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Private Passenger Vehicles in Urban China

Timo Tianhao Herrmann
timo_tianhao.herrmann.224@student.lu.se

Abstract: Rapid economic growth and rising income levels have driven private vehicle sales in China. Within just three decades, China has developed to the world's largest automobile market. This thesis aims at determining the factors which affect passenger vehicle populations in Chinese cities. An OLS regression using cross-sectional data reveals that large variations exist across cities in eastern, central and western China. On national level, the total population of a city has a negative impact on private vehicle levels and available roadway is enhancing private vehicle levels. Private vehicle levels are detached from other modes of transportation due to the psychosocial value of car ownership. Policy makers need to adapt to contemporary developments and integrate modes of transportation to ensure the development of sustainable urban transportation.

Key words: China, passenger vehicle, urban form, private transportation

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1. Introduction

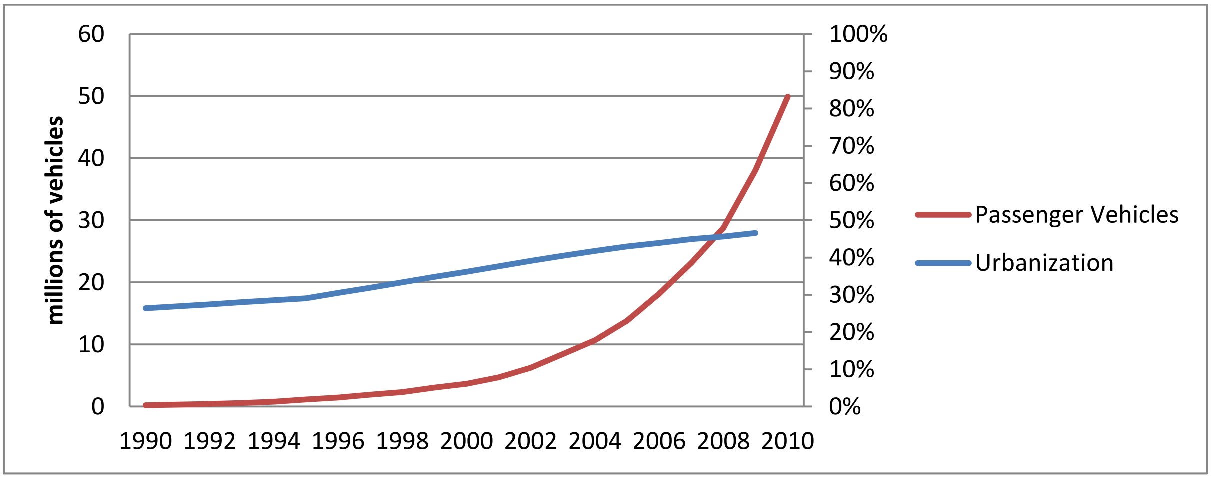
More than 30 years ago, China was known as the 'bicycle kingdom' (Xinhua, 2014). Just before the start of the market reforms, not every Chinese citizen was able to afford a bicycle at that time, not to mention motorized vehicles (Hook&Replogle, 1996). With the introduction of a socialist market economy in 1978, the living standards and wealth of the Chinese population started to increase. Many were pulled out of poverty as China's economic growth kept climbing (Naughton 2007, p. 275). The thriving economy and rising income levels enabled the population to increase their quality of life. In the process of catching up with developed countries, developing countries are striving for modernization by applying western standards of living. Part of this lifestyle is car ownership which represents a symbol of success and modernity (Riley, 2002; Ni, 2008). With only a short history of car ownership and an even shorter history of private cars as a mode of transportation, China's automobile market finds itself in a development stage of rapid growth. Whereas in 1990, 240,000 passenger vehicles were on Chinese streets, the number of vehicles increased to almost 50 million vehicles in 2010 (see Graph 1, China Statistical Yearbook 2011, 16-25). With 22 million vehicles sold in 2013, the Chinese automobile market became the largest market in the world for new automobile vehicle sales (Xinhua, 2014). Current vehicle levels are far from saturation. This trend is not going to stop in the near future. This development makes it crucial to understand the characteristics of car ownership in China.

Cities in China are both hubs for social activities and culture and very important locations of economic activity (Liu & Guan, 2005). These factors make a city attractive for living and working. The younger generation especially, with high levels of education and high aspirations, seeks careers in urban centers. Although the 'hukou' system was implemented to prevent mass migration from rural to urban areas, legislation was not able to stop this progress. In only 25 years, the urban population increased from 18% in 1978 to 46% in 2009 which in contrast took developed countries about 200 years to complete (Naughton, 2007, p. 9; Yu et al, 2014, see Graph 1). With masses entering the urban sphere every year, the urban transportation infrastructure must be able to accommodate the increase in commuters. This includes both the capacity of public transportation systems as well as the capacity of roadways to manage the rising levels of private transportation. In particular, the growing number of private cars leads to increased congestion and travel time.

In developed countries car ownership transitioned from a luxury product to a basic necessity, especially once private motorization became prevalent. Nevertheless, transportation by private passenger vehicle still remains an aspiration in developing countries (Dargay, 2001). As income rose in China, the amount of motorization increased rapidly and so did the number of trips and trip length (Paulley et al., 2006). Urban centers are affected by the impact of increased motorization as private vehicle populations have become an indispensable mode of transport in urban China.

This thesis will examine the factors determining private vehicle populations[1] in Chinese cities. First, the literature review reveals the factors determining car ownership. After explaining the methodology and data used in this thesis, an econometric regression is presented. Thereafter, the results are laid out and discussed. Finally, the conclusion summarizes all the relevant information and findings.

Graph 1: Private Vehicle Growth & Urbanization Rate



Source: China Statistical Yearbook 2011, 16-25, China Population and Employment Statistical Yearbook 2010, 1-4.

2. Literature Review

Although private car ownership in China does not have a long history, it has developed into the world's largest automobile market. This chapter provides an overview of car ownership in Chinese cities and examines different characteristics of urban form and infrastructure. After looking at the historical development of car ownership and urbanization, the aspects of urban form are introduced by explaining the impacts of urbanization and spatial, social attributes of a city.

2.1 Historical Perspective on Car Ownership in China

In the progress of economic development, China was and still is rapidly transforming itself into a thriving economic marketplace. In its process of modernization, China is adopting institutions from developed countries to emulate their path of success (Lin, 2011). This attempt has led to government officials considering the motorization process as crucially important to advance society. . Consequently, the expansion of roadways was highly supported (Liu & Guan, 2005). In the 1990s, the Chinese automobile industry was supported by the Chinese government to become a pillar of the industrialization of the economy. To jump start the automobile industry, joint-ventures with foreign automobile companies were initiated (Kenworthy & Townsend, 2002). With their expertise, foreign

[1] throughout this thesis the terms 'car ownership' and 'private passenger vehicle' as well as variations of these terms are used as synonyms as data is not distinguishing between the number of vehicles in private use and the number of people owning private vehicles.

companies were highly superior to local manufacturers and easily controlled the market. During the 1990s, these joint-ventures controlled around 80% of the total automobile sales. As Chinese automobile manufacturers gained ground they were still only able to compete in the low end market due to technological disadvantage and struggled to enter the high-end automobile market. However, the Chinese automobile industry was able to catch up twenty years of technological development since the start of the reforms in 1978 and raised the overall quality of the industry through FDI (Gallagher, 2006; Hook & Replogle, 1996).

Data research shows that private motorized vehicles increased 18-fold from less than 300,000 vehicles in 1985 to 5.4 million in 1999 in China (Liu & Guan, 2005). This growth was more extensive in private cars. The share of private passenger vehicles in China rose from 12% of the total vehicle population in 1980 to 41% in 1996 (Riley, 2002). In 2009, China has become the world's largest vehicle market. However, with a national ratio of 47 cars per 1000 inhabitants, China is still clearly below the world's average of 175 cars per 1000 inhabitants (Jie & vanZuylen, 2014). Dargay et al. (2007) project that until 2030 China's ratio will increase to 269 vehicles per 1000 people. However, Wang et al. (2011) observe that most forecasts for the vehicle population were too conservative. They predict that China's vehicle population will grow yearly by 13-17%, totaling 419 million vehicles in 2022.

Looking at car ownership levels during the developing stage across countries, Dargay et al. (2007) find that levels of private motorization are closely tied to rising income. During the period of per-capita income between $3000 - $10,000, vehicle ownership increased twice as much as income growth. Up to $20,000 of per capita GDP car ownership grew at the same levels as income. Higher income levels encountered decreased vehicle population growth as they reached the saturation limit. Currently, China is in the middle-income range of rapid vehicle ownership growth. The projected rate of vehicle growth for China being 2.2 times faster than per-capita income reflects growth rates of Japan since the 1960s or South Korea since 1982. Until 2030, China's per capita income will increase to $16,000, sustaining its high growth phase of vehicle ownership until then (Dargay et al., 2007).

Generally, increases in income also enhance the total amount travelled by the population. Not only the number of trips increases but also the length of travel increases (Paulley et al., 2006). This theory is supported with evidence found by Crane and Chatman (2003). Their research for cities in the USA shows that rising levels of income increased commuting distances. Furthermore, Cullinane (2003) points out that with the increase of income, the value of time also rises. This implicates that with a higher income the time that is saved by commuting with the fastest transportation mode outweighs the cost saved by travelling with any other mode of transportation.

For the most part, these findings can be applied to Chinese cities. Cao and Huang (2013) find a strong relationship between the stage of economic development and car ownership levels throughout the country. Wei et al. (2013) who examined 34 cities in China discovered that a city with higher status of economic development decreases the sustainability of urban transport. They conclude that the advances of urban transportation have a negative impact on urban quality of life. This can be partly explained by cities with low income keeping a high share of non-motorized travel and public transportation which diminishes with rising income levels (Kenworthy & Townsend, 2002). On the contrary, Manhattan in New York City is an example that car ownership is not necessarily tied to income levels. Liu and Guan (2005) found a negative correspondence between income and car ownership which shows that other factors may as importantly play a role in determining car ownership in urban areas. However, current statistics may be underestimating the future of private vehicle populations in China. In their global comparative study, Kenworthy and Townsed (2002) find that private transportation in low Income Asian countries as well as in China were performed to one fourth by motorcycles. This may to a certain extend explain low private car ownership levels in those countries and illustrates that mobility can be achieved by different means, adjusted to the countries domestic conditions. This fact has been neglected in many studies due to the lack of reliable data. However, individual motorized transportation by two-wheelers is an important factor for the urban transportation mix which will require future research.

2.2 History of Urbanization in China

To understand the situation and composition of the urban landscape the development of urbanization is studied by examining in which parts of China urbanization has been taking place and which factors promoted migration.

2.2.1 Geography of China

China is one of the biggest countries in the world by size and also inhabits one of the largest populations on earth. Land and people however are not equally spread over the country as over time Chinese people have settled in specific regions of the country due to geographic conditions. Whereas the western part of China is comprised of deserts and mountainous areas and demonstrates rather inhabitable conditions, the central region of China presents the granary of the country with large populations along the rivers with plenty of arable land. The coastal regions have historically been the center of commercial and political activity and also presented a hub for global interaction (Huang & Luo, 2009).

At the start of the economic reforms no blueprint guided the country to the economic success it has experienced in the recent decades. Many of the policies implemented in the process of industrialization were first tested on a small-scale before they were implemented nationally. This is found true for the special economic zones which were first developed in the coastal provinces of Guangdong and Fujian to test the effects of foreign direct investment on economic growth in miniature format. By having the first-mover advantage and being located geographically convenient the geographic advantages have intensified over time (Huang & Luo, 2009). At the same time, the extensive expansion of highways and rail infrastructure throughout the country was intended to decrease transportation cost and time. It enabled central and western regions with better access to the economic hubs at the coast to decrease national economic disparities. This approach has especially helped urban areas in those regions to develop and increased wage levels (Roberts et al., 2012).

2.2.2 Urbanization in China

At the start of the market reforms in 1978, 82 percent of the total Chinese population lived in rural areas. Within only 21 years, the rural population has decreased to 69% in 1999. The increase of the urban population was mainly attributable to rural-to-urban migration which accounted for 75%. The other form of urban population growth was caused naturally through a higher rate of reproduction in the cities than in rural areas (Zhang & Song, 2003). In total numbers, a total amount of 174 million people migrated into urban centers until the turn of the millennia which presents the world's largest domestic migration ever recorded. Up to 80 percent of the total migration took place among provinces with people moving from inland provinces to provinces at the east coast while people in the eastern provinces preferred to migrate within the province. Thereby, most of the migration took place from provinces in central China, being in geographical proximity of the provinces with the highest numbers of immigrants (Zhang & Song, 2003).

The reason for this large flow of inter-province migration has its origin in the course of industrialization. The process of industrialization is described by labor moving from the agricultural sector to the manufacturing industry (Song et al, 2012). An unintended consequence of the extensive transportation infrastructure was the empowerment for migrant workers to pursue employment opportunities (Roberts et al., 2012). During the socialist era, farmers used to be organized in work units and the rewards for working were the same no matter how much effort was made. Thus, the tragedy of the commons created an unproductive and job cuddling form of agriculture. With the start of the market reforms, farmers were allocated land by households and obtained the right to live off any produces exceeding the production quota. This dual-track approach triggered an enormous improvement in agricultural productivity and it took less people to farm the land to produce more harvest than required. This change of institutional environment created a surplus of labor in the agricultural sector which then entered the manufacturing sector and initially provided the labor force to start the Chinese economic miracle (Naugton, 2007, pp. 86-92).

Thereby, one of the most decisive factors explaining rural to urban migration on both inter and intra-provincial migration flow is found in the high variations of income (Zhang & Song, 2003). As income disparities between rural and urban spheres are still widening, a decrease in migration activities in

China is not to be seen. Song et al. (2012) suggest that improving the competitive advantage of rural firms within their regional markets by technological advance and the overall quality of business will lead to a reduction in income disparity and thereby de-incentivizing migration. Nevertheless, the attempt of the creation of Township and Village Enterprises (TVEs) in the early stage of economic development was meant to create jobs in the manufacturing industry in rural areas of China to keep farmers in their vicinity and prevent them from migrating. However, most of the founding of TVEs has been taking place in the coastal regions of the country (Song et al, 2012). This development explains to a certain extent that the rate of urbanization throughout the country varies enormously. While in the coastal cities urbanization levels are up to about 70%, the urbanization process in western provinces is far less developed (Yu et al., 2014). Furthermore, the 'hukou' system presented a hurdle to the migration process as permits had to be obtained and additional fees and taxes created a burden on seeking job opportunities in other parts of the country. Those barriers are still present today and are meant to decrease job mobility. However, income inequality and the additional gains were strong enough to compensate for the effort and make it lucrative to work away from home. Yu et al (2014) point out that migrant workers do not gain access to urban health care or the education system. Although implementing their human capital and economic power in urban areas, migrant workers do not obtain full urban residency, political rights or public benefits.

Starting from 1995, the urbanization rate exceeded that of economic growth which indicates that China has been under-urbanized in comparison to other countries at the same stage of economic development. In 2008, the population living in urban areas in China exceeded the population living in rural areas for the first time (Chen et al., 2013). In this progress, Zhang and Song (2003) find that migration has encouraged economic growth and not the other way round. Thus, urban expansion surpassing the rate of economic growth presents a challenge for policy makers to adapting the political environment to current circumstances.

2.3 Characteristics of Urban China

The historical perspective on the Chinese urbanization process revealed a natural imbalance of conditions which were reinforced by economic policies over time. After learning how cities developed, the unique features of a Chinese city are studied.

2.3.1 Urban Form in China

Space and land in the city is used for a variety of purposes. Not only do those areas provide living space for the urban population, but also incorporate an infrastructure of transportation connecting people's activities throughout the city. Liu and Guan (2005) find working trips and commuting to be the predominant form of travel activity within the city. In wealthy cities, especially in the USA, Canada and Australia, the majority of the trips were made by private transportation (Kenworthy & Townsend, 2002). When looking at the user characteristics of a car however, only 5% of its entire product lifetime is used for travel. The rest of the time it remains unused and has to be parked in a parking space that has to be provided by a city's infrastructure (Liu & Guan, 2005). Even though China heavily depends on its road transportation, Chinese cities are not able to manage high numbers of private passenger vehicles. With only 17 parking spaces per 1000 jobs in 1995 compared to 555 in the USA or 261 in western European cities, Chinese urban areas need a fundamental change to provide car user friendly environments (Kenworthy & Hu, 2002). Those concerns are especially accurate for Chinese cities as Cao and Huang (2013) find that car ownership in large cities is the highest. Surprisingly, small sized cities in China have higher car ownership levels than medium sized cities.

However, applying western car ownership standards of one private car per two inhabitants remains a dream of every automobile manufacturer worldwide. As automobile markets in developed countries have reached maturity and markets become saturated, automobile manufacturers are expanding into new and infant markets which promise large potentials of growth. However, the infrastructure of the city is a crucial factor of regulating car ownership in urban areas (Cullinane, 2003).

Population density

The findings of Kenworthy and Townsed (2002) as well as Ewing et al. (2003) emphasize that cities with higher levels of car ownership were also less densely populated. In other words, this indicates that high population dense cities have lower levels of car usage. Even in their sample group of low income cities the effect of population density was more significant than the variations in income. These findings are also supported by Paulley et al. (2006) who supports the validity of the hypothesis of a decrease in population density implicating an increase in car usage in the case of the United Kingdom. Further, Dargay et al. (2007) note that saturation levels of car ownership are lower in more densely populated areas. Nonetheless, these results do not indicate that car ownership in highly populated areas is stagnating or even declining. In Hong Kong, one of the less car dependent cities in East-Asia, car ownership has risen despite an increasing population density (Cullinane, 2003). The ratio of 76 vehicles per one thousand people in the year 2000 was still lower compared to regulated car ownership levels in Singapore, which were 120 respectively. While the number of private cars increased by almost 30% between 1980 and 2000 in Hong Kong, the number of journeys by public transportation increased by over 70% in the same time (Cullinane, 2002). This may be due to the city's limited size as well as its colonial heritage and early investment into an extensive public transportation system.

Urban sprawl

Ewing et al. (2003) identify a high significance between population density and the use of public transportation for commuting. The use of public transportation is significantly related to the location of jobs. In 1995, 51% of all jobs in the cities were downtown. This had a positive impact on the use of public transportation. The higher the decentralization of the city, the more private transportation was chosen as a transportation mode (Kenworthy&Townsed, 2002). In the case of Hong Kong, Cullinane (2003) describes this phenomenon with the shift of industries. In the 1990's, large parts of manufacturing were moved to mainland China and the share of jobs in the service industry increased. Those jobs were located in the center of Hong Kong which implicated an expansion of transport connections to the city center, foremost rail connections. However, the decentralization of jobs due to a shift of industries does not directly indicate a dispersion of job opportunities or longer commuting time. It could also indicate a clustering of certain industries on the outskirts of the city as it proofs to be more efficient for them to locate there. Findings from US cities suggest that decentralization of jobs in the construction and wholesale industry decrease the commuting distance for employees, whereas commuting distances grew for job decentralization of manufacturing and government jobs (Crane & Chatman, 2003). Overall, limitations in urban sprawl limit travel commuting time. Zhao (2011) discovers that in the case of Beijing interventionist policies decreased urban sprawl. This resulted in a reduction of travel time and travel distance creating a positive environmental impact. Additionally, car use was reduced due to the compactness of urban area allowing higher access to the public transportation grid. This may be part of the legacy of the socialist era, as Sailer-Fliege (1999) finds that former socialist cities in eastern central Europe comprise several common features like high accessibility of the city center by public transport, the settlement of the tertiary sector in the central business district and thus being a fairly compact city.

2.3.2 Public Transportation in Chinese Cities

In their attempt to expand road infrastructure, investments into the development of public transportation systems were neglected in China (Liu & Guan, 2005). In the 1990s, the focus of investment was on the extension of roads and freeways. This accounted for 3.17% of GDP whereas investment into public transportation only accounted for 0.86% of GDP. Therefore, Chinese cities have the poorest public transportation and urban rail infrastructure in per capita terms worldwide (Kenworthy & Townsend, 2002). However, the benefits of a functioning and efficient public transportation infrastructure are undeniable and should be given greater consideration by Chinese cities. Road transportation is still the predominant form of public transportation in urban China in 2013 (Wei et al., 2013). Metro systems were not favored by the Chinese government and have only recently been developed in major cities throughout the country. With the improvements of Chinese urban rail infrastructure come positive effects for road transportation as relocation of passenger traffic eases road traffic. Findings from Shanghai state that neighborhoods in the proximity of one kilometer to the metro system facilitated commuter's access to the location of the job and reduced commuting times (Cervero & Day, 2008). Metro infrastructure projects are time intensive and do not solve short term transportation challenges. Officials missed the opportunity to increase public road transportation during the start of the economic reforms due to the focus on private motorization.

Recently, the concept of Bus Rapid Transit (BRT) was introduced and encouraged by the Ministry of Construction as an immediate solution to traffic congestions. This concept has proven itself in developing countries in Latin America and can be implemented in Chinese cities without permission and at low cost of set up and maintenance compared to the construction of an underground metro infrastructure (Deng et al, 2013). The implementation of BRT systems poses a viable and near-term solution to keep up with the rapidly growing city and masses of migrants moving the urban area. In particular, the efficient usage of available road space by dedicated bus lanes allows a high passenger turnover. Thereby, not only more people are transported by road, also the travel speed increases and travel time is reduced compared to other modes of road transportation (Asian Development Bank (ADB), 2010). However, Li et al (2010) who examined car ownership in Chinese megacities found a positive relationship between BRT systems and car ownership. Consequently, the intended impact of car ownership reduction did not take place.

2.3.3 The Chinese Government and Transportation policies

Chinese leaders have been obsessed with economic growth. As political institutions have the responsibility to provide incentives and disincentives to cause a certain kind of behavior, many policies to modernize the country were enhanced to provide the highest economic progress in the shortest amount of time possible (Nee & Opper, 2007). The discrepancy of various forms of implementation across national, provincial and local institutional enforcement is widely known and also created varying urban transportation policy results among Chinese cities (Wachtmeister, 2013, Wei et al, 2013, Deng, 2007).

Before the economic reforms in 1978, investment was focused on rural areas and strict laws prevented the migration from rural to urban areas in China. All farmers were assigned land by the Chinese government and had the right to farm and live off their own produces. Hence, farmers were not able to sell their land and did not have the resources to move to the city (Hook & Replogle, 1996). Thus, urban development was strictly determined by local governments and expansion of the cities remained limited. These developments led to very compact cities with high population densities, making those cities favorable environments for bicycle riding (Hook & Replogle, 1996). However, the expansion of roadway for motorized transportation has created a hostile environment for bicycles. With rapidly expanding motorways, the transportation environment in urban areas has fundamentally changed within a short period of time. The increase of cars and taxis has decreased the efficient usage of road space and thus lead to slower traffic flow and higher levels of congestion (Hook & Replogle, 1996). A major reason for this development is the strong authority of political institutions within China which enforces the implementation of urban planning projects. As land is owned by the government decisions can be made for the good of the people or meet government objectives at the expense of minor resistance (Gackenheimer, 1999). Thus, legislations for private vehicles and physical environments shaped by legislation vary enormously from city to city. Consequently, due to city specific regulations it is complex to make general assumptions based on the institutional environment.

3. Methodology & Data

The previous chapter described car ownership in China from a historic, socio-economic and geographic point of view. Various theories about car ownership have been developed but many have not been applied to China yet. This paper is going to examine whether the theories of car ownership do apply on a large scale among cities across the Chinese nation.

The following hypotheses have been developed in order to address this complex relationship of car ownership in cities in China and its influencing factors:

H_1. Population density of the city has a negative impact on the private vehicle population in urban China.

H_2. The city's status of economic development has a positive impact on urban private car ownership.

H_3. The availability of road space increases car ownership levels in Chinese cities.

H_4. With an increase in number of public transportation vehicles and taxis car ownership levels in Chinese cities are negatively impacted.

H_5. The share of employment in the service industry has a negative impact on private vehicle levels in urban

3.1 Methodology

To test the stated hypothesis an econometric analysis will be conducted by using the Ordinary Least Squares (OLS) estimation method.

$$y = \alpha + \beta_1 + \beta_2 + \cdots . + \beta_7$$

The model consists of a dependent variable which is stated by a linear function. The function contains several variables, called independent variables. The variables chosen to explain the dependent variable are assumed to have an explanatory value to describe the variations of the independent variable

Cross-sectional data allows us to collect data from different fields of research and disciplines. It also helps to gain an overview of cities throughout the country at a certain point in time. It offers a snap shot of the actual situation of the respective point in time.

3.2 Data

A data set of 224 cities across China has been collected from the year of 2007 (see Appendix). The selection of the cities was chosen by the China Statistical Bureau according to the socio-economic and political significance of the city. Based on reasons mentioned below, only two sources, namely, the China Statistical Yearbook of Regional Economy 2008 and the China City Statistical Yearbook of 2008, have been selected for data collection. It is important to notice that the data used in this paper contains information only of the urban area of the city, not its administrative area which contains both rural and urban land.

The cities are situated in 24 of the 31 provinces in China. Municipalities on province level, namely Shanghai, Chongqing, Tianjin and Beijing have been disregarded for the construction of the dataset as they present extreme cases with special conditions. Further, the provinces of Tibet and Xinjiang have not been included in this sample due to data constraints. To explore regional variations, the provinces were further grouped into three regions, Eastern China, Central China and Western China with 87, 90 and 47 observations, respectively, as they stand in different stages of economic development (Cao & Huang, 2013).

Table 1: Regional Categorization

East	Zhejiang, Fujian, Guangdong, Hainan, Hebei, Heilongjiang, Jiangsu, Jilin, Liaoning, Shandong
Central	Anhui, Guangxi, Henan, Hubei, Hunan, Jiangxi, Shanxi
West	Gansu, Inner Mongolia, Ningxia, Qinghai, Sichuan, Yunnan

Not included: Beijing, Tianjin, Shanghai, Chongqing, Tibet, Xinjiang

Table 2 describes the relevant data used in this paper. The observations range from small cities with a population of 180,000 inhabitants to large cities with a population of up to 3.6 million citizens. GDP per capita ranges from about 400 Renminbi (RMB) to about 90,000RMB. Employment in the tertiary sector ranges from about 18% to 88%. Regarding transportation, the numbers of private vehicles also vary from 8 private passenger vehicles per 1000 people up to 468. Public transportation vehicles range between about 0.7 vehicles per 10,000 to around 16 vehicles. The number of Taxis per 10,000 inhabitants has a scope of about 1.5 to 62.5. Population density shows discrepancies between 61 people and 4407 people per square kilometer. In terms of available roadways in proportion to the total size of the city, it can be seen that the factor ranges from 0.02 up to 7.56. Those numbers indicate that the dataset has a large spread of observations and that we are dealing with a rather small sample with high deviations within each variable.

Table 2: Summary Statistics

Variable	**Obs.**	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Passenger Vehicles per 1000 people	224	97.671	88.065	8,114	468,477
GDP per capita	224	28,699	17,223	4,434	88,779
Population Density	224	994.52	860.03	61.81	4,407.58
Roadway to citysize	224	0.987	1.168	0.0249	7.568
Public Transportation Vehicle per 10,000 people	224	5.984	3.619	0.672	16.418
Taxi per 10,0000 people	224	20.220	13.866	1.562	62.563
Employment in Service Industry (%)	224	50.748	14.100	18.35	88.72
Total Population (in 10.000 people)	224	101.224	62.375	18.14	358.13

Reliability of Data

The reliability of Chinese statistics has always been viewed with a certain degree of skepticism by foreign organizations and authors. Especially in a large country like China with a multitude of reporting levels and many governmental layers, it is not easy to avoid discrepancies in the data agglomeration process and contain consistency. However, the Chinese government is aware of the possible inaccuracy of agglomerated data. As all numbers provided are approximates for a fast growing and rapidly changing economic environment; it may be possible that estimation techniques are not as accurate as in developed countries (China Economic Review, 2014). Nevertheless, the data provided by the China Statistical Bureau is the most extensive congregation of city level data. As the data in this thesis is retrieved from two statistical yearbooks it can be assumed that inaccuracies are held to the smallest level possible.

3.3 The Econometric Model

An econometric model has been developed for hypothesis testing. The proxies can be placed into three categories: variables on the city's socio-economic development, urban form and infrastructure and modes of transportation. Socio-economic variables contain GDP per capita and the percentage of employment in the service industry. Urban form is described by total population, population density, roadway in relation to the city size and the size of the city. Transport variables include total number of public transportation vehicles and number of taxis. Further, the model will be tested for three regions in China to distinguish regions variances. Unfortunately, not all discovered factors which may have an impact on private vehicle levels in Chinese cities can be implemented into this paper's model due to the limitation of data availability and accessibility.

Therefore, the following model has been constructed:

$$carpop = \alpha + gdppercap + ptveh + taxis + roadcity + citysize + popdensity + EmployServsector + population$$

Carpop = Total number of urban private vehicles per 1,000 citizens
Gdppercap= GDP per capita
Ptveh= Total number of public transportation vehicles per 10,000 people
Taxis= Total number of taxis per 10,000 people
Roadcity= ratio of roadway to citysize
Citysize= physical size of the city
Popdensity= population density
Employservsector= percentage employment in tertiary industry
Population= total urban population of city

Dependent variable

In the China Statistical Yearbooks passenger vehicles are grouped into civil and non-civil vehicles. For this dataset only private vehicles are considered which display a subcategory of civil vehicles. However, the definition of private vehicles does not completely match with private car ownership as private passenger vehicles also include the private possession of buses and trucks. Also, the numbers do not reveal the total amount of car owners but indicates the number of vehicles which obtained a license plate. Nevertheless, it is the best data which can be obtained (Deng, 2007). For measurement purposes a ratio has been generated for private vehicles per 1000 citizens.

Independent variable

The economic development of a city is viewed by academia as the most significant determinant of car ownership levels. Hence, the variable GDP per capita was chosen to describe the economic status of a city (Dargay et al., 2007; Kenworthy & Townsend, 2002; Gallagher, 2006). As found by Cullinane (2003) the shift from manufacturing jobs to service industry jobs lead to a shift in the location of jobs. The percentage of employment in the service industry had an impact on the usage of transportation modes in Hong Kong, hence indirectly influencing car ownership levels. Those findings are now being tested in the case of cities across China to examine whether this theory can be adapted to China. Population density is a decisive factor on urban car populations. It is expected that this variable has a negative relationship on car ownership levels. This variable is measured as inhabitants per square kilometer. The data on transportation is limited to transportation via roadways, as the majority of public transportation and private transportation takes place on the road. Other forms of transportation such as trams or metros or rarely developed in the majority of cities in China (Deng, 2007). Therefore, the variable of roadway in relation to total size of the city is chosen to indicate the availability of roadways within the urban area. However, the data available on roadways are only for the administrative area of the city which may lead to inaccuracies. Nevertheless, this data is the next best available measure for the amount of inner-city roadway. The public transportation infrastructure is an essential part of the urban transportation network. It is expected that an increase in transportation vehicles which are not private passenger cars have a negative impact on car ownership levels. Therefore, the variables public transportation vehicles per 10,000 citizens and taxis per 10,000 inhabitants are included in the model. The control variables 'total population' and 'citysize' are also included in the model.

Testing

The model shows signs of multicollinearity between the variables 'citysize' and 'population density' which would negatively affect the meaningfulness of the model. As population density is one of the major explanatory variables and necessary to test one of the stated hypotheses, the variable 'citysize' has to be dropped from the model. Further, the Kernel density estimate which visually displays the smoothness and normal distribution of a variable suggests that all variables used in this model should be processed by their logarithmic value. The variable 'Employment in the service industry' is the only exception and is used by its percentage value. A scatter matrix of all explanatory variables used in the model illustrates that the dataset does not contain any outliers and observations are normally distributed. Further, the Breusch-Pagan test does not indicate any signs of heteroskedasticity. Also, the test for normality describes a normal distribution of the residuals.

4. Results

After having developed a model for hypothesis testing an econometric analysis has been conducted. The output of the OLS (see Table 3) is first described and later analyzed. The model was constructed to explain the variation of the dependent variable with the independent variables. The r-squared value of 0.25 for the total model shows that this effort has been partly successful.

Table 3: OLS output

	Total	East	Central	West
GDP per capita (log)	.098	-.285	-.143	.156
Roadcity (log)	.315**	.586***	-.239	.190
Popdensity (log)	-.146	-.206	.351	-.259
PublicTransVeh per 10000 people (log)	.0499	-.166*	.0257	.119
Taxi per 10000 people (log)	.114	-.141	.645***	-.141
emplservice	-.002	.263	.003	.003
Population (log)	-.326***	-.002	-.480*	-.595*
cons	5.535	9.839	3.227	6.879
Sample Size	224	87	90	47
Adj. R-squared	0.25	0.33	0.33	0.27

Note: Dependent variable=private passenger vehicles per 1000 people (log)
* Significant at the 0.10 level ** Significant at 0.05 level *** Significant at 0.01 level

The variable GDP per capita is found to have no significant impact on car ownership regardless the regional factor. This finding proofs hypothesis H_2 as not valid. The ratio of roadways to total city size is significant on a 95% level and validates hypothesis H_3. However, the regional indicator shows that this factor proves to be highly significant for cities in the eastern provinces and not significant for the other two regions. The higher the ratio of roadway is to the total size of the city, car ownership levels rise. The values for population density do not show signs of significance throughout the country and therefore void hypothesis H_1. Percentage of employment in the service sectors also does not indicate any explanatory value to car vehicle populations in Chinese cities. Consequently, hypothesis H_5 cannot be validated. In regard of the other transportation modes the number of public transportation vehicles and taxis are not significant determinants of urban car populations. However, looking only at cities located in the eastern region, public transportation vehicles do have an expected negative impact on a minor significance level. Surprisingly, the number of taxis has a highly positive and significant impact in cities located in central China. Thus, hypothesis H_4can neither be fully validated nor denied.

However, the variable of the city's total population shows high levels of significance for the total model and also significance for the western and central regions of China, although at a low level. As previous literature only found the population density of the city as crucial determinant of car ownership, the overall size of the population has been disregarded. This finding indicates that the overall size of the city has a negative impact on private vehicle populations. Noticeable are the results when compared among the three regions in China. Especially, the estimates for the eastern China and central China model are diametrical different. In the model for central China, the variable taxi per 10000 people proofs highly significant and total population shows low significance. The region model for eastern China however finds estimates for roadcity highly significant and public transportation vehicles per 10000 people at low significance. For the western China model, no variables except for total population show signs of significance.

5. Discussion

The findings of the regression model have presented some interesting results which need further discussion. Why is the car population not determined by other means of transportation? Why is the population size significantly impacting private vehicle levels? Why is GDP per capita not a significant estimator and why has the total population a negative impact on private vehicle populations instead of population density? This chapter is going to shed some light into the confusion spread by the findings of the regression.

5. 1 Chinese Political Institutions

One should not underestimate the size of China. China is a big country and has extreme variations across the country. Not only do they differ in geographic, economic and social terms, also the administration of the country is fragmented. As the national government decides on policies, it is the responsibility of local government authorities to implement those standards. However, the methods to achieve these goals are free to choose for local governments, hence leading to heterogeneous legislation across the country. Thus, the transportation environment is strongly influenced by institutions that are locally in place (Peng et al., 2012).

Hao et al. (2011) finds different structures of private vehicle ownership due to local policies. In the case of Beijing, policies from 2008 restricted vehicle use to certain days of the week according to their tail number on the license plate to decrease congestions. Also special private vehicle use restrictions during the Olympic Games created a shift away from car usage to the use of the metro and bicycles. Also, a high degree of car pooling which means the coalition of commuters increased the efficiency of roadway usage (Yan et al., 2009). At the same time, it has been calculated that thirty percent of all car sales in Beijing were car purchases for a second car to bypass those restrictions. In the case of Shanghai, the issuance of license plates by auction has been introduced as early as 1994. The purchase of a license was 50,000RMB on average and thus made up a decisive share of the in some cases more expensive than the car itself. This implicated a large disincentive for car purchase and increased the share of luxury cars on the roads (Chen & Zhao, 2013). Li et al. (2010) supports this proposition that license fees have a significantly negative impact. In their survey conducted in Beijing, Yi and Zhang (2010) discovered that an increase in gasoline prices would convince 50.6% of the respondents to reduce their car usage and use other transportation modes, motorized and non-motorized, instead.

Certainly, reductions in car usage and travel distance of private cars were the case, especially for leisure and shopping. However, comparing price peaks in gasoline prices during the intensive motorization phase of other countries, for example market and consumers have changed to more fuel-efficient smaller cars instead of derogating the usage of private transportation (Wang et al., 2011; Dargay et al., 2007). This variety of implementation presents a challenge for measurability and thus no appropriate determinant was implemented in the econometric model. However, a possible assertion can be that cities with a higher urban population are more affected by congestion and traffic problems and thus take measures to curb private vehicle populations based on the models of Shanghai and Beijing.

Manhattan in the United States is given as an example by Liu and Guan (2005) which has an extensive subway and bus transit infrastructure. It is a model example that even in the country with the highest car ownership ratio in the world thoughtful urban planning can lead to improved travel behavior and have a positive impact on the urban environment in the near future (Zhao, 2011).To provide the best and most efficient mobility service possible, the city of Chengdu has created an administration for integrated transportation which coordinates all transport related issues across ministries to ensure a sustainable development of urban transportation infrastructure (Jiang et al, 2011; Chiao et al. 2007). The city of Guangzhou in the south-eastern province of Guangdong has implemented this approach successfully by incorporating the newly developed Bus Rapid Transit system into the existing public transportation infrastructure. The stations of the BRT are connected to stations of the Guangzhou metro lines and the BRT stations also have a bike sharing system and bike parking facilities, allowing better accessibility to and from the BRT stations (ADB, 2010). The cases of Guangdong and Chengdu show that the integration of transportation modes becomes highly important these days to improve the reduction of travel time and more coordinated flow of passenger traffic. Consequently, the communication among ministries and interaction across levels of governmental hierarchy are more important than ever before.

5.2 Economic Status and Form of the Chinese City

Especially the economic developmental status of the city does not seem to be a determinant of car ownership levels in China. One possible explanation is that previous research has mainly focused on time-series data. By looking at regional development over time GDP per capita has proven to have a positive impact on car ownership levels. However, the effect across cities is only marginal as one has to distinct between varying legislative environments and social attributes.

Previous literature states that with time and increasing wealth private vehicle population levels rises. However, comparing cities at a specific point in time does not give indication of a static relationship connected to GDP per capita. As Dargay et al. (2007) find that growth patterns of private vehicles are associated with the level of GDP per capita, it does not express that a certain level of GDP per capita indicates a certain level of car population. The percentage of employment in the service industry is not a sufficient reference to explain passenger vehicle ownership. Thus, general shares of industries do not significantly influence transportation choices. In terms of commuting, the concept of a central business district is not accurate anymore and has to be adjusted for more complex scenarios. The development of industrial areas or satellite communities changes the transportation system but also offers the opportunity for an integrated transportation network and urban planning infrastructure (Yang & Gackenheimer, 2007). As industries locate themselves differently in urban areas based on various factors like availability and cost of land, proximity to suppliers and industry clustering, it might be possible that the inclusion of more detailed factors can specify the interaction of certain industries and the choice of transportation modes. Crane and Chatham (2003) suggest for the industries in the United States that being located in the outskirts of a city may benefit its employees by lower traffic congestion which entails shorter commuting time. In the case of China, Baum-Snow and Turner (2012) find that cities with higher population growth grew more rapidly in its physical size leading to a decentralization of residential area. Especially affected by those developments are low-income and migrant workers who are forced to move to the periphery of the cities and consequently have lower access to job opportunities. Fan et al. (2014) find in the case of Beijing that city-center oriented public transportation created a mismatch with spatial developments of residential areas. With a change in size and form of a city, the modes of transportation change respectively. The multi-center layout of the city reduces travel time and distance as goods get closer to the vicinity of the consumer (Yang & Gackenheimer, 2007). This form increases the practice of short and micro trips and encourages the use of non-motorized transportation. Wang et al. (2010) find that more than half of their survey respondents use public transportation due to direct connection to the shopping facility. Nonetheless, bad weather or other reasons would change their mode of transport to private vehicles.

However, to better understand the interaction between transportation and urban form the intentions of travel have to be distinguished: shopping, leisure and commuting. For shopping trips, shopping locations have to be identified and distance matched to residential areas. The same goes for leisure activities. The allocation of workplace and residential areas has to be better understood through an analysis of commuting time and distance by transportation modes to the workplace. Also the number of working members of a household should be considered as commuting behavior and residential location may differ with several working members due to compromising (Baum-Snow & Turner, 2012; Crane & Chatham, 2003).

5.3 The Status of the Car

The perception of foreign car brands controlling large parts of the market over decades has created a strong image of high quality foreign cars and made the car a desirable mode of transportation in China. Until today, Chinese people view the quality of cars produced by Chinese automobile manufacturers as below standard and not safe. Also the design is based on western car brands and thus may motivate customers to purchase the original product rather than the copycat (Xinhua, 2014). This perception is so deeply engrained in Chinese citizen's minds that even attempts of the national government to revive its Chinese luxury car brand 'Hongqi' were not able to change the purchase behavior of its own citizens (Xinhua, 2014). Although, foreign brands are situated in the premium segment which only accounts for a minor share of the total automobile sales in China, the demand for those products is still unstoppable (Kwong, 2014). This raises the question if the choice of transportation mode is always based on a rational decision.

Private car ownership has been only permitted since the start of the economic reforms and rapidly became one of the most widely known status symbol for the wealthy (Cullinane, 2002). After decades of communism and conformity Chinese people seek to become detached from their past. The quote of Deng Xiaoping to let some people become rich first at the beginning of the market reforms triggered an unbalanced distribution of wealth leading to a diversification of society. As wealth in China becomes a matter of public display which contributes to enhance the concept of 'face', status symbols are a very common practice to display wealth (Zhou & Hui, 2003). Part of the modernization process is the adoption of visible status symbols to define ones character and social status, thereby locating the owner into a specific social group which he wants to be associated with. Materialistic values grow especially among the population group which enters adulthood (Chan et al., 2006). A group surveyed in Hong Kong by Cullinane (2002) stated that the choice of transportation mode was not a matter of status. Though, Zhu et al. (2012) find a high degree of psychosocial value of cars among Chinese university students. In their perception car ownership expresses a symbol of success and achievement.

However, the decision to use public transportation is also based on the subjective perception of the quality of its service. The survey of Cullinane (2002) finds that if public transportation is perceived as good and low-priced, the demand for car ownership decreases. Nevertheless, Paulley et al. (2006) also discovered a high price-sensitivity of public transportation fares and price elasticity increasing for short distance travels by rail. Wang et al. (2013) also finds that commuting by private car in Shanghai provides a reduction in travel time as well as a more comfortable travelling. Commuting by public transportation on the other hand provides cheaper transportation cost and more relaxation. Naess (2013) finds for the case of Hangzhou that the rationales influencing the decision of transportation mode are the factor of time-saving and comfort. Nonetheless, there are situations where a specific mode of transport is suitable. As certain occasions require a specific etiquette, especially in the Chinese business world, the arrival by other means of transport than a limousine car would indicate a loss of face in front of the business partner. Hence, particular modes of transportation do have image enhancing characteristics. As a result, the psychosocial value of transportation mode choice may outweigh the rationally best option of transportation (Zhou & Hui, 2003; Zhu et al, 2012).

5.4 Expansion of Urban Transportation modes

Public transportation vehicles and taxis did not have a significant impact on car ownership levels. The explanatory of the findings for other motorized transportation is limited as other motorized transportation modes have not been included in the model due to data constraints. However, the overall insignificance of other motorized transportation modes than private vehicles is supported by Li et al. (2010) who find the availability of metro systems in Chinese megacities insignificant. Also, non-motorized travelling like biking or walking also make up an essential part of the transportation mix which has to be considered (Jiang et al, 2011).

To counter traffic congestions and provide a better transportation infrastructure, some cities in China implemented bike sharing systems. The bike docking stations are located near popular spots or metro stations and allow commuters and tourists to cycle to their destination. Hangzhou has been selected for having one of the world's best city bike sharing infrastructure. However after years of motorization, bicycle lanes have given way to the car masses and existing biking lanes are often used by car owners as parking space, reducing the available bicycle lane even further (Liu, 2011). However a reversion of this trend is foreseeable as other modes of transportation enter the urban landscape. In the attempt to reduce dependency on gasoline and improve urban air quality, electric propulsion systems have been introduced to the Chinese market in form of electric bikes. Already in 2005, 10 million electric bikes were operating on Chinese roads. Due to their low operation cost and their low purchasing price, they provide the cheapest form of private motorized transportation (Cherry 2007).

As advanced those current developments might sound, one shall not forget that China has undergone great changes in a very short period of time. During the transformation process the agenda was to modernize the economy as fast as possible. This implicated that projects with a high long-term value but a low short-term result, for example underground metro-systems, to be suspended. Nowadays, they are considered as a feasible solution to mitigate future urban transportation challenges (Shih, 2012). By the end of this decade 38 cities will have at least one metro line. Additional metro and tram infrastructure projects are planned to build the world's largest urban rail infrastructure, increasing current urban railways tenfold by 2050 (Economist, 2013).

6. Conclusion

Urban transportation is a complex network of various transportation modes. The number of cars on city roads is therefore a part of a bigger transportation system that offers different options to reach designated destinations in the most time efficient and convenient way possible. This thesis examined the factors determining the population of passenger vehicles in Chinese cities. An OLS regression using cross-sectional data has been used. Hypothesis testing has revealed that most assumptions of private car ownership are insignificant on national level. Population density, per capita GDP and the share of tertiary industry of a city could not be detected to have an impact on car ownership levels in Chinese cities. However, the econometric model proved the significance of roadway to the physical size of the city on private vehicle populations. Thus, the availability of road space encourages car ownership. This availability is also significant for cities in the eastern region but insignificant for cities in other regions. Furthermore, the total number of the urban population was found to have a significantly negative impact on car ownership levels. A possible explanation for the negative relationship suggests that urban traffic issues intensify with increasing according to population increases, so legislation has taken measures to influence car ownership levels. Nevertheless, other modes of transportation did not have a significant impact on urban car populations. This indicates that the growth of cars is independent of the total transportation mix, and reasons for car ownership growth have to be found elsewhere. The purchase of a car and its usage may to a certain extent be motivated by the perception of prestige and status. Acquiring well-known brands, mostly foreign products, is a tangible symbol of a certain lifestyle and helps raise one's social status. Thus, the possession of a private vehicle has deeper meaning than simply a mode of transportation.

However, strong regional variances indicate fundamental differences in the impact of the designated variables on private vehicles. Hence, more attention has to be paid to the regional characteristics of Chinese cities. An extension of the model incorporating the legislative environment on car ownership and a more detailed indicator for residential areas and social and economic activities will give information on the impact of urban form and economic status of the city on private vehicle populations. Further, the inclusion of other modes of motorized transportation as well as non-motorized transport would help to specify the current model and become factors of measurement to determine passenger vehicle levels in Chinese cities.

Urban transportation is and will continue to be an important topic for urban life and has the potential to fundamentally contribute to the quality of life in the present and the future. If all transportation modes become integrated into an urban mobility concept, travel speed, travel time, and travel distance can be significantly reduced, particularly as half of current travel time is spent on waiting time (Jiang et al., 2011). Above all, public authorities need to take an integrated approach to urban transportation infrastructure to adapt to contemporary developments and mitigate future transportation challenges. Future research can help to reveal the effects on car ownership in the dynamic and fast growing economy in China to balance private and public transportation in Chinese cities.

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Appendix

Dataset (Cities sorted by Province)

Province	City
Anhui	Anqing, Bengbu, Bozhou, Chaohu, Chizhou, Chuzhou, Fuyang, Hefei, Huaibei, Huainan, Huangshan, Liuan, Maanshan, Suzhou, Tongling, Wuhu, Xuancheng
Fujian	Fuzhou, Xiamen
Gansu	Baiyin, Dingxi, Jiayuguan, Jinchang, Jiuquan, Lanzhou, Pingliang, Qingyang, Tianshui, Wuwei, Zhangye
Guangdong	Chaozhou, Heyuan, Huizhou, Jiangmen, Jieyang, Maoming, Meizhou, Qingyuan, Shanwei, Shaoguan, Yangjiang, Yunfu, Zhanjiang, Zhaoqing, Zhongshan, Zhuhai
Guangxi	Baise, Beihai, Chongzuo, Fangchenggang, Guigang, Guilin, Hechi, Hezhou, Laibin, Liuzhou, Nanning, Qinzhou, Wuzhou
Hainan	Haikou, Sanya
Hebei	Baoding, Chengde, Handan, Hengshui, Langfang, Qinhuangdao, Xingtai, Zhangjiakou
Heilongjiang	Daqing, Hegang, Mudanjiang, Qiqihar, Qitaihe, Shuangyashan
Henan	Anyang, Hebi, Jiaozuo, Kaifeng, Luohe, Luoyang, Nanyang, Pingdingshan, Puyang, Sanmenxia, Shangqiu, Xinxiang, Xinyang, Xuchang, Zhengzhou, Zhoukou, Zhumadian
Hubei	Huanggang, Huangshi, Jingzhou, Shiyan, Suizhou, Xiangfan, Xianning, Xiaogan, Yichang
Hunan	C hanged, Changhsha, Chenzhou, Hengyang, Huaihua, Loudi, Shaoyang, Xiangtan, Yiyang, Yongzhou, Yueyang, Zhangjiajie, Zhuzhou
Inner Mongolia	Baotou, Bayannaoer, Chifeng, Hohot, T ongliao, Wuhai
Jiangsu	Changzhou, Huaian, Nantong , Suqian, Taizhou, Xuzhou, Yancheng, Yangzhou, Zhenjiang
Jiangxi	Ganzhou, Jian, Jingdezhen, Jiujiang, Nanchang, Pingxiang, Shangrao, Xinyu, Yichun, Yingtan
Jilin	Baicheng, Changchun, Jilin, Liaoyuan, Siping, Songyuan, Tonghua,
Liaoning	Anshan, Benxi, Chaoyang, Dalian, Dandong, Fushun, Fuxin, Huludao, Jinzhou, Liaoyang, Panjin, Tieling, Yingkou
Ningxia	Guyuan, Shizuishan, Wuzhong, Yinchuan
Qinghai	Xining
Shaanxi	Ankang, Baoji, Hanzhong, Tongchuan, Weinan, Xianyang, Yanan, Yulin
Shandong	Binzhou, Dezhou, Jinan, Jining, Laiwu, Liaocheng, Linyi, Qingdao, Rizhao, Taian, Weihai, Yantai, Zaozhuang, Zibo
Shanxi	Changzhi, Datong, Jincheng, Jinzhong, Linfen, Lvliang, Shuozhou, Taiyuan, Xincheng, Yangquan, Yuncheng
Sichuan	Bazhong, Dazhou, Deyang, Dongshan, Guangyuan, Luzhou, Meishan, Mianyang, Nanchong, Neijiang, Panzhihua, Suining, Yaan, Yibin, Zigong, Ziyang
Yunnan	Baoshan
Zhejiang	Huzhou, Jiaxing, Jinhua, Lishui, Ningbo, Quzhou, Shaoxing, Taizhou, Wenzhou, Zhoushan