Economic and Environmental Effects of Water Pollution Abatement Policy in China: a Dynamic Computable General Equilibrium Analysis

Presented as 16th GTAP conference

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Abstract The rapid economic growth in China over two decades has unfortunately been accompanied by severe pollution problems. The environment pollution has increased dramatically and environmental cost wherefrom is enormous. In particular, water pollution situation remains a challenge in China despite substantial pollution control investments in recent years.

Chinese government has been seeking effective policy instruments to curb the increase of pollution while seeking high economic growth. Implementation of environmental pollution control policies such as command-and-control measures, pollution charge levy system and voluntarily measures play a big part in leveling off or even reducing pollution loads, particularly in certain targeted industrial sectors. However, to date, very little quantitative evidence is provided for which policy is actually effective and suitable in China. Therefore, exploring the pollution situation and control practice in the past years and evaluating effect of a series of abatement policy is a big concern and what are sustainable mechanisms for financing water pollution control is an imperative question for policy makers.

This paper aims to examine a series of water pollution abatement policy alternatives applied in paper &pulp industry using MCHUGE-WAT for China--- a dynamic general equilibrium model of the Chinese economy incorporated with environmental module. All of these policies alternatives are focused on reducing COD. For model specification, in this study, we integrate various water pollution control activities with economic activities in a CGE framework. The

environmental module includes mainly: (1)various pollution indicators including the levels of pollution abatement and water COD intensity, linking water pollution with production activities by pollution intensity, upgrading this intensity to 2010;(2) decomposition effect of water pollution discharge ;(3)water pollution abatement module disaggregating the industry into two types-“new industry” which adopts the water pollution abatement measure and “old industry “ which does not, to depict the policy of closing old and small-scale industry and the activity of purchase of wastewater abatement facilities by new industry, simulating the historical change of wastewater discharge standard-meeting rate; (4) water pollution taxes, i.e. production pollution emission taxes. The model can be characterized as an integrated economic and environmental model in the line of the CGE approach.

Taking paper &pulp industry as an example, it is disaggregated as new and old industry and the database of water pollution discharge and water pollution tax is built in reference of data of Environmental Yearbook. The historical baseline of macro-economy and water pollution discharge is upgrading basing on the data from 2005 to 2010 and the forecast baseline is developed as well.

For simulation design, firstly, the business-as-usual scenario is presented as baseline without any shock. This paper divides the paper industry into two groups: treated industries and untreated industries and assigns them to different pollution intensity. Then a historical simulation is presented to explain the big drop of total pollution intensity for paper industry. Then in scenario 1， this paper simulates the economic and environmental effect of cumulative environment investment as the fixed capital ---water treatment equipment.

Scenario 2 the effect of increase of operational costs like energy consumption and labor costs for water treatment is simulated. In scenario 3, environmental service is bought by government which is financed by pollution tax. In scenario 4, the increasing pollution tax rate is simulated.

Keywords Water Pollution Abatement Policy, Water Pollution Tax, Water Pollution Treat

1.Introduction

With the China's economic reform and strong economic growth over two decades, the environment pollution has increased dramatically and environmental cost wherefrom is enormous. According to the report *Cost of Pollution In China* by the World Bank (2007), the cost of air and water pollution in China amounts to 100 billion dollars, about 5.8 percent of GDP. In particular, water pollution situation remains a challenge in China despite substantial pollution control investments in recent years. China has some of the worst water pollution in the world, with as much as 70% of its rivers, lakes and reservoirs being affected by all types of pollutants.[1] During the period 2001-2009, on average about 58 percent of the seven main rivers in China contained water deemed unsafe for human consumption.

Chinese government has been seeking effective policy instruments to choke

[1] Green peace report, http://factsanddetails.com/china.php?itemid=391&catid=10&subcatid=66

off the increase of pollution while seeking high economic growth. Implementation of environmental pollution control policies such as command-and-control measures, pollution charge levy system and voluntarily measures play a big part in leveling off or even reducing pollution loads, particularly in certain targeted industrial sectors. However, very little quantitative evidence show that which policy is actually effective and suitable in China. Therefore, exploring the pollution situation and control practice in the past years and evaluating effect of a series of abatement policy is a big concern and what are sustainable mechanisms for financing water pollution control is an imperative question for policy makers.

The paper & pulp industry is such a typical example that it serves as the pillar of local economy while it is a big source of major industrial pollution as well. It produces ten percent of China's industrial wastewater emissions and one-fourth of its COD [2](chemical oxygen demand)(Huang and Bai,1992). This paper aims to examine a series of water pollution abatement policy alternatives applied in paper &pulp industry using MCHUGE for China. All of these policies alternatives are focused on reducing COD. Firstly, the business-as-usual scenario is presented as baseline without any shock. Then Scenario 1 assesses the

[2] The "Chemical Oxygen Demand" (COD) is commonly used to indirectly measure the quantity of organic compounds in wastewater or surface water (e.g. lakes and rivers), making COD a useful measure of water quality. The higher COD amount implies that the water is more heavily polluted.

economic and environmental impacts of the pollution effluent fee system, particularly the scenarios of raising the tax rate on heavily polluted industry-Paper &Pulp industry (ppp industry). Scenario 2 evaluates the effect of increasing abatement cost of PPP industry. In Scenario 3, the increasing abatement cost of PPP industry subsidized by government is simulated.

1.1 Status of paper & pulp industry pollution

China is the main country of producer and consumer of paper products and paper industry is the pillar of national economy but a big source of water pollution as well. In particular, paper industry is a big contributor to all the industrial COD discharge. In 2008, the total industrial output value of 5759 paper mills is 416.43 billion (current value), only 1% of the total output value of all the industries while the industrial waste water discharge is 4.077 billion tons, 18.76% of all industrial waste water discharge, and the emissions of COD are 1.28 million tons, 31.8% of all industrial COD emissions (See Table 1), the contribution rate of COD is thirty times more than its output.

There are major three problems existed in the paper industry which is responsible to its high pollution:

1.Small-scale enterprise production

The production scale of the company is related to the economic efficiency, competitiveness and the pollution control. Taking Haihe Basin as an example, while the majority is small-scale enterprise, the average production scale of the industry is 20,000 tons in 2005. However the average world production of paper-making is 80,000-100,000 tons in the year of 2003, and in advanced country the production can be the 200,000 tons (liu Yong, 2005). The small production scale limits its pollution control. According to (Zhong, 2008), the pulp and paper industry cannot afford pollution control facilities until its production scale reaches 50,000 ton.

2.Irrational Structure of raw materials

Wood pulp is the important material of high-grade paper products, but China has been used non-wood pulp (mainly straw pulp), which is the main contributor to water pollution and also constrains the quality of the products (Shi Ying-qiao et al., 2008) In Hebei province, the proportion of wood pulp is only 20%. In Henan province, the usage of wood pulp is less than half the nation average, but the straw pulp which pollution is serious accounts for 65%. Even in Shandong province, where the rather high proportion of wood pulp is used, the proportion is only 35% (Yearbook of China's paper, 2008)

3.Backward technology of pollution control and low rate of standard-meeting

Constrain with history, local social-economic situation, the production processes and technical equipment, the paper industry in China lags far behind the international advanced level. In June 25, 2008, National Quality Technical Inspection Bureau (AQSIQ) and State Administration of Environmental Protection (SAEP) released "Discharge standard of water pollutants for pulp and paper industry" (GB3544-2008). According to the new discharge standard, only 2 of the 26 cities in Haihe basin can reach the standard. Even compared with the old standard (GB3544-2001), there are still 9 cities exceeding the standard.

Chinese government began to implement a number of environmental policies to reduce water pollution from late 1970s and the number of these regulations has been steadily increasing. In the past 10 years, the COD intensity of paper industry has dropped down dramatically. (See Fig.1) To probe the historical situation, there are two main things government has done to get the big progress to reduce the pollution.

[Fig .1 about here]

1)Closing small scale enterprise

According to *Water Pollution Control Provisional Regulation in Huai he Basin*, 1111 chemical pulp equipment in small paper mills of the annual production capacity under 5000 tons has been stopped before June, 30,1996 and 3876 small scale industries with low profit and high pollution.

2)Increase the rate of stand-meeting discharge of paper industry by enacting strict standards and treatment

Until the end of year 1997, 1562 enterprises with wastewater discharge above 100 tons per day exceeding the standard of discharge has realized standard-meeting discharge. Among these, 73% through treatment without stopping production, 13.7% through treatment after stopping production, 12.2% is closed down owing to failure of enterprises itself such as going bankrupt, 1.1% was closed down by the government because of failure of treatment. Among the 1562 enterprises with wastewater discharge under 100 tons per day exceeding the standard of discharge, 81.7% enterprises has accomplished treatment obligation, the others have been closed down or merged by the big enterprises. The treatment rate has increased from 20% in 1997 to 94% in 2009.(See Fig.2)

[Fig.2 about here]

1.2 Chinese Water pollution Control Policy

Normally, the policy instruments for controlling pollution include direct instruments, which addresses the level of damages or emissions directly and indirect instruments, which work via other variables (see Table 1). China also adopted these measures in different times. “Command and Control” instruments are application of discharge standards, total load control and discharge permits and closing down small firms, the “Three Simultaneousness” requirement; “Market-based Regulatory Instruments” are pollution levy system and pollution right trading mechanism. The first legislation addressing water and air pollution was passed in 1979, with a series of acts and regulations followed. A pollution levy system was tried out in 1980 and imposed nationwide in 1982. Article 18 of China’s Environmental Protection Law specifies that “in cases where the discharge of pollutants exceeds the limit set by the state, a compensation fee shall be charged according to the quantities and concentration of the pollutants release." The levy rate later was reassessed in 1989 and raised by 40% in 1992. From the levy's inception in the early 1980's to 1996， almost all of China's counties and cities have implemented the levy system, Chinese regulators have collected about 30 billion RMB Yuan from more than 500,000 Chinese major polluters.

Due to lack of evidence that the levy system was effective in inducing polluting firms, the government initiated a nationwide campaigns to eliminate those small firms which failed to abate pollution by a given deadline. During the 11th Five Year Plan(FYP) period (2006-2010), the government increased water pollution regulatory enforcement combined with a major expansion of installed municipal wastewater treatment capacity, the municipal wastewater treatment plants (WWTPs) increased from 712 in 2005 to 1,521 at the end of 2008. A large part of the reason behind the government's water pollution control achievements under both the 10th and 11th FYPs is attributed to substantial pollution control investments made over the period. Between 2000 and 2008, total pollution control investments increased by 420% to CNY 449 billion (about 1.5% of GDP), of which CNY 180 billion (40%) was for urban environmental infrastructure, CNY 54 billion (12%) for upgrading existing treatment plants, and CNY 213 billion (48%) for the installation of pollution prevention and control equipment at new industrial facilities under the" Three Simultaneousness Requirement".[3] The levy collections had been used to finance pollution control projects. Since June, 1 2008, the revised *Water Pollution Control Act* has been

[3] The "three simultaneousness" requirement necessitated the design, construction, and operation of pollution control facilities simultaneously with the main project.

implemented, with the discharge permit and total load control explicitly prescribed the first time and the supervision of law enforcement intensified.

[Table 1 about here]

1.3 Literature Review

In recent years, there is growing interest in employing CGE models to evaluate the effect of environmental policy. Several reasons can account for the enthusiasm of researchers in application of CGE approach. One of the key features of CGE models is that a CGE models is an ideal bridge between economic theory and applied environmental policy research. An environmental policy aimed at significantly reducing pollution emissions may have great effects on prices, quantities, and the structure of the economy such as producer's behavior and consumer's welfare. Thus, analysis of environmental policy in a general equilibrium framework can give researchers a good idea of the qualitative results in production and welfare effects of a change in a given policy instrument. (Bergman, 1990) Another distinguished feature account for the wide spread use of CGE models is it can capture the inter-linkages between different agents and industries so that deeper insights into the interdependencies in the economy become available, which is superior to cost-benefit analysis just in a partial equilibrium framework. (Conrad and Schroder, 1993) Third strength in CGE models is there different groups of CGE models: static and dynamic, single-country and multi-country. For the dynamic one, CGE models can present likely magnitudes of policy-induced changes from future baselines, and rank alternative policy measures, which can have a lot to say for real economies.

The environmental CGE emerged in the late 1980s. Early development of environmental CGE models provides many insights to later application. (Forsund and Strom, 1988; Dufournaud, Harrington & Rogers, 1988; Bergman, 1989; Hazilla and Kopp, 1990; Robinson,1990; and Jorgenson and Wilcoxen， 1990). So far, there are many applied environmental CGE models to evaluate economic and environmental effects of policies. Tracing back to the history of development of CGE models, there are also three lines of development in environmental CGE models.

How to integrate environmental components with economic activities or how to add environmental module to core CGE model to analyze environment problems is crucial while sticky part for environmental CGE models, which is also the significant feature to distinguish categories of environmental CGE

[Table 2 about here]

models one from another. The different level of linking pollution-related activities with economic agent classifies the type of environmental CGE models from simply one to more complex one.

1)Serve as an “add-on” to core CGE model

Extensions to standard CGE models are linking economic output with environmental emissions using fixed pollution intensity per unit of output or intermediate inputs (Blitzer et al, 1993; Lee and Roland-Holst, 1993; Beghin, Rolland-Holst and van der Mensbrugglhe, 1994); or exogenously changing prices or taxes concerning environmental regulation without any changes in model structure. (Boyd and Uri, 1991) This type of CGE models does not change the behavioral specifications of the core model, but does provide a more description of production results from the environmental perspective.

2)Introduce environmental feedback into economic system

To portray environmental feedback, there are main three kinds of approaches. One way is incorporate environmental quality into production function. Like Jorgenson and Wilcoxen's (1990) model， this type of model specify pollution control costs in production functions. A further extension of production specification is to consider the effects of environmental quality on productivity. They have environmental quality indices and incorporate those indices into production functions to capture the effects of pollution emissions on productivity. Another way is incorporate environmental effects in utility function to capture the effects of pollution emissions and abatement activities on consumption. Robison(1999) included net pollution emissions in Stone-Geary utility function. Ballard and Medeama(1993) also added health damage to the Stone-Geary composite of consumption goods. Bergman(1993) specified the effects of environmental quality in a household utility function using an environmental quality index. Piggott, Whalley and Wigle (1992) put the environmental benefits of carbon emission reduction into the utility function of their model. The more initiative way is specify the production functions of pollution abatement activities or technologies. Robinson (1990) used a Cobb-Douglas production function to represent a pollution cleaning activity. Nestor and Pasurka(1994) adds the inputs and outputs of air pollution abatement activities into the main input-output table to model air pollution abatement processes and abatement tax rates. Robinson, Subramanian and Geoghegan

(1993) identified pollution production processes and abatement technologies for each process. The assumed that a firm would use a particular abatement technology only if its marginal cost of abatement did not exceed the pollution emission charge. Xie and Saltzemen (2000) specified pollutant-specific abatement sectors rather than pollution abatement activity in all sectors, to get the environmental feedback to economic system by depicting the input cost and environment outputs of these sectors.

What distinguishes our study from most of literature is that we present one of the first attempts to quantify the effect of water pollution abatement policy in dynamic general equilibrium framework.

2.Model Specification

The analytical framework applied in this study is a dynamic Computable General Equilibrium (CGE) model of the Chinese economy, the MC-HUGE model. This model was jointly developed by Hunan University and the Centre of Policy Studies. The model includes 57 sectors. Its base data reflects the 1997 input-output structure of the Chinese economy. The core CGE structure is based on ORANI, a static CGE model of the Australian economy (Dixon et al 1982).

2.1Core Model

In MC-HUGE, production is modelled using nested constant elasticity of substitution (CES) and Leontief production functions which allow substitution between domestic and imported sources of produced inputs and between labour, capital and land. The production functions are subject to constant returns to scale. Household demand is modeled by the linear expenditure system (ELES).

Trade is modeled using the Armington assumption for import demand and a constant elasticity of transformation (CET) for export supply. China is considered as a small open economy in import markets where foreign import prices are determined in world markets. Exports are demanded according to constant elasticity demand curves for most of commodities. In the model, capital stock is accumulated through investment activities (net of depreciation). Investors respond to changes in expected rate of return. In this version of the model, we assume static expectations. Under static expectations, investors only take account of current rentals and asset prices when forming current expectations about rates of return. The dynamic mechanism of MC-HUGE is based on the MONASH model of the Australian economy developed by Dixon and Rimmer (2002). The MC-HUGE model captures three types of dynamic links: physical capital accumulation, financial asset/liability accumulation; and lagged adjustment processed in the labour market.

2.2Environmental Module

In this study, we integrate various water pollution control activities with economic activities in a CGE framework. The environmental module includes mainly: (1)various pollution indicators including the levels of pollution abatement and water COD intensity, linking water pollution with production activities by pollution intensity, upgrading this intensity to 2010;(2) decomposition effect of water pollution discharge ;(3)water pollution abatement module disaggregating the industry into two types-"new industry" which adopts the water pollution abatement measure and "old industry " which does not, to depict the policy of closing old and small-scale industry and the activity of purchase of wastewater abatement facilities by new industry, simulating the historical change of wastewater discharge standard-meeting rate; (4) water pollution taxes, i.e. production pollution emission taxes. The model can be characterized as an integrated economic and environmental model in the line of the CGE approach.

The main equation for adding pollution activities is as follows

(all,j,IND) POLLUTION(j) = POLINTEN(j) * Q1TOT(j)

Where **POLLUTION(j)** is COD discharge amount by industry, here j represents paper & pulp industry. **POLINTEN(j)** is emission intensity, measured as COD discharge amount per output value of paper & pulp industry. **Q1TOT(j)** is the output value of paper & pulp industry eliminating the inflation factor.

Taking paper &pulp industry as an example, it is disaggregated as new and old industry and the database of water pollution discharge and water pollution tax is built in reference of data of Environmental Yearbook. The historical baseline of macro-economy and water pollution discharge is upgrading basing on the data from 2005 to 2010 and the forecast baseline is developed as well.

3.Simulation design

3.1Data and baseline results

The amount of water COD discharge and industrial output value of paper & pulp industry is from environmental statistical yearbook from 1997 to 2009.The labor & capital cost and running cost of water treatment by paper industry is also from environmental statistical yearbook in combination with Chinese Paper Industry Report.

Our analysis starts with historical simulations that update China's economic structure reflected in the model database to 2005. The historical and the forecast simulations provide us with a baseline scenario with which to compare the scenario a series of environmental policy is introduced. The baseline simulation from 2006 to 2015 follows Mai (2006). For the purpose of this paper, we extend the baseline further to 2020. The macroeconomic variables in the baseline scenario are shown in Table 3. In the baseline, the growth rate of real GDP is 7.9 per cent in 2008, and increases gradually to 8.11 per cent in 2020. The growth rate of the capital stock is determined by the growth of investment and net depreciation of capital. The growth of total factor productivity represents the difference between the GDP growth and the growth rate supported by the accumulation of labour and capital. This ranges from 2.59 – 3.22 percent over the simulation period. With continued strong growth of exports China's terms of trade slightly deteriorates.

The baseline scenario shows a big decrease of water pollution by paper industry from 14,924,039 ton in 1997 to 308311.8 ton in 2020, and the rate of reduction is as high as 98%. (See Table 3)

3.2Policy simulation and Results

3.2.1Scenario 1-economic and environmental effect of cumulative environment investment as the fixed capital ---water treatment equipment

3.2.2Scenario 2-effect of increase of operational costs like energy consumption and labor costs for water treatment

In the past years, Chinese paper industry just used minor cost, on the order of 1percent of its output. Increasing treatment cost of Chinese paper industry is represented by increasing all the cost (labour, capital, and running cost) by 1.5 percent to produce the same output

S**hock** a1tot(“ppp”)=3 in 2008

3.2.3Scenario 3-environmental service is bought by government which is financed by pollution tax

Pollution levy system is a successful means of raising funds for pollution control, but it has weakness:too low to give polluters an incentive to reduce their emissions and the need to raise the effluent fee has been discussed for years.

Pollution tax is equivalent to Production tax, adding pollution tax into model by changing production tax with delPTXRATE.

Put delPTXRATE(i)=delPTXRATEF(i)+delPTXRATEFF into model to increase tax of paper industry, while decreasing taxrate of other industry. Existing Pollution levy system adopts the standard with 0.7RMByuan/ton(COD)and we use this standard to do the first simulation:

Shock delPTXRATEF(“ppp”)=0.003 in 2008

3.2.4 Scenario 4-increase taxrate

With pollution emission tax rates incorporated into the CGE model, the model can be used to simulate the effects of increase in polluttion effluent fees. It was assumed arbitrarily that the government raises the tax rate by 50 percent. We increasing tax rate on COD discharge by 50%

Shock delPTXRATEF(“ppp”)=5.4 in 2008

4. Result

4.1Underlying Model mechanism

Figure 4.1 BOTE mechanism

(E1)	Production function	$Y = AF\left(K, L\right)$
(E2)	Labor market	$\frac{W}{P_V} = A^* F_l\left(\frac{K}{L}\right)$
(E3)	Capital market	$\frac{Q}{P_V} = A^* F_K\left(\frac{K}{L}\right)$
(E4)	Labor cost	$\left(\frac{W}{P_V}\right) = \left(\frac{W}{P_3}\right)\left(\frac{P_3}{P_{gne}}\right)\left(\frac{P_{gne}}{P_{gdp}}\right)\left(\frac{P_{gdp}}{P_V}\right)$
(E5)	Capital cost	$\left(\frac{Q}{P_V}\right) = \left(\frac{Q}{P_2}\right)\left(\frac{P_2}{P_{gne}}\right)\left(\frac{P_{gne}}{P_{gdp}}\right)\left(\frac{P_{gdp}}{P_V}\right)$
(E6)	GDP Identity	$Y = C + G + I + X - M$
(E7)	Consumption	$C + G = APC \cdot GNP$
(E8)		$C / G = \gamma$
(E9)	Investment	$I = F(Q / P_2)$
(E10)		$\psi = I / K$
(E11)	Export	$P_X = F(X, T_X, V)$
(E12)	Import	$M = F(Y, TOT, T_{M,} T, A_C)$
(E13)	Terms of trade	$TOT = P_X / P_m$
	Dynamism	
(E14)	Capital accumulation	$K_t = K_{t-1}(1 - D) + I$
(E15)	Foreign debt	$NFL = f(K, APC, GNP)$
(E16)	Labor market adjustment	$(W_t^{Policy} / W_t^{Basecase} - 1) = (W_{t-1}^{Policy} / W_{t-1}^{Basecase} - 1) + \alpha(L_t^{Policy} / L_t^{Basecase} - 1)$

(E17)	GNP	$GNP = Y \cdot f(TOT) - NFL \cdot R$
	Pollution	
(E18)	Pollution	$POL = f(PINT, Q\backslash TOT)$
(E19)	Pollution tax	$PTAX = f(T, Q\backslash TOT, PINT)$
(E20)	Pollution abatement cost	$PACOST = f(P_a, ABATE, PPOL, A)$

4.2Macroeconomic variables and disaggregated results (BOTE)

Short run closure

$$Y = C + I + G + \left(X - M\right)$$
$$Y = A.F_1(K, L, LND)$$
$$C + G = APC.GNP$$
$$C/G = \Gamma$$
$$GNP = Y.F_2(TOT) - NFL.R$$
$$M = F_3(Y, TOT, T_M, T, A_C)$$
$$P_X = F_4(X, T_X, V)$$
$$I = F(ROR) and \Psi = I/K$$
$$\frac{K}{L} = F_5(ROR, T_K, T_I, A, TOT, \Xi)$$
$$W = F_6(\frac{K}{L}, A, TOT)$$
$$NFL = F_7(K, APC, GNP)$$
$$TOT = \frac{P_X}{P_M}$$
$$\frac{W}{P} = \left(\frac{W}{P_3}\right)\left(\frac{P_3}{P_{gne}}\right)\left(\frac{P_{gne}}{P_{gdp}}\right)\left(\frac{P_{gdp}}{P}\right)$$

long-run closure

$$Y = C + I + G + \left(X - M\right)$$
$$Y = A.F_1(K, L, LND)$$
$$C + G = APC.GNP$$
$$C/G = \Gamma$$
$$GNP = Y.F_2(TOT) - NFL.R$$
$$M = F_3(Y, TOT, T_M, T, A_C)$$
$$P_X = F_4(X, T_X, V)$$
$$\Psi = I/K$$
$$\frac{K}{L} = F_5(ROR, T_K, T_I, A, TOT, \Xi)$$
$$W = F_6(\frac{K}{L}, A, TOT)$$
$$NFL = F_7(K, APC, GNP)$$
$$TOT = \frac{P_X}{P_M}$$
$$\frac{Q}{P} = \left(\frac{Q}{P_2}\right)\left(\frac{P_2}{P_{gne}}\right)\left(\frac{P_{gne}}{P_{gdp}}\right)\left(\frac{P_{gdp}}{P}\right)$$

5. Conclusion and Future Research

5.1tentative policy conclusion

5.2limitations of your simulation results

5.2.1only industrial

5.2.2no substitution for inputs

5.3future to remove or lessen these limitation

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Table 1. A Taxonomy of Policy Instruments

	Direct Instruments	Indirect Instruments
Command and Control (CAC)	Emission Regulations (source specific, non-transferable quotas)	Regulation of equipment, Processes, Input and Output
Market Based Incentives(MBIs)	Effluent Charges, Tradable Permits, Deposit Refund System	Input/Output taxes and subsidies, Subsides to substitutes and to abatement inputs
Government Production or Expenditures	Purification, Clean-up, Waste Disposal, enforcement and Agency Expenditures	Technological Development

Source: Gunnar S. Eskeland and Emmanuel Jimenez, 1991

Table 2 Environmental CGE development

lines of development	representative	main feature
Jorgenson, 1975	Harrington & Rogers, 1988; Robinson, 1990	incorporate pollution account into conventional I/O table
econometric CGE model	Hudson and Jorgenson, 1975; Hazilla& Kopp,1990; Jorgenson & Wilcoxen, 1990	using econometric approach in modeling producer behavior designed for environmental policy; inter-temporal, multi-sector model ; focus on the economic impacts of environmental regulations or programs; consider only environmental costs rather than environmental benefits

International trade and global environmental	Whalley & Wigle,1991; Piggott, Whalley & Wigle,1992	a static, multi-country CGE model of global trade and carbon emissions to analyze the international effects of carbon taxes.The environmental benefits obtained from slowed global warming through reduced carbon emissions are incorporated into the utility function

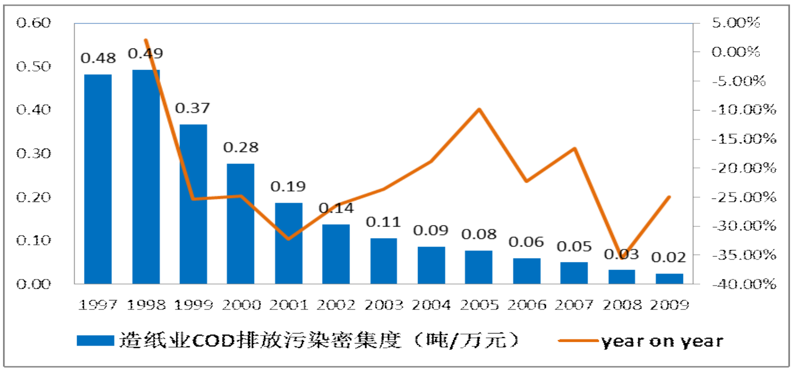

Fig.1 The Trend of COD intensity of Paper industry in past 12 years

Note:
1.The data is from the environment yearbook 2009.
2.COD discharge intensity=COD discharge/industrial output value

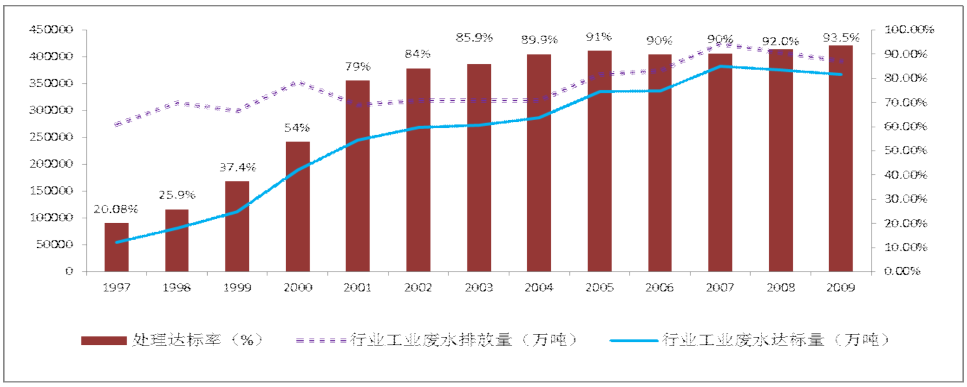

Fig.2 Wastewater treatment situation of paper industry

Table3 Some baseline results

	base year	2008	2010	2012	2015	2018	2020
Annual growth rate of economy-wide(%)							
GDP		7.86	7.88	7.86	7.88	8.02	8.11
Productivity improvement		2.59	2.72	3.02	3.11	3.25	3.33
Capital stock		10.66	10.41	10.19	9.91	9.69	9.56
Terms of trade		-0.15	-0.15	-9.48E-02	-9.00E-02	-0.11	-0.12
Real wage rate		6.72	6.70	6.70	6.71	6.76	6.80
Level of paper industry							
COD discharge (million ton)	14.94	2.45	1.68	1.2	0.72	4.35	0.3
output(billion $)	38.74	107.2	127.3	151.3	195.2	250.4	294.3

Source: baseline simulation results

Table 4

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Real GDP	-0.026	-0.024	-0.022	-0.021	-0.020	-0.020	-0.019	-0.019	-0.019	-0.015
Investment	-0.036	-0.037	-0.037	-0.038	-0.038	-0.039	-0.040	-0.040	-0.038	-0.013
Household Consumption	-0.024	-0.022	-0.021	-0.019	-0.019	-0.018	-0.018	-0.017	-0.017	-0.012
Employment	-0.027	-0.022	-0.019	-0.016	-0.014	-0.012	-0.010	-0.009	-0.008	-0.003
Capital Stock	-0.035	-0.035	-0.036	-0.037	-0.038	-0.039	-0.040	-0.041	-0.041	-0.038
Export	-0.025	-0.021	-0.017	-0.015	-0.013	-0.011	-0.010	-0.009	-0.009	-0.018
Import		-0.024	-0.023	-0.022	-0.021	-0.021	-0.021	-0.020	-0.019	-0.012