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The two faces of FDI in environmental performance: a meta-analysis of empirical evidence in China

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ABSTRACT

The extant literature has raised debates concerning environmental performance of foreign direct investment (FDI) in China. We applied meta-analysis of 121 estimates reported in 40 studies to quantitatively synthesize our knowledge and understanding of the topic. Our findings indicate that FDI leads to better environmental performance through a pollution abatement effect, but not through enhancements in green total factor productivity. The meta-regression analysis reveals that the degree of environmental pollution abatement effects is moderated by environmental regulations, FDI measurement, and the consideration of endogeneity in empirical estimations. The results are discussed with references to scholarly and practical implications.

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KEYWORDS
Environmental performance; foreign direct investment; meta-analysis; pollution haven hypothesis; pollution halo hypothesis

1. Introduction

The industrial and institutional reforms undertaken in China over four decades have promulgated a large number of policies to attract foreign direct investment (FDI), improving the business environment for multinational enterprises (MNEs) – the agent of FDI, and helping to facilitate their operations in China. This has resulted in China becoming one of the most attractive destinations for FDI in the world. The National Bureau of Statistics in China reported[1] that the country has attracted more than 2 USD trillion FDI since 1978, with an average annual growth rate of 6%. On one hand, it is widely acknowledged that China's economic development has immensely benefited from this significant inflow of FDI (Wei and Wang 2009). On the other hand, stakeholders are becoming increasingly aware of the negative externalities associated with China's unprecedented economic growth (Lin and Sun 2016; Llorca and Meunié 2009; Ma, Wu, and Wu. 2018; Pisani et al. 2019; Xu et al. 2019). The recent climate pledge by President Xi Jinping at the 2020 UN General Assembly to 'peak in carbon dioxide emissions before 2030 and carbon neutrality before 2060'[2] is a strong indicator of the country's appetite for rapid transformation and to lead the world in becoming an environmentally sustainable economy. This is likely to spur further efforts with a new set of policy measures and actions. However, policy instruments for driving radical change – for example, supply–push policies directing support to low-carbon innovation (Fu and Zhang 2011), carbon efficiency (Färe et al.

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2014), and pollution abatement efforts (Shimizu 2017) – have to be considered in the context of crucial trade-offs related to sustaining business opportunities or ensuring 'energy justice' (Heggelund 2021). In particular, a reorientation in the realm of sustainability-related challenges amidst economic growth effects and innovation catch-up that has been traditionally associated with inward FDI presence in China would be required. To better understand the effect of FDI on environmental performance in China, we take stock of the growing literature by utilizing meta-analytical techniques and address the following question: *Does FDI exacerbate environmental deterioration or improve green performance in a host country?*

Within the literature on the environmental impact of FDI, there are two contrasting theoretical arguments: the 'pollution haven' hypothesis and the 'pollution halo' hypothesis. The former suggests that negative environmental performance impact of FDI arises from the persistence of MNE subsidiaries within polluting industries to relocate in jurisdictions with less stringent environmental regulations (Dean, Lovely, and Wang 2009; Li and Ramanathan 2020; Wang et al. 2013). The latter argues for the positive effects of FDI (Ning and Wang 2018; Wang and Chen 2014) and emphasizes that the presence of foreign subsidiaries does not necessarily increase pollution levels in developing countries; instead, they can be more energy efficient and are more likely to use cleaner energy than local firms (Eskeland and Harrison 2003). This theoretical ambiguity is fueled further by mixed findings (see Appendix).

In the wake of ambiguous findings on a topical issue that requires evidence-based policy recommendations, we bring a degree of coalescence through a methodical assessment of the existing literature. More specifically, we employ meta-analytic techniques to systematically analyze a large collection of findings from quantitative studies in order to synthesize the evidence. Meta-analysis is a powerful tool for resolving theoretical debates in a more definitive way than a single study. This approach is widely used in various topics of FDI studies (e.g. Demena and Afesorgbor 2020; Görg and Strobl 2001; Hanousek, Kocenda, and Maurel 2011; Havranek and Irsova 2011; Iwasaki and Tokunaga 2016). Despite notable recent examples in the conscientious use of meta-analytic methods, there has been a rapid proliferation of meta-analytic studies that are of suspect quality (Ioannidis 2016). By utilizing state-of-the-art recommendations outlined in Havránek et al. (2020) and Steel, Beugelsdijk, and Aguinis (2021), we explicate the key components of a modern meta-analysis involving data collection, preparation, analysis and reporting, and embed this in our approach to make better sense of the voluminous literature on environmental performance of FDI in China. To the best of our knowledge, few meta-analytic studies explicitly examine the FDI-environmental performance relationship with the exception of Demena and Afesorgbor (2020) whose work focuses on the effects of FDI on environmental emissions of 65 primary studies. Building on Demena and Afesorgbor (2020), we zoom in on China, as focusing on a single country context is likely to minimize unobserved heterogeneities across studies, and overcome undesirable conceptual and statistical problems associated with a cross-country analysis (Levine and Zervos 1993). Our coverage of existing studies is more extensive, doubling the number of studies on China that were examined by Demena and Afesorgbor (2020), enabling a more precise assessment of the environmental performance of FDI in China.

The present paper is timely and important for two reasons. First, a critical need remains to establish discriminating evidence on the degree of FDI impacts on China's ecological environment. China is the world's biggest producer of greenhouse gases and has an ambition to reach carbon neutrality before 2060. An important question is what China could and should do to reach this long-term goal. Could FDI be a positive force towards reaching the country's environmentally sustainable economic development, like what it did to the development and catch-up of the Chinese manufacturing sector (Balasubramanyam and Wei 2015)? Thus, taking stock of the growing literature and synthesizing the empirical studies to identify robust findings are pertinent to policy making, as well as being a critical step in the progression of research. Our meta-analysis results reveal that, despite the inconsistent results in 40 primary studies, there is a systematic negative relationship between FDI and environmental pollution in China, albeit the main effect size is small. The impact of FDI on green total factor productivity (GTFP) has not been found to be significant. As such, the overall findings from the meta-analysis lends partial support to the pollution halo hypothesis. While more work is certainly needed in view of the small effect size of FDI on environmental pollution and the insignificant effect size of FDI on GTFP, our research sheds light on the beneficial effects of FDI, which support an argument for pro-free trade and investment policy.

Second, the meta-analytic methodology allows us not only to provide better assessment of the nature of the FDI-environment nexus than any single study, but also to examine contingencies that can be viewed as boundary conditions underlying the environmental performance of FDI. This can lead to novel insights and permit better appreciation of factors that influence the relationship. In light of the meta-analytical results, we point at future research directions to further explore the field that is still in its developmental stage, as well as a discussion of practical implications of the study.

The rest of the paper is organized as follows. Section 2 presents the theoretical debates on the effects of FDI on environmental performance. This is followed by a description of the method for literature search, the inclusion criteria of primary studies, and the operationalization of variables. Section 4 presents the meta-analytical methodology. The results are shown in section 5 where we first report main effects, then meta-regressions findings, followed by the investigation of publication bias. Section 6 concludes by providing a discussion of the academic and practical implications of the study and outlining the areas for future research.

2. Two faces of FDI: competing theoretical perspectives

There are two broad streams of literature on the environmental effects of FDI: one being directly related to their own operations (Bu and Wagner 2016; Dean, Lovely, and Wang 2009), and the other on the indirect effects of FDI associated with the spillover effects (Ning and Wang 2018; Wang and Chen 2014). In terms of the direction of effects, the negative environmental effects of FDI are represented by the 'pollution haven' hypothesis and the rationale is largely associated with MNEs' own operations. The positive environmental effects of FDI are represented by the 'pollution halo' hypothesis which recognize not only the direct effects but also the spillover effects of MNEs' local operations.

The 'pollution haven' hypothesis, also known as the 'pollution sanctuary' hypothesis, suggests that MNEs 'race to the bottom' and relocate their pollution-intensive activities from developed to developing countries in order to arbitrage the differential environmental standards and environmental regulations between the two groups of countries

(Dean, Lovely, and Wang 2009; Wang et al. 2013). This enables them to pursue greater profits, at the same time, enabling exploitation of cheaper factor endowments and favorable conditions offered as part of the FDI attraction incentives by host governments. The lax in environmental regulations and inadequate monitoring of firms' sustainable management practices in certain developing countries may constitute a locational advantage for MNEs (Dasgupta et al. 2002). Moreover, the pressures of global competition can influence MNEs' location choices as redirection to countries with less stringent environment regulations for certain types of environmentally polluting activities would be less costly (D'Agostino 2015). Once located in developing countries, MNE subsidiaries may move from regions that begin tightening up environmental regulations to those that still offer loose regulative institutions (Li and Ramanathan 2020). Consequently, developing countries/regions with loose environmental regulations and lower pollution costs may suffer serious environmental damage and gradually become a 'pollution haven' for pollution-intensive MNEs. However, an important point to note is that operations by MNEs' subsidiaries and affiliates generate more pollution than their domestic counterparts. This is because MNEs are more likely to be exposed to the adoption of environmentally sustainable corporate strategies as the bulk of their operations are in large advanced economies, where stakeholders insist on the consumption of greener products and implementation of sustainable management practices (Kolk and Van Tulder 2010).

The 'pollution halo' hypothesis, proposes that tighter environmental requirements at home trigger MNEs developing innovation solutions which result in economic and environmental performance being facilitated simultaneously (Ning and Wang 2018; Wang and Chen 2014). The extant literature has established the link between environmental management practices and economic, operational and social performance (Geng, Mansouri, and Aktas 2017). The advanced environmental technologies and management systems embedded in MNEs would be transferred to host countries, acting as ownership advantages. A case in point being MNEs from advanced economies are usually larger than firms in host developing countries. This implies that they can embark on risky green investments with the likelihood of eco-innovation occurring at a larger scale than the average domestic firm (Blomström and Kokko 1998). Moreover, affiliates of MNEs have been found to be more energy efficient and more likely to use cleaner energy than local firms (Eskeland and Harrison 2003). With these endowments of superior green technologies and management know-how in MNE subsidiaries, the prospects for knowledge diffusion, to host country firms increase substantially thereby leading to improvements in environmental performance. The channels through which local firms can acquire MNEs' knowledge and technologies include demonstration effects, linkage effects and labor turnover effects. The entry of MNEs demonstrates advanced green technology and managerial practices to local firms, which offers learning opportunities for local firms to improve their environmental performance. Transactional linkages with MNEs' local subsidiaries and affiliates are another learning channel for local suppliers and customers. Last but not least, workers trained by MNEs may set up their own businesses or be employed by local firms whose knowledge and skills can be leveraged by these local firms to improve their environmental performance. Hence, the presence of FDI generates positive spillover effects on domestic environmental performance. Ultimately, regardless of the levels of environmental regulations, FDI is likely to lead to improved environmental conditions of the host countries and their firms.

To consider the intellectual sustenance of these two competing theoretical perspectives, it is observed that the direction of the FDI-environment nexus can be better addressed through in-depth empirical examination of the existing evidence. In the literature, this has been undertaken mainly through two routes. The first is to determine whether MNEs prefer FDI locations with lax environmental regulations (e.g. Bu and Wagner 2016; Dean, Lovely, and Wang 2009; Lin and Sun 2016; Zhang and Fu 2008). However, due to the global scope and persistence of research implications on environmental regulation, the focus of the debate is shifting to the second stream of research, i.e. assessing the effects of FDI on environmental performance at the firm-, industry-, and region-level (including city, province and country). The focus of this meta-analysis is on the second stream of the literature as this is associated with higher volume and variety of empirical evidence.

Our extensive literature search identified at least 40 published journal articles on the environmental performance of FDI in China, published in 23 journals (see Appendix). In the literature, two broad measures of environmental performance are used, one being environmental pollution and the other, green total factor productivity (GTFP). Out of 35 studies on environment pollution, 12 studies find that FDI unambiguously improves environmental performance, i.e. more FDI is associated with less pollution (Bao, Chen, and Song 2011; Chen et al. 2014; Elliott, Sun, and Chen 2013; Hao and Liu 2015; Huang, Du, and Tao 2017; Jalil and Feridun 2011; Kang, Li, and Qu 2018; Kirkulak, Qiu, and Yin 2011; Liu, Hao, and Gao 2017; Ning and Wang 2018; Zhang and Zhou 2016; Zheng, Kahn, and Liu 2010). Ten studies reveal that there is a positive relationship (Baek and Koo 2009; He 2006; Jiang 2015; Lan, Kakinaka, and Huang 2012; Li et al. 2018; Li and Ramanathan 2020; Long et al. 2018; Sun, Zhang, and Xu 2017; Wang and Chen 2014; Wu, Wu, and Wang 2016). Nine studies show the insignificant relationship between FDI and environmental innovation (Huang et al. 2018; Huang et al. 2019; Jiang, Folmer, and Ji 2014; Jiang et al. 2018; Li and Ramanathan 2018; Lin 2017; Liu and Lin 2019; Tian, Chen, and Zhu 2017; Wang et al. 2013). The rest four studies present mixed findings (2) or nonlinear effects of FDI (2). The mixed findings appear in those research studies that utilize GTFP to capture environmental performance. In this regard, out of five studies, two show the negative effects (Shen et al. 2019; Xie, Yuan, and Huang 2017), two found insignificant effects (Miao et al. 2019; Zhou et al. 2019) and one detected positive effects of FDI on GTFP (Wang and Zhang 2020). In view of the set of mixed findings, we conduct a meta-analysis to aggregate these empirical studies to identify the overall direction and magnitude of the relation between FDI and environmental performance and to assess the heterogeneity of effect sizes across primary studies.

3. Literature search, inclusion criteria, and variable operationalization

We employed a two-step search technique to identify qualified empirical studies. First, we comprehensively searched the Web of Science (WOS) database, formerly known as ISI Web of Knowledge, for research articles. The WOS is a widely used database for systematic literature review, for example, see Beugelsdijk et al. (2018). We used the combination of two sets of keywords with the word ‘China’, ‘environmental performance’/‘environmental pollution’ and ‘foreign direct investment’/‘FDI’. Second, we consulted the reference sections of all the articles to identify any studies that we might have overlooked. The process resulted in a total number of 3023 papers.[3]

From this dataset of primary studies, we used the following selecting criteria to determine the appropriate manuscripts to be included in our meta-analysis. First, in the interest of preserving a quality threshold, we only included journal articles and excluded conference papers (Bergh et al. 2016). Second, we reviewed journal articles by reading the title, abstract, as well as other available information from the result of the search. To permit the use and comparability of statistical estimates, studies that lack focus on the FDI and environmental performance nexus and do not use quantitative modelling (e.g. qualitative studies, theoretical modelling research, and conceptual papers) were excluded. Third, we downloaded the full papers of those quantitative studies and examined whether they utilize the same datasets as other studies and whether they report the correlation coefficient (r) between FDI and environmental performance or relevant statistics that can be used to calculate r (Peterson and Brown 2005). The samples used in Huang, Hao, and Lei (2018) and Huang, Du, and Tao (2017) are the same, although different variables were tested in these two studies. As a result, only one of these two papers is included in the meta-analysis. Consequently, our search process and inclusion criteria yielded a final dataset consisting of 40 quantitative journal articles that were available in public domain in August 2020. Figure 1 presents the selection process for primary studies included in the meta-analysis.

Figure 2 shows the academic journals where 40 papers are published and their respective periods of publication. An interesting observation that deserves mention is that only three articles were published before 2010, whereas 37 papers appear between 2011 and 2020. 2010 is an important milestone marking the beginning of China's twelfth 5-year plan (2011–2015) and China's significant policy efforts on enhanced environmental

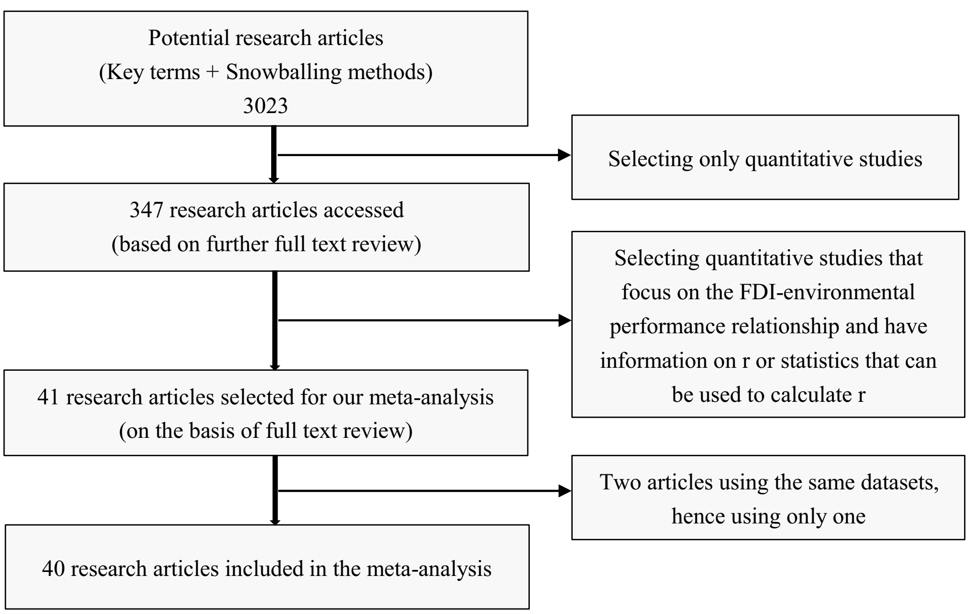

Figure 1. The Process of Selecting Primary Studies in the Meta-analysis.

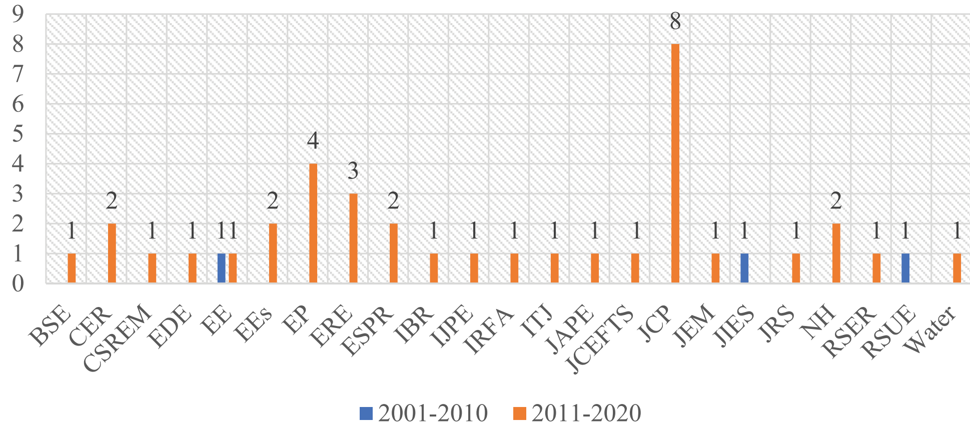

Figure 2. Distribution of Studies in Journals. BSE = Business Strategy and the Environment; CER = China Economic Review; CSREM = Corporate Social Responsibility and Environmental Management; EDE = Environment and Development Economics; EE = Ecological Economics; EEs = Energy Economics; EP = Energy Policy; ERE = Environmental and Resource Economics; ESPR = Environmental Science and Pollution Research; IBR = International Business Review; IJPE = International Journal of Production Economics; IRFA = International Review of Financial Analysis; ITJ = International Trade Journal; JAPE = Journal of the Asia Pacific Economy; JCEFTS = Journal of Chinese Economic and Foreign Trade Studies; JCP = Journal of Cleaner Production; JEM = Journal of Environmental Management; JIES = Journal of International Economic Studies; JRS = Journal of Regional Science; NH = Natural Hazards; RSER = Renewable and Sustainable Energy Reviews; RSUE = Regional Science and Urban Economics.

protection and sustainable growth including highlighting the need to increase FDI in resource-efficient and environmentally friendly sectors. This policy shift might explain the significant growth of studies on the environmental performance of FDI in China. The second interesting observation is the wide-ranging publication outlets of the primary studies. In total, the 40 papers are published in 23 journals, with *Journal of Cleaner Production* being the most popular publication outlet, having published eight studies. Nearly one-third of the primary studies (13) appear in CABS three-rated journals according to the Chartered Association of Business School (CABS) Academic Journal Guide (AJG) 2018. Nine papers are published in journals that are not listed in the CABS journal ranking list. The appendix presents a summary of these 40 studies including the bibliographical details, sample, and measurements of key variables (FDI and environmental performance).

To conduct meta-analysis, we followed specific procedures to develop the database. We first prepared a coding protocol specifying the information to be extracted from each study. This helps in reducing coding-related errors. A coding form was completed, by two coders, with extracted data on the variables of interest, including effect size estimates, statistical artifacts (e.g. endogeneity controlled or not in estimation), and study and sample characteristics. The intercoder reliability was high and small discrepancies were resolved through discussions until consensus was reached.

Although meta-analysis has been criticized for merging 'apples' with 'oranges,' the inclusion of 'studies that are diverse in terms of sample and measurement allows for more generalizable results and for an exploration of whether these differences explain variation in the observed results' (Post and Byron 2015, 1554). We first consider the measures of the

Table 1. Operationalization of FDI and Environmental Performance.

Construct	Category	Representative measures
FDI	FDI inputs	• FDI inflows • FDI stock • The ratio of FDI to GDP of the country/province/city • FDI per capita • The ratio of FDI to total industrial sales • Ownership dummy • Equity share of foreign investors
	FDI outputs	• The share of industrial output generated by foreign-invested enterprises
Environmental performance	Environmental pollution (EP)	• The amount of energy consumption • The ratio of energy consumption to GDP • The ratio of energy consumption to industrial added value • Pollution emission indicators, including industrial NO_x, SO_2, COx, soot, dust, gas wastes, water wastes, and solid wastes • The ratio of environmental levies paid by a firm to its total assets • The ratio of pollution fees to total sales
	Green total factor productivity (GTFP)	• Input indices (labor input, energy consumption, capital input) + output indices (the gross industrial output values, main pollution emissions/a comprehensive index of environmental pollution) • Luenberger productivity index

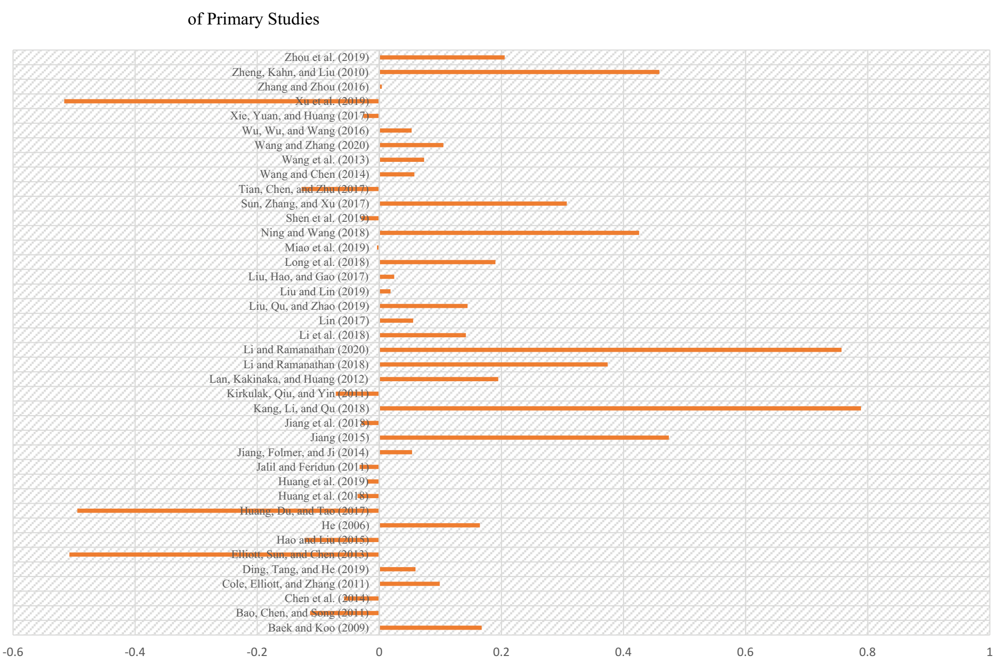

Figure 3. Mean Effect Sizes of Primary Studies.

environmental performance variable. Table 1 summarizes how the variable is operationalized in primary studies. Broadly speaking, we divide it into two groups, environmental pollution (e.g. energy consumption, pollution emission, and pollution fees in absolute and relative terms) and GTFP.

In the second step of the empirical section, we further drill down reasons for the heterogeneity of effect sizes across primary studies by employing the meta-regression analysis. As the effects of FDI on environmental pollution and GTFP are most likely to be opposite, i.e. when the relationship between FDI and environment pollution is shown to be negative, the relationship between FDI and GTFP is likely to be positive, we only employ the correlation coefficient between FDI and environmental pollution as dependent variable for meta-regression analysis.

Reflecting the theoretical perspectives on the FDI-environment nexus, environmental regulations are frequently cited. However, out of 40 primary studies in this meta-analysis, only 14 included environmental regulations as an explanatory variable or a moderator. We coded the environmental regulations as variable to examine whether its inclusion in primary studies explains the variation in the effect sizes. The role of environmental regulations is also highly debatable (see Iraldo et al. 2011, for a review). The 'traditionalist' view sees environmental regulations as additional costs on firms, reducing firms' competitiveness. The 'revisionist' view considers environmental regulations serving as an incentive mechanism for firms to develop competitive advantages. Empirical evidence on the impact of environmental regulations on firm performance does not provide unequivocal corroboration. Due to space constraints and the focus of our paper, readers are directed to Li and Ramanathan (2018) which provide a thorough discussion of the effects of different types of environmental regulations, namely command-and-control regulations and market-based regulations, on environmental performance, and a comprehensive review on empirical evidence. In view of mixed theoretical reasoning and empirical findings, we do not expect a priori the direction of the moderating effects of environmental regulations on the focal relationship of FDI and environmental performance.

We consider that FDI measures can be split into two groups based on FDI inputs (e.g. FDI flows and FDI stocks in absolute and relative terms scaled by GDP, industrial sales, and population) and FDI outputs (the share of foreign-investment enterprises in industrial output). Although higher FDI inputs are expected to be associated with proportionally higher FDI outputs, their effects on environmental pollution may not necessarily be similar. FDI outputs can be more visibly observed by local firms than FDI inputs. We thus expect the effects associated with FDI outputs measures to be more pronounced than those with FDI inputs measures.

In addition to the variables related to FDI measures and environmental regulations, we consider a particular type of statistical artifact, i.e. whether endogeneity is controlled for in the estimations of primary studies. Endogeneity may arise because of measurement errors, omitted variables, reverse causality and sample selection bias (Bascle 2008). Particularly, the last two, i.e. reverse causality and sample selection bias, are central to our question of interest. First, the environmental costs or benefits of FDI may not be instantaneous and the effects are likely to materialize over a period of time (He 2006). Second, FDI may be attracted to locations with weak environmental regulations (Dean, Lovely, and Wang 2009) or good environmental performance for the welfare of their staff (Pisani et al. 2019), which makes environmental performance of the location being an antecedent of FDI, rather than the outcome. Third, the influence of FDI on environmental performance could be because firms self-select into engagement of particular activities so as to attract foreign investments and receive preferential treatments that the Chinese government has been offering foreign investors (Long, Yang, and Zhang 2015). For research on the impact of FDI on environmental pollution, controlling for endogeneity is not a technical nicety, but a necessity for gaining unbiased estimates and, more importantly, testing the veracity of theories. Nevertheless, not all primary studies included

Table 2. Description of the Variables.

Variable	Measure
FDI outputs	A dummy variable, coded 1 for FDI outputs and 0 FDI inputs
Environmental regulations	A dummy variable, coded 1 if environmental regulations variable considered and 0 otherwise
Endogeneity control	A dummy variable, coded 1 if the estimation of primary study accounted for endogeneity and 0 otherwise
Publication year	A dummy variable, coded 1 if the primary study published 2011 and after, and 0 if not
Sample period	A dummy variable, coded 1 if the sample included 2011 and after, and 0 if not
Firm-level data	A dummy variable, coded 1 for firm-level data and 0 otherwise
Industry-level data	A dummy variable, coded 1 for industry-level data and 0 otherwise
City-level data	A dummy variable, coded 1 for city-level data and 0 otherwise
Country-level data	A dummy variable, coded 1 for country-level data and 0 otherwise
CABS journal ranking (3-rated)	A dummy variable, coded 1 for CABS 3-rated journals and 0 otherwise
CABS journal ranking (2-rated & 1-rated)	A dummy variable, coded 1 for CABS 2-rated and CABS 1-rated journals, and 0 otherwise

in meta-regression have considered endogeneity. Out of 35 studies on FDI-environmental pollution, only 18 account for endogeneity.

Similar to other meta-analysis research, we control variables that capture the study and sample characteristics including the year of publication, publication outlets, whether the sample covers data in the last decade (i.e. 2011–2020), and the level of analysis (firm-level, industry-level, city-level, province-level or country-level). As mentioned above, 2010 marks the significant growth of studies on the environmental performance of FDI in China. We are therefore interested in whether the effect size differs between studies published before and after 2010. We also consider publication bias from the perspective of ranking of the journals. CABS ranked journals on the scale of 1 to 4 with 1-rated journals publishing research of a recognized but more modest standard, 2-rated journals publishing original research of an acceptable standard, 3-rated journals publishing original and well-executed research that is highly regarded and 4-rated journals publishing the most original and best-executed research.[4] As the environmental performance of FDI is likely to be dynamic, we account for the sample data period and whether it covers more recent data. Finally, we reflect on whether the level of analysis matters to the heterogeneity of effect sizes. The variables included in the meta-regression are listed in Table 2.

4. Methodology

Meta-analysis is a quantitative technique to combine evidence from different primary empirical studies. It offers an effective tool to address the inconsistencies in studies by allowing scholars to synthesize previous results into a single effect size that reflects the magnitude and direction of the association between two variables – FDI and environmental performance (Bergh et al. 2016). This study used two commonly adopted methodological procedures in Social Sciences, Business and Economics (Ringquist and Anderson 2013; Stanley and Doucouliagos 2012): Hedges and Olkin meta-analysis to explore directions and strengths of the direct effects between FDI and environmental performance, and meta-regression technique to investigate moderating factors that accounting for the variations of effect sizes across primary studies.

We used the correlation coefficient *r* as the effect size (Stanley and Doucouliagos 2012). For some studies that do not report r, we transformed beta coefficients into correlation coefficients following recommendations by Peterson and Brown (2005). Figure 3 presents the mean effect sizes of primary studies.

To perform meta-analysis, *r* is converted to Fisher's *Z* which has approximately normally distributed statistical properties:

$$z = 0.5 * ln\left(\frac{1+r}{1-r}\right)$$

The variance of Fisher's *Z* is approximately

$$V_z = \frac{1}{n-3}$$

where *n* is each sample size, and the standard error of Fisher's *Z* is $SE_z = \sqrt{V_z}$.

Each mean effect size is computed with its inverse within-study variance (V_{Y_i}) and the between-study variance (τ^2):

$$\tau^2 = \frac{Q_w - df}{C}$$

where $df = k - 1$, $Q_w = \sum_{k}^{i=1} W_i Y_i^2 - \frac{\left(\sum_{i=1}^{k} W_i Y_i\right)^2}{\sum_{i=1}^{k} W_i}$ and $C = \sum_{k}^{i=1} W_i - \frac{\sum_{i=1}^{k} W_i^2}{\sum_{i=1}^{k} W_i}$.*k* is the number of effect sizes. W_i is the weight of the random-effects model assigned to each effect size and $W_i = \frac{1}{V_{Y_i}^*}$, where $V_{Y_i}^* = V_{Y_i} + \tau^2$. Y_i is the observed effect size.

The weighted average effect size (M_r), its variance (V_{M_r}), standard error (SE_{M_r}) and 95% lower (LL_{M_r}) and upper confidence interval (CI) (UL_{M_r}) are calculated as

$$M_r = \frac{\sum_{i=1}^{k} W_i Y_i}{\sum_{i=1}^{k} W_i}$$

$$V_{M_r} = \frac{1}{\sum_{i=1}^{k} W_i}$$

$$SE_{M_r} = \sqrt{V_{M_r}}$$

$$LL_{M_r} = M_r - 1.96 * SE_{M_r}$$

$$UL_{M_r} = M_r + 1.96 * SE_{M_r}$$

In these equations 1.96 is the Z-value corresponding to confidence limits of 95% (allowing for 2.5% error at either end of the distribution).

Finally, a *Z*-value to test the null hypothesis that weighed average effect size is zero is calculated using

$$Z = \frac{M_r}{SE_{M_r}}$$

and the *p*-value is given by

$$p = 2[1 - (|Z|)]$$

where (Z) is the standard normal cumulative distribution. There is a relationship between the p-value for Z and the confidence interval, such that the p-value will be less than 0.05 if and only if the confidence interval does not include the null value.

Some of the factors that affect precision are unique to each effect size. Some are also unique to each study. Furthermore, two factors that have an important and predictable impact on precision are the size of the sample, and the study design. For example, larger samples tend to yield more precise estimates than smaller samples. Matched groups tend to yield more precise estimates and clustered groups have less precise estimates, as compared to independent groups. Therefore, the weighted average effect size (M_r) is not a sample size effect, but on the basis of the sample size.

To assess the extent of statistical inconsistency among findings of effect sizes across primary empirical studies can be related to one or more attributes of the studies, we estimate the following equation.

$Y_i = \beta_0 + \sum_{k=1}^{K} \beta_k Z_{ik} + \varepsilon_i$ I = 1, 2, . . ., N

where Y_i is the sample correlation coefficient r in study i from a total of N empirical studies, and Z_{ik} are meta-independent variables that capture attributes of the studies. βs are the set of coefficients to be estimated and ε is the error term.

5. Results

Table 3 reports the results for the main effects of the relationship between FDI and environmental performance. FDI exhibits a significantly negative relationship with environmental pollution at the aggregated level (M_r = –0.040). Cohen (1988) suggests the thresholds for interpreting effect size being 0.1, 0.3, and 0.5 for small, medium, and large effect size, respectively. Thus, the synthesized effect size for FDI on environmental pollution is small. The relationship between FDI and GTFP is statistically insignificant (M_r = –0.004). Therefore, this study supports the pollution halo hypothesis in that FDI lowers environmental pollution, albeit without improving GTFP, at the aggregated level. As the significant Q statistic associated with the FDI-environmental pollution relationship suggests the necessity of the moderating effect analysis, we conduct a meta-regression.

Table 4 presents the meta-regression results. The findings are summarized in Table 5 for ease of interpretation. The coefficient on environmental regulations is positive and significant ($\hat{\beta}$ = 0.3915, $p < 0.01$). This indicates that in studies that considered environmental regulations as an explanatory variable and/or a moderator, the effect size of FDI on environmental pollution is pushed towards more positive direction, i.e. reducing less or generating more pollution. This may not be surprising given the debates on the effects of environmental regulations (He 2006; Iraldo et al. 2011; Li and Ramanathan 2018). In our research context of a developing country, for Chinese firms, the positive effects of environmental regulations may not be easily realized. In the short term, firms' capabilities to conform to environmental regulations may be limited, forcing them to incur significant costs for compliance first before moving to innovation and the development of competitive advantages (Xie, Yuan, and Huang 2017). Additionally, Chinese pollution regulations remain under developed and enforcement is a continuous challenge (Dean, Lovely, and Wang 2009; Shen et al. 2019; Wang, Wu, and Zhang 2018). Under the simultaneous environmental regulative pressures and competitive pressures from foreign-invested enterprises, domestic firms may find it is more cost-effective to comply to the regulations, to relocate to China's less developed areas with lax environmental regulations, or to develop political connections to circumvent penalties (Li et al. 2020).

The negative coefficient on FDI outputs ($\hat{\beta} = -0.1841$, $p < 0.1$) indicates that research employing FDI outputs measures tend to observe more negative effects of FDI on environmental pollution. This is in line with our expectation. FDI outputs measures 'are concerned with the demonstration effects of not only the superior product but also such characteristics of scale or scope economies. They may also be linked with knowledge acquisition via reverse engineering of the product' and transactional linkage effects, whereas FDI inputs measures may be 'more closely related to the demonstration effect of the suitability of the project, or the superiority of machinery or equipment embodying updated technologies' (Wei and Liu 2006, 549). Thus, FDI outputs measures may capture greater spillover effects than FDI inputs measures.

In order to address the endogeneity concern that such results of the FDI and environmental pollution relationship are due to omitted variables or reverse causality, we explore whether the endogeneity control moderated the association between FDI and environmental pollution. The negative coefficient on endogeneity control ($\hat{\beta} = -0.2051$, $p < 0.05$) indicates that the focal relationship between FDI and environmental pollution tends to be

Table 3. Bivariate Meta-Analytical Results for the FDI-Environmental Performance Relationship.

FDI	Environmental performance	k	N	M_r	95% CI	Z	p_z	Q_w	Q_b
Overall effect	EP	108	382,425	−0.040*	(−0.043, −0.037)	24.80	0.000	7044.64*	7.28*
	GTFP	13	5,856	−0.004	(−0.030, 0.021)	0.34	0.732	12.66	

k = number of effect sizes; N = total sample size; M_r = mean effect size; 95% CI = 95% confidence interval around the meta-analytic mean;
Z = significance of the effect within the subgroups; Q_w= Q statistic of the within-group; Q_b= Q statistic of the between-group. *p < 0.05.

Table 4. Meta-Regression Results for Moderator Analysis.

Variable	$\hat{\beta}$	s.e.	p
Environmental regulations	0.3915***	0.1026	0.000
FDI outputs	−0.1841*	0.1021	0.075
Endogeneity control	−0.2051**	0.0970	0.037
Publication year	−0.6278***	0.2203	0.005
CABS journal ranking (3-rated)	−0.0598	0.1242	0.631
CABS journal ranking (2-rated & 1-rated)	−0.1221	0.1113	0.275
Sample period	0.1023	0.1130	0.367
Industry-level data	0.7904***	0.2803	0.006
City-level data	0.5745**	0.2352	0.016
Province-level data	0.4043*	0.2231	0.073
Country-level data	0.3048	0.3364	(0.367
Constant	0.2386	0.3203	0.458
k		108	
Model F		2.71	
(df)		(11, 96)	
(p-value)		(0.0044)	
Adjusted R^2		0.3812	
τ^2		0.0135	

τ^2= MOMENTS estimate of between-study variance. ***p <0.01; **p <0.05; *p <0.10.

Table 5. FDI and Environmental Performance in China: A Summary of Evidence.

Key perspectives	Findings from meta-analysis
Pollution-halo hypothesis	Partially supported. Negative effect size indicating that higher level of FDI is associated with lower environmental pollution. Insignificant effect size indicating that FDI has an insignificant effect on GTFP.
Pollution-haven hypothesis	Not supported.
Environmental regulations	Studies accounting for the role of environmental regulations tend to find weaker support for pollution-halo hypothesis.
FDI measurement (FDI outputs vs. FDI inputs)	In comparison to studies that employ FDI inputs measures, those that use FDI outputs tend to find stronger support for pollution-halo hypothesis.
Endogeneity control	Studies accounting for the endogeneity of environmental performance tend to find stronger support for pollution-halo hypothesis.
Unit of analysis	In a ranking order, the support for pollution-halo hypothesis is the strongest in studies using firm-level data, followed by those using province-level data, city-level data and industry-level data.

more negative when potential endogeneity issue is addressed in a primary study. Thus, future studies should particularly control for endogeneity when analyzing the environmental performance of FDI. Although authors often have reasons for not accounting for endogeneity, e.g. difficulty in finding instrumental variables and using cross-sectional datasets (Hamilton and Nickerson 2003), the techniques to mitigate endogeneity have been well established including, using dynamic specifications (e.g. lagged variables, or difference-in-difference estimator), adding many control variables, instrumental variables (IV) methods, Heckman's two-step sample selection model and propensity matching model (Bascle 2008; Hamilton and Nickerson 2003; Reeb, Sakakibara, and Mahmood 2012). Future studies, therefore, should adopt one or more of these methods to tackle the endogeneity so as to obtain a more precise effect size.

Turning our attention to the variables associated with study and sample characteristics, we first discuss findings in relation to the publication year. The negative significant coefficient ($\hat{\beta} = -0.6278$, $p < 0.01$) indicates that primary studies published in the second decade of 2011–2020 tend to find more negative effect size on the focal relationship than those published in the first decade of 2001–2010.

The coefficients on both ABS journal ranking variables ($\hat{\beta} = -0.0598$, $p > 0.1$; $\hat{\beta} = -0.1221$, $p > 0.1$) are statistically insignificant, revealing that publication outlets do not explain the heterogeneity of effect sizes in primary studies. This is also a piece of evidence that suggests no publication bias.

The coefficient on sample period are also statistically insignificant ($\hat{\beta} = 0.1023$, $p > 0.1$), revealing that the inclusion of more recent data in the sample does not account for the heterogeneity of effect sizes in primary studies.

Finally, we evaluate whether the level of analysis, i.e. firm-, industry-, and region-level (e.g. city-level, province-level, and country-level), matters. The level of analysis is clearly relevant to the effect size of the focal relationship between FDI and environmental pollution. Studies employing firm-level data tend to reveal the most negative effects of FDI on pollution, as the coefficients on Industry-level data ($\hat{\beta} = 0.7904$, $p < 0.01$), City-level data ($\hat{\beta} = 0.5745$, $p < 0.05$), Province-level data ($\hat{\beta} = 0.4043$, $p < 0.1$) and Country-level data ($\hat{\beta} = 0.3048$, $p > 0.1$) are all positive and the first three are also statistically significant. Studies employing province-level data, on average, have the second-smallest effect size in terms of magnitude. There is no statistical difference in terms of effect sizes between studies employing province-level data and city-level data. The effect sizes are least negative in studies employing industry-level data. These findings therefore bear testimony to the importance of the unit of analysis. Better and more disaggregated data are likely to help produce more robust evidence on FDI impacts and reduce aggregation bias (Dechezlepretre and Sato 2017).

We apply the Egger's test procedure to further assess publication bias. Table 6 presents the results that show all explanatory and control factors exceeding the critical level of 0.05. The publication bias, therefore, is not a serious concern in our meta-analysis.

6. Discussion and conclusion

The generally accepted view is that FDI has played a positive role in China's economic development. In contrast, the relationship between FDI and environmental degradation is highly contestable, in particular as a careful interpretation is required of the intermediate and final outcomes as evident from the mixed empirical findings. Our paper systematically synthesizes the evidence to provide a more accurate account of the environmental impact of FDI in China. Based on our meta-analysis results, we reinforce and clarify the proposed notion of the two competing faces of FDI with regard to environmental impacts in China. The picture that emerges from the meta-analysis is that, overall, there is a systematic relationship between FDI and environmental pollution in China. More specifically, a higher level of FDI is associated with lower level of environmental pollution, albeit with a smaller effect size. However, the impact of FDI on green productivity has not been found to be significant. To answer our original research question posited earlier, the overall findings from the meta-analysis lends partial support to the pollution halo hypothesis.

In view of the negative relationship between FDI and environmental pollution, results from the meta-regression analysis show that primary studies employing FDI outputs measures and accounting for endogeneity tend to find more negative effect size than those employing FDI inputs measures and not accounting for endogeneity, respectively. In contrast, the studies that have accounted for environment regulation tend to find that the negative effects of FDI on environmental pollution are weakened. Additionally, the level of analysis matters as the effect sizes vary by the aggregation level of the data.

For future evidence-based research, our first suggestion is to employ both FDI input- and output-based measures to gain a comprehensive understanding of the environmental performance of FDI. Research design should employ techniques that mitigate endogeneity and aggregation bias, and empirical models should consider the boundary conditions of environmental regulation.

Table 6. Publication Bias.

Egger's test	k	N	Coefficient	s.e.	t	p > |t|	95% CI
FDI – EP	108	382,425	1.7679	0.9127	1.94	0.055	(−0.0416, 3.5774)
FDI – GTFP	13	5,856	1.9406	1.2094	1.60	0.137	(−0.7213, 4.6025)

An analytical model

The review highlights opportunities for further research. Figure 4 summarizes our comments into an overall analytical model. First, the extant research has largely treated the mechanisms through which FDI impact on environmental performance as a black-box. The FDI-environmental nexus could be better understood through a stakeholder expectations lens relating to green management practices in MNE subsidiaries, in addition to the FDI spillovers (Buysse and Verbeke 2003; Chen, Newburry, and Park 2009; Ning and Wang 2018; Pisani et al. 2019). Although a proactive approach towards incorporation of green management practices in foreign firms has evolved rapidly with evidence suggesting that there are beneficial effects on financial performance (Feng et al. 2018), competitiveness (Yang et al. 2017) and product innovation (Shu et al. 2016) of firms, these beneficial effects are likely to yield under specific circumstances (Aragón-Correa et al. 2008). The strategic decisions of MNE subsidiaries to adopt and embed green management practices beyond what is required by environmental regulation can be regarded as a means to improve their alignment with expectations of stakeholders (Buysse and Verbeke 2003). Depending on whether MNEs in a specific country has the strategic requirement to engage with these expectations expansively (or sparingly), they are likely to position themselves to recognize salient stakeholders (Mitchell, Agle, and Wood 1997) and develop resources to respond adequately to pressures from such stakeholders. Although the importance of stakeholders may change over time and will depend on the context (for example, change in political agenda and host country mimetic pressures), a proactive approach by firms to managing stakeholder expectations related to green management (or lack of it) is likely to alleviate unwarranted consequences (Burritt et al. 2020) and thereby create beneficial effects for the host economy.

Second, the weak effect size associated with FDI confirm that the understanding of China's environmental performance needs to zoom in non-FDI factors that either directly contributes to environmental upgrading or helps domestic firms absorb the benefits from FDI. The extant research on FDI spillovers has widely recognized that the beneficial effects of FDI spillovers are conditioned by resources such as technological capability, human capital, knowledge intensity, absorptive capacity, and local networks (Hanousek, Kocenda, and Maurel 2011; Huang, Hao, and Lei 2018; Huang et al. 2018; Long, Yang, and Zhang 2015; Ning and Wang 2018). The argument is that to benefit from FDI presence, Chinese firms need to have the resources and capabilities that enable them to absorb, adopt and integrate the acquired advanced technologies and knowledge. Future research therefore may dissolve the theoretical and empirical ambiguity through focusing on such resources, as Chinese firms are particularly suffering from resource constraints.

Another set of variables is related to institutions. Institutional theory has highlighted that institutions specify rules for firms as a condition of conferring legitimacy and support (Wang and Chen 2014). MNEs adopt and adapt their environmental strategies in view of different institutional constraints and their negotiation with institutional regulators (Child and Tsai 2005). MNEs are exposed to pressures from both home and host countries and they are increasingly subject to the scrutiny of transnational/global monitors and media, which put pressures on MNEs to improve their worldwide environmental performance (Kolk and Pinkse 2008). Further efforts therefore could focus on the contextual variations associated with national institutions (home and host countries), subnational institutions

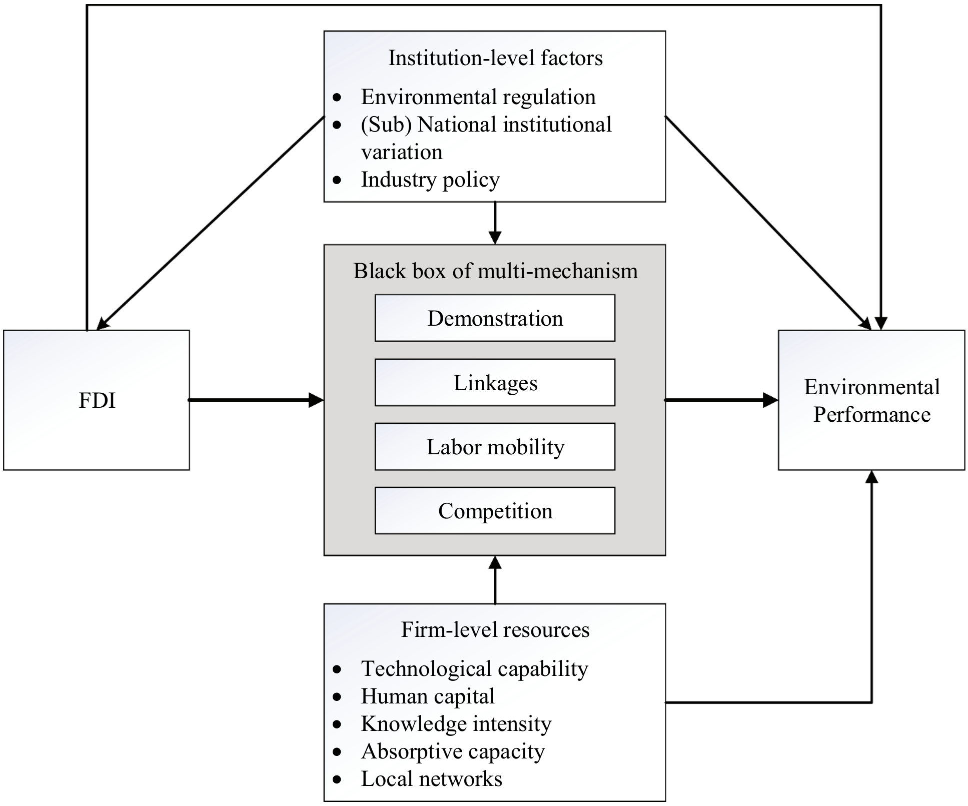

Figure 4. An Analytical Model.

(provinces and cities), and industry. This will provide more clarity and better understanding of environmental performance of FDI in China. Government efforts may focus on incentivizing firms by improving the institutional context, and not just coercing them through environmental regulations.

In various sections of this paper, we have hinted at the role of time in studying the environmental performance of FDI. Chen, Newburry, and Park (2009) has developed an international evolutionary framework, suggesting that the changing institutions in China over time have resulted in changing expectations of MNEs regarding their appropriate roles within China, from capital and/or technology providers to holding responsibility for sustainability, including ecological sustainability. It is therefore plausible to expect that the environmental effect of FDI will evolve over time. Yet the literature on environmental performance of FDI in China has devoted little, if any, attention to the dynamic/temporal effects of FDI.

Limitations

It goes without saying that the present paper, though offers a synthesis of the literature and present a more definitive answer to the role of FDI in China's environmental performance, has limitations. First, given the nature of meta-analysis, qualitative research, theoretical modelling studies and conceptual papers, which represent a majority of research in the extant literature, are excluded from our analysis. This limits the scope of our discussions. Second, we only examined journal articles and did not include books, book chapters, conference papers, or working papers. We therefore may have missed high-quality work that is yet to be published. For example, none of our included primary studies appears in ABS 4-rated journals. Third, although focusing on one host country has its advantages as outlined in the Introduction, it may come at the expense of generalizability of findings.

Policy and managerial implications

This paper provides policymakers and managers with a systematic understanding of the environmental effects of FDI in the host country of China. The conclusive evidence on the pollution reduction effects of FDI, albeit with small effect size, indicates the need to continue with proactive policies to attract FDI. However, the joint effects of existing environment regulations and FDI on environmental pollution seem to be less than optimal. In view of the existing debates on the effectiveness of environmental regulations (Dechezlepretre and Sato 2017) and many of the regulations only being launched recently and not always rigorously enforced (Liao 2018), policymakers need to exercise environmental policy instruments with caution. Research suggest that public and private regulations, the presence of NGOs and institutionalized norms regarding appropriate firm behavior, organized dialogues among firms and their stakeholders and demand from the general public spur green management practices of firms (Campbell 2007; Cheng 2020; Matten and Moon 2008). Also, robust commitment to upholding green management practices through FDI projects can be sustained in a strong and comprehensive welfare state due to the extent of comparative institutional advantage (Gjølberg 2010).

The stringency of national environmental policy is also likely to aid in consolidating and spreading the beneficial effects of green management practices. Given the growing public concern for global issues related to environmental sustainability such as climate change, labor standards and human rights, the development of national and international policy frameworks to address these issues effectively has been slower (Muller 2006). Overall, the increase in societal demand for development of regulations to monitor aforementioned environmental sustainability and green management practices of firms has not been encountered by the ability of policymakers globally to supply an institutional basis for regulation (Kolk and Van Tulder 2010). MNE subsidiaries which operate in countries with stringent environmental regulations are more likely to implement robust green management policies to build legitimacy among its urgent stakeholders such as customers, employees and suppliers as well as to mitigate against punitive actions as a consequence of non-adherence to these regulations. Thus, stringent national environmental policies are likely to compel MNEs to avoid negative publicity and avoid consumer flight to competitors (Doh and Guay 2006).

In addition, managers of MNE subsidiaries need to recognize that the extent of successful appropriation of green management capabilities is quasi-automatic (Dzhengiz and Niesten 2020; Scarpellini et al. 2020) given the public good nature of green management and difficulties that firms face in appropriating its full value (Teece 2007). Moreover, MNE subsidiaries are exposed to different degree of stakeholder expectations within and across countries and will require adaptation in terms of depth of local orientation, governance and flexibility in managing such expectations (Aragón-Correa et al. 2008).

Notes

1. http://www.stats.gov.cn/ztjc/ztfx/ggkf40n/201808/t20180827_1619235.html (accessed on 31 March 2021)
2. https://www.reuters.com/article/un-assembly-climatechange-idUSL2N2GJ105 (accessed on 31 March 2021)
3. We also searched Scopus, Emerald, EBSCO, and JSTOR. The papers returned from these databases have all been included in 347 papers, the search results of the WOS database.
4. https://charteredabs.org/academic-journal-guide-2018/

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Appendix. An Overview of Studies on Environmental Performance of FDI in China

No	Study	Journal	CABS 2018 journal ranking	Sample time period	Unit of analysis	Data structure	Measure of environmental performance	Mean of envir-onmental performance	Measures of FDI	r-based effect sizes	Environmental regulation considered	Endogeneity controlled	Methods	n
1	Baek and Koo (2009)	JIES	n.a.	1980–2007	Country	Panel	Industrial CO2	n.a.	FDI inputs	0.2362	No	No	ARDL	28
										0.0990				
2	Bao, Chen, and Song (2011)	EDE	2-rated	1992–2004	Province	Panel	Industrial SO2	n.a.	FDI inputs	0.2162	Yes	Yes	3SLS	377
							Industrial smoke		FDI inputs	0.2252				
							Industrial polluted water		FDI inputs	0.1846				
							Industrial solid wastes		FDI inputs	0.2296				
							Chemical oxygen demand		FDI inputs	0.0500				
							Industrial SO2		FDI outputs	−0.4643				
							Industrial smoke		FDI outputs	−0.3786				
							Industrial polluted water		FDI outputs	−0.2340				
							Industrial solid wastes		FDI outputs	−0.3692				
							Chemical oxygen demand		FDI outputs	−0.2429				
							Industrial SO2		FDI outputs	0.1152				
							Industrial smoke		FDI outputs	0.0873				
							Industrial polluted water		FDI outputs	0.1154				
							Industrial solid wastes		FDI outputs	0.0884				
							Chemical oxygen demand		FDI outputs	0.1501				
3	Chen et al. (2014)	IRFA	3-rated	2004	Firm	Cross-sectional	Environmental levies paid for pollution divided by total assets	0.002	FDI outputs	−0.075	Yes	No	OLS	79,531
										−0.087				79,531
										−0.0002				75,982
										−0.067				79,531
4	Cole, Elliott, and Zhang (2011)	JRS	3-rated	2001–2004	City	Panel	Wastewater (tons per person)	38.49	FDI outputs (fromHongKong, Macao, and Taiwan)	0.1019	No	No	Linear and quadratic log model	424
							Petroleum (tons per 10^6 persons)	46.33		0.1215				424
							Waste Gas (m3 per person)	4.70		0.0902				439
							SO2 (tons per 10^4 persons)	325.39		0.0961				428
							Soot (tons per 10^4 persons)	138.54		0.0833				436
							Dust (tons per 10^4 persons)	118.09		0.0882				424
							Wastewater (tons per person)	38.49	FDI outputs (from other foreign countries	−0.0118				424
							Petroleum (tons per 10^6 persons)	46.33		0.2901				424
							Waste Gas (m3 per person)	4.70		0.1108				439
							SO2 (tons per 10^4 persons)	325.39		0.1108				428
							Soot (tons per 10^4 persons)	138.54		0.0549				436
							Dust (tons per 10^4 persons)	118.09		0.0510				424
5	Ding, Tang, and He (2019)	Water	n.a.	2006–2016	Province	Panel	Industrial water pollution (water utilization efficiency)	0.8001	FDI inputs	0.0592	Yes	No	Panel threshold model	121

(*Continued*)

Appendix. (Continued).

No	Study	Journal	CABS 2018 journal ranking	Sample time period	Unit of analysis	Data structure	Measure of environmental performance	Mean of envir-onmental performance	Measures of FDI	r-based effect sizes	Environmental regulation considered	Endogeneity controlled	Methods	n
6	Elliott, Sun, and Chen (2013)	EEs	3-rated	2005–2008	City	Panel	Energy consumption	n.a.	FDI inputs	−0.4759	No	Yes	2SLS	747
										−0.4841				730
										−0.5121				747
										−0.542				730
									FDI outputs	−0.5286				708
										−0.528				693
										−0.4744				708
										−0.5185				693
7	Hao and Liu (2015)	NH	n.a.	1995–2011	Province	Panel	Industrial CO_2 (log (per capita CO_2 emissions) (kg/person))	8.163	FDI inputs	−0.1225	No	Yes	Two-equation model	493
8	He (2006)	EE	3-rated	1994–2001	Province	Panel	Industrial SO_2 (Annual industrial SO_2 emission, 1000 tons)	500.599	FDI inputs	0.1647	Yes	Yes	Dynamic GMM	232
9	Huang, Du, and Tao (2017)	EP	2-rated	2000–2013	Province	Panel	Energy consumption	n.a.	FDI outputs	−0.4947	No	No	FGLS	420
10	Huang et al. (2018)	EP	2-rated	2000–2014	Province	Panel	Industrial CO_2 (log(CO_2 emissions divided by GDP))	1.2147	FDI outputs	−0.0357	No	No	Panel data model	450
11	Huang et al. (2019)	ESPR	n.a.	2000–2010	Industry	Panel	Energy consumption (log (CO_2 emissions divided by GDP))	−0.1024	FDI outputs	−0.0201	No	Yes	FGLS	340
12	Jalil and Feridun (2011)	EEs	3-rated	1978–2006	Country	Panel	Industrial CO_2	n.a.	FDI inputs	−0.0323	No	Yes	ARDL	54
13	Jiang, Folmer, and Ji (2014)	CER	2-rated	2003–2011	Province	Panel	Energy consumption (the amount of energy consumed to generate a unit of provincial output)	1.68	FDI inputs	0.0536	No	Yes	Spatial Durbin error model	261
14	Jiang (2015)	ITJ	1-rated	1997–2012	Province	Panel	Industrial SO_2	n.a.	FDI inputs	0.4743	No	Yes	Fixed effects model	448
15	Jiang et al. (2018)	EP	2-rated	2003–2015	Province	Panel	Energy consumption (The ratio of energy consumption to GDP)	1.5531	FDI inputs	−0.0293	No	No	Fixed effects spatial model	116
16	Kang, Li, and Qu (2018)	JCP	2-rated	2005–2014	City	Panel	Industrial CO_2 (Prefecture-level CO_2 emissions)	5330.086	FDI inputs	0.7889	No	No	GMM	500

(*Continued*)

Appendix. (Continued).

No	Study	Journal	CABS 2018 journal ranking	Sample time period	Unit of analysis	Data structure	Measure of environmental performance	Mean of envir-onmental performance	Measures of FDI	r-based effect sizes	Environmental regulation considered	Endogeneity controlled	Methods	n
17	Kirkulak, Qiu, and Yin (2011)	JCEFTS	n.a.	2001–2007	City	Panel	Industrial SO2 (Per capita emissions of industrial SO2 (tons per 10^4 persons))	59,040.98	FDI inputs FDI outputs	−0.1333 −0.0108	No	Yes	OLS, Panel data model, GLS	1967
18	Lan, Kakinaka, and Huang (2012)	ERE	3-rated	1996–2006	Province	Panel	Industrial waste water (Industrial waste water emission divided by industrial value added)	0.025	FDI inputs	0.3401	No	Yes	OLS	319
							Industrial soot (Industrial soot emission divided by industrial value added)	0.056		0.3401				
							Industrial SO2 (Industrial SO2 emission divided by industrial value added)	0.057		−0.096				
19	Li and Ramanathan (2018)	JCP	2-rated	2004–2014	Province	Panel	Comprehensive Environmental Pollution Index	0.781	FDI inputs	0.374	Yes	Yes	OLS	330
20	Li and Ramanathan (2020)	BSE	2-rated	2004–2015	Province	Panel	Comprehensive Environmental Pollution Index	0.637	FDI inputs	0.757	Yes	No	Two-way fixed-effects model	360
21	Li et al. (2018)	IJPE	3-rated	2005–2010	Industry	Panel	Green management of waste water (10^4 tons)	0.94	FDI inputs	0.07 0.18 0.13	No	Yes	Dynamic panel data model	144
							Green management of the SO2 (10^4 tons)	0.85		0.21 0.16 0.1				
22	Lin (2017)	CER	2-rated	2001–2007	City	Panel	Industrial SO2 (Concentrations in μg/m^3)	1.561	FDI inputs	0.0935	No	Yes	OLS	2496
							Industrial NO2 (Concentrations in μg/m^3)	3.285		0.0838				2496
							Industrial aerosols (Concentrations in μg/m^3)	6.143		−0.0113				2496
23	Liu, Qu, and Zhao (2019)	JCP	2-rated	1996–2015	Province	Panel	Industrial CO2 (Carbon emission per capita)	5.66	FDI inputs	0.14	No	No	Fixed effects model	580

(*Continued*)

Appendix. (Continued).

No	Study	Journal	CABS 2018 journal ranking	Sample time period	Unit of analysis	Data structure	Measure of environmental performance	Mean of environmental performance	Measures of FDI	r-based effect sizes	Environmental regulation considered	Endogeneity controlled	Methods	n
24	Liu and Lin (2019)	JCP	2-rated	2000–2015	Province	Panel	Comprehensive environmental pollution index	0.0323	FDI inputs	−0.0002 0.0598 −0.00001 −0.0001 0.0504 −0.0002	No	No	Spatial error model	465
25	Liu, Hao, and Gao (2017)	EP	2-rated	2002–2015	City	Panel	Industrial SO2 (Per capita SO2 emissions (kg/person))	24.2	FDI inputs	0.0774	No	Yes	OLS	1404
							Industrial soot (Per capita soot emissions (kg/person))	12.11		−0.0284				1409
26	Long et al. (2018)	ESPR	n.a.	1997–2014	Province	Panel	Industrial CO2 (CO2 intensity, 10^4 ton/10^8 Yuan)	17.05296	FDI inputs	0.1901	No	No	2SLS	540
27	Miao et al. (2019)	ERE	3-rated	2006–2012	Province	Panel	The growth of the atmospheric GTFP	0.01	FDI inputs	−0.0039	Yes	No	Spatial Durbin model	78
28	Ning and Wang (2018)	ERE	3-rated	2003–2012	City	Panel	Industrial soot (Tons per square kilometer)	0.441	FDI inputs	0.338	Yes	Yes	System GMM	2118
							Industrial SO2 (Tons per square kilometer)	1.365		0.406				2120
							Industrial waste water (Tons per square kilometer)	8.295		0.532				2127
29	Shen et al. (2019)	JCP	2-rated	2000–2016	Industry	Panel	GTFP (Metafrontier Malmquist Luenberger productivity index)	1.023	FDI outputs	−0.0225 −0.0314 −0.0363 −0.0206 −0.0284 −0.0382	Yes	No	Threshold regression model	612
30	Sun, Zhang, and Xu (2017)	JCP	2-rated	1980–2012	Country	Panel	Industrial CO2 (Total CO2 emissions, metric tons per capita)	3.059	FDI inputs	0.3070	No	No	ARDL	33
31	Tian, Chen, and Zhu (2017)	NH	n.a.	1992–2014	Country	Panel	Industrial CO2	n.a.	FDI inputs	−0.1666 −0.0882	No	No	ARDL-ECM	23
32	Wang and Chen (2014)	JEM	3-rated	2002–2009	City	Panel	Industrial SO2 (Industrial SO2 emission (tons))	10.539	FDI outputs	0.074 −0.021 0.119	Yes	Yes	Fixed-effect model	2296

(*Continued*)

Appendix. (Continued).

No	Study	Journal	CABS 2018 journal ranking	Sample time period	Unit of analysis	Data structure	Measure of environmental performance	Mean of environmental performance	Measures of FDI	r-based effect sizes	Environmental regulation considered	Endogeneity controlled	Methods	n
33	Wang et al. (2013)	IBR	3-rated	1999–2005	City	Panel	Industrial SO2 (Total factory SO2 emission divided by land area (tons/square kilometer))	2.89	FDI outputs	0.05 0.11 0.06	Yes	Yes	GLS	2009
34	Wang and Zhang (2020)	CSREM	1-rated	2004–2015	Industry	Panel	GTFP (Global Malmquist Luenberger index)	1.11	FDI inputs	0.1049	Yes	Yes	Difference-in-difference model	456
35	Wu, Wu, and Wang (2016)	JAPE	n.a.	2002–2011	City	Panel	Industrial CO2 (Per capita CO2 emission, 10^4 tons)	881.4	FDI inputs	0.0529 0.0528	No	No	Double censored Tobit model	2860
36	Xie, Yuan, and Huang (2017)	EE	3-rated	2000–2012	Province	Panel	GTFP (Luenberger productivity index)	1.22	FDI inputs	−0.0478 −0.0047	Yes	Yes	Panel threshold model	390
37	Xu et al. (2019)	JCP	2-rated	2006–2016	Province	Panel	Eastern region PM2.5 Eastern region Nox Central region SO2 Central region PM2.5 Central region Nox Western region PM2.5 Western region Nox	n.a.	FDI inputs	−0.5557 −0.6007 −0.2597 −0.5008 −0.0953 −0.6762 −0.8840	No	No	STIRPAT	132 132 99 99 99 99 99
38	Zhang and Zhou (2016)	RSER	n.a.	1995–2010	Province	Panel	National CO2 Eastern region CO2 Central region CO2 Western region CO2	n.a.	FDI inputs	−0.0048 0.0631 −0.0246 −0.0125	No	No	STIRPAT	464 176 128 160
39	Zheng, Kahn, and Liu (2010)	RSUE	3-rated	1997–2006	City	Panel	Air pollution: PM10 concentration in the air (mg/m3) Industrial SO2 (Concentration in the air (mg/m3))	0.056	FDI inputs	0.9761 −0.0588	No	Yes	OLS	120
40	Zhou et al. (2019)	JCP	2-rated	2006–2015	Province	Panel	GTFP	n.a.	FDI inputs	0.0637 0.0667 0.0608	Yes	No	Endogenous threshold model	270 300 300

EP = Environmental pollution; GTFP = Green total factor productivity. STIRPAT = Stochastic Impacts by Regression on Population, Affluence and Technology model. See notes to Figure 2 for the abbreviations of journals. n = Sample size. n.a. = not available