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Water Pollution in China

- Study on the relationship between economic development and water pollution

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Executive summary

This dissertation was commissioned to study the relationships between water pollution (WP) and economic development in China. Our goal is to explain a vicious cycle of water environment and economy, and analyze the solution of WP.	Terms of reference statement of problem/topic
The thesis used questionnaires as a main method of data collection. We surveyed four different areas in China, collected data about the economic situation and the pollution volume. The related data is analyzed by Chi-square test. Through the results of tests we got lots of findings.	Methods and analysis
The key findings show that there is difference depending on areas and WP. The population distribution and economic development influence the level of WP. The results also proved that there is relationship between WP-levels and economic loss. Faced huge loss caused by WP, we point out some solutions.	Key findings summarized
About solutions, we supplied four recommendations to the Chinese government. There are as follows: 1. Improve financial support, administrative management and legal safeguards. 2. Increase the engineering and technological support. 3. Strengthen the municipal management measures. 4. Encourage public participation in water protection.	Recommendations summarize

Abstract

Purpose/aim The purpose of the research is to analyze the relationship between water pollution (WP) and the economic development in China. We found a vicious cycle that at the same time as China's economy has developed; the WP has become the focus of attention, and has also caused huge economic losses. Faced with this situation, this topic is really worth to study.

Design/methodology/approach The research adopted a quantitative methodology for the exploration, and conducted a survey through questionnaires which were answered by different people. These respondents come from four areas in China. After having conducted the survey, we selected three typical provinces as representative for each area, and surveyed the basic information about these places. The sample information was calculated by the Chi-square test. The results will be analyzed together with the findings below.

Findings The findings indicated that through an analysis of GDP, population, the economic development level and the degree of WP, there is relationship between economic development and WP. When people ignore the problem of WP, and just focus on the economy, the relationship shows that the more developing of economy, the more serious the WP becomes.

Originality/value The original idea in our dissertation is to discuss the relationship between economic development and WP in China. The water problem and economic development form a vicious circle. And it seriously affects the whole China. The study has a value for the improvement of the environmental awareness of all the people in China, and advocates the government to develop the economy, and at the same time protect the water sources.

Key words: Water pollution, economic development, urbanization and industrialization, Chi-square test, GDP, population

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Ch 1. Introduction

Chapter 1 will introduce the current situation and basic structure of this dissertation, and also include the research questions.

In China, rapid development of economy has caused serious environmental pollution. Usually, these pollutions will last for a long period of time, and become the important factors which constrain the country's economic development. Faced with many kinds of environmental problems, this thesis chose the water pollution as a subject, and introduces its basic situation in the following part.

In recent years, water pollution (WP) in China has become more serious. Especially since 1979, when China went into the era of economic reform, and the government adjusted the structure of market competition, it started to open the door, frequent to trade with other countries. At the moment, there is a booming population in China and the new factories emerge in an endless stream. The huge amount of polluted water sprung up in China bringing diseases and a lot of losses that make the government panic.

Zheng, B. F, *et al* (2008) mentioned that in developing countries, water scarcity and pollution problems are more prominent than in developed countries, because of the rapid economic growth and population explosion. So, in China, although the economy growth is fast, compared to developing countries, the economic loss caused by WP is still prominent. According to the survey, in 2008, the economic losses by WP cost the government approximately 1% of GDP in this year (Meier, S & Tra, R, 2008).

Claimed by the researchers Wang, M. *at el*. (2006), China's extraordinary economic growth, industrialization and urbanization, coupled with inadequate investment in basic water supply and treatment infrastructure, have resulted in widespread WP. With the industrialization and urbanization, the water quality continues to deteriorate. Human health and economic development have been severely affected. The direct influences by WP include the losses in industry, agriculture and fishery. The indirect

influences of WP mainly include the loss of human health.

Facing the complicated relationship between WP and economic development, this dissertation focuses on the two sides to study. On the one hand, we will analyze the influence of the population and geographical factors on the WP-levels. On the other hand, we will research the relationship between WP and its economic losses. Through this research, the thesis will present three contributions:

I. It provides the evidence about the dangers and losses of WP and through this paper remind people to protect the water sources.

II. It proves the relationships between WP and economic development. Also it provides a scientific theory for the government and reminds them to pay more attention to the pollution control.

III. It shows the importance about keeping the balance between future development and environmental protection.

The dissertation is structured as follows. 1) According to the topic we make two hypotheses. 2) We using questionnaires to collect the data and calculate related data by the Chi-square test. 3) Get results of the Chi-square, questionnaires and the related findings 4) Discuss and analyze these results combined with different areas information, and also discuss the control methods of WP in the future. 5) Summarize the whole thesis and evaluate reliability and validity of this thesis.

1.1. Problem

The research question in this dissertation is: *Is there any relationship between WP and economic development?* The report extended this question to two aspects. One is depending on the impacts of geographical factors. Another is researching the relationship between WP and its economic losses.

1.2. Purpose

Our purpose is to research the relationship between WP and economic development in China. The analysis of the relationship can help to solve the problem with WP.

1.3. Limitation

The thesis focus on water environment in China, so there is a limitation that the results and suggestions of this thesis maybe cannot be used in other countries. Another limitation is that we divided China into only four parts (east, west, north and south).

1.4. Outline

The thesis is through the seven chapters show the results we found. First, introduce the basic information of the WP in China. Then we use more words to describe the history and background, and add the related literatures. In chapter 4 we point out the main hypotheses and use Chi-square test calculate the results. Then chapter 5 was presented the analysis of these results. Through this analysis we get new point and the discussion of this point was shown in chapter 6. The last part is a conclusion of this whole thesis and the suggestion for the future research.

After this introduction, the following content is the background and history of WP in China.

Ch 2. Background

This part presents the background of WP in China.

With industrialization and urbanization, the Chinese government expands the trade markets continuously. In addition to owning factories, foreign countries also build many factories. The increase of industrial buildings has brought a huge amount of industrial wastewater. According to China Environmental Quality Report, (China Environmental Protection Administration, 2012), in 2011, the total polluted water emission in China was $659.2*10^8$ tons, where 35% of the polluted water came from the industry. Most of these factories were built in the coastal areas. The wastewater of these factories was usually discharged directly to the nearby sea. Even the government makes many policies to stop factories discharging wastewater into the sea without treatment. The execution of the government regulation policy cannot be as effective as we expected. Until 2011, the East China Sea received direct emissions that are beyond $27.02*10^8$ tons, Zhejiang, Guangdong and Fujian are the biggest emitters (China Environmental Protection, 2012; Institute of Public & Environment Affairs (IPE)-China Water Pollution Map, 2011). Generally, the coastal provinces are relatively developed, so until now, China is still in the stage of sacrificing the environment to develop the economy.

We will take Guangdong (southeast province in China, near the South China Sea) as an analysis sample. Through two figures, we can see the GDP changes in Guangdong and its polluted water volumes during 2005 to 2009. (Yi=10^8 CNY)

Observing figure 2.1, it's easy to find that during 2005 to 2009, every year the GDP value in Guangdong increased. The highest growth rate was presented in 2007 and it has slowed down since 2008. Figure 2.2, this table introduced the changes of total the volume polluted water in Guangdong, 2005 to 2009. Watching this table, the highest volume was also presented in 2007, and after that, the volumes began to fall.

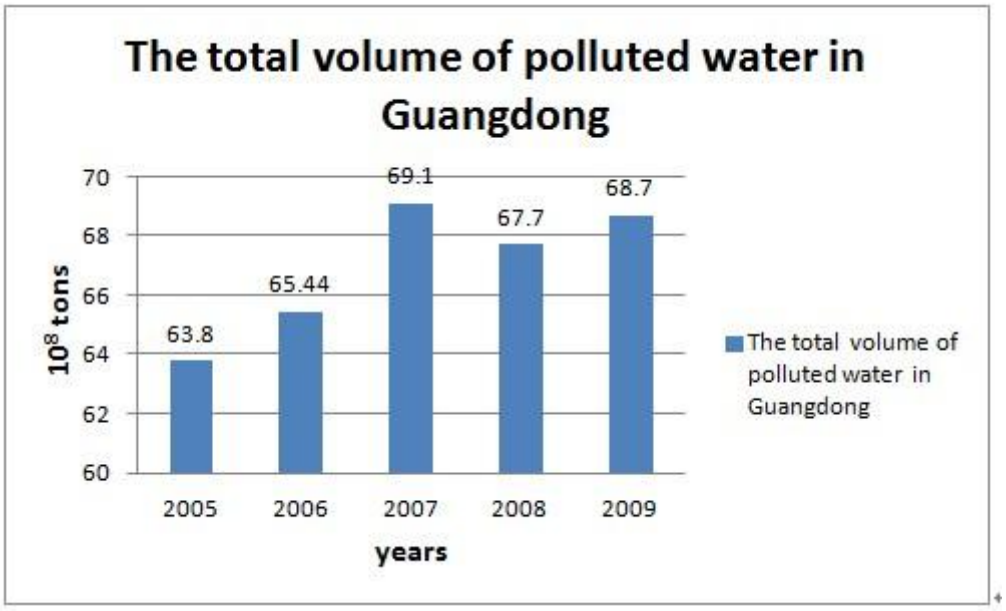
Through the tables we found that the volume of polluted water is depending on the

speed of economic development.

Figure 2.1 Total GDP value and growth rate in Guangdong 2005-2009

(National Bureau of Statistics of China)

Figure 2.2 Total volume of polluted water in Guangdong 2005~2009



(Institute of Public & Environment Affairs (IPE)-China Water Pollution Map)

Except these seaside cities, other cities also have varying degrees of WP. Rivers and lakes are the main receivers of these cities' wastewater. In 2011, the government surveyed the water quality in 194 rivers. They found that the water quality in most of

these rivers is poor. 27.8% of them are class[12] IV~ V and 27.3% of them are lower than class V (Institute of Public & Environment Affairs (IPE)-China Water Pollution Map, 2011; China Environmental Protection, 2012).

What is said above all it is proved that industrialization and urbanization can cause more polluted water. In fact, the WP also restricts the development of economy and human health. The economic loss as the result of water pollution each year was widely believed to be about 0.8-1.5% of China's GDP (OuYang, Z. Y& Wang, R. S, 2000). According to the World Bank (2007), in the period from 2000 to 2003, the government controlled about $25*10^8$ m^3 of the polluted water, the value of 1 m^3 water is 1-5 CNY, and the total cost of this polluted water is up to 2.5-12.5 billion CNY. In Shanghai, 90% of the water in urban areas was polluted. People in cities were under the threat of losing their clean drinking water (OuYang, Z. Y& Wang, R. S, 2000).

Here shows the economic losses caused by WP in different sectors.

A. Agriculture

The total domestic sewage in 2010 was $329*10^8$ m^3. Polluted water caused millions of tons of loss grain, and 10% of the grain could not reach the government standard (IPA-China Water Pollution Map, 2013).

The total economic loss in agriculture in 2003 was about 1 billion USD, it equaled to 0.05% of GDP (Meier, S & Tra, R, 2008). Here we collect the rate of the agriculture losses in the different classes in the table below.

Table 2.3 Rate of economic losses in different agriculture classes

Classes	Grain	Vegetable	Meat	Eggs	Milk
Rate of AEL	12%	17.6%	8.6%	19%	2%

AEL: Agriculture economic losses (OuYang, Z. Y& Wang, R. S, 2000)

[1] According to Surface Water Quality Standards of P. R. China, the government uses five levels to divide the water quality. I is the source of water, it belongs to the National Nature Reserve. II is the source of drinking water. III is the substitutes of drinking water source. The levels under the III are not good for human body. (China Environmental Protection Administration, 2002)

B. Fishery

The fisheries suffer a lot of direct and indirect loss from WP. Large numbers of dead fish, crabs or shrimps will pollute rivers and lakes again, like a vicious cycle. In 2003, a total direct economic loss in the fishery sector was 0.713 billion CNY, and the indirect loss up to 3.6 billion CNY (Meier, S & Tra, R, 2008)

C. Human health

Wastewater pollutes plants and animals, causes diseases, and threatens the human health. Every year the economic loss of the health problem caused by WP is up to $236*10^8$ CNY (OuYang, Z. Y& Wang, R. S, 2000)

D. Industry

Claimed by World Bank in 2007, 20% of the polluted water belongs to the industry. If the government finds highly polluting factories, they will require them to close the factories. That make people lose their jobs, and stopped production causes money loss. For instance, the WP, Chongqing Yongchuan Silk- Making Plant stopped the production in 1995. Thus it bears economic loss of 50.2 million CNY. Industry polluted water makes the government bear 50 billion CNY of economic loss every year (Meier, S & Tra, R, 2008).

Overall, in China, the WP and the economy are interactional. This point also is confirmed by many researchers. Their scientific articles as the literatures will be presented in the next chapter.

Ch 3. Literature review

The scientific literatures which discuss the same topic as this dissertation are presented in this part.

In the chapter 2 we argued two sides to prove the relationship between WP and economic development. One is the economic loss from WP. Another is the negative impacts of urbanization and industrialization on water quality. In this chapter we collected many scientific articles for further studies. The authors of these articles point out many different views but they are all related to the two sides we talked about before. These views are presented below.

3.1. Economic loss from WP

Some parts of this dissertation are built on the work of Meier, S and Tra, R (2008). They claimed that in China still half of the population is facing the safety problem of drinking water. If you know the population situation in China, you will understand how horrible this problem is. On the other hand, WP as a growing problem costs the Chinese government too much money. The article also mentioned: the harm of water pollution that cost a lot of money has approximately the amount of $147*10^9$ CNY. It is about 1% of the GDP in China. Even the control methods of WP also cost the government too much money. In the period from 2000 to 2003, the costs in China were more than $25*10^9$ CNY to suppress polluted water (World Bank, 2007).

3.2. Economic impacts in different cities by WP

Shanghai is one of the cities we surveyed. As China's economic center, the problem of WP in Shanghai is notorious. Xu, B & Liu, Y (2013) claim that in Shanghai, the loss in plantation by WP is up to 0.516 billion *RMB* and the loss in fishery from WP is 0.274 billion CNY.

He, H. M *et al*. (2007) said that in Xi'an, the most important city in north of China, the economic loss caused by WP from 1996 to 2003 reached $6.096*10^9$ CNY. The total economic loss of agriculture in 2003 has doubled in the past seven years. The

author pointed out that people can't overlook the negative impacts of WP. The people have no awareness of the economic impact and health problems that are caused by WP.

3.3. Impacts of urbanization and industrialization on water quality

With the urbanization and industrialization, China's population is booming. Too many buildings spring up. After controlling the effects of government efforts and socio-economic environments, the regression analysis shows that both the population size and the population growth have significantly negative impacts on water quality (Ito, C, 2005). Since the 1970s, China's population in urban areas has almost doubled from 1978 to 1995, the population has grown fast, and urbanization emerged rapidly. At the same time, the WP became more serious. Much of the untreated industrial wastewater is dumped into rivers and lakes, and even the government made the policy that the industry must treat their wastewater. (Ito, C, 2005) Huge amounts of polluted water bring the disease and economic loss, and threaten human health and development. In order to achieve the stable development, people need to balance the economic development and environment bearing capacity. (Yan, Z. P & Wei, Q, 2000)

These literatures have presented many different views, some from the macro perspectives talk about the harm of WP in whole China, and some analyzed different cities. Most of their opinions claimed that there is a relationship between WP and economic loss. However, this dissertation needs more scientific methods to prove this relationship, and here we start from the microscopic view, to study the relationship between WP and areas.

The next chapter will describe two hypotheses, which are about areas, WP and its economic loss. The contents also include methods of data collection and statistic test.

Ch 4. Empirics

The key point in chapter 4 is building the hypotheses, and through the statistic test proves the reliability of them.

The first step of this part introduces the main hypotheses of the thesis. Then we describe the method of data collection. The data prepare for the statistic test. Through the test we can prove their reliability. The sample and operation of this survey will be presented after the hypotheses, and the related data were calculated by the Chi-square test. The final step of this part is the introduction of some findings about the typical provinces in different Chinese areas.

4.1. Hypothesis

In China, the polarization is serious. Each province has a different speed of development. For example, the east-coastal area in China is a highly developed area. In the year 2000 the level of urbanization was 66.17%, near twice the size of the average urbanization level in whole China (Yan, Z. P *et al*, 2000). These developed provinces always have a large population but the acreages of these places are not so big. Conversely, some sparsely-populated western provinces account for 50% avreage of the whole land, like Xinjiang, Tibet, Gansu and Qinghai (National Bureau of Statistics of China, 2009-2010). These places are poor and backward, but always have a better environment. So, different areas have different economy, population and acreage, and these factors influence the environmental quality. That's why the relationship between areas and WP is worth to discuss. Here the dissertation makes the first hypothesis:

1) H_0: There will be no difference of water pollution in different areas.

   H_1: There will be a difference.

In China, the eastern, southern and northern areas have a better situation of the economic development, but at the same time they have a serious WP. The WP-level in the west of China is significantly lower than in other places. However, in 1997, Zheng,

Y. S *et al.* pointed out that in the east of China, the economic losses caused by WP is nine times bigger than in the western area. Only through this information it's easy to find that serious WP can bring more economic loss. But from a strictly scientific standpoint, we still need to prove it. So the dissertation has another hypothesis:

2) H_0: There will be no difference between the WP-levels and economic loss.

H_1: There will be a difference

In order to prove the hypotheses, the thesis prepared the questionnaire to collect related data. The sample and operation of this survey are shown next.

4.2. Method

I. Sample

The subject of this research is about WP and its economic loss in China. The data were collected by using questionnaire survey, and respondents come from four areas in China, i.e.: they come from east, west, north and south (Details about the questionnaire are presented in the Appendix). The main content of the questionnaire is asking people their opinions about water quality in their living environment. In order to decide the number of respondents, we used the following formula to calculate:

$$M = Z\sqrt{\frac{\pi(1-\pi)}{n}}$$

Suppose the margin error (M) is equal to 6%, the confidence level is 95%, and the corresponding P-value (Z) can be found in the table B (Agresti, A & Finlay, B, 2009,). It is 1.96. If we need at least 50% of the respondents to support this hypothesis (π), the total number of respondents will be calculated like this:

$$1.96\sqrt{\frac{0.5(1-0.5)}{n}} = 0.06$$

n≈267, so this questionnaire needs at least 267 effective feedbacks.

II. Operationalization

According to the result of the calculation above, we surveyed 335 respondents, and 16

of them are not Chinese. In order to make respondents understand the questions, this questionnaire is translated into English and Chinese. We used many different ways to collect our survey responses. The main ways include sending E-mails, website, making phone calls, and face to face interviews. Some feedbacks need time to collect, however some we can get immediately. The survey took about one month, and finally we got 280 effective feedbacks.

With the careful organization and analysis, we found that not all the data can be used in the statistical test. Only part of the data can be calculated by Chi- square test. This data influences the hypotheses in a direct way, like the levels of WP, the samples distribution, and the level of economic losses. The test is compared with observed values and expected values to get results. If the final result is bigger than the significant level, we accept H_0, otherwise, we reject it.

III. Sample description

We surveyed 335 respondents, of which 280 feedbacks were effective. Here is the basic information of these 280 respondents. All this information is from the results of the questionnaires.

Table 4.2.1 Results of question 1, 2 and 3 in the sector one

Question	Option	Numbers	Percentage
Q1.	Female	148	53%
	Male	132	47%
	Total	280	100%
Q2.	Under 24 years	80	28.6%
	25-34 years	96	34.3%
	35-50 years	63	22.5%
	Above 51 years	41	14.6%
Q3.	High school	55	19.6%
	Bachelor or junior colleges	158	56.4%
	Master or above	67	24%

Table 4.2.1 presents the basic information about the respondents. The total number of respondents is 280, of which 53 percent are female, and there are 132 respondents that are male. In order to avoid the bias from gender, the numbers of male and female are similar.

All of the respondents are younger at age. More than 60% of the respondents are younger than 35 years. Most of the respondents are Chinese, and 16 of them are Swedish. There are 158 respondents that have one or two bachelor degrees. 24% of the respondents have the master. High education backgrounds make their opinions more reliable. But we still need some other representative, so there are 55 respondents that just graduated high school.

Table 4.2.2 Results of question 1, 6 and 10 in the sector two

Question	Option	Numbers	Percentage
Q1.	East	68	24.3%
	West	72	25.7%
	North	67	24%
	South	73	26%
Q2.	Under 3000yuan	58	20.7%
	3000-4999yuan	102	36.4%
	5000-9999yuan	79	28.3%
	Above 10000yuan	41	14.6%

The respondents' living place and their salary are presented in table 4.2.2. The numbers of respondents in these four areas are similar. It is to make sure that the deviation of the results is not too big. Through the salary, we can know the basic level of the economic development in cities where they are living. Most people earn 3000 to 4999 CNY per month. Only 20.7% of the respondents' salaries are under 3000 CNY each month, also just 15% of the respondent's salaries are under 10000 CNY each month, which means the economic level in China still has room to improve.

After sample selection and data collection, the related data will be calculated by Chi-square test, and the whole computational process will be shown below.

4.3. Chi-square test

Here is the process of Chi-square test for the first hypothesis, the related data shows in the table 4.3.1.

Table 4.3.1 for 4 areas and WP

Table 4.3.1 Result about survey the WP-levels in four areas in China

Area / WP-level	East	West	North	South	Total
Serious (V~ under)	50 *(32.5)*	7 *(35.8)*	41 *(32.5)*	34 *(31.1)*	132
Normal (III~IV)	14 *(19.2)*	21 *(21.2)*	18 *(19.2)*	25 *(18.4)*	78
No serious (I~II)	5 *(17.25)*	48 *(19)*	10 *(17.25)*	7 *(16.5)*	70
Total	69	76	69	66	280

I. Null hypothesis:

H_0: There will be no difference depending on WP-levels and areas.

H_1: There will be differences.

II. Statistical test:

$$\chi^2 = \sum \frac{(f_0 - f_e)^2}{f_e} = \frac{(50 - 32.5)^2}{32.5} + \cdots + \frac{(7 - 16.5)^2}{16.5} = 100.416$$

III. Significance level: 5%

IV. Sampling distribution: $df = (4-1)\times(3-1) = 6$

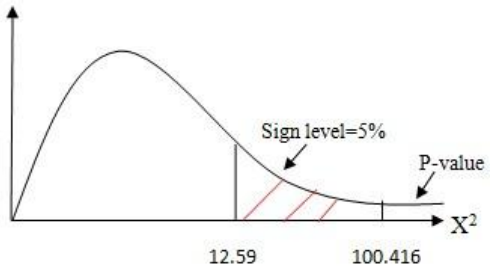
V. Rejection region: χ^2=100.416, df = 6, see the figure below.

χ^2 value here is much bigger than12.59. Significance level=5%, so the P-value of χ^2 is smaller than 5%, we reject H_0.

P-value $<$ 0.05 $\rightarrow$ reject H_0.

VI. Decision: We can prove that there are differences depending on WP-levels and areas.

Figure 4.3.1 Chi-square distribution values for various right-tail probabilities



(Refer to Table C, Agresti,A & Finlay, B, 2009).

The process of Chi-square test for another hypothesis shows below, the related data is presented in the table 4.3.2.

Table 4.3.2 for 4 areas and EL

Table 4.3.2 WP-level and the EL-level in four areas

WP-level / EL-level	Serious (V~ under)	Normal (III~IV)	No serious (I~II)	Total
High	87 *(55.75)*	28 *(25.06)*	6 *(40.19)*	121
Middle	33 *(25.8)*	16 *(11.6)*	7 *(18.6)*	56
Low	9 *(47.45)*	14 *(21.34)*	80 *(34.21)*	103
Total	129	58	93	280

(WP: water pollution. EL: economic loss.)

I. Null hypothesis

H_0: There will be no difference between the degree of WP and economic loss.

H_1: There will be a difference.

II. Statistical test:

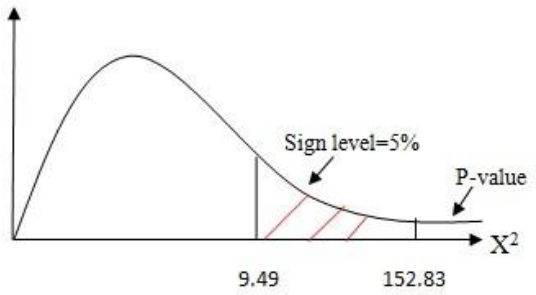
$$\chi^2 = \sum \frac{(f_0 - f_e)^2}{f_e} = \frac{(87 - 55.75)^2}{55.75} + \cdots + \frac{(80 - 34.21)^2}{34.21} \approx 152.83$$

III. Significance level: 5%

IV. Sampling distribution: df=(3-1)×(3-1)=4

V. Rejection region: χ^2=152.83, df = 4, see the figure below.

Figure 4.3.2 Chi-square distribution values for various right-tail probabilities



(Refer to Table C, Agresti,A & Finlay, B, 2009)

χ^2 value here is much bigger than 9.49. Significance level=5%, so the P-value of χ^2 is smaller than 5%, we reject H_0.

VI. Decision: We can prove that there are differences between the degree of WP and economic loss.

4.4. Findings in different provinces

The tables below show the basic information in 12 Chinese provinces. These provinces represented the four areas we surveyed. The information covered economy, population and volume of wastewater. All this information comes from IPA-China Water Pollution Map-2009 and National Bureau of Statistics of China, 2009-2010.

Table 4.4.1 Basic information about GDP, population and polluted water in some Northern provinces (2009)

Northern Provinces	**GDP growth rate Billion/%**	**Population (Million)**	**Polluted water (10^8 t)**
Hebei	2013.7 12.6%	67.82	27.53
Liaoning	1750 11.6%	41.62	21.80
Shandong	3816.5 10.9%	90.18	43.60
Total	7580.2	199.62	92.93

These three provinces belong to the Northern areas in China. The average rate of GDP-growth from 2009 to 2010 was 11.7%, and the total GDP value of these provinces in 2009 was 7580.2 billion Yuan (equal to 1110.25 USD). The total population was up to 199.62 millions. So the per capita GDP in these provinces was 37,973.15 Yuan.

In 2009, the total polluted water in the northern area was $92.93*10^8$ tons, and 47% of the emissions were from Shandong province. We can observe that compared with other two provinces, Shandong has the largest population and the highest GDP value, and also has the largest emission of polluted water.

Table 4.4.2 Basic information about GDP, population and polluted water in some Southern provinces (2009)

Southern Provinces	**GDP growth rate Billion/%**	**Population (Million)**	**Polluted water (10^8 t)**
Guangdong	4563.6 12.8%	72.23	72.3
Fujian	1360.1 12.3%	33.50	23.9
Yunnan	700.2 12.2%	41.76	14.7
Total	6623.9	147.49	110.9

These three provinces belong to the Southern areas in China. The average rate of GDP-growth from 2009 to 2010 was 12.43%, and the total GDP value of these provinces was 6623.9 billion Yuan (is equal to 970.18 USD). The total population was 147.49 million. We can calculate the per capita GDP in these provinces. It is 44,910.84 Yuan which is higher than in the northern area.

In 2009, the total polluted water in these three provinces was $110.9*10^8$ tons, and 65% of the emissions were from Guangdong province. Guangdong was the first province in China that opened the door, and traded with other countries in the world. It is a very important economic center in China.

We found that 49% of the total population in these three provinces belongs to Guangdong. Observing the population and the volume of polluted water in Guangdong, we can make a simple operation. Comparing the population and the volume of polluted water ($72.3*10^8$ tons÷72.23 million), we can find that in 2009, one person could produce about 10 tons polluted water in Guangdong. How horrible that is.

Table 4.4.3 Basic information about GDP, population and polluted water in some Eastern provinces (2009)

Eastern provinces	**GDP growth rate Billion/%**	**Population (Million)**	**Polluted water (10^8 t)**
Zhejiang	2700.5 8.9%	45.52	39.5
Jiangsu	4008.8 10.4%	71.64	55.5
Shanghai	1684.5 11.2%	13.42	24.8
Toyal	8393.8	130.58	119.8

These three provinces belong to the eastern areas of China. The average rate of GDP-growth from 2009 to 2010 was 10.2%. It seems slower than in other areas, that is because most cities in the eastern area are coastal. Their economy is highly developed, the total GDP value of these provinces in 2009 was 6623.9 billion Yuan, which is equal to 970.18 USD (1USD = 6.8275 Yuan), so the room of economic improvement is small. The total population is smaller than in the north and in the south, so the per capita GDP is much higher than these two areas. But the emissions of polluted water in eastern provinces are also bigger than in other areas, and it becomes the most serious area of WP.

Let's see the last table below. Through the table 4.4.4 we found that these provinces belong to the western areas of China. The average rate of GDP-growth from 2009 to 2010 was 12.8%. It is the fastest growing area in China. Although the room of improvement is big, the economic situation is still poor. In 2009, the total GDP value

in these provinces was 699.4 billion Yuan, which accounts for approximately one-tenth of the GDP value in the eastern area. Of course these three provinces cannot represent the whole western areas, but the general situation is the same.

Table 4.4.4 Basic information about GDP, population and polluted water in some Western provinces (2009)

Western provinces	**GDP growth rate Billion/%**	**Population (Million)**	**Polluted water (10^8 t)**
Qinghai	134.2 14.5%	4.92	2.07
Tibet	62.6 12.1%	2.59	0,4
Xinjiang	502.6 11.8%	18.89	8.4
Total	699.4	26.4	10.87

There are vast areas in the west of China, but the population is relatively small. We can see that the total population in these provinces is 26.4 million. But these provinces account for 40% of the area of whole country.

The total volume of polluted water in 2009 in these three provinces is $10.87*10^8$ tons. It is interesting that this volume is also one-tenth of the emissions of the eastern areas.

Ch 5. Analysis

The analysis of two Chi-square tests, questionnaires and the conclusion of four areas findings are presented in this part.

Chapter 5 presents the analysis of two hypotheses, and also analyzes the feedback of the questionnaire and findings. Combined with these analyses, we point out the new problem and will explain it in the next chapter.

5.1. Analysis of hypothesis one

Hypotheses 1 has been tested with a questionnaire and the statistical results are shown in the table 4.3.1. As can be seen in the table, the table shows the survey of WP-levels in four areas. The survey shows that the WP is most serious in the east of China, and the west of China has a better situation. The Chi-square present a significant association between the WP-level and different areas. Through the calculations of the Chi-square test in hypothesis one, the P-value of the result is smaller than the significant level. Therefore we reject $H_{0,}$ which means the result of the test can prove that there are differences depending on areas and WP-levels.

5.2. Analysis of hypothesis two

The data of hypothesis 2 are shown in table 4.3.2. As can be seen in the table, hypothesis 2 is the research about the WP-level and the EL-level in four areas. Observing the table, it is presented that some areas have a high level of WP; most of them also have a high level of economic losses, and vice versa. Or in other words, there was a significant association between the WP-level and the EL-level. Through the calculation of the Chi-square test in hypothesis two, the P-value is also smaller than the significant level. We reject H_0 which means the WP-levels and the levels of economic losses (caused by WP) are correlated with each other.

5.3. Analysis of questionnaire

Table 5.3.1 Results of question 1, 6 and 10 in the sector two

Question	Option	Numbers	Percentage
Q1.	East	68	24.3%
	West	72	25.7%
	North	67	24%
	South	73	26%
Q6.	Serious(V or under V)	132	47.1%
	Normal(III~IV)	78	27.9%
	Not serious (I~II)	70	25%
Q10.	Large	130	46.4%
	Normal	98	35%
	Small	52	18.6%

In order to avoid some errors in the results, the numbers of respondents in four areas are very similar.

There are 47.1% of the respondents that think their living place has a serious WP. The common water source looks awful. Through the questionnaire we found people who think this mostly comes from east and north, and they also think a serious WP causes large economic losses. There are 70 respondents that think the WP in their living place is not serious. We also found out that 60% of these people come from the western area.

In general, most eastern and northern respondents think the problem of WP is serious in their living place and bad water quality causes large economic losses. The western area has a better situation.

The following table below can strengthen this opinion.

Table 5.3.2 Results of question 8 and 9 in the sector two

Question	Option	Numbers	Percentage
Q8	East	120	42.8%
	West	24	8.6%
	North	82	29.3%
	South	54	19.3%
Q9	East	33	11.8%
	West	123	43.9%
	North	54	19.3%
	South	70	25%

The answers to these two questions discussed the WP-levels in different areas. The maximum values (120 and 123) in table 5.3.2 show that, almost half of the respondents think the eastern area has the worst WP, and the western area is better than other areas.

Table 5.3.3 Results of question 3 and 4 in sector two

Question	Option	Numbers	Percentage
Q 3.	High developed	65	23.2%
	Developed	109	38.9%
	Underdeveloped	91	32.5%
	Don’t know	15	5.4%
Q4	Large	111	39.6%
	Normal	87	31.1%
	Small	65	23.2%
	Don’t know	17	6.1%

174 people think their city is developed or highly developed. Most of them come from east and south of China. However, the most western people think their city is poor and underdeveloped.

People think the population in the northern area is larger than other areas. The southern area is right behind them and has become a second large population area. The western area has the smallest population in China.

5.4. Analysis of findings

According to the basic information about the provinces in the four tables in chapter 5, we can find that the western area is the least polluted area. Here the population is so much smaller than in other areas and the level of economic development is low.

The WP in south and east is terrible. Interestingly, the highest value of total GDP and the per capita GDP are also presented in the south and east. It means these two areas are richer than other areas, and the level of economic development in east is the highest.

The peak value of population is to be found in the northern area. Although the level of economic development is not as high as in the east, it is still developing fast and it is so much better than in the west. The polluted water volume in the northern area is nine times bigger than in the western area.

In this part we already proved the relationship between areas and WP-levels, and that the levels of economic loss (caused by WP) are related to the WP-levels. But these relationships still lack the rational explanations. The following chapter will explain these relationships one by one and also discuss how to improve the methods to control the WP.

Ch 6. Discussion

The deeper discussion of hypothesis one and the control method will be shown in this chapter.

This chapter is combined with the findings in chapter 4 and 5 to analyze the new question. This question relates to the result of hypothesis one, and the content below discusses the explanation of this question. Moreover, it is also introduced the control method of WP.

6.1. Why is there a difference depending on areas and WP-levels?

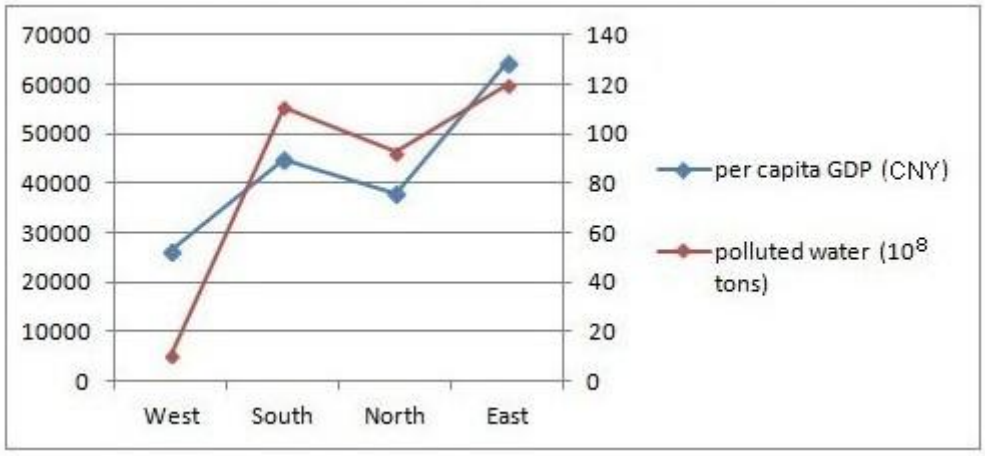
According to the findings in chapter 4, we know that in China, different areas have different situation of economy and population, and the gaps are very big. This point also gets confirmation in the table 5.3.3. West is poor and sparsely populated, whereas other areas, especially east, are developed and with a large population. Did this population and economic differences influence the WP-levels? We showed this result below.

We showed the polluted water volume in four areas in an earlier chapter, and also introduced the GDP value and population. Here we used this information and calculate the per capita GDP values in different areas, and found that the levels of per capita GDP are the same with levels of polluted water volume.

We present this information in the figure 6.1.1, which supply a more indicative view of the relationship between polluted water and per capita GDP.

It’s easy to find that the per capita GDP value and the polluted water volume are positively correlated with each other. Obviously, per capita GDP values are depending on the population and total GDP value. It means that the economic development and the population are both influencing the volume of polluted water. This dissertation earlier showed that the situation of economy and population in each area are quite different. That is why there is difference depending on areas and WP-levels.

Figure 6.1.1 Volume of polluted water and per capita GDP in four areas



(IPA-China Water Pollution Map-2009; National Bureau of Statistics of China, 2009-2010)

6.2. How to improve the methods to control the WP?

This dissertation supplies three contributions. One of them is combined with all the content we introduced and all the data we collected to discuss the control methods of WP. The four steps should be noticed:

1) Financial, administrative and legal safeguards.

I. Suggest the government to invest the appropriate sum of money, supply enough financial support to control the WP, and protect the water source.

II. It is not enough that only set the environmental departments to pay attention to the pollution problem. In order to solve WP, we need a big support by the government.

III. Strengthen the related laws and regulations. The related laws must be observed and strictly enforced, and lawbreakers must be prosecuted.

2) Engineering and technology

I. Related departments must separate rain and polluted water; polluted water needs treatment, and rainwater can divert into the natural water sources.

II. Improve the technology to control the WP and treat the polluted water. Change the old sewer line.

3) Municipal management measures

I. In the city, the sanitation managers are sharpening.

II. Improve the efficiency of the environmental protection department.

III. Reasonable arrangement of waste disposal stations and public toilets, because of the population, the volume of polluted water in public toilets is real huge.

IV. Demolish illegal buildings which can cause WP.

4) Encourage public participation in water protection

I. Encourage people to join the protection actions. Punish polluters, reward whistleblowers.

II. Strengthen the public education for protecting water quality. Establish some warning signs along the rivers or other water sources.

Ch 7. Conclusion

The final chapter sums up the whole thesis, and evaluates its reliability and validity.

This part first is the summary of whole thesis, and our expectations of Chinese water environment for the future. In the final step of this part, we made an evaluation of this thesis. It can help the future research.

7.1. Conclusion of the whole thesis

This dissertation mainly argues the relationship between WP and economic development. Through the many analysis and statistic tests, we can prove that there are differences depending on the WP-levels and areas. These relationships are not only related to geographical factors, but also depend on the different economic situations and the size of populations. Urbanization and industrialization exacerbates the level of WP. Conversely, WP causes more losses in economy and human health, and hindered the development of urban and industry. In China, development and WP already have become a vicious cycle, and it's insurmountable. When a country wants to improve the technology and economy to solve the WP, always more issues come out of it.

We think it all depends on that the humans broke the balance of water environmental carrying capacity. People overlook that the protection of the environment is a precondition of all development. So the other aim of this dissertation is to suggest the government to pay more attention to the environmental protection, and advise them to strengthen the related policies about discharging polluted water without treatment. The government also needs to improve the technology of pollution treatment and shift industry structure.

In the future, when people talk about China, it is not just a country with the high speed development of economy, but also has a great environment, no safety problem of drinking water, and people and animals will not get sick because of the sewage.

7.2. Evaluation of reliability and validity

This thesis built on scientific literature and data. The rigorous statistic tests are tests in contact with real life. No malicious falsification. We think this thesis is reliable and valid for future research. In addition, this relationship and solution only focus on China.

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Appendix1: Questionnaire in English

Water pollution questionnaire

Sector one: Personal Information

Q1. What is your gender?

□ Female □ Male

Q2. How old are you?

□ Under 24 years □ 25-34 years

□ 35-50 years □ Above 51 years

Q3. What is your education level?

□ High School

□ Bachelor or Junior Colleges

□ Master or above

Sector two: The survey of water pollution and the economy in China.

Q1. In which part of China do you live?

□ East □ West □ North □ South

Q2. How much is your salary per month?

□ Under 3000yuan □ 3000-4999yuan

□ 5000-9999yuan □ Above 10000yuan

Q3. What do you think about the economic development of the city you live in?

□ Highly developed □ Developed

□ Underdeveloped □ I don't know

Q4. Do you think that the city you live in has a large population?

□ Large □ Normal □ Small □ I don't know

Q5. Do you know the status of water pollution in China?

□ Yes □ No □ I don't know

Q6. Do you think the water pollution is serious[1] in the city you live in?

□ Serious (V or under V) □ Normal (III~IV) □ Not serious (I~II)

□ I don't know

Q7. What do your nearby water sources (like rivers or lakes) look like? (Multi-select)

□ It is a protection zone, not any bad smell, limpid, no obvious rubbish, (I)

□ It is a source of drinking water, no bad smell, little turbid, no or few obvious rubbish but have dustmen, have many kinds of animals. (II~III)

□ Water for the industrial use or amusement purposes (not to be touched), turbid, have obvious rubbish, few animals. (IV)

□ It's for irrigation or landscape needs, turbid, have rubbish, no dustmen, few animals. (V)

□ Useless, stinky, muddy, have rubbish, no dustmen, no or few animals. (Under V)

Q8. Which area do you think has the most serious water pollution?

□ East □ West □ North □ South

Q9. Which area do you think has a better situation?

□ East □ West □ North □ South

Q10. What level of water pollution do you think have an effect on the city economy?

□ Large □ Normal □Small □ I don't know

Q11. Do you agree that the government should invest a lot of money to control the water pollution?

□ Agree □ Disagree □ I don't know

Q12. In order to protect the environment, the government should to slow down the speed of economic development. Do you agree?

□ Agree □ Normal □ Disagree □ I don't know

1: based on the report about surface water quality standards (China Environmental Protection Administration, 2002), the water quality in China is divided in to five levels (only defined from senses)：

I. Belongs to national protection areas, it is the source of water. The water is limpid, no rubbish and no smell.

II. This kind of water is mainly applied to supply the drinking water. It's a habitat of rare aquatic life, fish and shrimp production field. No smell, no rubbish or have dustmen.

III. This kind of water manly applied to supply the drinking water. It's a substitute of II-level water. No smell, no rubbish or have dustmen, little turbid.

IV. This kind of water only suitable for the industrial use or amusement purposes that does not involve the liquid coming in to contact with human skin (www.Chinadaily.com.cn).

V. This kind of water mainly for the agricultural use or landscape needs. (Under V: useless water).

Thanks for your cooperation in this study!

Appendix2: Questionnaire in Chinese

水污染问卷

第一部分：个人信息

Q1.您的性别是什么？

☐ 女性 ☐男性

Q2. 您的年龄？

☐ 24 岁以下 ☐ 25-34 岁

☐ 35-50 岁 ☐51 岁以上

Q3.您的学历？

☐ 高中

☐ 本科或大专

☐ 硕士以上

第二部分：调查中国水污染和经济

Q1. 你住在中国的哪个区域？

☐ 东部 ☐ 西部 ☐ 北部 ☐ 南部

Q2. 您的月薪是多少？

☐ 3000 元以下 ☐ 3000-4999 元

☐ 5000-9999 元 ☐ 10000 以上

Q3. 你认为你所在的这个城市经济发达吗？

☐ 很发达 ☐ 发达

☐ 不发达 ☐ 我不知道

Q4. 你认为你生活的这个城市人口多吗？

☐ 多 ☐ 一般 ☐ 少 ☐ 我不知道

Q5. 你了解中国水污染的状况吗？

☐ 了解　　☐ 不了解　　☐ 我不知道

Q6. 你认为你所在城市的水污染严重[1]吗？

☐ 严重(五级或以下)　　☐ 一般(三级到四级)　　☐ 不严重(一级至二级)

Q7. 你家附近的水源（像是河流湖泊）看起来怎么样？（多选）

☐ 是属于保护区域，没有异味，清澈，没有明显的垃圾（I）

☐ 是饮用水水源，没有异味，有些许浑浊，没有或者有些许明显的垃圾但是有垃圾清理工， 动物种类繁多（II~III）

☐ 用于工业或者娱乐设施的水源，非人体直接接触，浑浊，有明显垃圾，有少许水生生物。（IV）

☐ 用于灌溉或者景观需要，浑浊，有明显垃圾，没有垃圾清理工，动物稀少。（V）

☐ 无用水源，恶臭，浑浊，很多垃圾，没有清理工人，没有动植物，或者动植物稀少。

Q8. 你认为哪个区域水污染最严重？

☐ 东　　☐ 西　　☐ 北　　☐ 南

Q9. 你认为哪个区域水资源最好？

☐ 东　　☐ 西　　☐ 北　　☐ 南

Q10. 你认为什么水污染对城市经济影响大吗？

☐ 大　　☐ 一般　　☐ 小　　☐ 不知道

Q11. 你是否同意政府应该投入大量的资金去治理水污染？

☐ 同意　　☐ 不同意　　☐ 我不知道

Q12. 为了保护环境，政府应该放慢经济发展的速度。你同意吗？

☐ 同意　　☐ 不同意　　☐ 我不知道

基于地表水质报告（中国环境保护总局，2002），中国把水源划分为五种级别（仅从感官上定义）：

I：属于国家保护区，这是水的源头区，清澈，没有垃圾，无异味。

II：这类水源主要适用于供给饮用水。是珍稀水生生物的栖息地，鱼虾产场，没有异味，没有垃圾或者有环卫工人。

III：这类水源属于二类水源的替代品，水质较二类稍差，些许浑浊，无异味，无垃圾或有环卫工人。

IV：这类水源适用于工业或者娱乐设施，不能直接接触人体皮肤。
（www.Chinadaily.com.cn ）

V：这类水源主要用于农业和景区需要。
（V 级以下： 无用水源。）

谢谢您的合作！