Can Social Capital Drive Economic Growth and Environmental Protection?—Evidence from China

Jianxiang Wan[1*], Haiyan Wan[2]

[1]School of Information Technology, Jiangxi University of Finance and Economics,Nanchang,China;zhwjx2002@163.com

[2]School of Information Technology, Jiangxi University of Finance and Economics,Nanchang,China;why6034581@163.com

*Correspondence: zhwjx2002@163.com; Tel.: 15607913003

Key words: Social Capital; Economic Growth; Environment Protection

Abstract: we construct Hamilton model with endogenous social capital being included. By employing mathematical analysis and making numerical calibration, we find that: under the incentives of environmental policy, environmental awareness and environmental action gradually internalize into social capital, deriving from dwellers, enterprises and government. Acting as health assurance，social capital is the key source of economic growth and environmental protection. Panel model further shows that social capital plays a greater role on the win-win of economic growth and environmental pollution: among the three types of social capital, the performance of harmony social capital is the maximum, with that of social resources being the second, and the ability of social participation being the minimum. Once again prove that social capital is the important driving force of economic growth and environmental protection. Lastly we put forward the feasible ways to cultivate social capital.

Introduction

Ever since Aghion and Howitt (1998) voiced that human capital and intellectual capital helps to settle the paradox of economic growth and environment protection, there occur more and more literatures about the win-win of environment and economy both in mathematical analysis and empirical research (Lucas, 2005; Xepapadeas, 2005; Gupta, 2009). Nevertheless, the contradiction between environmental protection and economic development are still acute. At the same time, both at domestic and abroad, regardless of government, academia or NGO, they all appeal the public to participate in environmental protection. Can public participation contribute to the solution of the environment and growth contradiction? Does it works? Can we find empirical facts and theoretical background for public participation?

To answer these questions, we analyze public participation and describe its characteristics as social capital from the sociological point, explore the possible mechanism how social capital promotes economic growth and environmental protection. It not only helps to understand the importance of public participation, figuring out the accumulation of social capital from public participation, but also provides a new theoretical basis, by which government exerts its social guidance, excites resident's public enthusiasm and environment awareness, fundamentally promotes economic growth and Environmental Protection.

Firstly, we establish the accumulation equation of social capital and introduce it into the CD production function as the new engine of economic growth, basing on this, we set and solve

Hamiltonian optimization model, exploring the mechanism how social capital promotes economic growth and environmental protection under the stimulation of the environmental policy. To show more intuitive description, we make numerical calibration. Secondly, based on the panel data of 31 Provinces in China from 1998-2011, we make empirical investigation on how social capital promote economic growth and environmental protection. Lastly we make policy recommendations for social capital accumulation for win-win station of economy and environment.

Unlike previous literatures, our contributions lie in: First, social capital is introduced into the field of environmental economics. There are lots of literatures on how social capital promoting economic growth, examining its impact on economic growth (LLSV, 1997), on financial development (Guiso, 2004), on the stock market participation (Guiso et al, 2008), on venture capital (Bottazzi et al, 2008) as well as on investment (Pan Yue, 2009), but there has been few on how social capital contributes to environment. We introduce it into environmental topic to analyze the win-win of environmental protection and economic growth. Secondly, we explore the accumulation of social capital. To overcome the defects that previous studies only set the social capital as exogenous variables, we not only define the accumulation process of social capital (Owen and Videras, 2006; Torgler and Garc á-Valinas, 2007), moreover we set social capital linked to environmental policy, government guidance and residents environmental protection. Compared with Roseta-Palma (2010), we stress the social nature of social capital. Thirdly, through panel estimation, we conclude that social capital plays an important role on the win-win of economic growth and environmental protection, overcoming the defect of existing research lacking of empirical test, such as(Zhang Hongfang, 2010; Wu Xiaolu, 2010).

The paper is organized as follows: Section I is literature review and introduction. In Section II, we employ mathematical analysis and make numerical calibration. Section III makes empirical analysis by panel estimation. Section IV concludes.

Literature Review

Ever since Putnam's (1993) influential work which shows that social capital contributes to economic progress, we have witnessed a surge of empirical research on the link between social capital and economic growth. G. Meier, the Well-known development economist, professor at Stanford University ever pointed out that economists take "social capital" as the same engine of growth after introducing physical capital, human capital, and intellectual capital. Social capital is defined as trust, interpersonal networks, and cooperative norms by Putnam(1993).By the penetration of the social norms and shared values, transaction costs are reduced and efficiency is improved, from this perspective, social capital plays a positive role on individuals, organizations, and even on social performance (Rolf Huppi and Patricia Seemann,2001) .China is still in the early time of "the 12th Five-Year Plan", also we are at the crucial stage of economic development mode shift, therefore, social capital may be understood as that the public trust each other and benefit mutually, environmental awareness and public participation grows more enthusiastic, virtue and morality are accept more widely and social relations become more harmonious.

However, the study on social capital theory is still in the initial stage, how and whether social capital being introduced into economics should be improved (Guo Xubao, 2004). Most Economists introduce social capital into economics, just caring about how it helping to the management efficiency and the external effects of economic growth, seldom considering it as an engine of economic growth as physical capital, human capital, and mathematical analysis and empirical research are seldom seen. Based on the above analysis, we attempt to make the following efforts: analyze the accumulation of social capital together with physical capital, human capital, and discuss

their output elasticity effect on economic growth.

On the other hand, Ang et al (2009) argue that social capital is an alternative mechanism of legal system which contributes to attracting foreign investment to high-tech enterprises. Pan Yue et al (2009) find that companies with higher social capital are more inclined to foreign investment and diversify investment. As Knack and Keefer (1997) emphasize that social integrity, ethics and teamwork spirits belong to the economic conception of social capital. This definition is consistent with the current Chinese situation, which helps to technological progress and efficiency promotion (Zhang kezhong, 2006). However, in the field of environmental economics, scholars analyzed how to achieve a win-win situation between the economic growth and environment protection by studying human capital, physical capital, technological progress, environmental incentive policy, but most ignore social capital. Basing on the above analysis, we try to make the following attempt: introducing social capital into the issues about environment protection and economic growth, demonstrating the existence of the mechanism and the strength of it, if it does exist.

Hamilton Model and Mathematical Analysis

To answer these questions, mathematical analysis is needed. We introduce environmental policies to construct Hamilton optimization model, on which we analyze the mechanism how social capital promotes economic growth and environment protection under environmental policy incentives by employing optimal equilibrium analysis and numerical calibration.

Model Specification. *(1) Three-sector set. The utility function of representative household:*

$$U(C, H_L, E) = u_1 \log C + u_2 \log H_L - u_3 \log E \qquad u_1,\ u_2,\ u_3 > \qquad (1)$$

Where C is material consumption, H_L is leisure, E is the pollution stock. Government impose pollution tax by τ .Tax revenue is allocated to abatement expenditure I and public infrastructure G by proportion b . Then we have a balanced government budget constraint:

$$G + I = \tau R, G = b\tau R, I = (1-b)\tau R \qquad (2)$$

We adopt model of Romer (1990) and D-S function as product C-D technology:

$$Y = A_Y H_Y^{\alpha_1} D^{\alpha_2} R^{\alpha_3} \cdot O \ , 0 < \alpha_1, \alpha_2, \alpha_3 < 1, \sum_i \alpha_i = 1 \qquad (3)$$

Where H_Y is Human capital, D is intermediate products, R is natural resource. a_i is the output elasticity of input factors. $O = G^g E^{-e} S^s$ is the external effects on economic growth, S is social capital. Then production equation can be changed as follows:

$$Y = A_Y H_Y{}^{\alpha_1} N^{\frac{\alpha_2}{\beta} - \alpha_2} K^{\alpha_2} R^{\alpha_3} G^g E^{-e} S^s, \quad 0 < \alpha_1, \alpha_2, \alpha_3, \beta, e, s < 1, \sum_i \alpha_i = 1 \qquad (3)'$$

β is the substitution elasticity of different patented technology; g, e, s are the external elasticity of G, E and S respectively.

First $b\tau R$ acts as productive externality, the rest $(1-b)\tau R$ acts as abatement expenditure. So we can combine market with administrate policy together, analyzing the role of environmental policies, which is an innovation of this paper.

In the social planner position, the physical capital accumulation equals to the final output minus the consumption and pollution tax, its accumulation equation is as follows:

$$\dot{K} = Y - C - \tau R \tag{4}$$

(2) Environment quality equation of motion

Environment quality is measured through the change rate of pollution stock, it depends on three factors: First the degree of cleaner production technology which depends mainly on natural resources consumption or pollution emission R. The greater it is, the more damage it does. Secondly the government efforts in environmental policy, we choose abatement expenditures I, such as clean technology investment in human capital. Thirdly, self-purification capacity of environment matters. Basing on Jhy-hwa Chen (2008), giving that environment self-purification system without being damaged, pollution stock decreases at a rate of δ. Considering all of these, the motion of environment quality can be written as:

$$\dot{E} = \frac{R}{I} - \delta E \tag{5}$$

(3) Social capital accumulation equation of motion

With resident's green consumption preference and enterprise's environmental awareness increasing, social universal awareness of environmental protection gradually forms from streamlet to river. This environmental awareness is spontaneous initially. Under government and authorities' guidance and encouragement, residents and businesses are becoming to understand and accept the government environmental policies, laws and regulations. Fundamentally, these environmental awareness converts from spontaneous to conscious state, environmental awareness transforming into practical action, actions transforming into environmental charity, and environmental charity condensing into social wealth, lastly forming the source of social capital accumulation, just as physical capital, human capital, and technology, this promotes economic growth and environmental protection, we call this process social capital accumulation.

Adopting the social capital definition of Meier and Putnam, referring to the settings of health capital of Gupta.M.R and Trishita Ray Barman.T.R (2009), we take into account resident environmental preferences u_3, corporate environmental protection stress Y/R, and social environmental protection ability S; so social capital accumulation can be written as below:

$$\dot{S} = u_3 \frac{Y}{R} S \tag{6}$$

The greater the value u_3, the more helpful to social capital accumulation; The greater the ratio Y/R, indicating that enterprise lay more emphasis on the efficiency of natural resources,

namely, the same amount of final product need less natural resources; The more the stock S, the faster the accumulation of S.

Here, we combine social capital accumulation with residents, enterprises, communities, together determining its motion equation. It is true to its social nature of social capital, and this is the second innovation of our paper. We introduce social capital into production function as public participation. Then we can analyze the role of social capital on economic growth and environmental protection, then introducing social capital into the field of environmental economics which is the third innovation of this paper.

Social optimal equilibrium analysis. Then we solve the model to seek the balanced growth path. Also we make numerical calibration to illustrate the inherent mechanism of how social capital promotes environment protection and economic growth.

(1)The balanced growth path GBP

The social optimal equilibrium means (first best allocation, FBA) that household utility and profit maximization, and environmental quality not deteriorated. Under FBA, we construct current value Hamilton function about the representative household optimization problems as below:

$$\begin{aligned} CVH &= u_1 \log C + u_2 \log H_L - u_3 \log E \\ &+ \lambda_1[A_Y H_Y^{\alpha_1} N^{\frac{\alpha_2}{\beta}-\alpha_2} K^{\alpha_2} (b\tau)^g R^{\alpha_3+g} E^{-e} S^s - C - \tau R] + \lambda_2[\frac{1}{(1-b)\tau} - \delta E] + \lambda_3 \frac{Y}{R} u_3 S \end{aligned} \tag{7}$$

Where $\{C, H_Y, R, \tau, B\}$ are decision variables, $\{K, E, S\}$ are state variables, and $\{\lambda_1, \lambda_2, \lambda_3\}$ are co-state variables which represent shadow price of $\{K, E, S\}$ respectively. Then the first-order conditions of utility maximization are as below:

$$\frac{u_1}{C} = \lambda_1 \tag{8}$$

$$\frac{-u_2}{H - H_Y} + \lambda_1 \frac{\alpha_1 Y}{H_Y} + \lambda_3 \frac{u_3 S}{R} \frac{\alpha_1 Y}{H_Y} = 0 \tag{9}$$

$$\lambda_1[\frac{(\alpha_3 + g)Y}{R} - \tau] + \lambda_3 u_3 S(\alpha_3 + g - 1)\frac{Y}{R^2} = 0 \tag{10}$$

$$\lambda_1(\frac{gY}{\tau} - R) - \lambda_2 \frac{1}{(1-b)\tau^2} + \lambda_3 u_3 S \frac{gY}{\tau R} = 0 \tag{11}$$

$$\lambda_1 \frac{gY}{b} + \lambda_2 \frac{1}{(1-b)^2 \tau} + \lambda_3 u_3 S \frac{gY}{bR} = 0 \tag{12}$$

$$\dot{\lambda}_1 = \rho\lambda_1 - \lambda_1\frac{\alpha_2 Y}{K} - \lambda_3 u_3 S\frac{\alpha_2 Y}{KR} \tag{13}$$

$$\dot{\lambda}_2 = \rho\lambda_2 + \frac{u_3}{E} + \lambda_1\frac{eY}{E} + \lambda_2\delta + \lambda_3 u_3 S\frac{eY}{ER} \tag{14}$$

$$\dot{\lambda}_3 = \rho\lambda_3 - \lambda_1\frac{sY}{S} - \lambda_3\frac{u_3(s+1)Y}{R} \tag{15}$$

Tansversality conditions(TVC): $\lim_{t\to\infty}\lambda_1 K e_0^{-\rho t} = 0$, $\lim_{t\to\infty}\lambda_2 E e_0^{-\rho t} = 0$, $\lim_{t\to\infty}\lambda_3 S e_0^{-\rho t} = 0$ (16)

With (1) - (7) and (8) - (15), we can get a set of simultaneous equations (Eqs.) about the unknowns $\{Y/R, Y/C, Y/K, 1/E\}$ as follows:

$$(*)\begin{cases} \dfrac{u_2}{u_1\alpha_1}\dfrac{H_Y}{H_L} = \dfrac{Y}{C} + \dfrac{1}{1-g-\alpha_3}[(\alpha_3+g)\dfrac{Y}{C} - \tau\dfrac{Y}{C}\Big/\dfrac{Y}{R}] \\ \rho - \dfrac{u_3}{u_1\tau^2(1-b)^2 E}\dfrac{Y/R}{Y/C} - \dfrac{e}{\tau^2(1-b)^2}\dfrac{Y}{RE} + \dfrac{e}{\tau^2(1-b)^2(1-g-\alpha_3)}\dfrac{\tau-(\alpha_3+g)\dfrac{Y}{R}}{E} + \dfrac{1}{(1-b)\tau E} = 0 \\ \rho + (1-\alpha_2)\dfrac{Y}{K} - \dfrac{Y}{K}\Big/\dfrac{Y}{C} - \tau\dfrac{Y}{K}\Big/\dfrac{Y}{R} - \dfrac{\alpha_2[(\alpha_3+g)\dfrac{Y}{K} - \tau\dfrac{Y}{K}\Big/\dfrac{Y}{R}]}{1-g-\alpha_3} = 0 \\ u_3 s(\dfrac{Y}{R})^2 - [\rho(\alpha_3+g) + u_3 s\tau]\dfrac{Y}{R} + \rho\tau = 0 \end{cases}$$ Solving

the (*) to get $\{Y/R, Y/C, Y/K, 1/E\}$,we can get g_S by Substituting Y/R into Eq.(6);By the Eq. (14) that $g_E + g_{\lambda_2} = 0$ .Substituting $1/E$,we can get g_E ;according to Eq. (2-3),we have $g_K = \alpha_1 g_{H_Y} + (\dfrac{\alpha_2}{\beta} - \alpha_2)g_N + \alpha_2 g_K + (\alpha_3+g)g_R - eg_E + sg_S$, because the model does not introduce technical progress and human capital accumulation, so $g_{H_Y} = g_H = g_N = 0$;and by the Eqs. (4) and (10-11), we know $g_R = g_K$; so $(\alpha_1 - g)g_K = sg_S - eg_E$,then substitute g_S, g_E together, we can get:

$$\gamma = g_K = (sg_S - eg_E)/(\alpha_1 - g) \tag{16}$$

We can get equilibrium growth rate γ from (16) and summarize proposition as follows:

Proposition: Under FBA, inspired by the government environmental policy, Government, enterprise and residents three together promote the internalization of social capital accumulation. Driven by social capital and with the parameters $\{u_3, \tau, b, s, g, e, ..\}$, there exists the balanced growth path BGP. Along the BGP, $\{C, K, Y\}$ grow at the same constant positive rate γ , and $\gamma = (sg_S - eg_E)/(\alpha_1 - g) > 0$ .As long as pollution stock grows with constant negative rate, namely g_E <0, then environment quality improves gradually.

Proposition shows that social capital accelerates its own accumulation under the help of environmental policy incentives, corporate environmental pressures and environmental awareness, and its accumulation rate is $g_S = g_S(u_3, \tau, s, g, \Lambda)$ .Besides other resources, social capital is an important endogenous growth momentum. Its contribution rate to economic growth is $\eta_S = \alpha_1 - g + eg_E / g_K$ .Just because of its accelerating accumulation, social capital relaxes the growth pressure of resource inputs, reduces pollution emissions, and improving environmental quality. In return, the improvement of environment brings positive and external economic effects to economic growth, even reduce the pressure of economic growth which depends on resource adding. Then virtuous circle occurs. This is not only the essence of social capital accumulation, but also the mechanism of win-win, which is resulted from social capital-driven.

(2) Numerical calibration of model solution

To help understanding the mechanism that social capital drive economic growth and environmental protection, we will show more intuitive by numerical calibration. Adopting the output elasticity and the related parameter settings in Liu fengliang(2009)and Catarina R.P (2010), we set the parameters as follows: $\alpha_1, \alpha_2, \alpha_3 = 0.46, 0.34, 0.20$, $\rho = 0.05$, $\delta = 0.035$, $u_1 = 1$, $u_2 = 0.625$, $e = 0.10$, $g = 0.30$, $b = 0.95$; $\tau = 0.15$, $a = 0.32$. According to the practical weekend system, employees work five days and have two days for rest, actually they can only have one day for their own recreation leisure, so set $H_L / H_Y = 1/5$.

As social capital accumulation is directly related to residents' environmental preferences u_3 and social capital spillovers flexibility s , thus we just focus:① simulate the impact on economic growth and environment when s changing, say $s = 0.055, 0.06, \text{K}, 0.10$, $u_3 = 1$; ②simulate the impact on economic growth and environment when u_3 changing, say $u_3 = 0.55, 0.60, \Lambda, 1$, $s = 0.10$. Numerical calibration results are shown in Table 1:

Table 1 The numerical calibration results under the FBA model

The impact on the economy and environment with s changing, $u_3 = 1$								
s	Y/R	Y/C	Y/K	E	g_S	g_E	γ	η_S
0.055	0.302	6.74	6.89	24100.85	0.302	-0.030	0.122	0.136
0.060	0.283	7.22	7.38	20771.56	0.283	-0.029	0.124	0.137
0.065	0.267	7.74	7.91	17954.46	0.267	-0.028	0.126	0.138
0.070	0.254	8.32	8.50	15539.81	0.254	-0.026	0.128	0.139
0.075	0.242	8.96	9.15	13447.11	0.242	-0.025	0.129	0.141
0.080	0.231	9.67	9.88	11616.00	0.231	-0.024	0.130	0.142
0.085	0.222	10.47	10.70	10000.31	0.222	-0.022	0.132	0.144
0.090	0.214	11.37	11.62	8564.15	0.214	-0.019	0.133	0.145
0.095	0.207	12.40	12.68	7279.16	0.207	-0.017	0.133	0.147
0.1①	**0.200**	**13.59**	**13.89**	**6122.67**	**0.200**	**-0.013**	**0.133**	**0.150**
The impact on the economy and environment with u_3 changing, $s = 0.1$								
u_3	Y/R	Y/C	Y/K	E	g_S	g_E	γ	η_S
0.55	0.302	6.74	6.89	16928.19	0.166	-0.027	0.121	0.138
0.60	0.283	7.22	7.38	15188.86	0.170	-0.026	0.123	0.139
0.65	0.267	7.74	7.91	13656.72	0.174	-0.025	0.124	0.140

0.70	0.254	8.32	8.50	12287.39	0.178	-0.024	0.126	0.141
0.75	0.242	8.96	9.15	11048.30	0.181	-0.023	0.128	0.142
0.80	0.231	9.67	9.88	9915.02	0.185	-0.022	0.129	0.143
0.85	0.222	10.47	10.70	8868.89	0.189	-0.020	0.130	0.145
0.90	0.214	11.37	11.62	7895.39	0.193	-0.018	0.132	0.146
0.95	0.207	12.40	12.68	6983.04	0.196	-0.016	0.133	0.148
1	**0.200**	**13.59**	**13.89**	**6122.67**	**0.200**	**-0.013**	**0.133**	**0.150**

Now analyze the mechanism of social capital driving economic growth and environmental protection. As table 1,with parameters s,u_3 changing, social capital is always accelerating with a higher rate than that of economic growth, namely $g_S > \gamma$,thus its contribution to economic growth is higher than their output elasticity, namely $\eta_S > s$ .Specifically, when $s = 0.055,0.06,\mathrm{K},0.10$,its contribution rate is $\eta_S = 0.136,0.137,\Lambda,0.15$,we have $\eta_S > s$;when $u_3 = 0.55,0.60,\Lambda,1$,its contribution rate is $\eta_S = 0.138,0.139,\Lambda,0.15$,and the output elasticity $s = 0.1$,we also have $\eta_S > s$. Since social capital accumulation accelerates, its excess portion over output elasticity can offset the negative impact resulting from the reducing resource. So pollution stock reduces, environment quality improves, and economy grows in the mean time.

Parameter s changes. From table 1, as Parameter s becomes larger, the rate of economic growth increases gradually and pollution stock decreases. g_S decreases while s increase, but its contribution to economic growth η_S is still larger. The reason maybe that s increasing means the output elasticity of social capital increasing, to maintain a certain growth rate, even if social capital accumulation rate is not too high, there can still achieve economic growth. It is just because of social capital contribution rate η_S increasing, such that the pressure of economic growth from resource increasing eases, pollution emissions decreases, environmental quality improves, namely we achieve economic growth and environmental protection which basing on capital-driven.

Parameter u_3 changes. From Table 1, as Parameter u_3 increases, the rate of economic growth increases and pollution stock decreases gradually. Increasing u_3 means residents environmental awareness increasing, which accelerates social capital accumulation. With its contribution rate η_S increasing, it accelerates economic growth, while the pressure of economic growth by increasing resource consumption eases, pollution emissions decreases, and environmental quality improves; again we achieve economic growth and environmental protection which is capital-driven.

Empirical Analysis of Panel Model

To provide empirical support for the mathematical analysis, we analyze to what degree social capital promote economic growth and environmental protection with panel data. And prove the existence and validity of the three relationships: social capital →economic growth; social capital→energy consumption; social capital →environmental protection.

Variables Choice and Data Preparation. As endogenous economic growth theory insists, technology, human capital, and social capital are the engines of economic growth, not destroying environment, finally promoting the transformation of economic development mode. Therefore, corresponding with the mathematical analysis, now we take human capital, technology, social capital as the explanatory variables, especially analyzing of the effect of

social capital on economy and environment which maybe higher than that of other capital. The Twelfth Five Year Plan clearly puts forward the transformation of the mode of economic development and focuses on resource conservation and environmental protection. So we chose economic growth, environmental pollution, energy consumption as explained variables.

(1) Variables choice

Human capital is the product of education investment, and it is more important than physical capital to economic growth (Schultz, Becker, 1986). Therefore, we choose the proportion of population with college degree to those above 6 years old (*Hum*, %) [1]as deputy.

Technology is the fundamental driving force for the transformation of economic development mode. Therefore, considering the data availability, we use annual patent quantity authorized (*Pat, term*)[1]. Since it will take time before patents works, we use its one period lag as the representative.

So far there is no unified index system for measurement of social capital. Zhao Yandong, Luo Jiade [2] put forward a systematic social capital measurement system——the strength and frequency of social interaction, quality level of social relations, the sparse degree of the network connection. Inspired by it, we describe the social capital from the following aspects: the harmony of social relations, the availability of social resources, and the ability to participate in social activities. Since social capital is a kind of public resources, its performance also depends on the social atmosphere and public participation, which is true to the present state of our China. Among them, social harmony includes 3 kinds: harmony between urban and rural areas, social integrity, and harmonious interpersonal relations. We choose per capita income of rural residents to city residents (*Ru-city*, %), quality monitoring and inspection product rate (*ratio*, %), and the ratio of marriage to divorce (*Marri*, Times) respectively. The available social resources is the external environment or resources, which are helpful to enterprises and residents in production or living, here we choose the road area per capita(*Uti*,m^2) and the number of books published (*Lib*,million) respectively. The ability to participate in social activities reflects to what degree enterprise or residents can participate in social affairs, we select employees of environmental protection (*Env*, people), and letters and visits from the masses (*Let*, letter) respectively.

Environmental policy and control variables measure the impact of environmental policy and macro economic environment on economy and environment. Environmental policy variables include the charge of pollution emission(*Cha*,million),the "three simultaneous" completed programs (*Pro* ,item),the investment of pollution abatement(*Aba*, million);control variables include the market rate (*Mar* ,%), the number of the full-time teachers (*Tea*, human)，foreign direct investment (*Fdi*, million dollars) .The market rate refers to the non state owned and non collective enterprises output value account for the proportion of total output value [3].

Indicators of economic growth. We chooses *Gdp* (100 million yuan) and fiscal revenue (*Rev*, ten thousand yuan), because huge GDP and fiscal revenue are the strong economic foundation to resist the risk, deal with the market failure, implement government reform. Economists have been warning that our fundamental goal is to make people rich and powerful. Therefore, we also choose social retail sales of consumer goods (*Sal*, 100 million yuan), per capita living consumption expenditure (*Cons*, yuan) to reflect resident's purchasing and consumption power.

Pollution emission. Pollution mainly come from industrial "three wastes", And in gas emission,

sulfur dioxide is an important index. Therefore, we choose So2 emissions (*So2*, tons), industrial wastewater (*Wat*, 10000 tons), industrial solid waste (*Sol*, 10000 tons), industrial waste Gas (*Gas*, billion m3) [3-5].

Resource consumption. During industrial production and residents living, energy consumption directly influences sustainable development. It mainly includes coal consumption, power consumption, together with other auxiliary energy consumption, they all can be converted into the total energy consumption. Therefore, we take the *Coa* (million tons) as coal consumption, *Ele* (billion kilowatt hours) as power consumption, and *Ena* (million tons of coal) as total energy consumption [6].

(2)Data description and unit root test

Basing on 1999-2012 "statistical yearbook of China", "China Environment Yearbook", "China Statistical Yearbook", we collect 1998-2011 provincial panel data of 31 regions in China as table 2:

Table 2. Statistical description of data

variables	**Obs**	**mean**	**deviation**	**min**
explained variables				
economic growth regional gross national product(*Gdp*,100 million yuan)	433	7266	8114	98.1
government receipts revenue (*Rev*, ten thousand yuan)	434	5865878	7266467	36393
the retail sales of consumer goods (*Sal*, 100 million yuan)	432	2506	2761	42.9
per capita living consumption expenditure (*Cons*, yuan)	433	7754	3949	1339
Environmental pollution So2 emissions (*So2*, tons)	433	674045	455246	734
industrial wastewater (*Wat*, 10000 tons)	434	71652	62050	363
industrial solid waste (*Sol*, 10000 tons)	434	4754	4961	5.49
industrial waste Gas (*Gas*, billion m3)	434	9610	9744	12
Resource consumption coal consumption (*Coa*, million tons)	416	8541	7279	169
power consumption(*Ele*, billion kilowatt hours)	424	837	758	15
total energy consumption (*Ena*, million tons of coal)	415	7661	6218	407
explanatory variables				
Human capital the proportion of population with college degree to those above 6 years old (*Hum*, %)	434	0.0666	0.0507	0.0009
Technology authorized patents (*Pat*, tem)	434	8613	19606	7
Social capital——social harmony degree				
urban and rural harmonious degree——the per capita income of rural residents to city residents (*Ru-city*, %)	433	0.35	0.075	0.18
social integrity——quality monitoring and inspection product rate (*ratio*, %)	377	72	20	4.5
harmonious interpersonal relations——the ratio of marriage to divorce (*Marri*, Times)	428	5.95	2.69	2.23
Social capital——available social resources				
the road area per capita(*Uti*,m^2)	434	10.62	3.73	3.9
the number of books published (*Lib*, million)	372	2454	4675	48
Social capital——ability to participate in social activities				

employees of environmental protection (*Env*, people)	434	5102	4100	137
letters and visits from the masses (*Let*, letter)	434	15524	19917	24
Environmental policy the charge of pollution emission(*Cha*,million)	398	33551	40045	142
the "three simultaneous" completed programs (*Pro* ,item)	395	2835	5239	1
the investment of pollution abatement (*Aba*, million)	429	697619	4166139	129
Control variables the market rate (*Mar*, %)	396	0.237	0.195	0.0007
the number of the full-time teachers (*Tea*, human)	434	28287	21541	541
foreign direct investment (*Fdi*, million dollars)	434	5034126	8530890	25648

To avoid spurious regression, variables are set to I (1). Leave off the results for space limitations.

Model Estimation and Results Analysis. We use $LN(Y_i) = \alpha_0 + LN(\text{Hum}) + LN(\text{Pat}) + \sum_{k=1}^{3} \alpha_k LN(\text{Social cap}) + \sum_j \beta_j Z_j$ as our model, where Y_i is the explained variable, representing economic growth, environmental pollution and resource consumption respectively, and we use human capital, technology and social capital as explanatory variables. Also we take the environmental policy and Z_j reflecting the influence of control variables [7, 8]. The results are shown in Table 3:

Table 3. the win-win of social capital promoting economic growth and environment protection

Var \ Eqs	*Hum*	*Pat*	Social capital						
			Harmony degree of social relation			Available social resource		Capacity of social activities	
			Ru-city	*Ratio*	*Marri*	*Uti*	*Lib*	*Env*	*Let*
Economic growth R-squared(Rev，Gdp，Sal，Con)=0.96，0.97，0.97，0.67									
Rev	0.18*** (3.57)	0.48*** (15.4)	-0.33*** (-2.44)	0.03 (0.75)	0.22*** (5.02)	0.05 (0.95)	0.21*** (4.90)	-0.09** (-2.2)	-0.05*** (-3.6)
Gdp	-0.15*** (-3.66)	0.38*** (14.7)	0.18* (1.63)	-0.003 (-0.06)	0.13*** (3.47)	0.20*** (4.63)	0.19*** (5.71)	0.04 (1.25)	-0.02** (-1.83)
Sal	-0.16*** (-3.8)	0.38*** (14.4)	0.16 (1.42)	0.05 (1.14)	0.07** (1.96)	0.14*** (3.18)	0.17*** (5.12)	0.04 (1.08)	-0.01 (-0.7)
Con	0.19*** (2.97)	0.11*** (2.88)	-0.43*** (-2.63)	0.14** (2.26)	0.07 (1.12)	-0.04 (-0.60)	0.05 (1.14)	-0.17*** (-2.97)	0.18*** (8.38)
Environmental pollution R-squared(So2，Wat，Sol，Gas)=0.83，0.89，0.87，086									
So2	-0.156 (-1.27)	-0.13* (-1.68)	-0.51** (-1.87)	-0.159 (-1.31)	-0.048 (-0.44)	-0.81*** (-5.43)	-0.052 (-0.57)	0.29*** (2.96)	0.11*** (3.12)
Wat	-0.63*** (-6.76)	0.069 (1.14)	0.33 (1.47)	-0.159** (-1.89)	-0.023 (-0.29)	0.028 (0.27)	0.19*** (2.70)	0.007 (0.09)	0.17*** (6.58)
Sol	-0.08 (-0.64)	-0.26*** (-3.06)	-0.07 (-0.22)	-0.25*** (-2.32)	0.03 (0.23)	-0.81*** (-5.71)	-0.08(-0.96)	0.35*** (3.97)	0.04 (1.19)
Gas	0.24** (1.9)	-0.11* (-1.4)	-0.01 (-0.02)	-0.21** (-1.92)	0.11 (0.96)	-0.32** (-2.11)	0.02(0.22)	0.15** (1.87)	0.004 (0.15)
Resource consumption R-squared(Coa，Ele，Ene)=0.87，0.91，0.92									
Coa	-0.07 (-0.94)	-0.07* (-1.55)	0.31* (1.68)	-0.11* (-1.57)	-0.24*** (-3.38)	-0.37*** (-3.92)	-0.19*** (-3.03)	0.37*** (4.96)	0.04* (1.62)

Ele	0.09 (1.41)	0.18*** (4.2)	-0.21* (-1.27)	-0.23*** (-3.0)	0.02 (0.39)	-0.14** (-2.1)	-0.19*** (-3.2)	0.09** (1.88)	0.04** (1.95)
Ene	0.006 (0.12)	0.15*** (4.9)	0.05 (0.37)	-0.12** (-2.3)	-0.14*** (-2.8)	-0.20*** (-3.4)	-0.09** (-2.2)	0.24*** (4.98)	0.01 (0.80)

①The figure in parentheses is T statistics, the superscript "***", "**", "*" represent the coefficients are significant under the level of 1%, 5%,10%. ②For the limited of width of the table, it doesn't show the regression result of environmental policy variable and control variable.

First analyze the economic growth in the upper part of Table 3.The more significantly positive the coefficient, the better the result. The coefficients of human capital and technology are mostly positive and significant, showing that human capital and technology contribute to improving economic growth, which is identical to the existing research [9, 10]. As for social capital——including three types and seven indexes which reflect the harmony degree of social relations, available social resource and the capacity of social activities, 70% of the coefficients in the equation of economic growth are positive and relatively significant, showing that the social capital contributes to improving economic growth, improving household consumption. Among the three types of social capital, the effect of harmony degree of social relations and available social resource is more significant, while the capacity of social activities is weaker.

Then analyze the environmental pollution and energy consumption in the half part of Table 3. The more significantly negative the coefficient, the better the result. The coefficients of human capital are mostly significantly negative, showing that human capital contributes to pollution reduction and resource reservation. The coefficients of technology are negative, but not as significant as human capital. On one hand, it reflects technology contribute to pollution reduction and resource reservation, on the other hand there is a gap before technical progress or patented technology turn into productivity, especially clean technology productivity. As for social capital, the coefficients of three index about social harmony are significant and negative, explaining that social harmony contribute to mobilizing residents environmental enthusiasm, reducing pollution emission and resource conservation; the coefficients of the two available social resource are mostly negative but not as significant as the harmony degree of social relations, showing social resource is beneficial to reduce environmental pollution and resource consumption, but the resource utilization efficiency need to be improved. For example, there is time-delay before such road facility, book publishing and the establishment of library turn into productivity of producers and residents, and this need effort from government guidance, incentive of enterprise and participation of residents. The coefficients of the participative capacity are mostly positive, and not significant enough. All these shows that, only with higher and broader participation together, can harmonious social relations and social resource turn into social capital as an engine or productivity, consistent with the existing research [11-13] which insist that social capital contribute not only economy but also to environment.

Conclusion

By employing mathematical analysis and making numerical calibration, we find that: Social capital promotes economic growth and environmental protection through endogenous accumulation, and get empirical support from panel model. Accordingly, things as follows need to be considered:

Accelerate the cultivation of social capital, strengthen the government, enterprises and resident's environmental awareness, fundamentally contributes to the internalization and accumulation of social capital. From section Ⅱ, we know social capital accumulation is accelerating

under the incentive of government environmental tax, enterprise cleaner production and residents green consumption preference, which promote resource conservation, environmental protection and economic growth, achieve win-win state of economy and environment, all these can also be seen in panel model. Therefore, environmental awareness of government, enterprises and residents will provide endogenous motivation for a win-win state.

Form a common learning organization about environmental protection and resource conservation among government, enterprises and residents, so as to improve the output elasticity of social capital. From section Ⅱ, we know the larger the output elasticity, the higher social capital contribution rate to economic growth. Social capital output elasticity means social capital output efficiency, only if form the common learning organization by the three parts, achieve the environmental consciousness, promote environmental cooperation, take common norms or values, can social capital work as a positive performance of individuals, organizations and society, can it bring about higher output elasticity, can it have larger contribution rate to economic growth, which is identify with Putnam [10] and Meier's definition about social capital.

Strengthen the ability of participation, promote social capital acting as productivity as possible, and achieve the win-win of economy and environment. we can see from sectionⅢ, the coefficients of the harmony social relations are the most significant on promotion of economic growth and environmental protection, while the available social resources be weaker and the participation social activities be weakest, showing that there is a process transforming social resource or social capital into productivity, it need government guidance, enterprise incentive, participation of residents and other various efforts. If residents can participate in social affairs, fully enjoy community facilities, public library and other public resources, there will be a potential benefit to material capital and human capital, knowledge capital, when social capital is forming, promoting economic growth and environment protection.

Acknowlegements

The paper is supported by the program of NSFC 2010 (NO: 71063006) , NSFC 2012 (NO:71273122) , NSFC 2013(NO: 71340010) and NSFC 2015(NO: 71540025) ; Supported by NSSP(2012GXS4D089)、 Jiangxi Province 2012 young university teacher development plan of Visiting Scholars Program; Supported by the China Postdoctoral Science Foundation (NO: 2013M541066).

Reference

[1] Pan Y.;Dai Y.Y,Wu C.P, Liu J.L..Social Capital, Political Connections and Corporate Investment Decision.Economics Research, 2009, 11:82-94.
[2] Zhang H.F.,Wu W..A Research on Synergic effect among Psychological Capital, Human capital and social capital. Economic Management, 2009, 7:14-27.
[3] Li Y.Y.,Shen K.R..The emission reduction's effect of pollution control policy in China—empirical analysis of provincial industrial pollution data. management World, 2008, 7: 7-17.
[4] Liu F.L., Lv Z.H..The optimal environmental tax and its supporting policies under the framework of economic growth—Base on the simulation operation of Chinese data[J] .management World , 2009, 6:4-15.
[5] Zhang H.F., Zhou F., Yang H., Guo Q..Regulation Performance of the Win-win of Environmental Protection and Economic Development. economics research,2009,3:14-27.
[6] Wan J.X., Mei G.P.. Can social capital drive economic growth and environmental protection?.The Journal of Quantitative & Technical Economics,2012,27 (7): 61-75.
[7] Gradus R., Smulders S..*The Trade-off between Environmental Care and Long-term Growth: Pollution in Three Prototype Growth Models*. Journal of Economics,1993, 58, 25-51.

[8] Smulders S., Gradus R..*Pollution Abatement and Long-term Growth*. European Journal of Political Economy,1996, 12, 505-532.
[9]Gupta M.R., Barman T.R..*Fiscal Policies, Environmental Pollution and Economic rowth*. Economic Modeling, 2009, 26, 1018-1028.
[10] Putnam R..*Marking Democracy Work Civic Traditions in Modern Italy*. Princeton University Press. 1993.
[11] Owen A., Videras, J..*Civic Cooperation, Pro-environment Attitudes and Behavioral Intentions*. Ecological Economics, 2006, 58, 814–829.
[12] Torgler B., Garc á-Valinas M.A..T*he Determinants of Individuals' Attitudes towards Preventing Environmental Damage*. Ecological Economics , 2007, 63, 536–552.
[13] Catarina R.P., Alexandra F.L., Tiago N.S..*Externalities in an Endogenous Growth Model with Social and Natural Capital*. Ecological Economics , 2010, 69, 603–612.

