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Financial development and environmental performance: evidence from China*

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ABSTRACT. This paper extends the debate on the environmental performance of developing countries by focusing on a new factor. Theoretically, financial development has capitalization, technology, income, and regulation effects on the environment. Using the provincial panel data of China, the econometric analysis provides some evidence of a linkage between financial development and industrial pollution discharges. In recent years, the environmental performance of China has been significantly improved by financial development and some environmental protection schemes. This relationship offers new implications for policy makers in developing countries.

1. Introduction

In recent decades, China has tried to establish a high-quality legal framework for pursuing sustainable development and environmental progress. For example, some modern environmental legislation has been introduced in order to encourage water conservation (see, Appendix). Nevertheless, the destruction of the environment is still one of the serious challenges China faces at present because of its rapid urbanization and economic growth. The air pollution levels in some cities are among the worst in the world; about a third of China's total river length is highly polluted (OECD, 2007). Pollution has caused huge damage to the economy of China (Chang *et al.*, 2001); the significant regional differences in pollution intensities (see, figures 1 and 2) have made the enforcement

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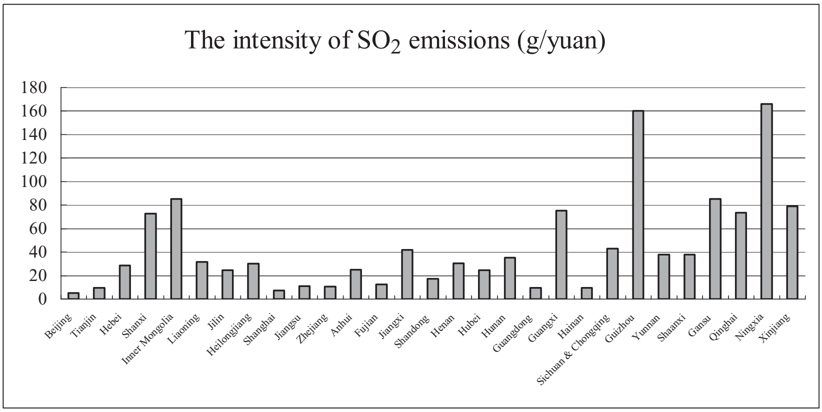

Figure 1. *Regional differences in the intensity of industrial SO_2 emissions in 2006*
Data sources: China Statistical Yearbook and China Environment Yearbook.

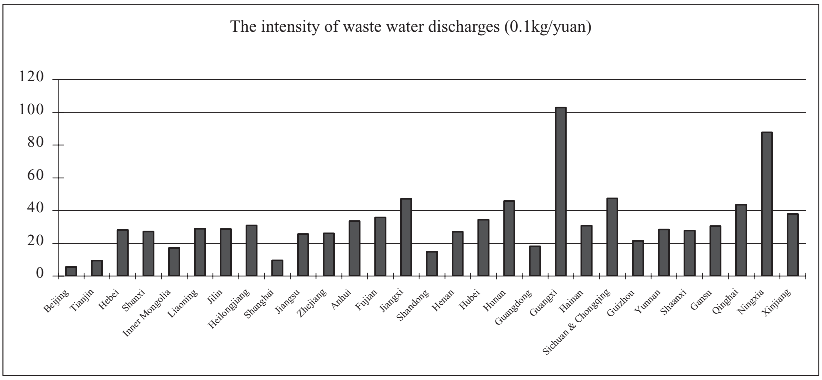

Figure 2. *Regional differences in the intensity of industrial waste water discharges in 2006*
Data sources: China Statistical Yearbook and China Environment Yearbook.

of environmental regulations quite difficult. More effective environmental policies, therefore, are needed to improve the environmental performance of China.

To formulate effective policies, the factors that influence environmental performance should be well studied. The previous literature has emphasized the importance of income and growth, technology, foreign direct investment, government expenditure, corruption, and informal regulations (Grossman and Krueger, 1995; Pargal and Wheeler, 1996; Lopez and Mitra, 2000; Eskeland and Harrison, 2003; He, 2006; Karen *et al.*, 2006; Cole, 2007; Tsuzuki, 2008; Yuxiang and Chen, 2010a). Almost all the previous studies have the implicit premise that enterprises can get enough financial services to conduct environment-friendly production. Unfortunately, this assumption is challenged by the evidence from developing countries, in which there are significant financing constraints on small and medium-size enterprises, and even some of the large ones

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have limited access to formal sources of external finance (McKinnon, 1973, 1994; Shaw, 1973; Perotti, 1993; Athey and Laumas, 1994; Chow and Fung, 2000; Perotti and Vesnaver, 2004; Beck and Demirgüc-Kunt, 2006). In such circumstances, financial development can profoundly change the countries' economic performance.

As the largest developing country, China also experienced substantial changes in its financial system in recent decades. Before the 1970s, the state-owned enterprises (SOEs)' investment was financed mainly from interest-free budgetary grants and retained profits. During the 1980s, the SOEs came to rely on banks and the share of their total investment financed by bank loans increased from 14.3% in 1983 to 30.4% in 1992 (Cull and Xu, 2003). The banks' lending decisions were much less susceptible to political influence than was the allocation of government grants (Cull and Xu, 2000).

Subsequently, the financial reform that began in 1993 significantly improved the performance of financial institutions. For example, in 1994, three policy banks were established to provide noncommercial financial services; in 1995, the Commercial Bank Law was introduced. As a result, the state-owned commercial banks could be free to pursue commercial objectives. Owing to the series of reforms, financial development was stimulated, and the ratio of the bank loans to gross domestic product (GDP) increased from 0.83 in 1995 to 1.44 in 2007 (China Finance Association, 2008). A survey of enterprises for the period between 2000 and 2002 indicated that the bank loans were supporting valid investment, and the better performing private enterprises were more likely to receive loans (Cull and Xu, 2005).

To what extent does such financial development influence the enterprises' environmental performance? This question has not been well answered by the previous literature. An exception is the recent studies of Tamazian *et al.* (2009), who found that financial development was one of the key factors in the carbon dioxide (CO_2) reduction of the Brazil, Russia, India, and China (BRIC) economies. To get improved insights into this topic, further analysis is still needed. With the aim of making a contribution, we compile detailed provincial panel data of China to analyze the relationship between financial development and industrial pollution discharges. As shown in figure 3, while the ratio of total loans to GDP increased steadily in recent years, the intensities of pollution discharges decreased gradually. This inverse relationship will be analyzed in the following sections.

The rest of the paper is organized as follows: Section 2 provides the theoretical analysis. The empirical results are reported in section 3, and section 4 concludes the paper.

2. Theoretical analysis

Financial development, in this paper, refers to the increased quantity and improved quality of the provision of financial services. During the process, enterprises, especially those of relatively high productivity, get access to external finance more easily or at lower cost than they did before. The effects of financial development on the environmental performance of developing countries can be classified into the following four aspects.

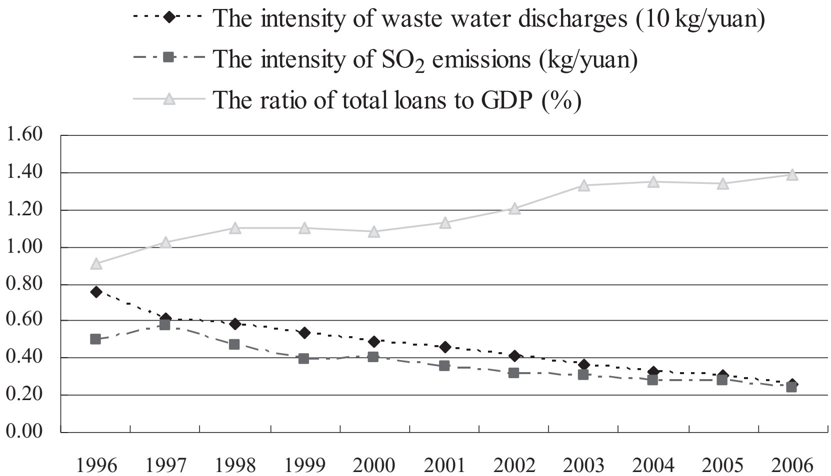

Figure 3. *Financial development and the evolution of the intensities of industrial pollution discharges in China*
Data sources: China Finance Yearbook and China Environment Yearbook.

First, financial development facilitates the investment of enterprises and thus has capitalization effects on their environmental performance. On one hand, some of the effects are positive, because the investment in abatement equipment may be facilitated. Such investment is beneficial to enterprises because of environmental regulations and the consumer preference for green products (Lundgren, 2003). Thus, the introduction of environment-friendly technologies will be encouraged if enterprises get access to external finance more easily or at lower cost. Furthermore, financial development tends to encourage the growth of large and medium-size enterprises, since it reduces financing constraints on them. As a result, their environmental performance may be improved, because such enterprises have the benefits of economies of scale in both resource use and pollution abatement (Cole *et al*., 2005).

On the other hand, some of the capitalization effects may be detrimental to the environment, as the growth of capital-intensive sectors may be encouraged by financial development. When the provision of financial services increases, some enterprises may become reliant on industrial machinery. Consequently, such upward movement in the capital intensity tends to increase pollution intensities, since there is a positive correlation between them (see Cole *et al*., 2005). Moreover, financial development may also stimulate the entry or growth of small enterprises, which have few benefits of economies of scale in resource use and pollution abatement. As a result, such entry or growth may increase the pollution intensities, though this detrimental effect is trifling because of the minor role played by such enterprises in changing the environmental performance of the whole industry. Therefore, the capitalization effects of financial development are mixed according to the theoretical predictions.

Second, financial development has technology effects on environmental performance, because it can stimulate R&D activities and technological improvements. The significant linkage between R&D activities and external finance has long been recognized by Switzer (1984) and Hansen (1999). This relationship is important, because technology is regarded as a crucial factor in determining the environmental performance of enterprises (Cole *et al.*, 2005; Karen *et al.*, 2006; Ma and Stern, 2008). Theoretically, technological improvements have two different effects on the environment. On one hand, such improvements may encourage the introduction of new environment-friendly technologies, which are beneficial to the environment. On the other hand, technological improvements may also increase the demand for natural resources such as energy. This reverse effect is named as the rebound effect by some previous studies (Sanstad *et al.*, 2006; Brännlund *et al.*, 2007). Therefore, the technology effects of financial development are also mixed according to the theory.

Third, financial development has income effects on the environmental performance, as it constitutes an important mechanism for long-run growth (McKinnon, 1973; King and Levine, 1993a, b; Odedokun, 1996; Levine and Zervos, 1998; Christopoulos and Tsionas, 2004; Yuxiang and Chen, 2010b). According to the Environmental Kuznets Curve (Grossman and Krueger, 1995; Suri and Chapman, 1998), the income effects can be either positive or negative.

Finally, if some environmental regulations are incorporated in the provision of financial services, financial development, which makes enterprises dependent on external finance, tends to strengthen the effects of environmental policies. For example, the People's Bank of China issued The Ordinance on the Implementation of Credit Policy to strengthen Environmental Protection in 1995. The banks were required to support environmental policies when assessing loans to enterprises. Specifically, the ordinance encouraged banks to assign high priority to the projects that were aiming at abating industrial pollution, or had authorized reports on environmental impact assessment. Subsequently, environmental performance rating and information disclosure schemes have been used to publicize the environmental performance of enterprises since 2002. These schemes are taken into account by banks when making decisions (OECD, 2007).

The banks have incentives to assess the environmental risks, since they do not want to run the risk of losing their money. Such incentives are influenced by the legal framework for the protection of the environment. Thus, this regulation effect of financial development will become stronger if a sound framework of environmental protection comes into operation. In this regard, such effects may be small at present, but they have the potential to play an important role in the future.

In summary, financial development has capitalization, technology, income, and regulation effects on the environmental performance of developing countries. Its real effects can be either positive or negative according to the theoretical analysis. This reveals the necessity of conducting empirical analysis to examine the effects in specific situations.

3. Econometric analysis

3.1. Data description and summary statistics

The analysis uses the provincial panel data of China from 1999 to 2006. The time span is decided by the availability of the data of private loans. Because the data of several provinces are unavailable, the sample includes twenty-nine provinces. All the data come from China Statistical Yearbook, China Environment Yearbook, China Finance Yearbook, and China Science and Technology Statistical Yearbook.

3.1.1. The variables of water and air pollution

The intensities of industrial waste water and chemical oxygen demand (COD)-related discharges are selected as the variables of water pollution. The following equations are used to estimate the two variables:

$$\mathrm{IWWI}_{it} = \frac{\mathrm{WWD}_{it}}{\mathrm{VAI}_{it}},$$
$$\mathrm{CODI}_{it} = \frac{\mathrm{CODD}_{it}}{\mathrm{VAI}_{it}},$$

where IWWI is the intensity of industrial waste water discharges and WWD the volume of such discharges. VAI denotes the value added of the industry at the 1995 price. Similarly, CODI is the intensity of industrial COD-related discharges, and CODD the volume of such discharges.

In addition, the changes in sulfur dioxide (SO_2) emissions are also estimated as another pollution variable. The amount of industrial SO_2 emissions divided by the value added of the industry at the 1995 price is estimated as the variable of air pollution intensity.

The pollution data are collected by the State Environmental Protection Administration (SEPA), which surveys 85% of the pollution-intensive enterprises and estimates the other ones' pollution discharges according to their production. As the data come from the authoritative yearbook on this subject, these variables can soundly indicate the changes in the environmental performance of the industry.

3.1.2. The variables of financial development

In China, the main access of enterprises to external finance is provided by banks. Because of this bank-dominated characteristic of the financial system, this variable should be an indicator relevant to banks. According to the China Statistical Yearbook, there is a substantial difference between the deposits and loans of financial institutions, and more than 30 per cent of the deposits have been sleeping in banks in the past decade. Thus, the ratio of the deposits to GDP can hardly indicate the financial development in China.

Since loans are more relevant to the activities of enterprises, the ratio of bank loans to GDP is estimated as the proxy for financial development. This ratio indicates how many financial services are needed in order to produce a unit of GDP and is the commonly used indicator in the previous studies (Liang and Teng, 2006; Baltagi *et al.*, 2009; Giuliano and Ruiz-Arranz, 2009; Hasan *et al.*, 2009; Lu and Yao, 2009; Yuxiang and Chen, 2010b).

In addition, two other financial variables are also introduced to provide alternative proxies for assessing the pace of financial development. The first one is the ratio of the private loans to GDP. In the yearbooks of China, private loans include short-term loans to agriculture, township enterprises, domestic private firms, and foreign-funded enterprises. Agriculture is privately operated, because it is household based in China. The township enterprises are legally owned by town or village collectives, but they are treated differently from the SOEs in the access to bank loans (Lu and Yao, 2009). In the official statistics, the domestic private firms include only those owned by a single private owner. As a result, the private loans in our estimation cover only a portion of the loans to the private sector, but this indicator is the best proxy that is available.

The second variable is the value of the nonprivate loans (total loans minus private loans) divided by GDP. In our analysis it is as important as the variable of private loans, because some if not all of the loans to SOEs also reflect the pace of financial development.

3.1.3. The control variables

To control the impacts of other factors, four variables are also included in our models.

First, the impacts of R&D activities should be controlled, since they are important and not fully decided by financial development. The annual R&D expenditure of industrial enterprises divided by gross industrial output value is estimated as the proxy for R&D intensity. In the estimation, the expenditure on Science and Technology Activities (S&TA) is used instead of standard R&D expenditure, because the latter's time-series data are unavailable in the official statistics. The S&TA includes the research activities and the purchase and construction of fixed assets for scientific research. Thus, the expenditure on S&TA can be a good proxy for R&D activities.

Second, the value of annual foreign direct investment (FDI) divided by the gross investment in fixed assets is estimated as the variable of FDI, since it is the commonly used proxy in the previous Chinese studies (see, e.g., Zhang and Song, 2000). The foreign direct investment refers to the investment inside China by foreign enterprises, organizations, or individuals (including overseas Chinese, compatriots from Hong Kong, Macao and Taiwan, and some Chinese enterprises registered abroad) for the establishment of ventures exclusively with foreign own investment, Sino-foreign joint ventures and cooperative enterprises, or for cooperative exploration of resources with enterprises in China. This variable is used to control the environmental impacts of FDI.

To explain the FDI-environment nexus in developing countries, two conflicting theoretical hypotheses have been formulated by some previous literature. The pollution haven hypothesis emphasizes the importance of the relatively lax environmental regulations in developing countries, and thus predicts a positive correlation between FDI and environmental pollution. By comparison, the pollution halo hypothesis stresses the importance of advanced technologies and environmental management systems that are utilized by the foreign-funded enterprises (see Cole *et al.*, 2008). It, therefore, points out that the inflow of foreign capital can yield environmental benefits to developing countries. Since this nexus attracts special attention, using this variable helps compare the environmental impacts of FDI and financial development.

Third, provincial GDP per capita at the 1995 price is included to control the effects of income growth according to the Environmental Kuznets Curve.

Finally, a dummy variable is included to control the impacts of environmental performance rating and information disclosure schemes, which have been used in China since 2002.

3.1.4. Summary statistics

Table 1 presents summary statistics of the above variables.

3.2. Econometric approach

In order to control the habitual inertia and adjustment cost, the lagged dependent variable is included in the models. Thus, the optimal lag period of the dependent variable needs to be selected. Following Arellano and Bond (1991), the autocorrelation test is employed to identify the most appropriate lag. That is to say, the selection is based on the absence of significant second-order serial correlation in the panel vector auto-regression (VAR) residuals (Huang *et al.*, 2008).

In addition, province dummies are included to capture the time-invariant specific effects. Time dummies are also introduced to control the effects of other exogenous factors. Specifically, the basic equation is

$$y_{it} = \alpha y_{i(t-1)} + \beta' X + \eta_i + \lambda_t + \nu_{it},$$

where y denotes a dependent variable and X a vector of independent variables. α is a parameter, and β a vector of parameters. η denotes province dummies and λ time dummies. ν is the usual error term.

To deal with the time-invariant fixed effects, the first-difference transformation is suggested by Arellano and Bond (1991). Thus, the equation becomes

$$\Delta y_{it} = \alpha \Delta y_{i(t-1)} + \beta' \Delta X + \Delta\lambda_t + \Delta\nu_{it},$$

where Δ is the first-difference operator.

According to the simulation results of Blundell and Bond (1998), when the coefficient of the lagged dependent variable is close to one, the efficiency of using the system generalized method of moments (GMM) estimator is improved substantially. Moreover, the one-step estimator is selected according to the studies of Bond (2002). Therefore, the robust one-step system GMM estimator is employed in our empirical analysis.

3.3. Results

3.3.1. Financial development and industrial waste water discharges

Equation (1) in table 2 shows that the variable of financial development significantly and negatively correlates with the intensity of waste water discharges. In equation (2) of this table, this correlation remains statistically significant, implying a negative impact of financial development on waste water discharges. Such negative relationships can also be found in

Table 1. *Summary statistics, 1999–2006*

Variables	*Units*	*Year*	*Mean*	*Standard deviation*	*Minimum*	*Maximum*
The intensity of waste water discharges	0.1 kg/yuan	1999	65.26	29.13	20.44	138.16
		2000	59.60	27.67	22.34	126.93
		2001	54.94	27.10	22.91	143.17
		2002	49.25	25.86	19.62	136.20
		2003	44.85	26.88	12.25	147.71
		2004	39.37	23.15	9.72	129.89
		2005	39.80	27.69	7.56	133.48
		2006	32.86	20.44	5.57	102.91
The intensity of COD-related discharges	0.01 g/yuan	1999	267.52	207.93	45.11	883.81
		2000	266.83	333.06	28.60	1609.13
		2001	217.13	311.68	21.82	1621.40
		2002	160.22	184.13	15.53	788.11
		2003	141.54	166.84	9.75	774.36
		2004	118.47	141.39	8.73	733.91
		2005	129.25	148.40	6.48	609.06
		2006	110.43	131.29	5.07	542.32
The intensity of industrial SO_2 emissions	0.1 g/yuan	1999	61.57	59.10	12.61	248.28
		2000	60.60	53.13	13.83	213.02
		2001	52.92	46.53	10.53	181.91
		2002	48.50	44.32	8.70	173.79
		2003	53.34	49.84	9.54	199.53
		2004	48.15	41.53	8.99	169.85
		2005	48.52	40.42	6.20	170.45
		2006	44.90	41.49	5.15	166.05
The ratio of total loans to GDP	10^{-2}	1999	112.99	33.24	63.53	187.21
		2000	108.22	35.35	62.21	239.82
		2001	108.24	28.44	72.76	205.15
		2002	113.51	32.32	73.98	224.09
		2003	120.01	35.14	82.54	240.02
		2004	110.05	31.83	73.53	224.05
		2005	101.69	33.20	64.19	222.69
		2006	100.78	34.19	64.95	230.65
The ratio of private loans to GDP	10^{-2}	1999	24.99	9.60	9.91	50.87
		2000	26.87	10.11	14.48	50.94
		2001	23.02	6.89	14.00	40.05
		2002	24.78	6.92	13.76	41.89
		2003	25.80	7.38	13.92	43.47
		2004	23.78	6.75	12.67	41.93
		2005	21.84	6.47	11.54	39.50
		2006	20.19	6.16	10.87	39.32
The ratio of nonprivate loans to GDP	10^{-2}	1999	88.00	31.16	42.27	152.16
		2000	81.35	33.53	38.40	201.86
		2001	85.22	27.43	50.26	178.53
		2002	88.73	30.22	53.20	195.75
		2003	94.21	31.85	55.94	208.80
		2004	86.27	28.18	51.37	192.49
		2005	79.85	28.77	45.45	189.17
		2006	80.58	30.98	47.66	204.45

Table 1. *Continued.*

Variables	*Units*	*Year*	*Mean*	*Standard deviation*	*Minimum*	*Maximum*
The R&D intensity	10^{-4}	1999	4.79	0.41	3.91	5.49
		2000	4.97	0.39	4.15	5.61
		2001	4.96	0.46	3.52	5.74
		2002	5.03	0.40	3.76	5.53
		2003	4.93	0.44	3.69	5.69
		2004	4.90	0.39	3.56	5.56
		2005	4.98	0.30	4.38	5.63
		2006	4.98	0.28	4.35	5.56
The ratio of FDI to gross investment	10^{-3}	1999	83.28	88.00	3.61	336.20
		2000	72.76	75.10	2.44	301.85
		2001	76.94	81.17	2.34	286.47
		2002	74.38	74.16	1.83	233.15
		2003	58.99	53.94	1.18	171.25
		2004	50.98	50.15	2.67	161.26
		2005	39.29	43.01	0.47	146.86
		2006	33.36	39.73	0.65	123.96
GDP per capita	10^3 yuan	1999	7.52	4.92	2.37	25.81
		2000	7.98	4.96	2.54	25.69
		2001	8.74	5.56	2.73	28.86
		2002	9.62	6.18	2.95	31.91
		2003	10.66	6.74	3.22	34.02
		2004	11.98	7.60	3.56	38.18
		2005	13.41	8.23	4.16	41.56
		2006	15.04	9.09	4.60	45.60

Note: All the variables have 232 observations except the FDI-investment ratio, which has 224 observations because the data of a province are unavailable.

equations (3) and (4) of table 2, but the negative coefficient of nonprivate loans is more significant than that of private loans. This suggests that the loans to SOEs play an important part in the negative relationship between financial development and waste water discharges.

In equations (2) and (4) of table 2, the income variable has both negative and positive coefficients, which indicate two different impacts of income growth. The fact that its positive coefficient is smaller than the negative one implies the income growth tends to reduce the intensity of waste water discharges. According to the negative coefficient of the 2002 dummy variable in table 2, the environmental protection schemes that have been used since 2002 also help reduce waste water discharges.

3.3.2. Financial development and COD-related discharges

In equations (5) and (6) of table 3, the negative coefficient of financial development is statistically significant and confirms the above findings. But its positive coefficient is significant too, implying some positive impacts of financial development on the intensity of COD-related discharges. Such impacts may be largely due to the capitalization effects

Table 2. *Financial development and waste water discharges: equations (1)–(4)*

Explanatory variables (in differenced log form)	*Equation (1)*	*Equation (2)*	*Equation (3)*	*Equation (4)*
	Dependent variables (in differenced log form)			
	The intensity of waste water discharges (0.1 kg/yuan) t			
The intensity of waste water discharges t-1	0.954[a]	0.955[a]	0.964[a]	0.959[a]
	(0.042)	(0.047)	(0.039)	(0.042)
The ratio of total loans to GDP t	−0.251[b]	−0.243[b]		
	(0.107)	(0.107)		
The ratio of total loans to GDP t-1	0.084	0.062		
	(0.092)	(0.085)		
The ratio of private loans to GDP t			−0.098	−0.099
			(0.065)	(0.063)
The ratio of private loans to GDP t-1			0.083	0.094
			(0.061)	(0.058)
The ratio of nonprivate loans to GDP t			−0.154[c]	−0.143
			(0.093)	(0.096)
The ratio of nonprivate loans to GDP t-1			0.022	−0.008
			(0.076)	(0.075)
The R&D intensity t		0.054		0.052
		(0.035)		(0.041)
The R&D intensity t-1		−0.067		−0.068
		(0.044)		(0.048)
The ratio of FDI to gross investment t		−0.003		0.005
		(0.019)		(0.015)
The ratio of FDI to gross investment t-1		0.018		0.008
		(0.026)		(0.022)
GDP per capita t		−0.831[c]		−0.861[c]
		(0.459)		(0.462)
GDP per capita t-1		0.788[c]		0.810[c]
		(0.450)		(0.451)
Dummy 2002	−0.115[a]	−0.018	−0.117[a]	−0.018
	(0.038)	(0.044)	(0.042)	(0.045)
Time dummies	Yes	Yes	Yes	Yes
AR(1) Test	−2.65	−2.39	−2.54	−2.24
	[0.01]	[0.02]	[0.01]	[0.03]
AR(2) Test	−0.64	−0.50	−0.69	−0.64
	[0.52]	[0.62]	[0.49]	[0.52]
Hansen Test	15.16	9.85	13.77	7.23
	[0.77]	[0.97]	[0.74]	[0.99]
Observations	203	196	203	196

Notes: [c], [b], and [a] denote the significance at the 10 per cent, 5 per cent, and 1 per cent level, respectively. Robust standard errors are in parentheses. AR (1) and AR (2) Tests denote Arellano-Bond first- and second-order autocorrelation test, respectively; Hansen Test is the Hansen χ^2 test of over-identifying restrictions (Hansen, 1982). Their p values are shown in square parentheses.

Table 3. *Financial development and COD-related discharges: equations (5)–(8)*

Explanatory variables (in differenced log form)	*Equation (5)*	*Equation (6)*	*Equation (7)*	*Equation (8)*
	Dependent variables (in differenced log form)			
	The intensity of COD-related discharges (0.01 g/yuan) t			
The intensity of COD-related discharges t-1	0.953[a]	0.975[a]	0.941[a]	0.981[a]
	(0.048)	(0.048)	(0.060)	(0.047)
The ratio of total loans to GDP t	−0.584[a]	−0.595[a]		
	(0.175)	(0.173)		
The ratio of total loans to GDP t-1	0.468[a]	0.474[a]		
	(0.136)	(0.148)		
The ratio of private loans to GDP t			−0.235[b]	−0.235[a]
			(0.099)	(0.106)
The ratio of private loans to GDP t-1			0.094	0.140
			(0.103)	(0.090)
The ratio of nonprivate loans to GDP t			−0.461[a]	−0.437[a]
			(0.175)	(0.159)
The ratio of nonprivate loans to GDP t-1			0.405[a]	0.362[a]
			(0.138)	(0.134)
The R&D intensity t		0.005		−0.003
		(0.050)		(0.052)
The R&D intensity t-1		0.024		0.036
		(0.059)		(0.062)
The ratio of FDI to gross investment t		−0.087		−0.091[a]
		(0.054)		(0.049)
The ratio of FDI to gross investment t-1		0.074		0.080
		(0.062)		(0.059)
GDP per capita t		−0.443		−0.516
		(0.546)		(0.532)
GDP per capita t-1		0.421		0.516
		(0.569)		(0.554)
Dummy 2002	−0.091	−0.066	−0.120[c]	−0.092
	(0.058)	(0.058)	(0.067)	(0.066)
Time dummies	Yes	Yes	Yes	Yes
AR(1) Test	−2.55	−3.20	−2.25	−2.77
	[0.01]	[0.00]	[0.03]	[0.01]
AR(2) Test	−0.77	−0.11	−0.33	1.02
	[0.44]	[0.91]	[0.74]	[0.31]
Hansen Test	21.39	13.18	20.42	12.34
	[0.37]	[0.87]	[0.31]	[0.83]
Observations	203	196	203	196

Notes: [c,b,] and [a] denote the significance at the 10 per cent, 5 per cent, and 1 per cent level, respectively. Robust standard errors are in parentheses. AR (1) and AR (2) Tests denote Arellano-Bond first- and second-order autocorrelation test, respectively; Hansen Test is the Hansen χ^2 test of over-identifying restrictions (Hansen, 1982). Their p values are shown in square parentheses.

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of financial development. If enterprises get access to external finance more easily or at lower cost, the growth of capital-intensive sectors will be stimulated, and thus the intensity of pollution discharges will increase. These positive impacts are large in comparison with those on waste water discharges. A possible explanation is that waste water pollution is more strictly regulated than COD-related discharges, and the pollution charge has been extended to all waste water discharges instead of those exceeding the effluent standards since 1993. This suggests that more effective environmental regulations be incorporated in the provision of financial services to reduce the detrimental effects of financial development.

These positive impacts come later than the negative ones, because a substantial change in capital formation usually requires more time than does the introduction of environment-friendly manufacturing methods. More importantly, the negative coefficient is larger than the positive one; this indicates that the main impact of financial development on COD-related discharges is negative.

The above findings are confirmed by equations (7) and (8) in table 3. The significant coefficient of private loans is negative, implying that the loans to the private sector help reduce COD-related discharges. The coefficients of nonprivate loans are similar to those of total loans, suggesting that the positive impacts of financial development on COD-related discharges are largely connected with the loans to SOEs. As many SOEs have acquired interest-free budgetary grants and become relatively capital-intensive before the financial reform, financial development may further increase their capital intensity, natural resources use, and hence COD-related discharges.

As regards the control variables, the negative coefficient of FDI is also significant in equation (8) of table 3. It suggests that the growth of FDI is associated with the reduction in COD-related discharges. This relationship offers some support for the pollution halo hypothesis, which predicts that the multinationals' advanced technologies and environmental management systems will yield benefits to the environment of developing countries. Similarly, the coefficient of the 2002 dummy variable is also negative and indicates a significant impact of the environmental protection schemes on COD-related discharges.

3.3.3. Financial development and SO_2 emissions

In equations (9) and (10) of table 4, the variable of financial development has two significant coefficients, and the negative one is larger than the positive. The results are similar to those in table 3 and indicate some significant impacts of financial development on industrial SO_2 emissions. According to these coefficients, the main effect of financial development is negative, though there are also some positive impacts. This negative relationship is confirmed by equations (11) and (12) in the same table. The growth of nonprivate loans tends to reduce the intensity of industrial SO_2 emissions. However, the coefficients of private loans are statistically insignificant. The most likely explanation is that the main source of industrial SO_2 emissions is the sector of Electric Power and Heat Supply, in which the SOEs have dominant positions.

Table 4. *Financial development and SO_2 emissions: equations (9)–(12)*

Explanatory variables (in differenced log form)	*Equation (9)*	*Equation (10)*	*Equation (11)*	*Equation (12)*
	Dependent variables (in differenced log form)			
	The intensity of SO_2 emissions (0.1 g/yuan) t			
The intensity of SO_2 emissions t-1	1.019[c]	0.938[c]	1.033[c]	0.987[c]
	(0.041)	(0.049)	(0.047)	(0.057)
The ratio of total loans to GDP t	−0.451[b]	−0.447[b]		
	(0.181)	(0.176)		
The ratio of total loans to GDP t-1	0.356[a]	0.341[b]		
	(0.185)	(0.170)		
The ratio of private loans to GDP t			−0.078	−0.061
			(0.066)	(0.067)
The ratio of private loans to GDP t-1			0.029	0.039
			(0.052)	(0.055)
The ratio of nonprivate loans to GDP t			−0.214[a]	−0.230[b]
			(0.112)	(0.112)
The ratio of nonprivate loans to GDP t-1			0.157	0.144
			(0.109)	(0.105)
The R&D intensity t		0.124[a]		0.072
		(0.070)		(0.071)
The R&D intensity t-1		−0.091		−0.067
		(0.071)		(0.077)
The ratio of FDI to gross investment t		−0.063[a]		−0.054
		(0.033)		(0.039)
The ratio of FDI to gross investment t-1		0.037		0.043
		(0.033)		(0.039)
GDP per capita t		−0.257		−0.266
		(0.500)		(0.500)
GDP per capita t-1		0.203		0.240
		(0.536)		(0.534)
Dummy 2002	−0.060	−0.068[a]	−0.123[b]	−0.106[b]
	(0.040)	(0.041)	(0.051)	(0.049)
Time dummies	Yes	Yes	Yes	Yes
AR(1) Test	−3.38	−3.53	−2.87	−3.03
	[0.00]	[0.00]	[0.00]	[0.00]
AR(2) Test	1.35	1.25	1.21	0.85
	[0.18]	[0.21]	[0.23]	[0.40]
Hansen Test	24.39	15.06	18.74	15.95
	[0.23]	[0.77]	[0.41]	[0.60]
Observations	203	196	203	196

Notes: [a,b,] and [c] denote the significance at the 10 per cent, 5 per cent, and 1 per cent level, respectively. Robust standard errors are in parentheses. AR (1) and AR (2) Tests denote Arellano-Bond first- and second-order autocorrelation test, respectively; Hansen Test is the Hansen χ^2 test of over-identifying restrictions (Hansen, 1982). Their p values are shown in square parentheses.

As to the control variables, the R&D intensity has a significant and positive coefficient in equation (10) of table 4. This is consistent with the results of Ma *et al.* (2008), who found that the increased use of energy-intensive technologies had driven the energy intensity up in China since 1995. In this table, the significant coefficient of FDI variable is negative, implying the FDI is beneficial to air pollution control. Therefore, some support for the pollution halo hypothesis is provided by this table. In addition, the 2002 dummy variable has a significant and negative coefficient in most of the equations in table 4. This indicates that the environmental protection schemes bring significant impacts on industrial SO_2 emissions.

4. Conclusions

Theoretically, financial development can facilitate enterprises' investment, stimulate their R&D activities, constitute a mechanism for long-run growth, and strengthen the effects of environmental policies. It, therefore, has capitalization, technology, income, and regulation effects on the environmental performance of developing countries. Some of the effects are mixed according to theoretical analysis, and thus the real effects of financial development can be either positive or negative.

Using the provincial panel data of China, this paper examines the impacts of financial development on industrial water and air pollution discharges. The empirical results reveal that financial development tends to reduce the pollution intensities, though some of its capitalization effects are detrimental to the environment. In recent years, financial development has played an important role in improving the environmental performance of China.

According to our analysis, environmental regulations are important as well, because they are also found to play a crucial rule in pollution control. If a sound framework of environmental protection comes into operation, the beneficial impacts of financial development on the environment can be strengthened considerably.

These results offer new implications for policy makers in developing countries. On one hand, there may be good news for them, because FDI and income growth can provide some stimuli for improvement in environmental performance. On the other hand, the gains will be limited if the financing constraints on enterprises are not reduced substantially. Financial development not only constitutes an important mechanism for long-run growth, but also helps improve the enterprises' environmental performance; it seems necessary for developing countries to stimulate the development of their financial systems.

Our analytical framework can be extended into the analysis of international differences in environmental performance, as the developing countries have diverse financial systems. More importantly, this finance-environment relationship may be influenced by their different economic situations and environmental regulations. Further analysis, therefore, is called for to verify this relationship and to examine the factors in determining its presence.

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Appendix: Selected water-related rules and regulations in China

1993	Since 1993, the pollution charge has been extended to all waste water discharges instead of those exceeding the effluent standards.
1996	The 1984 Law on Prevention and Control of Water Pollution was amended. It established the framework for industrial and municipal pollution discharge control and charges.
1997	The State Environmental Protection Administration (SEPA) issued The Recommendation on Promoting Cleaner Production (CP) in China, requiring local environmental protection agencies to integrate CP into environmental management policies.
1997	The State Bureau of Technical and Quality Supervision introduced the ISO 14000 series into equivalent national standards.
1998	The Ordinance on Environmental Management for the Construction Projects was issued by SEPA. It prescribed three different levels of assessment depending on the potential environmental impacts of proposed projects.
1998	The Ordinance on Price Management of Urban Water Supply was issued. It opened the way for water pricing reform. Consequently, water prices were raised substantially in China's developed areas.
1999	The framework of user charges for waste water treatment has been established, but such charges have not fully covered all operating and investment costs until 2006.
2001	The 1979 Environmental Protection Law was amended. It contains provisions for imposing fines in cases of refusing an on-site inspection, resorting to fraud during inspections, refusing to file a report, submitting a false pollution report, exceeding national or local discharge standards, or failing to pay fees for exceeding pollutant discharge limits. Different levels of Environmental Protection Bureaus have different levels of responsibility and authority to impose penalties.
2002	The 2002 Law on Environmental Impact Assessment was introduced in order to prevent the adverse environmental impacts that might result from policies, plans and projects.

2002	The 1988 Water Law was amended. It prescribed integrated river basin management and the use of market mechanisms in water management.
2003	The 1998 Law on Promotion of Cleaner Production was amended. It encouraged enterprises to introduce CP to improve their environmental management.

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