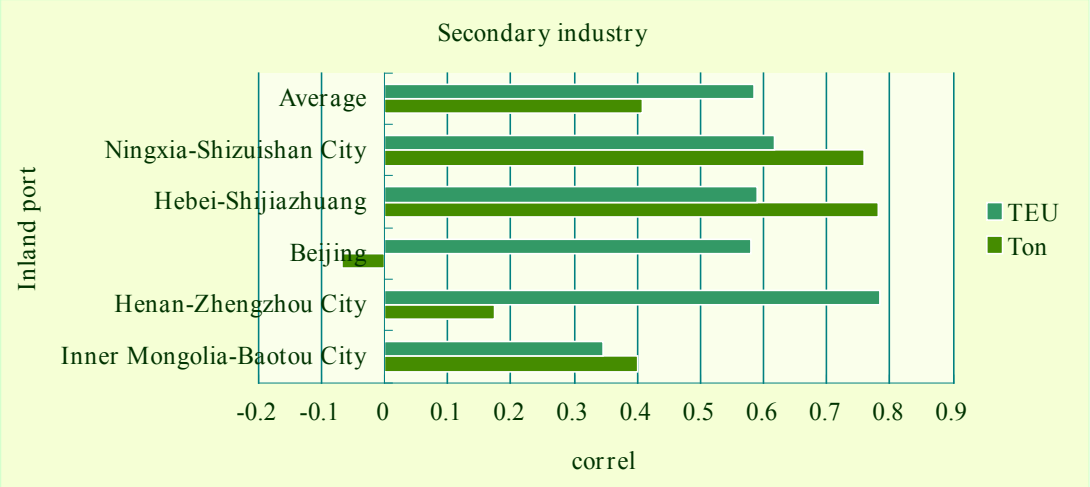

Figure 5.8 Secondary industry

(Source: research calculation)

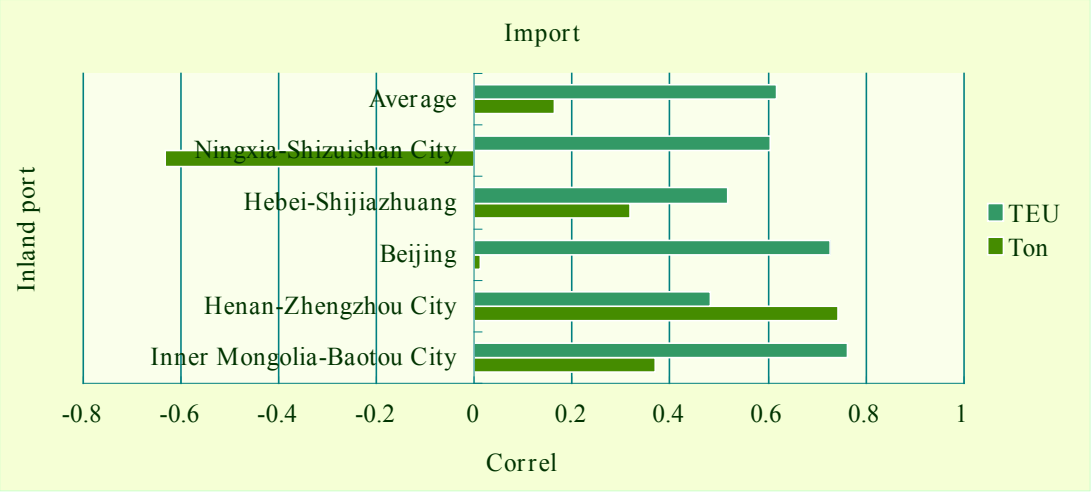

Figure 5.9 Import

(Source: research calculation)

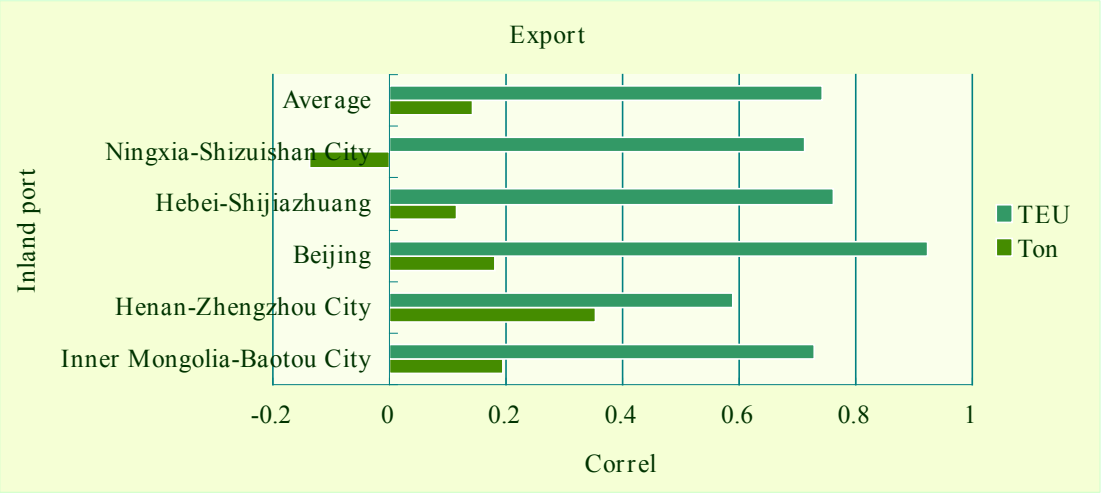

Figure 5.10 Export

(Source: research calculation)

If we pay close attention to Total Retail Sales of Consumer Goods, we shall find that the link between it and Tianjin port's total import and export are so small that we can hardly notice. And as it is known to all that domestic demand can be well expressed by Total Retail Sales of Consumer Goods, judging from the gloomy performance of correlation of Total Retail Sales of Consumer Goods, we could identify a weak correlation between domestic needs with the total import and export of Tianjin port.

However, it is quite the contrary that imports and exports of inland ports share a relatively higher correlation with the performance of Tianjin port,which somehow reflects the fact that foreign trade instead of domestic demand plays a dominant part in the performance of Tianjin port.

During the period from 2005 to 2011, import and export have enjoyed a higher correlation with Tianjin port compared with all the other factors and averaged around 0.6, which made it the major propelling force in driving the demand in container transportation. According to other's research that in the decade before 2005, the average growth in China's exports was almost hitting 19%, such strong growth had greatly accelerated the containerization in China and had at the same time contributed 42% to the coastal ports container turnover. The history of the situation of the whole country is in conformity with the development in Tianjin port. Within the research period, the rapid development of foreign trade in Tianjin port's inland ports has promoted the container turnover in Tianjin port as well as speeding its development progress.

5.2.2.4 Exports overweight imports

As we have already noticed that import and export in each inland port can explain the development of Tianjin port well, and it is also worth noting that export has a bigger influence than import, which could tells us China now is shifting into a outbound trading giant. This strong relation are even magnified in Beijing and Heibei-Shijiazhuang where the figure is around 0.9 and 0.8 ,respectively. In order to identify the difference, I have made the figures into the following graph figure5.11. Although it seemed that our country were doing good in export-oriented trade, there is still a hidden reason within the figures, which is, most 3 of the inland ports we have selected are lack of development in tertiary industry but focused themselves more on exporting raw materials or those products with just primarily process that is at the upstream of industry chain and the downstream of the value chain. That means even with a large quantity of export goods, these inland port might still make only a little profit because of the lower price of their product. So as a matter of fact, the

following might tell us how strong we are in terms of export, while we shouldn't ignore that there still could be caused by the problem rooted in the industry structure of the inland ports of Tianjin port, especially in Inner Mongolia and Ningxia. Because if we further exam the figures of Inner Mongolia, we can see that its correlation with Tianjin port in terms of Total volume of cargo does not fit the average low level as we have agreed in chapter **5.2.2.2**, but it did convey an information that help us to confirm the industry structure of Inner Mongolia is leaning to primary industry and secondary industry with low added value, thus quantity of goods could explain the development of Tianjin port better than in value.

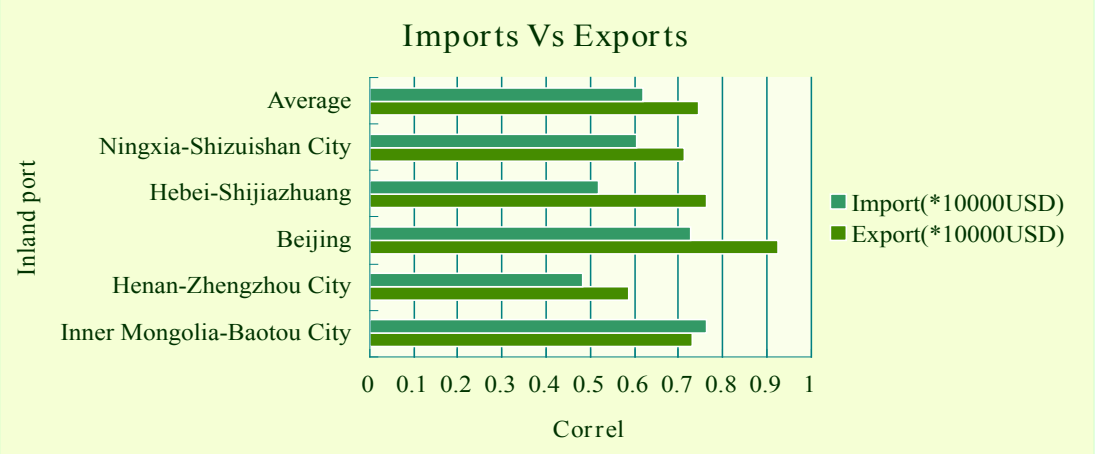

Figure 5.11 Imports and exports

(Source: research calculation)

5.2.2.5 Inefficient investment

We can see with the total social investment in fixed assets growing, there is no positive relationship between the performance of Tianjin port. We may conclude that investment in the inland port do not seem to be rewarding or the investment is of less efficiency. The local government of the inland port region should pay more attention to the investment distribution, first to diagnose the weak point try to improve the these weak points.

5.3 Recommendations for improvement based on result

With the help of what we have discussed in chapter 4—the cooperation mechanism between inland ports and coastal ports together with our findings from the attractive

force model, this paper will provide some guidelines for the improvement of both inland port and coastal port. Hence, we are going to divide the following paragraph into 2 parts with regard to 5 inland ports and Tianjin port, respectively.

5.3.1 From inland ports' point of view

Index collected from 2009 to 2010 In which Annual customs revenue of Beijing is the figure of Chaoyang inland port while that of the others are the figure of regional custom duties; Average raiway freight is calculated by (5.1)

$$Fr=1.3774*\text{Length of the railway}+723.4 \quad (5.1)$$

[46]

Table 5.12 Information of inland ports during 2009-2010(Source: Statistic book and related papers)

Index \ Inland port	Beijing	Shijiazhuang	Henan	Baotou	Ningxia
Warehouse(m^2)	17088	19900	80000	6600	15922
CY(m^2)	32000	39820	24600	30000	80000
Total social investment in fixed assets(billion RMB)	485.84	243.64	228.91	150.026	20.625
GDP of the region(billion RMB)	1215.3	311.49	330.04	216.88	27.078
Imports and exports of the region(billion USD)	214.76	5.508	3.6	1.284	0.4
Value added in logistic service(billion RMB)	42.77	28.23	19.8	28	3.284
Run-through highway	7	4	5	2	0
Run-through railway	6	4	4	2	1
Distance to the nearest airport(mile)	34	47.4	45.6	12.4	95.7
Airport turnover(*10000tons)	147.6	1.9	7.1	0.5	1.5
Overall cargo turnover of the city(billion ton/mile)	62.65	18.79	40.42	36.66	7.08
Government supporting project	4	3	3	0	1
Average railway freight(RMB/TEU)	888.7	1256.5	1823.9	2012.6	2698.6

[46] Song Bingliang. Ports' hinterland competitiveness and regional economic development. Shanghai Economic Review. 2008(04):61-65.(宋炳良，港口腹地竞争力与区域经济发展,上海经济研究,2008(04):61-65.)

Annual container handling capacity(10000TEU)	15	20.5	10	3.8	10
Annual customs revenue(billion RMB)	8.232	15.59	3.606	0.649	0.912
Reduced day in customer clearance	2	1.2	6	3.5	9
Total investment(billion RMB)	0.34	0.268	0.16	0.124	0.117
Land price for industry use(RMB/m^2)	652.8	771.6	546.6	156.7	104.3
Plan area(10000m^2)	72.5	27.2	17.5	19	23
Growth rate of GDP(%)	15	13.9	19.1	26.5	25.9
Growth rate of foreign trade(%)	17	7.9	18.7	16	16.3

Since the inland area do not enjoy the favorable geographic location of a close access to river and sea, the construction of inland port plays a essential role in the regional economic development. Inland port could not only speed up the regional economic development, but also accelerate the internationalization of regional development.

After analysis on the 5 selected inland ports of Tianjin port, we are able to identify the correlation effect between inland ports and Tianjin port as well as detecting the underlying causes behind them. Meanwhile, we have further discovered development trend and potential in the attractive force between 5 inland ports and Tianjin port, and we also listed the possible drivers for that phenomenon. Thus with the help of findings in the development trend of 5 selected ports of Tianjin port, we may able to raise some practical ways to seek improvement. As Tianjin port now has a wide range of inland coverage with more than 20 inland ports scattered all over the country. While the manpower, financial resources or materials that inland ports and Tianjin ports processed are not endless, our aim is to identify the difference between the existing ports and to realize the optimal outcome in terms of turnover, regional development in inland port, internationalization of the region and so on by careful allocation of limited resources.

First group is what we think have a great potential for further development, though, at the first glimpse, they are not as overwhelming as the figures in group. In fact for their growth rate in the last decade, they are no doubt blue chip stocks among others.

As for the future development of Tianjin port, members of this group will be sure to serve the their role as the powerful propeller, we have to devote more to improve their development pattern and try our best to make sure their growth is steady and sustainable.

The most urgent requirement that the first group should lay emphasis on is to speed the industrial structure reform from primary oriented to more of secondary and tertiary industry with more added value and from resource-consuming to high technology based with less cost for per unit growth in GDP.

Inner Mongolia-Baotou: As for Baotou in particular, besides from its underdeveloped industrial structure, railway access is another bottleneck that keeps strangling the development pace of Baotou inland port. The dedicated railway line in Baotou international CFS had not linked up with Baotou railway line, which make it impossible to open the railway freight transportation between CFS and Tianjin port thus leading to a stubbornly high transportation cost. Baotou government should conduct cooperation with railway departments to address the linkage problem between two railway lines. Not only do Baotou inland port need to link the railway line, but it is also expected to be Baotou's duty to serve as the center port among Baotou, Erdos, Hohhot by utilizing the railway resource of existing Bao-Lan(Baotou-Lanzhou) railway line.What's more, with fast development in inland CFS construction, Baotou inland port should accordingly, fasten its pace in tackling the uneven infrastructure construction as well as the problem of CFS being too small in size. And it is also recommended that Baotou inland port should maintain and further develop the cooperation with port agency so as to facilitate the direct train to ship transportation and minimize the time and cost caused by wasteful duplication of container loading and unloading; and the cooperation with shipping agency to install more container return spot to ensure the sufficient supply containers so as to secure the punctual departure of the goods.

Secondly, the primary channel for financing the inland port in Baotou is the aids from World bank and loan from domestic banks, but as we know that the share of domestic investment is limited, high debt to asset ratio and shortage in cashflow are highly likely to further impeded the future growth of Baotou inland port.

Finally, and it is also the common problem faced by those distant, less technology intensive places, that is the incomplete online platform for logistic information exchange Therefore, Baotou custom and inspection and quarantine departments cannot use E-clearance(clearance via electronic method) to provide one-stop custom clearance.Moreover, we have also notice Baotou inland port is lagged behind in terms of its construction of information channel between itself and Tianjin port and also other parties concerned when compared to its construction of infrastructure, which acts like an invisible wall between Baotou and the outside world.

The second group is the mainstay inland ports of Tianjin port with a strong attractive force between inland port and Tianjin port, which are mainly due to their geographical advantage. Judging by their recent development state, they are comparatively well-developed in all round, it won't be wise or necessary to spend great effort on shaping these two inland ports, but it is advised that some little manoeuvre should be done to prefect their performance. And when considering to improve these inland port, attentions are needed to be shifted from increasing the turnover alone but with more attention to be attached to how to maintain the growth with less cost, not only in terms of money but environment as well.

Hebei-Shijiazhuang: Logistics resources in Hebei Shijiazhuang is still being controlled by separate department with a low degree of systematization. For example, its railway, airport and road are planning on their own hub and logistic park individually and seldom can we see the overall planning for some comprehensive transportation hub and logistic park, which might heavily hindered the development of modern logistics service. Considering the weak financial support in Shijiazhuang, those financial institutions should step up in supporting logistic project, which means

so long as the project meet the requirement of loan application and can legally provide enough asset to justify the loan, a loan should be extended. By doing so, a better environment for financing can be created so as to turn logistics inland port into a economic growth point. And to ensure the smooth operation, the logistics system need to be compatible to international logistics standard. In the aim of building Shijiazhuang inland port into a top class park managed by information technology, active adoption of international logistic technologies should be encouraged to standardize all the logistics procedures.

Beijing-Chaoyang: Except from the similar problem with Heibei, there's one thing like the Achilles' heel to the prosperous situation of Beijing inland port, that is with the irresistible tide of trade related logistics activities brought by inland port the environment in Beijing is getting worse, especially in terms of traffic condition and carbon emission from the car exhaust. Beijing should given more attention to increase the transportation efficiency by reducing container transferring among different carriers as well as better scheduling and designing the transportation plan. And full play should be given to the railway transportation to minimize the use of road transportation so that to lift Beijing from the dual blow of both sand storm and manmade pollution of car exhaust.

The last group contains only Ningxia inland port. Frankly speaking, Ningxia inland port should have been classified into group one, but for now it is just like an uncultivated birthday cake,and it will finally be discovered with enough effort being devoted. Both Ningxia inland port authority and Tianjin port authority should make joint effort to accelerate the construction of sea-train transportation between two places.And Ningxia itself have to strive harder on attract more freight forwarding companies, container services, cargo owners these kind of large companies to settle down in inland port so as to increase its competitiveness speeding itself up to join the first group in the near future. What makes us more confident of the above concept is that from the table 5.12 we see that the time saved by the creation of inland port in Ningxia tops the other 5, it is some 5 times bigger than that of Beijing, which

indicates the potential of Ningxia inland port is huge, and of we are careful enough to notice the number of government support project in Ningxia is only 1, we shall foresee that if more attention could be directed to Ningxia, the speed of its forwarding march is sure to be remarkable.

5.3.2 From Tianjin port's point of view

As from the result we have reached before, we can tell that the GDP growth in each inland ports has a positive relation with the import and export growth in Tianjin.thus for Tianjin port, they should improve the correlation effect between itself and its inland ports in the following aspects:

First, change the development pattern in order to speed up the coordinative development with inland ports. From figure(correlation coefficient table) we know that the economic development in inland port can spur the development of Tianjin port, when making the plan of the port, government should not focus only on increasing the turnover but should also attach importance to the development status and trends of the regional economy in inland ports. Government in Tianjin port should free themselves from the mindset of valuing turnover only to expand the handling capacity as well as catering to the requirement of economic development of the hinterland and city.

Second, stick to the strategy that to develop in the sense of the big picture and to expand and enhance the cooperation with surrounding coastal ports. Tianjin port was suited near cluster of coastal ports. Such as Qinhuangdao port and Huangye port. Although in the business of coal transportation, Tianjin are competitor to its neighboring ports, after 2008 since Qinhuangdao port and Huangye port have already reached their limitation in handling capacity plus they had not shown any further attention in expanding the coal business, the threats they have posed to Tianjin port is easing. Moreover, as each coastal port has fostered their own inland port and hinterlands, coastal could establish a better cooperative relationship with each other and to differentiate from each other by specialized in different field of cargo

transportation. By enhancing the development with surrounding ports, Tianjin port could achieve win-win situation with them and will thus propel the regional economic development.

Third, improve the transportation system so as to speed up the economic development in Tianjin as well as in its inland ports. We should admit that Tianjin port do has certain advantage in its existing transportation system, while the railway connection between inland ports and Tianjin port were has not been well and completely established. In the field of sea-train transportation, Tianjin may draw the strength upon Qingdao port, Lianyungang port ans Dalian port. With the help of China's plan on building 18 railway logistics center for container, Tianjin may seek the opportunity from to cooperate with railway departments in order to set up 5-fixed freight train, to set up international cargo route, to provide international logistics service and transshipment service. What's more it is also recommended that railway should be extended directly into Tianjin port's inner area. A dedicated railway within Tianjin port area would allow cargoes to be directly loaded and discharged alongside the port so as to realize a fully covered railway network and a sea-train transportation in real sense.

Technology is sure to be a critical competitiveness for ports. Tianjin port has put on a information platform in 2007, but to be honest that platform didn't seemed as it was advertised, it is actually a no more than a basic frame work. To create a E-logistics environment, Tianjin port has to spare no effort in enhancing the electronic operation, increase the utilization of electronic office in inland port. a virtual port service should entail the service of custom declaration, inspection and quarantine declaration and etc.. And for instance, Tianjin port may introduce the new ideas such as create a internet of things by the help of RFID on containers. At the same time, Tianjin port should try their utmost to facilitate the procedures in custom hand in hand with its inland ports via getting more and more of its inland port online to share and deliver cargo related information.

Last but not least, the low correlation coefficient of the total social investment in fixed assets tells us the investment in the society rarely goes to the infrastructures in local inland port or, to be more fair, there is less effective investment in the infrastructures in local inland port in recent years, which means the local authorities should think hard to improve the supporting facilities by making more effective investment in multimodal transportation, construction of CFS, management of transportation service and so on. And in addition to these tangible investment, inland port should also endeavor to build a information system which can be smoothly conform with other related parties along the whole supply chain.

In short, we are aware that curbed by the its geographic location, Tianjin port are not being a favorable place place for international transshipment goods, so the importance of hinterland can not be emphasized too much. As we are speaking now, more than 70% of the goods in Tianjin port and some 50% of the import and export's turnover come from outside Tianjin. The operation of inland ports can better secure the orderly endorsement flow and optimum distribution of resources as well as expand hinterland and cargo supply.

To give the full play to the potential of inland port, after the equipment construction in inland port, Tianjin port should form a long-term relationship and to carry out regular communication with inland ports in operation details and to facilitate the customer by offering convenient customs clearance service and to provide inland port with more support in work and policy ,especially to solve shortage of funds as well as increasing the cargo traffic.

5.3.3 General improvements

Actually the above mentioned possible ways to improve the positive correlation between Tianjin port and its inland port, actually all fit in the following 3 aspects in general as what we have discussed in chapter 4.1:

(1) Function harmonization

To achieve which we must has vision and insight in the interest of the overall supply chain. To give full play to character of inland port, intermodal container transportation should be encouraged. The function of container consolidation, de-consolidation, storage, transshipment, custom clearance and even inspection and quarantine those used to belong to the basic function of coastal port are expecting to be transferred to inland port. A well established transportation network featuring high speed and safety will create favorable conditions for the development of cooperative main and branch line operation, short and long distance transportation so as to achieve the goal of attracting surrounding imports and exports by further narrow the distance between inland region and international market. With regard to cargo owners, neighboring with inland ports could not only enable themselves to gain a convenient service, but it can also help the cargo owner to save considerable time, money to develop their core competency.

(2) Operation harmonization

Inland port is a combination of different function part, which need the well coordination from government, local port authorities, railway departments, shipping companies and customs office. Especially, when speaking to speed up the custom clearance time, a door to door cooperation system between railway station and port will be highly valued, moreover, when planning the train schedule, railway department should try to make it accord with ships' schedule, and in turn shipping companies should as well try to adjust its timetable to suit the cargo full as much as possible.

(3) Information harmonization

A information exchange platform should be launched to facilitate information sharing among inland port, railway department and costal port so as to form e-business platform where online booking, dealing, cargo info searching, transportation plan consulting, tailor-made service, storage management, electronic

payment and agent management and other relevant functions could be consolidated together.

6. Conclusion and prospect

6.1 Achievements and conclusions

This thesis assesses and compares the attractive forces between Tianjin port and its 5 inland ports, namely, Beijing Chaoyang inland, Hebei Shijiazhuang inland port, Henan Zhengzhou inland port, Ningxia Shizuishan(Luhuinong) inland port, Inner Mongolia Baotou inland port. Under the help of related economic theory, Grey correlation theory and the gravity model as a prototype, this thesis has built a gravity model based attractive force model assessing the correlation effect between inland ports and coastal ports. During the process of model construction, an important parameter called 'k-gravity coefficient' in the attractive model was quantified based on the evaluation index system generated by the cooperation mechanism between inland ports and coastal ports as well as the technical support from Grey theory. It is because of the quantification of k that facilitate the later analysis. Our main conclusions are as follows:

(1) The 5 inland ports enjoyed different attractive forces with Tianjin port, although in absolute number that Beijing inland port as well as Hebei Shijiazhuang inland port seemed to be the best 2. However, when we look into their annual growth rate, these 2 were no longer the bests, instead Inner Mongolia Baotou inland port and Henan Zhengzhou inland port topped the rest. As what we have discussed in chapter 5.2, we now know it is due to the fact that Beijing and Hebei boast geographic advantage as well as a comparatively well developed economic system which enables they to develop against a sound foundation, while the others were developing almost from scratch, no solid foundation, but with a relatively high speed of growth thanks to their large untapped potential.

(2) The distribution of attractive forces features some kind of a radiant effect (or ladder effect). Since, numerically, the attractive force decreases as the distance grows. This thesis believe such radiant effect could be largely explained from 2 aspects, one is the accessibility, the other is the industrial structure of the place. With regard to the former one, we are convinced that there's a ladder effect within the attractive force in terms of the different geological location of each inland port, while the location alone can not explain the whole story, the convenience of the traffic flow is also the decisive fact. As for the later one, we find the different kind of industrial structure contributes a considerable part to the attractive force. For those industrial structure which lean to the primary industry and have diversified industries but without a considerable scale,(usually, those places fed on industries that are more of energy consuming or resources consuming), thus, they usually have more diversified requirement in transportation which will pose pressure on both coastal side and inland side. And it is quite understandable those kinds of industrial structures tend are often seen in distant areas, because such places are usually less developed than the cities close to coastal port.

(3) In the light of model application, a few interesting phenomenon are also uncovered.

1) Low correlation expressed by Total volume of cargo. Such phenomenon are attributable to 2 facts, one is that Tianjin port has its own limitation in cargo handling capacity it can not absorb all the cargo flow generate from its inland port. The other is ,for inland ports like Beijing Chaoyang, Henan Zhengzhou who are comparatively close to Bohai bay, they enjoy a relatively low switching cost if they direct their cargo to other coastal ports in that region. We may notice this entitles these ports

with a big bargaining power allowing them to gain better service even with a good price.

2) Foreign trade plays a big part(Total Retail Sales of Consumer Goods). We have identified a low correlation between domestic needs and Tianjin port's imports and exports through the figures from Total Retail Sales of Consumer Goods. While, on the contrary, imports and exports of inland ports share a relatively higher correlation with the performance of Tianjin port,which somehow reflects the fact that foreign trade instead of domestic demand plays a dominant part in the performance of Tianjin port.

3) Exports overweight imports. As we have already noticed that import and export in each inland port can explain the development of Tianjin port well, export has a bigger influence than import, which could tells us a rosy fact that China now is shifting into a outbound trading giant. While, we still consider other thorny reasons. Because this phenomenon could also be caused by the problem rooted in the industry structure of the inland ports of Tianjin port. Places like Inner Mongolia are primary industry and raw material export oriented, the volume of exports is huge but nevertheless unsustainable and is continuing posing threat to the local economy development as well as eco-system.

4) Inefficient investment. The less linkage between total social investment in fixed assets and development of Tianjin port warns a the undeniable fact that it is either less investment being used to develop inland ports or the money are not being used properly, which cautioned the inland ports and local government to reconsider the how they deploy their resource and to give more attention to develop local inland port so as to open the gateway to the outside world, respectively.

Nowadays, Tianjin port has formed a inland port net work with Tianjin port as its pivot covering 10 provinces, autonomous regions and municipalities such as Beijing , Xinjiang, Ningxia, Inner Mongolia, Shanxi, Hebei etc.. According to statistics, by the end of last year, Tianjin's inland ports had handled more than 240000 TEU, up by around 46%. And the two inland ports in Beijing—Chaoyang and Pinggu last year had handled more than 100000 TEU. The interaction between Tianjin port and its inland ports have been intensified through years of experience, their correlation effect has benefited both sides, especially the benefit that inland port services has brought to the local area which can be easily tell from the local economic progress. The role that inland ports of Tianjin have played in spurring local economy in the places where inland ports are located has become both an important link and loading to facilitate mutual-development.

However, as what have been done in this paper enabled us to see the part of the iceberg which is below the surface, we shall notice the merit and demerit of each inland ports as well as Tianjin port, by further research this paper has come up with some ideas in improving the overall benefit of the inland ports of Tianjin port, which is sure to be a more cost effective and rewarding way than blindly expand inland ports in numbers.

6.2 Limitations and suggestions for future work

The main research tool in this paper is gravity model which is a spark, but as far as I am concerned, I believe there is still much thing to be done in exploiting gravity model in analyzing the correlation between inland ports and coastal ports. As the the information and data is not so complete and for the purpose of model building in this paper, I have to sacrifice some up to data in order to insure all the data needed of the 5 inland port are all complete in the same time period. That's why in this paper our time line ends at 2011. However, we are still able to monitor the development trend of these inland ports, so the shortage won't make too much problem.We should admit there some inland ports are officially open to the public in 2006 or 2007, but we still

collect the data from 2005, that is because we have to secure the certain length of the research time period if the duration is too short we are not able to generate something meaningful, and as a matter of fact even before the official use of the inland ports the local economy and infrastructure and many other sectors are gradually changing thanks to the construction procedure of inland port. So what we are doing are mainly in favor of the research. And even though we included 2005 into the research period, it still seemed a little unconvincing, this paper has tried its best to explain all the figures generated by resorting to the information practice and experience as much as possible. Still this paper could be more convincing if the data is sufficient enough.

Except from the shortage in data collection, this paper is somehow stressed itself more on theory and mathematical analysis, even through a lot of real examples and data are used to justify the results, we are aware of the tough work of trying to combine the research methodology in this paper to real daily practice of both inland ports and coastal ports.

Furthermore, speaking of the application of the model in this paper, there's one typical thing that shouldn't be ignored—the k-gravity coefficient, which could still be modified according to our needs and purposes, it is in fact not a fixed term. Fact as it is, with the growing cargo supply in inland port, there is sure to be more factors affecting the selection of coastal port to cooperate. Factors such as types of supply, liner trade route of the coastal port, the start and end points of foreign trade goods and etc. should be considered as well, and the other demanding task followed by is how to quantify them which requires much effort in the further study.

Besides, there's also an arduous task awaits, which is how to quantify a lot of important criterion related to the evaluation of inland port and coastal ports. What's more, it is also feasible that as the cooperation net work of coastal ports are not limited to the inland port but they has also got involved in the win-win strategy with overseas inland ports or coastal ports, which means the correlation is developing

from national wide into world wide. Consequently, our model are sure to be applied in researching that kind of relationship with a few proper modification.

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Appendix

1.Raw data

Raw data collected from government report, released news as well as from relevant companies.

Table A.1 Annual throughput of Tianjin port

Tianjin port	X1	X2
Year	Cargo throughput(10000Tons)	Container throughput(10000TEU)
2005	24,068.80	480.1
2006	25,759.80	595
2007	30,946.50	710.2
2008	35,593.20	850.3
2009	38,111.00	870
2010	36,946.00	1,000.00
2011	45,338.00	1,158.80

Table A.2 Table A.1 being standardized

Tianjin port	X1	X2
Year	Cargo throughput(10000Tons)	Container throughput(10000TEU)
2005	-1.310735101	-1.407558713
2006	-1.083512121	-0.916132107
2007	-0.386565087	-0.423422402
2008	0.237821089	0.175784452
2009	0.576142804	0.260041233
2010	0.419599473	0.816050448
2011	1.547248943	1.495237089

Table A.3 Variable declaration

Variable	Name
X3	Regional GDP(*1000RMB)
X4	Regional GDP per capita(RMB)

X5	Primary Industry(*100 million)
X6	Secondary industry(*100 million)
X7	Tertiary Industry(*100 million)
X8	Total Retail Sales of Consumer Goods (*10000RMB)
X9	Total volume of cargo (*10000Tons)
X10	Total social investment in fixed assets (*10000RMB)
X11	Export(*10000USD)
X12	Import(*10000USD)
X13	Highway mileage(km)
X14	Length of Railways in Operation(km)

Table A.4 Data of Inner Mongolia-Baotou City

Inner Mongolia-Baotou City												
	X3	**X4**	**X5**	**X6**	**X7**	**X8**	**X9**	**X10**	**X11**	**X12**	**X13**	**X14**
2005	8486991.0	40457.0	31.1	450.1	367.8	2900778.0	20492.0	5600000.0	177362.0	310263.0	4015.0	6246.2
2006	10101178.0	47902.0	35.2	548.7	428.5	3494203.0	23627.0	6300000.0	214050.0	382032.0	4484.0	6382.6
2007	12771982.0	59719.0	45.2	657.5	574.6	4168581.0	28323.2	8450000.0	294439.4	479149.1	4608.0	6694.2
2008	17600038.0	70004.0	52.1	1003.9	704.0	5157426.0	38841.2	11380000.0	359185.0	532663.0	5021.0	6840.3
2009	21687980.0	84979.0	55.3	1175.2	938.3	6177157.0	22493.1	15002586.0	231547.6	445859.0	5233.0	8074.2
2010	24608100.0	94269.0	66.4	1331.5	1062.8	7308066.0	28374.2	18005021.0	334000.0	538409.0	5602.0	8531.2
2011	30054000.0	112372.0	80.2	1665.3	1260.2	8575447.0	32390.0	21605981.0	468723.1	725651.7	5769.0	8988.2
Average	17901467.0	72814.6	52.2	976.0	762.3	5397379.7	27791.5	12334798.3	297043.9	487718.1	4961.7	7198.0
Std	7988324.9	25884.7	17.2	447.7	335.4	2072901.0	6358.2	6096487.3	100174.3	132719.9	630.9	842.2

The figure in grey is not collected directly, as the figure was absent for 2 years, this paper assumes the figure of these two years use the average growth based on the previous years. (The figures hereafter apply the same rule)

$$X14(2010) = X14(2009) + \text{average growth}(2005 \sim 2009) \qquad \text{(A.1)}$$

Table A.5 Data of Henan-Zhengzhou City

Henan-Zhengzhou City												
	X3	**X4**	**X5**	**X6**	**X7**	**X8**	**X9**	**X10**	**X11**	**X12**	**X13**	**X14**
2005	16606006.0	25474.0	72.4	872.8	715.4	7066837.0	8770.0	8200000.0	508753.0	263739.0	6102.3	4098.7
2006	20134777.0	29366.0	77.1	1071.0	865.6	8221881.0	9808.0	10319917.0	663440.0	316016.0	9261.0	4038.7
2007	24867470.0	34069.0	79.3	1314.5	1092.7	9787214.0	11481.6	13673122.0	837491.6	441021.1	9689.0	4041.7

2008	30039925.0	40616.0	94.9	1664.3	1253.3	12062520.0	14499.1	17727409.0	1071890.0	676044.0	9793.3	4041.9
2009	33085053.0	44231.0	103.2	1786.6	1419.0	14347614.0	16958.0	22890810.0	734537.6	613103.9	10141.0	3949.2
2010	40408926.0	49947.0	124.5	2269.8	1646.3	16780339.0	20599.5	27569763.0	1053447.2	726000.0	10318.3	3911.9
2011	49798455.0	56855.0	131.5	2874.4	1974.0	19871147.0	24369.0	30025000.0	1924040.5	1340171.9	9317.0	3874.5
Average	30705801.7	40079.7	97.6	1693.3	1280.9	12591078.9	15212.2	18629431.6	970514.3	625156.6	9231.7	4009.8
Std	11614797.9	11258.6	23.4	700.1	440.0	4679438.7	5788.6	8476905.7	466773.5	361535.5	1433.7	60.3

Table A.6 Data of Beijing

Beijing												
	X3	**X4**	**X5**	**X6**	**X7**	**X8**	**X9**	**X10**	**X11**	**X12**	**X13**	**X14**
2005	68863101.0	45444.0	99.0	2051.1	4819.4	28968163.0	32103.0	28272000.0	3086590.0	9464052.0	14481.0	1125.4
2006	78702835.0	50467.0	101.5	2260.0	5756.3	33707447.0	32998.0	33715013.0	3795398.0	12008265.0	20223.0	1121.5
2007	93533200.0	58204.0	106.3	2641.9	7098.6	38002053.0	19894.8	39665657.0	4892639.4	14407336.7	20535.0	1119.9
2008	104880500.0	63029.0	120.0	2854.3	8141.7	45889850.0	20515.4	38485466.0	5749961.0	21419329.0	20135.0	1166.5
2009	121530000.0	70452.0	117.9	2856.0	9179.2	53098869.0	20485.9	48584051.0	4837932.0	16635373.3	20551.0	1169.5
2010	141135800.0	75943.0	124.2	3388.7	10600.7	62292986.0	21885.8	54935179.0	5547000.0	24594000.0	20921.0	1180.5
2011	162519300.0	81658.0	136.5	3752.6	12362.8	69003246.0	24788.0	58515201.0	5902502.2	33046977.8	21155.0	1191.5
Average	110166390.9	63599.6	115.1	2829.2	8279.8	47280373.4	24667.3	43167509.6	4830288.9	18796476.3	19714.4	1148.8
Std	33738167.8	13272.5	13.5	596.0	2665.3	14937083.5	5626.4	11171235.4	1050757.2	8171865.3	2335.5	24.9

Table A.7 Data of Hebei-Shijiazhuang

Hebei-Shijiazhuang												
	X3	**X4**	**X5**	**X6**	**X7**	**X8**	**X9**	**X10**	**X11**	**X12**	**X13**	**X14**
2005	17867750.0	18671.0	247.8	865.7	673.4	6061650.0	11942.0	9290289.0	1092430.0	514605.0	7948.7	4652.0
2006	20266320.0	21000.0	257.6	979.9	789.2	6988128.0	12142.0	10994463.0	1283400.0	569688.0	12671.0	4818.2
2007	23607230.0	24243.0	304.5	1231.6	824.6	8210983.0	12614.8	13901235.0	1700040.6	852300.9	12825.0	4837.8
2008	28383712.0	28923.0	309.7	1424.6	1104.1	10051958.0	12512.5	17310339.0	2400412.0	1441641.0	13260.0	4853.5
2009	30012797.0	30428.0	308.2	1488.0	1205.0	11905536.0	15150.9	24363602.0	1568890.2	1393835.1	13949.0	4880.3
2010	34010186.0	33915.0	369.7	1653.9	1377.8	14098923.0	19688.6	29579966.0	2257002.8	1936113.0	14198.0	4937.4
2011	40826833.0	39919.0	414.8	2032.0	1635.9	16629864.0	24273.0	30269778.0	2858157.4	2502200.9	14614.8	4994.4
Average	27853546.9	28157.0	316.0	1382.2	1087.1	10563863.1	15474.8	19387096.0	1880047.6	1315769.1	12780.9	4828.9
Std	8025658.4	7458.4	59.1	400.1	348.5	3871842.7	4757.7	8697531.9	642277.8	733449.5	2248.3	81.7

Table A.8 Data of Ningxia-Shizuishan City

Ningxia-Shizuishan City												
	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14
2005	1096294.0	15118.0	6.7	52.1	24.2	271481.0	1771.0	738215.0	68742.0	27915.0	1620.0	791.9
2006	1297701.0	17863.0	7.1	63.9	27.4	307553.0	1893.0	869048.0	94262.0	49450.0	2231.0	789.5
2007	1693068.0	22264.0	8.6	87.4	32.3	354692.0	1930.0	985400.0	108567.4	49584.1	2135.0	789.4
2008	2287270.0	32102.0	10.5	125.6	39.6	438103.0	4740.0	1611000.0	125837.0	62104.0	1801.0	811.4
2009	2707801.0	37050.0	10.9	133.1	58.8	522746.0	4629.0	2062483.0	74293.0	45954.9	2021.0	890.0
2010	2985969.0	41163.0	13.2	136.9	68.5	614776.0	5063.0	2700384.0	117033.8	79023.2	2180.0	914.5
2011	3680209.0	50377.0	15.2	172.3	80.1	672829.0	7014.0	2999884.0	159944.7	68629.8	2339.0	939.1
Average	2249758.9	30848.1	10.3	110.2	47.3	454597.1	3862.9	1709487.7	106954.3	54665.9	2046.7	836.0
Std	943945.9	13022.7	3.1	43.5	21.9	154560.3	2029.7	908782.7	31508.7	16773.6	254.3	51.0

2. Caculation for k-gravity in attractive force model(SAMPLE: Mongolia)

Steps: Standardizing the raw data of Inner Mongolia

[year]/[ind	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14
2005	-1.1785	-1.2501	-1.2276	-1.1747	-1.1763	-1.2044	-1.1480	-1.1047	-1.1947	-1.3371	-1.5005	-1.0310
2006	-0.9765	-0.9624	-0.9863	-0.9545	-0.9955	-0.9181	-0.6550	-0.9899	-0.8285	-0.7963	-0.7572	-0.9085
2007	-0.6421	-0.5059	-0.4072	-0.7115	-0.5596	-0.5928	0.0836	-0.6372	-0.0260	-0.0646	-0.5606	-0.6285
2008	-0.0377	-0.1086	-0.0078	0.0622	-0.1738	-0.1158	1.7378	-0.1566	0.6203	0.3386	0.0940	-0.4973
2009	0.4740	0.4699	0.1787	0.4448	0.5248	0.3762	-0.8333	0.4376	-0.6538	-0.3154	0.4300	0.6112
2010	0.8396	0.8288	0.8246	0.7941	0.8960	0.9217	0.0916	0.9301	0.3689	0.3819	1.0148	1.0218
2011	1.5213	1.5282	1.6255	1.5396	1.4845	1.5331	0.7232	1.5207	1.7138	1.7927	1.2795	1.4323

Figure A.1 Calculation for k-gravity: Standardized data

A: According to $\left|X_i - X_j\right|_t = \left|X_{i(t)} - X_{j(t)}\right|$

A	| X1-X3 |	| X1-X4 |	| X1-X5 |	| X1-X6 |	| X1-X7 |	| X1-X8 |	| X1-X9 |	| X1-X10 |	| X1-X11 |	| X1-X12 |	| X1-X13 |	| X1-X14 |
2005	0.1322	0.0607	0.0831	0.1360	0.1344	0.1063	0.1627	0.2060	0.1160	0.0263	0.1898	0.2797
2006	0.1071	0.1211	0.0972	0.1290	0.0881	0.1654	0.4285	0.0936	0.2550	0.2872	0.3263	0.1750
2007	0.2556	0.1194	0.0206	0.3250	0.1731	0.2062	0.4702	0.2507	0.3606	0.3220	0.1741	0.2420
2008	0.2756	0.3464	0.2456	0.1756	0.4117	0.3536	1.5000	0.3944	0.3825	0.1008	0.1439	0.7351
2009	0.1021	0.1062	0.3975	0.1314	0.0514	0.2000	1.4095	0.1385	1.2300	0.8915	0.1462	0.0351
2010	0.4200	0.4092	0.4050	0.3745	0.4764	0.5021	0.3280	0.5105	0.0507	0.0377	0.5952	0.6022
2011	0.0260	0.0190	0.0783	0.0076	0.0628	0.0141	0.8240	0.0265	0.1666	0.2455	0.2677	0.1149

Figure A.2 Calculation for k-gravity: Step A

B: According to $\left|X_i - X_j\right|_t = \left|X_{i(t)} - X_{j(t)}\right|$

B	| X2-X3 |	| X2-X4 |	| X2-X5 |	| X2-X6 |	| X2-X7 |	| X2-X8 |	| X2-X9 |	| X2-X10 |	| X2-X11 |	| X2-X12 |	| X2-X13 |	| X2-X14 |
2005	0.2290	0.1575	0.1799	0.2328	0.2312	0.2032	0.2595	0.3029	0.2128	0.0705	0.0930	0.3765
2006	0.0603	0.0463	0.0702	0.0384	0.0793	0.0020	0.2611	0.0737	0.0876	0.1198	0.1590	0.0076
2007	0.2187	0.0825	0.0163	0.2881	0.1362	0.1694	0.5070	0.2138	0.3974	0.3589	0.1372	0.2051
2008	0.2135	0.2844	0.1836	0.1135	0.3496	0.2915	1.5621	0.3324	0.4445	0.1629	0.0818	0.6731
2009	0.2140	0.2099	0.0814	0.1848	0.2647	0.1161	1.0934	0.1776	0.9139	0.5754	0.1699	0.3512
2010	0.0235	0.0128	0.0086	0.0219	0.0800	0.1057	0.7244	0.1140	0.4471	0.4341	0.1988	0.2057
2011	0.0260	0.0330	0.1303	0.0444	0.0108	0.0379	0.7720	0.0255	0.2186	0.2975	0.2157	0.0629

Figure A.3 Calculation for k-gravity: Step B

C: According to $\Delta\max = \max_i \cdot \max_j \cdot \left|X_i - X_j\right|_t$ and $\Delta\min = \min_i \cdot \min_j \cdot \left|X_i - X_j\right|_t$

C	Δmax	Δmin
2005	0.1053	0.0019
2006	0.1119	0.0002
2007	0.2384	0.0003
2008	2.3431	0.0082
2009	1.5410	0.0029
2010	0.4362	0.0003
2011	0.6361	0.0001

Figure A.4 Calculation for k-gravity: Step C

D: According to $r(t) = \dfrac{\Delta\min + 0.5\Delta\max}{\Delta_{ij}(t) + 0.5\Delta\max}$

D	r1-3	r1-4	r1-5	r1-6	r1-7	r1-8	r1-9	r1-10	r1-11	r1-12	r1-13	r1-14
2005	0.2949	0.4810	0.4015	0.2889	0.2914	0.3429	0.2531	0.2107	0.3232	0.6902	0.2248	0.1640
2006	0.3443	0.3171	0.3665	0.3035	0.3898	0.2536	0.1159	0.3752	0.1805	0.1636	0.1468	0.2430
2007	0.3190	0.5011	0.8550	0.2691	0.4090	0.3673	0.2028	0.3232	0.2492	0.2709	0.4076	0.3310
2008	0.8153	0.7772	0.8325	0.8758	0.7452	0.7736	0.4416	0.7534	0.7592	0.9272	0.8969	0.6188
2009	0.8862	0.8821	0.6622	0.8575	0.9410	0.7969	0.3548	0.8507	0.3866	0.4653	0.8437	0.9600
2010	0.3423	0.3482	0.3505	0.3686	0.3145	0.3033	0.4000	0.2998	0.8127	0.8540	0.2686	0.2663
2011	0.9248	0.9438	0.8027	0.9768	0.8353	0.9578	0.2786	0.9233	0.6565	0.5645	0.5431	0.7348
	r2-3	r2-4	r2-5	r2-6	r2-7	r2-8	r2-9	r2-10	r2-11	r2-12	r2-13	r2-14
2005	0.1935	0.2594	0.2344	0.1909	0.1920	0.2131	0.1746	0.1533	0.2053	0.4427	0.3743	0.1270
2006	0.4827	0.5489	0.4450	0.5951	0.4149	0.9687	0.1770	0.4328	0.3909	0.3193	0.2612	0.8826
2007	0.3538	0.5927	0.8825	0.2935	0.4680	0.4142	0.1909	0.3590	0.2314	0.2501	0.4662	0.3686
2008	0.8518	0.8104	0.8706	0.9181	0.7756	0.8064	0.4316	0.7845	0.7300	0.8841	0.9413	0.6396
2009	0.7856	0.7888	0.9079	0.8096	0.7470	0.8722	0.4149	0.8157	0.4591	0.5746	0.8223	0.6895
2010	0.9041	0.9460	0.9635	0.9099	0.7327	0.6746	0.2318	0.6577	0.3284	0.3349	0.5240	0.5154
2011	0.9245	0.9063	0.7096	0.8778	0.9675	0.8937	0.2919	0.9260	0.5929	0.5168	0.5960	0.8351

Figure A.5 Calculation for k-gravity: Step D

$$\text{Thus} \quad k = \frac{1}{m \times n} \sum_{i=1}^{m} r_t \sum_{j=1}^{n} r_t$$

k	
(r2005)	0.2587476
(r2006)	0.3507208
(r2007)	0.3606146
(r2008)	0.7177181
(r2009)	0.6759328
(r2010)	0.4866018
(r2011)	0.6992389

Figure A.6 k-gravity coefficient

3. Attractive forces of 5 inland ports in different years

Table A.9 Results of Attractive forces in 2005

Inland port	（r2005）	D_I(drive)	R_{cp}	R_{ip}	Attractive force-2005
Inner Mongolia-Baotou City	0.258747605	807	81929000	487625	15872775.95
Henan-Zhengzhou City	0.683480953	733.5	81929000	772492	80400328.72
Beijing	0.680746536	144	81929000	12550642	33757016167.62
Hebei-Shijiazhuang	1.147475093	334.7	81929000	1607035	1348636261.22
Ningxia-Shizuishan City	1.253772135	1256.5	81929000	96657	6288753.80

Table A.10 Results of Attractive forces in 2006

Inland port	（r2006）	D1(drive)	Rcp	Rip	Attractive force-2006
Inner Mongolia-Baotou City	0.350720808	807	101885000	596082	32706247.69
Henan-Zhengzhou City	0.710464253	733.5	101885000	979456	131776259.55
Beijing	0.5725858	144	101885000	15803663	44461447656.47
Hebei-Shijiazhuang	0.948959313	334.7	101885000	1853088	1599346119.53
Ningxia-Shizuishan City	0.663161363	1256.5	101885000	143712	6150317.17

Table A.11 Results of Attractive forces in 2007

Inland port	（r2007）	D_1(drive)	R_{cp}	R_{ip}	Attractive force-2007
Inner Mongolia-Baotou City	0.360614575	807	129000000	773588.5	55258096.60
Henan-Zhengzhou City	0.722629483	733.5	129000000	1278512.7	221518599.55
Beijing	0.825409738	144	129000000	19299976.1	99103977569.53
Hebei-Shijiazhuang	0.985609437	334.7	129000000	2552341.5	2896822738.23
Ningxia-Shizuishan City	0.808518987	1256.5	129000000	158151.5	10447882.10

Table A.12 Results of Attractive forces in 2008

Inland port	（r2008）	D1(drive)	Rcp	Rip	Attractive force-2008
Inner Mongolia-Baotou City	0.717718147	807	163102000	891848	160308661.13
Henan-Zhengzhou City	0.737007338	733.5	163102000	1747934	390531340.46
Beijing	0.688888329	144	163102000	27169290	147218171396.61
Hebei-Shijiazhuang	0.689766844	334.7	163102000	3842053	3858455785.78
Ningxia-Shizuishan City	0.794692152	1256.5	163102000	187941	15429603.22

Table A.13 Results of Attractive forces in 2009

Inland port	（r2009）	D1(drive)	Rcp	Rip	Attractive force-2009
Inner Mongolia-Baotou City	0.675932819	807	124224000	677406.6	87339639.93
Henan-Zhengzhou City	0.779548328	733.5	124224000	1347641.5	242561960.28
Beijing	0.847996099	144	124224000	21473305.3	109087070264.71
Hebei-Shijiazhuang	0.809586227	334.7	124224000	2962725.3	2659797552.40
Ningxia-Shizuishan City	0.813903614	1256.5	124224000	120247.9	7700714.12

Table A.14 Results of Attractive forces in 2010

Inland port	（r2010）	D1(drive)	Rcp	Rip	Attractive force-2010

Inner Mongolia-Baotou City	0.486601821	807	164110000	872409	106974888.59
Henan-Zhengzhou City	0.764539033	733.5	164110000	1779447.2	414972749.41
Beijing	0.745569858	144	164110000	30141000	177850897145.86
Hebei-Shijiazhuang	0.459319213	334.7	164110000	4193115.8	2821467738.32
Ningxia-Shizuishan City	0.503412264	1256.5	164110000	196057	10259263.96

Table A.15Results of Attractive forces in 2011

Inland port	**（r2011）**	**D1(drive)**	**Rcp**	**Rip**	**Attractive force-2011**
Inner Mongolia-Baotou City	0.699238943	807	197249000	1194374.8	252949590.21
Henan-Zhengzhou City	0.84550641	733.5	197249000	3264212.4	1011835444.12
Beijing	0.760993506	144	197249000	38949480	281950221825.09
Hebei-Shijiazhuang	0.609943584	334.7	197249000	5360358.3	5756875969.53
Ningxia-Shizuishan City	0.653942204	1256.5	197249000	228574.5	18674843.44