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WANG, Danny T; Chen, Wendy Y.

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**Foreign Direct Investment, Institutional Development, and Environmental Externalities:
Evidence from China**

(Suggested running title: FDI and the environment in China)

DANNY T. WANG
Department of Marketing
School of Business
Hong Kong Baptist University
Kowloon Tong, Hong Kong
email: dtwang@hkbu.edu.hk

WENDY Y. CHEN
Department Geography
The University of Hong Kong
Pokfulam Road, Hong Kong
email: wychen@hku.hk

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Foreign Direct Investment, Institutional Development, and Environmental Externalities: Evidence from China

Abstract

The question of how foreign direct investment (FDI) affects a host country's natural environment has generated much debate but little consensus. Building on an institution-based theory, this article examines how the institutional development of a host setting affects the degree of FDI-related environmental externalities in China (specifically, industrial sulfur dioxide emissions). With a panel data set of 287 Chinese cities, over the period 2002–2009, this study reveals that FDI in general induces negative environmental externalities. Investments from OECD countries increase sulfur dioxide emissions, whereas FDI from Hong Kong, Macau, and Taiwan shows no significant effect. Institutional development reduces the impacts of FDI across the board. By focusing on the moderating role of institutions, this study sheds new light on the long-debated relationships among FDI, institutions, and the environments of the host countries.

Keywords: foreign direct investment; institutional development; environmental externalities; industrial sulfur dioxide emission; China

1. Introduction

Based on the common belief that foreign direct investment (FDI) benefits its host economies, governments of emerging economies such as China have granted FDI a high priority on their development agenda. Often they offer a wide array of incentives—including subsidies, lower taxes, duty exemptions, and local market access (UNCTAD, 2001)—with the expectation that any FDI they attract will contribute positively to the local economy due to technology transfer, management know-how, global market access, and industrial competitiveness (Blomström and Kokko, 1998; Javorcik, 2004). However, the potential effects of FDI on host countries' natural environments remain controversial (Meyer, 2004). This question holds great importance, especially considering expanding worldwide initiatives to address environmental concerns.

Researchers offer competing hypotheses about FDI's environmental externalities. For example, one stream of literature suggests a possible asymmetry between foreign and local environmental standards that attracts dirty industries to developing countries, because multinational companies are motivated to reduce the pollution abatement costs associated with their operations. This perspective represents the “pollution haven hypothesis,” according to which FDI aggravates pollution (Mani and Wheeler, 1998; Bommer, 1999; Cole, 2003, 2004; List et al., 2003; Levinson and Taylor, 2008; Lan et al., 2012). In contrast, some researchers claim that FDI diffuses best management practices and advanced environmental technologies, creating “pollution halos” in developing countries and thereby reducing pollution (Christmann and Taylor, 2001; Eskeland and Harrison, 2003). These conflicting views cite evidence in support of each direction, and to date, little consensus has been achieved.

The unsettled question results in part from the lack of a well-defined framework to explicate the institutional contexts for FDI's environmental externalities. Existing economics literature largely focuses on empirical examinations of the processes by which FDI exerts an impact on environments, namely, through changes in economic scale, industrial composition, and techniques (Grossman and Krueger, 1995; He, 2006). This approach is similar to the one economists have used to explore the dynamics by which economic development (Grossmann

and Krueger, 1995) and trade liberalization (Antweiler et al., 2001; Copeland and Taylor, 2004) influence the environment. Although this process-oriented approach documents various environmental externalities due to the inflow of FDI, it largely ignores the role of local institutions in the FDI–environment relationship, despite increasing evidence that institutions are critical influences on FDI-related strategic choices (Dunning and Lundan, 2008; Cantwell et al., 2010). In this realm, previous research on FDI fruitfully explores how institutional factors, such as environmental standards, corruption, and democracy, affect the location and environmental behavior of multinational companies (Eskeland and Harrison, 2003; Javorcik and Wei, 2004). However, this institution-based perspective is yet to be fruitfully exploited in investigating the consequences of FDI on a host country’s environment, which represents a significant gap in our understanding.

In response, with this study we ask: Does FDI generate significant impacts on the environment in China, and if so, in what direction? Do institutions matter for FDI’s environmental impact? How does FDI with different ownership origins—such as investments originating from Hong Kong, Macau, or Taiwan versus those from other countries—differ in its environmental impacts or the way it gets affected by institutions? We consider these questions in the context of 287 Chinese cities over the period 2002–2009,¹ which offers an apt study context for several reasons. First, China has been one of the greatest FDI recipients since 1990s, featuring steady growth in FDI inflows, unlike the sluggish performance exhibited in some OECD economies. But this remarkable progress seems to parallel some serious environmental pollution problems and the influence of FDI on China’s environment is still unclear (Dean et al., 2009; Wei et al., 2012). According to one study, two-thirds of Chinese cities fail to meet the air quality standard established by China’s Environment Protection Agency, which means that more than three-quarters of its urban population suffers from seriously polluted air (He, 2006). The simultaneous momentum in FDI inflows and aggravated environmental conditions suggests the need to investigate the FDI–environment link using a comprehensive, updated data set.

Second, emerging economies such as China experience fundamental institutional changes across multiple dimensions, such as legal systems, regulatory frameworks, intermediary

sectors, and the role of governments (Xu, 2011; Yang and Wu, 2012). Such institutional changes coevolve with the countries' economic development and significantly shape the ways that multinational firms behave in host countries (Cantwell et al., 2010). International business (IB) researchers note that though institutions shape the markets of all countries, their impacts are most salient in emerging markets, whose institutions are in transition and constantly evolving (Peng et al., 2008). In addition, China is characterized by a regionally decentralized, authoritarian system (Xu, 2011), in which subnational governments have overall responsibility for local economic growth and for initiating and testing new policies and reforms. The resulting differences in institutional development provide a unique, within-country setting for examining how institutions affect FDI's environmental impacts.

Third, we find two main types of foreign investors in China: overseas Chinese investors from Hong Kong, Macao, or Taiwan (HMT) and other foreign investors, mainly from OECD countries. Previous literature has documented greater productivity spillovers by OECD investors, because of their generally superior technology and innovation capabilities (Wei and Liu, 2006; Buckley et al., 2007). However, few studies assess the environmental consequences of each type of FDI. In particular, we cannot specify how the clustering patterns of investors from different source countries might differ in their environmental impacts or their interactions with institutional forces. This study makes an initial attempt to examine these issues.

Furthermore, this study contributes to literature pertaining to FDI's environmental externalities. In particular, we build on an institution-based view and find that the environmental externalities of FDI are subject to the host country's own institutional development. In places with more developed institutions, the potential damage of inflowing FDI can be mitigated. However, in places with underdeveloped institutions, the potential damage may be magnified. This new perspective partly resolves the inconsistent findings in previous literature that suggest FDI's environmental impact is positive, negative, or insignificant. In addition, we amass large-scale panel data (2002–2009) from multiple data sources, including the *Urban Statistical Yearbooks of China*, China's Environmental Protection Agency, and National Economic Research Institute, to provide insights into this

topic. Finally, our analysis of how institutions interact with FDI of different origins provides several fine-grained implications for host governments, in terms of their potential reform and development of local institutions and more discriminant management of FDI.

2. Conceptual framework and hypotheses

2.1. FDI and the environmental externality

The growing importance of FDI as an engine for economic growth has prompted considerable debate about its other impacts, including on the environment. Literature on the relationship between FDI and the environment has pointed to both positive externalities through a pollution halo effect (Birdsall and Wheeler, 1993; Vogel, 1995; Antweiler et al., 2001; List et al., 2003; Levinson and Taylor, 2008) and negative externalities through a pollution haven effect (Leonard, 1988; Low and Yeats, 1992; Mani and Wheeler, 1998; Bommer, 1999; Cole, 2003, 2004). Central to debates about FDI's environmental externalities are economic processes, including growth (scale effect), industrial composition (structural effect), and environmental technology spillovers (technique effect) (Grossman and Krueger, 1995).

Scale effect is a pollution-increasing factor. It indicates the increase in pollution that would be generated if the economy were simply scaled up, holding constant the mix of goods produced and production techniques (Antweiler et al., 2001). The structural effect is associated with changes in the patterns of economic activity, such that it might imply positive or negative environmental externalities (Araya, 2005). The FDI-related transition in OECD countries from manufacturing to services could be beneficial from an environmental viewpoint, because services tend to be less pollution-intensive than traditional industrial activities (OECD, 2001). Or this transition could lead to the relocation of manufacturing industries from developed to rapidly industrializing countries, which ultimately might induce negative environmental externalities (Araya, 2005). Furthermore, the structural effect comprises two forces related to environmental regulation. On the one hand, relatively lax environmental regulations in emerging markets attract the inflow of dirty foreign capital, leading to a greater proportion of polluting sectors in industrial composition. On the other

hand, emerging markets' rich endowment in cheap labor may allow less polluting, labor-intensive industries to expand due to FDI inflows (He, 2006). The ultimate structural transformation and subsequent environmental externalities likely depend on the contrast between these two forces in the host economy (Copeland and Taylor, 2004). The technique effect refers to positive spillovers from the use of environmentally friendly technology. Direct technique effect denotes the transfer of advanced environmental technology through collaboration and cross-nation diffusion of technological innovation (OECD, 2001; Zhu et al., 2007). The indirect technique effect arises when FDI enhances economic growth and hence a wealth increase and rising demand of cleaner environment that may result in the introduction of cleaner technologies (Grossman and Krueger, 1993; Antweiler et al., 2001; Hübler and Keller, 2010).

Although FDI thus might exert differentiated impacts on the natural environment, in China, we predict a greater pollution haven effect. As China has sought annual economic growth rates of greater than 10% in the past few decades, the scale effect has been paramount, leading to serious pollution problems. In terms of structural effect, nearly half the volume of FDI concentrates in manufacturing industries, such as transportation machinery, electrical and electronics equipment, textiles, chemical products, and the electricity, gas and water sectors. These industries are also the primary sources of environmental pollution in China (see Figures 1 and 2). In addition, environmental regulations in China tend to be flexible, such that it might attract more polluting foreign investments and tolerate the pursuit of efficiency, at the expense of the environment. For example, firms that emit pollutants beyond official standards are not treated as legal violators but instead simply pay a compensation fee, according to the quantities and types of pollutants they have released. Because it is often more economical for firms to pay the compensation fee than reduce their pollution levels, pollution is not effectively curtailed. Moreover, the regulatory system varies across provinces and depends largely on the interpretation and enforcement of local authorities (Christmann and Taylor, 2001), so foreign firms can select operating locations with less stringent regulations. In contrast, the technique effect is relatively less substantial. Increased income through FDI reinforces public exigencies for improving the environment, and its contribution to pollution

abatement capacity accumulation in China may be limited, due to foreign firms' technology controls and local firms' learning inefficiencies (Dean et al., 2009). Considering all these factors together, the overall impact of FDI on China's local environments likely tilts toward the negative side. Formally,

Hypothesis 1: FDI has negative environmental externalities for host cities in China.

--- Insert Figures 1 and 2 about here ---

2.2. *An institution-based perspective*

Uncertainty about FDI's environmental impact arises in part because existing studies are hamstrung by the lack of a well-defined theory, which makes inferences difficult. Recent IB developments suggest the appropriateness of an institution-based perspective for understanding the impact of FDI in emerging economies (Dunning and Lundan, 2008; Peng et al., 2008). We adopt this institution-based view as a guiding paradigm. It suggests that institutional development in the host economy—including that of formal organizations, such as social, economic, and political bodies, together with social norms and rules (North, 1990; Scott, 1995)—influences the policies and behaviors of multinational firms; patterns of interaction between multinational and local firms; transfers of technology, resources, and capabilities to the local community; and national economic, social, and ecological systems (Hoskisson et al. 2000; Cantwell et al., 2010; Zhu et al., 2013). Thus, the questions of whether FDI produces negative environmental externalities and how they vary across urban settings may be addressed by the level of institutional development.

China's remarkable growth in the past three decades also has occurred within a relatively undeveloped and still feeble institutional system (Xu, 2011). Retaining a one-party monopoly, democracy and political transparency are not integral to the Chinese polity, which inhibits institutional development. However, there has been some gradual development of legal institutions, decentralization of political institutions, and rapid privatization. But Chinese institutional development is far from homogeneous. The country is characterized by substantial regional disparities in institutions at provincial and city levels, such as *de facto* property rights protections and law enforcement capability (Du et al., 2008). The institutional influences on FDI's environmental performance using cross-country data thus might be

difficult to interpret, considering the vast diversity of China's political contexts and social and cultural norms. Instead, by examining within-country variation, we can focus on the specific influence of institutional development on FDI's environmental externalities, while controlling for national differences.

Institutions have an essential role in a market economy: They support the effective functioning of the market mechanism, such that firms and individuals can engage in market transactions without incurring undue costs or risks (North, 1990; Meyer et al., 2009). These institutions include the legal framework and its enforcement, private sector development, government intervention, regulatory regimes, and product and intermediary market development. We consider institutions strong or developed if they support voluntary exchanges that underpin an effective market mechanism. Conversely, we refer to institutions as weak or underdeveloped if they fail to ensure effective markets or even undermine them.

The development of host institutions should help alleviate FDI's negative environmental externalities, because where institutions are strong and developed, the environmental protection regulatory system is transparent, consistent, and stringent. The high cost of transgressive behavior deters firms from such actions. Multinational firms facing high environmental standards thus are likely to adopt global environmental policies, invest in more environmental friendly technology, and act more responsibly in waste generation and management (King and Shaver, 2001; Christmann, 2004). Moreover, in a more institutionally developed setting, local firms enjoy less government protection, leaving them exposed to intensified competition from foreign investors in their home markets. They thus are motivated to counter the challenge by raising their own productivity and innovation. In such circumstances, competition should crowd out inefficient local firms and improve overall energy efficiency; in this way, FDI might alleviate environmental problems. Strong institutions also support a greater proportion of service sectors in the host economy, such that foreign capital likely invests less in energy-consuming manufacturing sectors and more in cleaner services.

In contrast, if markets malfunction, the absence of market-supporting institutions constrains the competitive exertion of foreign investors, and local firms can take advantage of

their protected positions to persist with outdated technology and high-waste production. Such inefficient market competition likely exacerbates the negative environmental impact of FDI. Moreover, the weak and inconsistent regulatory system associated with environmental protection cannot prevent local or multinational firms' opportunistic behavior, at the expense of environmental welfare. Combining this reasoning, we hypothesize:

Hypothesis 2: Institutional development alleviates the negative environmental externalities of FDI on host cities in China.

2.3. Distinct nature of FDI origin

Previous studies indicate that FDI with different country-of-origins tends to exhibit contrasting profiles in its spillover effects (Dunning, 1988; Wei and Liu, 2006; Buckley et al., 2007). In China, two types of FDI are common: those from overseas Chinese investors in Hong Kong, Macau, and Taiwan (HMT) and those from other foreign investors (mostly from OECD countries). The reason for this grouping is the geographic distance and the presence of an ethnic Chinese community or influence of Chinese culture. On the basis of the proposition that OECD firms possess more technological, or knowledge-based, assets than HMT firms, Buckley et al. (2007) indicate that these firms thus can enjoy more advantages and generate positive productivity spillover. However, few studies have compared the environmental consequences of each type of FDI. In a pioneering work, Cole, Elliott, and Zhang (2011) gather a data set from 112 major cities in China between 2001 and 2004 and find a weaker environmental impact of output shares for HMT firms than that from other foreign countries. However, they do not offer theoretical explanations for why these two types of FDI might exert different environmental impacts.

Consistent with Cole et al. (2011), we argue that though in general FDI has negative environmental externalities, the impact of HMT firms may be weaker than that of OECD firms. The OECD firms, though they may possess more advanced technology, tend to express a lower commitment to and weaker embeddedness in local communities than HMT firms (Gao, 2003). That is, more advanced technology may lead to technique effects that reduce pollution. However, in China, firms often engage in environmentally unfriendly behavior, not

because they lack cleaner technologies or resources but because they have insufficient motivation to protect the environment. With their shared ethnic origin, HMT firms often focus on areas near ancestral homes (Smart and Smart, 1991) and invest in building long-term relationships with the host government (Yeung, 1998). They also emphasize corporate social responsibility as a differentiator in their competitive positioning. For example, HMT firms are among the top sources of philanthropic donations in response to major natural disasters; in 2008, 75% of the charitable overseas donations received in China came from HMT, and Hong Kong alone contributed 64% (China Charity and Donation Information Center, 2009). Thus the relationship of HMT firms with the local community is often characterized by the belief that “blood is thicker than water” (Hsing, 1996). When it comes to environmental protection, they are sensitive to laws and regulations, and perhaps even more important, to the attitudes of the host government and the general public. To preserve their positive corporate image, HMT investors are motivated to adopt practices that comply with environmental standards, which should lead them to produce fewer negative environmental externalities than other foreign investors.

Hypothesis 3: FDI from Hong Kong, Macau, and Taiwan has less negative environmental externalities for host cities in China than FDI from other foreign countries.

Finally, we expect that the mitigating role of institutional development applies to the environmental impacts of both types of FDI. Although they may have different relationships with host communities, both forms of FDI are subject to evolving environmental protection regulatory systems. In places where the regulatory institutions are more developed, they must take responsibility for their waste production. Meanwhile, the competitive pressures created by the presence of both types of FDI works more effectively in a more developed institutional environment. Because more market-based competition drives out inefficient firms and pushes the economy toward greater environmental concerns, we hypothesize:

Hypothesis 4: Institutional development mitigates the negative environmental externalities of FDI from both (a) Hong Kong, Macau, and Taiwan and (b) other foreign countries for host cities in China.

3. Method

3.1. Data Sources

We tested the hypothesis using multiple data sources, pertaining to 287 Chinese cities at the prefecture level or above, over the period 2002–2009. Most of the city-level data come from *Urban Statistical Yearbooks of China*, published by National Bureau of Statistics of China (2003–2010). To address missing data, we complemented this database with the *Provincial Statistical Yearbooks* and *China Statistical Yearbooks* (various years). Moreover, we obtained city-level data about industrial sulfur dioxide emissions from China's Environmental Protection Agency. To represent the institutional development of the host setting, we adopted the NERI index, published by the National Economic Research Institute, which is the only official and most reliable measure of China's institutions, widely adopted in recent economics and IB literature (Du et al., 2008; Gao et al., 2010; Li et al., 2011). This multisource database took us more than a year to compile, but by integrating these multiple sources, we created a consistent database with which to analyze FDI's environmental impact and the moderating role of local institutions.

3.2. Variables and measures

Table 1 summarizes the key variables, measures, and data sources. The industrial emission volume of sulfur dioxide (SO₂) in each city (tons) served as the dependent variable, which is one of the major air pollutants and accounted from 84% of the total SO₂ emission in China in 2009 (Wei et al., 2012). The level of sulfur dioxide pollution in China is recorded in two ways: by ambient concentration (ug/m³) and by mass emission (tons). Whereas the ambient concentration is a widely used air quality indicator (Grossman and Krueger, 1995), recorded by monitoring stations located within the cities, that provides accurate ground-level air quality information, it combines all sources of sulfur dioxide, including industrial, residential, and natural sources, such that it can be influenced by climate factors (e.g., wind direction). Because our focus is specifically on industrial pollution, we deemed the ambient concentration data inappropriate for our purposes. Instead, we turned to the mass sulfur dioxide emission data collected from factories and compiled by China's Environmental

Protection Agency. Local bureaus calculate mass emissions by factories by combining their self-reported data on fuel consumption and industrial processes with periodic boiler stack testing data. This approach, though not as robust as ambient data, is more accurate than ambient data for estimating industrial pollution specifically. On the basis of these considerations, we used mass industrial emission data for this study.

--- Insert Table 1 about here ---

Unlike previous studies that measured foreign presence as the overall input shares of foreign capital, we used the share of industrial output generated by foreign-owned enterprises in a city to assess foreign presence (FP_{total} , %). While consistent with Kokko et al. (1996) and Konings (2001), this output-based measure enabled us to avoid potential pitfalls of using the input of FDI to predict output which may generate biased results arising from potential quality problems of Chinese statistics². To assess the differential impacts of FDI from HMT compared with from other foreign countries, we separated foreign presence into two subscales: the output share accounted for HMT investments in each city (FP_{hmt}) and the output share accounted for other foreign investments (OTHER) in each city (FP_{other}).

To measure the level of institutional development of the host settings, we adopt the NERI index of institutional development (2002–2009), as developed and annually updated by the National Economic Research Institute of China. The index consists of 19 institutional arrangements and policies, categorized into five dimensions: (1) government and market relations, referring to the extent to which the economy is market driven or controlled by governments; (2) economic structure, or the growth of non-state sectors and reforms of state enterprises; (3) interregional trade barriers, referring to price controls by bureaucratic departments; (4) factor-market development, which is the mobility of production factors; and (5) legal frameworks, including the development of intermediate institutions and legal enforcement. Component scores were computed using data from statistical yearbooks, reports from industry and commerce administrations, survey data, and so forth. Each province received a score, based on objective measures, such as the ratios of lawyers or accountants to the total provincial population, then normalized to a proportionate value between 0 and 10, so that we could measure the institutional conditions relative to those in other provinces. The

final index score for each province equaled the weighted average of the five dimensional sub-indices; higher scores indicated a more developed institutional setting.³ Institutional development in China is unbalanced across regions and disparate in multiple dimensions, so the NERI index offers an effective means to capture provincial differences in institutional development over time. In particular, the NERI index can also reflect the local variation in environmental stringency, as the institutional reform and economic developments have determined local environmental management capacity (Lo and Tang, 2006) and the synthetic institutional factors account for the variation in the enforcement capacity of environmental laws (Van Rooij and Lo, 2010). However, due to data limitation, this index could only control for provincial-level environmental stringency.

We included several control variables, used in previous studies, to capture the three corresponding emission determinants: scale, structural, and technique effects. First, for the scale of economic activity, we measured economic activity within a city (Antweiler et al., 2001). This intensity measure was gross domestic product (GDP) per square kilometer. We expected a positive sign for its coefficient. Second, to capture the structural effect, we included both the capital/labor abundance ratio, CAPINT (Kaufmann et al., 1998; Cole et al., 2011; Lan et al., 2012), and the investment ratio (INVR) measured as the ratio of fixed investments to GDP.⁴ We again expected a positive sign for their coefficients. Third, for the technique effect, following existing literature, we used per capita real income (INCO) (Grossman and Krueger, 1995; Antweiler et al., 2001). Both demand and supply capacities for environmental improvements increase with income, so we expected a negative sign.

3.3. Analytical Method

To test our hypothesis on the moderating role of institutions empirically, we estimated several reduced-form equations (Grossman and Krueger, 1995) that considered the mass industrial emission of sulfur dioxide in a city as a function of foreign presence, institutional development, interaction terms between foreign presence and institutions, and the other control variables. An alternative approach to this reduced form equation would be to model a simultaneous system that links foreign presence to scale, technique, and industrial

composition effects, and then to pollution (He, 2006). We considered reduced-form equations more appropriate for our research, for two reasons. First, the reduced-form estimates provided direct evidence of the net effect of a city's foreign share of output on pollution. If the simultaneous equations were estimated, we would need to solve backward to find the net effect of foreign presence through multiple stages, such that confidence in the implied estimates depends on the precision and potential biases of the estimates at every stage (Grossman and Krueger, 1995). Second, considering our objective to assess the moderating effect of local institutions on FDI's environmental impact, the reduced-form approach spared us from needing to collect data on intervening variables, such as technology transfer and industry composition, which are not readily available and may have questionable validity.

Our basic specification thus was as follows:

$$Y_{it} = \beta_0 + \beta_1 FP_{itp} + \beta_2 IST_{it} + \beta_3 FP_{itp} * IST_{it} + X_{it}\gamma + \varepsilon_{it} \quad (1)$$

where Y_{it} is industrial SO₂ emissions for city i in year t ; β_1 , β_2 , and β_3 are the parameters of interest; FP_{itp} is the proportion of foreign output to total industrial output in city i for year t , with p denoting the total share of FDI, FDI from HMT, and FDI from other foreign countries ($p = 1, 2, 3$, respectively); and IST_{it} is the institutional variable measured by the NERI index. All variables in our sample underwent a log transformation to ensure that the coefficients fell within the easy-to-interpret range, as well as to partly resolve outlier and heteroskedasticity problems. The key variable of interest was $FP_{itp} \times IST_{it}$, that is, the interaction between FDI presence and the institutional development in the city. Finally, X_{it} is a vector of control variables; γ is a vector of other parameters; and ε_{it} is the combination of intercept and error terms, which reflects the effects of unknown factors.

Because our panel sample contains repeated city-level observations over 2002–2009 that might be subject to an unobservable heterogeneity bias over time, ordinary least squares modeling is not appropriate. To exclude the heterogeneity bias, we estimated an individual effect model for the error term (ε_{it}) in Equation (1), decomposed into three independent elements:

$$\varepsilon_{it} = u_i + \eta_t + v_{it} \quad (2)$$

where u_i and η_t denote any unobservable city- and time-specific effects not included in the regression. The v_{it} term represents the remaining disturbance and varies over cities and time, that is, the usual disturbance in a regression.

Both the fixed-effect and the random-effect models accommodate unobservable heterogeneity in city effects. In the fixed-effect model, the u_i values are fixed parameters to be estimated, whereas in the random-effect model, they are assumed to be random, independent, and identically distributed. Whereas random-effects estimation is in theory more efficient, it is unclear whether excluded city-specific effects subsumed in the error term are uncorrelated with the regressors. Although fixed-effects estimation is preferable in just these cases, fixed-effects limits the cross-sectional variation we can exploit for separating scale from technique effects (Judge et al., 1985).

Consistent with previous studies using panel data (e.g., Antweiler et al., 2001), we constructed a set of unrestricted city and time dummies to capture the unobservable city- and time-specific unobservable and employed Hausman tests to decide whether the fixed- or random-effects model was appropriate for estimating FDI's environmental externalities. The test basically examines whether the unique errors (u_i) are correlated with the regressors, the null hypothesis is they are not. If the test result is insignificant, the random-effect model should be applied. Otherwise, the fixed-effect model is preferred (Wooldridge, 2002, p.288). Because our results rejected the random-effect assumption, we used fixed-effect models.

3.4. Diagnostic tests

We performed a series of diagnostic tests to mitigate potential bias. First, we conducted a Wald test to determine if time fixed effects were needed in the fixed-effect model. The result rejected the null prediction that all year coefficients would jointly equal zero. Therefore, we need time fixed effects and used the two-way fixed effects model to control for both year- and city-specific effects. Second, we checked for potential serial correlation in the residuals using the test developed by Wooldridge (2002) for panel data models. We also checked for potential heteroskedasticity using a standard likelihood ratio test. Both tests rejected the null hypothesis, suggesting first-order autocorrelation and heteroskedasticity in our data. To

account for these problems, we scaled the standard errors to allow for correlated errors within the cluster at the city level. According to Wooldridge (2002), this clustering approach, based on the robust variance matrix, offers an effective way to correct such problems and obtain reliable results in the fixed effects estimations. Third, we checked the variance inflation factors (VIF) for all variables. In all the equations, the VIF ranged from 1.08 to 3.91, indicating that multicollinearity among independent variables was not a serious problem. Fourth, we conducted Fisher-type Augmented Dickey–Fuller (ADF) test ensure our dependent variable is trend stationary. The result is highly significant ($t = -21.20$, $p < 0.001$), suggesting stationarity in the panels.

3.5. Potential endogeneity concern

We considered the potential for endogeneity in our estimation, which may arise as a result of measurement error, autoregression with autocorrelated errors, simultaneity, omitted variables, or sample selection errors. If endogeneity occurs, the regression coefficients in an Ordinary Least Squares (OLS) regression would be biased. Theoretically, the problem of endogeneity arises when the factors that are supposed to affect a particular outcome, depend themselves on that outcome (Greene, 2008). In our study, it is less of a concern, because our dependent variable (i.e., volume of industrial SO₂ emissions) is unlikely to exert a reverse affect our main independent variables (i.e., foreign presence and local institutions). To confirm these independent variables were exogenous, we employed (a) number of new FDI contracts signed, and (b) telephone lines (per 1,000 people) (Cole et al., 2011) as instruments to run two-stage least squares regressions⁵ where we predict the level of FDI using our two instruments in the first step, and use the predicted FDI values and other predetermined variables to explain variations in SO₂ emission. We then performed Hausman tests of endogeneity (Hayashi, 2000, pp. 233-34) which compare the parameters estimated by OLS with the parameters estimated by instrumental variable approach. If there is no significant difference in the parameters, then the null hypothesis of exogeneity can be accepted and OLS can be used for estimation. We obtained insignificant results in all cases, suggesting our key explanatory variable in concern (i.e. FDI) can actually be treated as exogenous (Anselin et al.,

2000).

To further rule out the endogeneity concerns, we performed the tests of strict exogeneity (see Wooldridge, 2002, p.285) for all explanatory variables in our equations⁶. The test is implemented by adding lead values of inputs in the set of explanatory variables and testing their joint significance in the fixed-effect regression. Since all p -values are above 0.1, we cannot reject strict exogeneity in all specifications at conventional levels of significance. We therefore concluded that two-way fixed effects models are appropriate to estimate the causal effect of FDI on environment.

4. Results

We report the summary statistics, including means, standard deviations, and pairwise correlations of all variables from our study equations, in Table 2. The pattern of correlations is largely consistent with previous research and our subsequent analysis. For example, consistent with the pollution haven hypothesis, overall foreign presence relates positively to SO₂ emission ($r = 0.074$, $p < 0.05$). In addition, FDI from Hong Kong, Macau, and Taiwan tends to generate less pollution for host cities than FDI from other foreign countries ($r = -0.021$, $p > 0.05$; and $r = 0.119$, $p < 0.05$ respectively). These results provide some initial evidence to Hypotheses 1 and 3.

--- Insert Table 2 about here ---

Table 3 presents the result of our hypothesis tests using two-way fixed effects models.

--- Insert Table 3 about here ---

The first column of Table 3 includes all control variables and year dummies in the regression for industrial SO₂ emission. The first four control variables captured three corresponding emission effects (scale, structural, and technique). The positive, significant relationship between the intensity of economic activity (i.e., GDPSK) as measured by GDP/km² and SO₂ emissions, supported the scale effect. A positive structural effect also emerged, because both the capital/labor abundance ratio (i.e., CAPINT) and investment ratio (i.e., INVR) exerted significant effects on SO₂ emissions. The technique effect, measured by per capita real income (i.e., INCO), was not significant though. This result suggested that

when foreign investment brings more jobs and increases local income, local constituents do not ask for, or cannot demand, higher standards or more stringent regulations related to the environment. While a bit surprising, this result can be explained by the fact that in many places in China, people complain about ecological deterioration, but their complaints remain largely ignored by local government officials who pursue their own self-interest at the expense of the environment.

In column 2 of Table 3, in addition to the control variables and year dummies, we included foreign presence (i.e., FP) in the regression. The results showed that foreign presence significantly affected the natural environment by increasing industrial SO₂ emissions in the host city ($\beta = 0.084, p < 0.01$), in support of Hypothesis 1.

When we also added institutional development and its interaction with foreign presence to the equation (column 3, Table 3), the coefficient of FP remained positive and significant ($\beta = 0.081, p < 0.01$). The interaction term also exerted a significant and negative impact ($\beta = -0.217, p < 0.01$), providing strong support for Hypothesis 2. The results showed that while one unit of increase in FP by itself brings 0.081 unit of increase in SO₂ emission, when combined with one unit of improvement of institutions, actually it reduces 0.136 unit of SO₂ emission. It suggests that the institutional development of the host setting mitigated the negative environmental externalities of FDI.

We divided overall foreign presence into HMT and OTHER types of presence and report these regression estimates in column 4 of Table 3. Consistent with Hypothesis 3, the coefficients of FP_{hmt} were non-significant ($p > 0.1$), whereas FP_{other} was positive and significant ($\beta = 0.068, p < 0.01$). This finding points to the potential double-edged effects of non-ethnic FDI: It may have greater productivity spillover (Buckley et al., 2007), but it also causes more environmental pollution than ethnic-linked FDI (i.e., from HMT).

Finally, we tested the interactions of institutional development and the two types of foreign presence. These results demonstrated that that both interaction terms exerted significantly negative impacts on SO₂ emission ($\beta = -0.166, p < 0.01$ for IST*FP_{hmt}; $\beta = -0.124, p < 0.01$ for IST*FP_{other}). When there is one unit of increase in institutional development, a unit of increase in FP_{other} will reduce SO₂ emission by 0.056 unit. These results showed strong

support for Hypothesis 4.

The main effect of IST was insignificant (column 3, Table 3), probably because our measure of institutional development, though the most official and widely used version in academic research on China, captures multiple, disparate dimensions of institutions. These dimensions may exert differential impacts on the environment. For example, institutional development related to market economy indicates increasing reliance on market forces rather than the government power. Thus it could motivate firms to learn advanced technologies, enhance efficiency, and build a socially responsible enterprise. But the functioning of the free market also can fail if opportunistic behaviors cannot be punished by the weak government enforcement mechanisms. The total effect of market-economy-related institutions on environment thus appears ambiguous. However, we suspect that contract enforcement-related institutions help reduce pollution, because a sound, consistent legal system that has strong enforceability effectively detects and punishes rule violators. If they anticipate high detection risk, firms should refrain from producing excesses that harm the environment.

To gain more insights into the possibly differential moderating impacts of the five dimensions of institutional development, we performed post hoc analyses in which we replaced the composite institutional measure (IST) with five institutional aspects (i.e., IST_{1-5}) in the regressions. The control variables and model specifications remained the same as in our previous hypothesis testing model; we report the results of the separate runs in Table 4. The significance levels of the control variables were consistent with those in Table 3, and the effect of foreign presence remained positive and significant ($p_s < 0.01$). All interaction terms were highly significant ($p_s < 0.01$), suggesting that each institutional dimension effectively mitigated the environmental impact of FDI. Interestingly, market economy related institutional factors including IST_1 , IST_2 , and IST_4 , representing government and market relations, economic structure, and factor-market development, respectively, were insignificant in their direct effects on SO_2 emissions. Similarly, IST_3 , representing freer price setting and fewer trade barriers indicated a marginal ($\beta = -0.214$, $p < 0.10$) effect. In contrast, IST_5 , representing availability of a sound legal framework, showed a significantly negative ($\beta = -0.475$, $p < 0.01$) impact. This result was consistent with our conjecture that contract

enforcement–related institutions should be more effective than other market related institutional forces for reducing FDI’s impact on the environment. This finding represents just the first attempt to use the institution-based view to clarify FDI’s environmental externality, so we hope that further research pursues better measures of institutional dimensions and explicates their relationships with FDI and the environment.

--- Insert Table 4 about here ---

5. Discussion and conclusion

Questions about whether the net welfare outcomes of FDI for the host country are positive and what stance a host country should take toward FDI if it generates negative environmental externalities remain challenging. Especially in China, the strong growth of FDI in recent decades has made Chinese economy stronger, but also more vulnerable. While moving from relatively state-led growth strategies to more open, market-oriented regimes, the strong inflow of FDI coexists with immense institutional transformations and sometimes aggravating environmental problems. Thus a challenge facing policy makers in the coming decades is to ensure sustainable growth. This study has attempted to untangle the nuanced relationships among FDI, institutions, and the natural environment from an institution-based perspective.

With the panel data of 287 Chinese cities, over the period 2002–2009, our findings support pollution haven hypothesis: Foreign capital flocks to places with lax environmental regulations and generates negative environmental externalities. The weak and inconsistent environmental regulations, together with local government’s pursuit of high economic growth, and competition inefficiency, likely combine to explain the negative environmental externalities brought about by FDI. Additionally, the changing institutions effectively influence foreign firms’ environmental policies, practices, and interactions with local firms. In host settings in which institutions are more developed and environmental management capacities are strong, foreign firms likely adopt global environmental standards, and the overall environmental quality of the hosting city should increase. In contrast, in places where institutions are not well developed, profit-driven capital may initiate a “race to the bottom,” yet their polluting practices cannot be effectively regulated by the host country’s relatively

weak institutions, leading to serious environmental problems. This institution-based perspective echoes and even explains some previous findings. For example, in studying trade and environment quality, Managi et al. (2009) find that trade benefits the environment in OECD countries but has detrimental effects on SO₂ and CO₂ emissions in non-OECD countries. We suggest that the vastly different levels of institutional development in these two types of countries may contribute to the varying effects.

By focusing on within-country institutions, this study complements existing literature that focuses the variance of institutions at the national level and their influence on the host country's capability to manage the environmental implications of FDI (Javorcik and Wei, 2004). Our research also acknowledges the so-called regionally decentralized authoritarian regime of China (Xu, 2011). In this singular system, the national government takes substantial control over the country's political and personnel governance structure, but the subnational governments have overall responsibility for local economies. They control or directly influence rights to vast resources; they also compete in initiating or testing new reform policies. These regional reform experiments have led to diverse institutional environments in China over the past three decades. To some extent, the differential levels of institutional development in local contexts explain why some places receive benefits, while others face grave environmental problems due to the inflow of FDI.

Of particular interest is our finding about the differing environmental impacts of FDI. Although previous research has indicated that FDI from non-ethnic-linked origins (mostly OECD countries) offers greater technological advantages and generates greater productivity spillovers to the host country, we find that ethnic-linked FDI (from Hong Kong, Macau, or Taiwan) manifests a greater commitment to the local environment. Reflecting the motivation to build long-term relationships with local governments and communities, ethnic-linked FDI exerts a non-significant impact on the host city's SO₂ emissions. In contrast, FDI from OECD countries relates significantly to higher volume SO₂ emissions. These findings complement previous research that focuses on the productivity outcomes of FDI from various origins (Buckley et al. 2007). That is, it seems that FDI from HMT generates less productivity gains, but also fewer environmental problems, whereas FDI from other countries creates greater

productivity gains but also inflicts more pollution. These double-edged effects demand a more discriminant view of FDI, in both research and practice, that acknowledges their distinct nature, motives, and characteristics. Moreover, our institution-based perspective is useful for explaining the varying environmental effects of both types of FDI, which are contingent on the level of institutional development in the host settings. We thus confirm the importance of local institutions for moderating FDI's environmental externalities.

The research provides thoughtful implications to policy makers as well. In China, the connection between economic growth (FDI as an engine) and environmental consideration tends to be neglected. A variety of economic incentives seek to attract FDI inflow. Yet incomplete assessments of its externalities often lead to irreversible consequences for the natural environment. Our study suggests that both the direction and the magnitude of the FDI–environment relationship depend on institutional development, which suggests that host governments should manage FDI by consolidating their legal systems and enforcement capacity, and encouraging the development of intermediaries and market mechanisms. With more developed institutions, local governments can more effectively guide, control, and dampen the negative environmental externalities brought about by FDI. In the meantime, because foreign investors currently can negotiate for lower environmental standards in places with high corruption levels (Cole et al., 2006), it is imperative for governments to enact reforms to reduce corruption to improve the stringency and consistency of their environmental policies. A coherent development strategy and sound institutions are prerequisites for China to move in the direction of sustainable development. Managing FDI to reap both ecological and economic benefits requires an enabling environment: legal, regulatory, and political institutions, as well as effective social infrastructure, which provide transparency and stability for foreign (and domestic) investors.

We acknowledge several limitations to our study. First, data availability considerations left us with only provincial-level data about China's institutional development (and the environmental stringency) and the total volume of SO₂ emission without specification of different industrial sectors and different FDI sources). If resources allowed, we could consider conducting surveys to collect local level data relevant to institutional situation and

pollutant emission in representative cities, such as first-tier, second-tier, coastal, and inland locations, so as to derive more accurate estimates. Second, we were unable to examine the effects of specific dimensions of the institutional factor, such as regulatory, normative, and cognitive institutions, which may have differential effects on the influence of FDI. As the first study to employ an institution-based perspective to study FDI's environmental externalities, our results suggest a promising direction though. Further research with more refined data should be able to explore this topic more fruitfully. Third, we found that institutions moderate the environmental impact of FDI, but we did not model institutions as antecedents or consequences of FDI. Additional investigations might expand our study focus to examine a broader picture of the coevolution of FDI and institutions (Cantwell et al., 2010) and provide significant implications for both host governments and multinational corporations.

¹ As a key indicator of environmental condition, sulfur dioxide emission data have been published by the Environmental Protection Agency and National Bureau of Statistics since 2002. The institutional data were published by the National Economic Research Institute during 1997–2009. Therefore, the longest window of data available to examine the relationships among FDI, institutions, and environmental externalities in our study context was 2002–2009.

² According to Xiao (2004), FDI inflows to PRC are often overstated. Using the output-based FDI measures can help avoid the potential pitfalls which may generate biased results.

³ For more details on the NERI index, please refer to Fan, G., Wang, X., and Zhu, H. (2011). *NERI Index of Marketization of China's Provinces*. Beijing: Economics Science Press.

⁴ The two measures of structural effects arguably are complementary, with CAPINT focusing more on the stock of capital assets, whereas INVR centers more on the flow of capital assets in the city.

⁵ We ran underidentification and overidentification tests to ensure the validation of the two instruments. Underidentification test (Kleibergen-Paap rk LM statistic) showed significant results ($p < 0.001$) for all equations (including the main effect models and the interaction models), indicating our models are identified, whereas Hansen J statistics (overidentification tests of all instruments) are insignificant, suggesting the two instruments are valid. Meanwhile, the large Kleibergen-Paap rk Wald F statistics rule out the concerns for the weak instruments.

⁶ According to Wooldridge (2002, p.285), a test of strict exogeneity using fixed effects (for $T > 2$) can be obtained by specifying the equation: $y_{it} = x_{it}\beta + w_{i,t+1}\delta + c_i + u_{it}$; where $w_{i,t+1}$ is a subset of $x_{i,t+1}$. Under the null hypothesis of strict exogeneity, $\delta = 0$. Failing to reject the null means that our explanatory variables are indeed exogenous.

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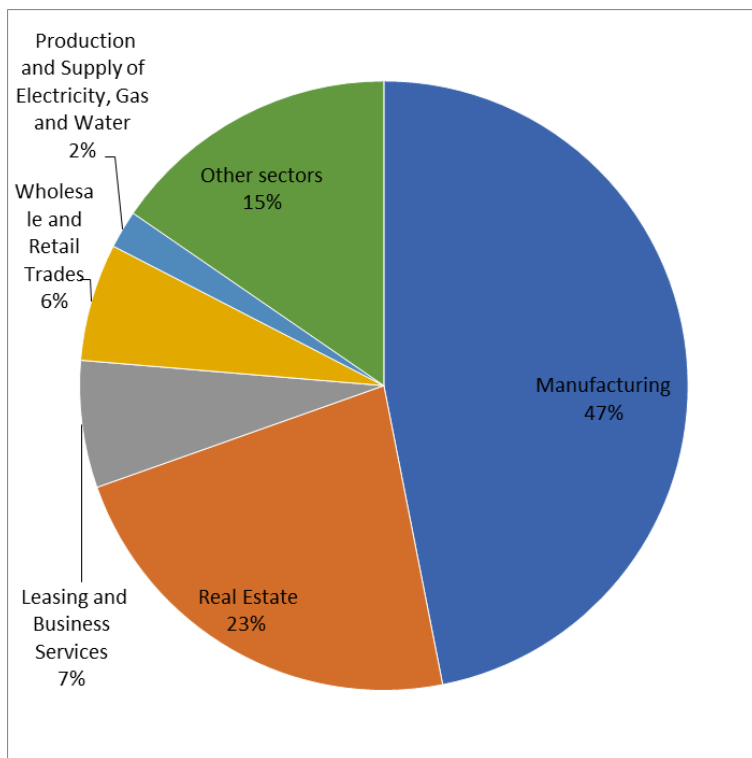
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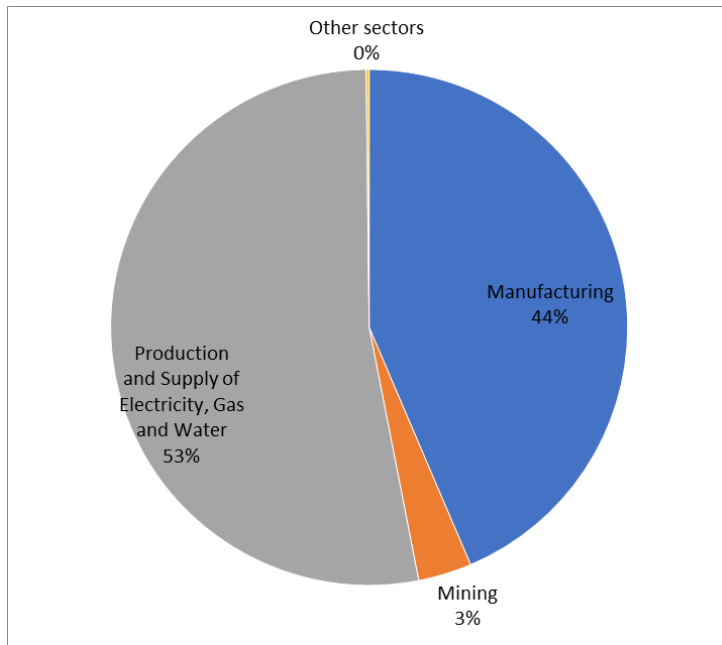
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Figure 1 China's Foreign Direct Investment (Actually Used) by Industry Sectors in 2010



Source: China Statistical Yearbook 2011

Figure 2 China's Sulfur Dioxide Emission by Industry Sectors in 2010



Source: China Statistical Yearbook 2011

Table 1 Variables and Measures

	Variable	Measure	Abbr.	
Dependent variable	Volume of industrial SO ₂ emission	Total industrial sulfur dioxide emission of individual cities (tons)	SO ₂	
Independent variables	Overall foreign presence	Share of industrial output generated by all foreign-owned enterprises in each city (%)	FP _{total}	
	Foreign presence of HMT	Share of industrial output generated by HMT firms in each city (%)	FP _{hmt}	
	Foreign presence of OTHER	Share of industrial output generated by other foreign countries in each city (%)	FP _{other}	
	Institutional development	Total score of the NERI index	IST	
	Five dimensions of institutional development	Government and market relations dimension		IST ₁
		Economic structure dimension		IST ₂
Inter-regional trade barriers dimension			IST ₃	
Factor-market development dimension			IST ₄	
	Legal frameworks dimension		IST ₅	
Control variables	Capital intensity	The ratio of net value of fixed assets per worker (100 million yuan/person)	CAPINT	
	Investment ratio	The ratio of fixed investment to GDP (%)	INVR	
	Per capita real income	Income per worker (yuan/person)	INCO	
	GDP per square kilometer	Gross domestic product per square kilometer of urban land (10,000 yuan/square kilometer)	GDPSK	

Table 2 Descriptive Statistics and Correlations

	Mean	Std.	1	2	3	4	5	6	7	8
1 SO ₂	10.54	1.20								
2 FP _{total}	-2.23	1.25	0.04							
3 FP _{hmt}	-3.46	1.52	-0.02	0.72						
4 FP _{other}	-2.91	1.43	0.11	0.85	0.37					
5 IST	1.89	0.28	0.07	0.35	0.33	0.28				
6 CAPINT	1.86	0.75	0.35	-0.02	-0.04	0.03	0.35			
7 INVR	-0.73	0.42	0.03	0.01	-0.01	0.01	0.16	0.05		
8 INCO	9.79	0.42	0.27	0.15	0.10	0.18	0.54	0.51	0.17	
9 GDPSK	7.21	1.42	0.36	0.26	0.24	0.27	0.35	0.36	0.03	0.48

Note: All variables have been log-transformed.

Table 3 Moderating Role of Institutional Development in FDI's Environmental Externalities: City-Level Baseline Regression Results

Dependent variable: Variables/Column	Industrial SO ₂ Emission				
	(1)	(2)	(3)	(4)	(5)
Constant	8.232*** (0.812)	8.881*** (0.851)	8.908*** (0.856)	9.151*** (0.914)	9.100*** (0.908)
CAPINT	0.121*** (0.035)	0.119*** (0.040)	0.104*** (0.040)	0.137*** (0.040)	0.122*** (0.040)
INVR	0.314*** (0.050)	0.345*** (0.055)	0.351*** (0.055)	0.372*** (0.056)	0.372*** (0.056)
INCO	0.022 (0.086)	0.002 (0.090)	-0.021 (0.090)	-0.023 (0.096)	-0.043 (0.096)
GDPSK	0.250*** (0.038)	0.230*** (0.043)	0.251*** (0.043)	0.233*** (0.042)	0.249*** (0.042)
Year Dummy	Included	Included	Included	Included	Included
FP _{total}		0.084*** (0.022)	0.081*** (0.022)		
IST			0.283 (0.320)		0.141 (0.323)
FP * IST			-0.217*** (0.058)		
FP _{hmt}				0.006 (0.018)	0.015 (0.018)
FP _{other}				0.068*** (0.018)	0.076*** (0.018)
FP _{hmt} * IST					-0.166*** (0.057)
FP _{other} * IST					-0.124** (0.054)
Adjusted R ²	0.842	0.844	0.846	0.846	0.849
Hausman test/Wald χ^2 (df)	38.45***	27.60***	43.15***	28.38***	55.34***

Notes: The total number of observations is 2,296, and the total number of groups is 287. All regression estimations were robust to heteroskedasticity and autocorrelation; the robust standard errors appear in parentheses (***) $p < 0.01$, ** $p < 0.05$, * $p < 0.1$). The year and city fixed effects are included but not reported.

Table 4: Moderating Role of Institutional Development in FDI's Environmental Externalities: Regression Results Based on Five Dimensions of Institutions

Dependent variable: Variables/Column	Industrial SO ₂ Emission				
	(1)	(2)	(3)	(4)	(5)
Constant	7.984*** (1.031)	8.790*** (0.864)	9.309*** (0.863)	8.822*** (0.864)	9.575*** (0.869)
CAPINT	0.110*** (0.040)	0.114*** (0.039)	0.115*** (0.039)	0.112*** (0.040)	0.111*** (0.040)
INVR	0.354*** (0.055)	0.347*** (0.055)	0.367*** (0.054)	0.353*** (0.055)	0.355*** (0.055)
INCO	-0.004 (0.089)	-0.019 (0.090)	0.005 (0.089)	-0.015 (0.090)	-0.008 (0.090)
GDPSK	0.251*** (0.043)	0.247*** (0.043)	0.242*** (0.042)	0.243*** (0.043)	0.242*** (0.043)
Year Dummy	Included	Included	Included	Included	Included
FP _{total}	0.081*** (0.022)	0.083*** (0.022)	0.097*** (0.022)	0.084*** (0.022)	0.086*** (0.022)
IST ₁	0.449 (0.320)				
IST ₁ * FP _{total}	-0.261*** (0.078)				
IST ₂		0.127 (0.136)			
IST ₂ * FP _{total}		-0.157*** (0.042)			
IST ₃			-0.214* (0.120)		
IST ₃ * FP _{total}			-0.416*** (0.076)		
IST ₄				0.090 (0.106)	
IST ₄ * FP _{total}				-0.100*** (0.035)	
IST ₅					-0.475*** (0.145)
IST ₅ * FP _{total}					-0.091*** (0.033)
Adjusted R ²	0.846	0.846	0.847	0.845	0.846
Hausman test/Wald χ^2 (df)	62.29***	40.02***	36.14***	37.10***	38.05***

Notes: The total number of observations is 2,296, and the total number of groups is 287. All regression estimations were robust to heteroskedasticity and autocorrelation; the robust standard errors appear in parentheses (***) $p < 0.01$, ** $p < 0.05$, * $p < 0.1$). The year and city fixed effects are included but not reported.