

Title: Does Environmental Regulation Improve the Enterprises' Productivity?—
Evidence from China's Carbon Reduction Policy

Response to Reviewer 2 Comments

Thank you very much for the serious, meticulous and rigorous comments of the reviewers. Restricted by the ability to express in English, we have made many detailed mistakes in the paper. We are very sorry. These detailed errors were pointed out by the reviewers, and we were very moved. Regarding the modification of detailed errors, we have marked them in yellow in detail in the reworked manuscript. The major adjustments that the reviewers pointed out, and we give a detailed response.

Point 1: Abstract: Already the first sentence is incomprehensible. What you mean is “Environmental regulations may have two effects...” – but this becomes clear only after reading the article. Likewise, the actual meaning of many expressions remains unclear (“intensity of policies”? “ordination” [you mean implementation]? “policy shock” [the implementation of a policy is not necessarily a shock]? Etc. pp.). Moreover, grammatical mistakes abound in the whole abstract. It urgently needs a complete revision, in terms of content as well as language.

Response 1: We checked the expression in the Abstract section, and indeed many expressions are vague and confusing. We revised the Abstract part as follows:

“Theoretical research finds that environmental regulation has both positive and negative effects on enterprise productivity. Based on the Energy Conservation and Carbon Reduction policy implemented by the Chinese government, this paper empirically analyzes the policy treatment level boundary condition of positive and negative effects which dominated and its moderating factors. The generalized propensity score matching model was used to analyze the net effect of the policy on the total factor productivity (TFP) of Chinese manufacturing enterprises. The results showed that: (1) The low treatment level of the policy can promote the growth of enterprises' TFP; (2) On the contrast, the treatment level of the policy exceeds a certain threshold gradually led to an inhibitory effect on enterprises' TFP; (3) The mechanism that the policy forced the enterprises to innovate which enhanced their TFP would take time to release gradually; (4) The enterprises with stronger capacity for innovation or larger size were easier to transform the pressure from the policy into innovative impetus to improve their TFP; (5) However, the government subsidies distorted the forced-innovation effect of the policy on the enterprises' innovation, Furthermore, which restrained the positive effect of the policy on the TFP. ”

Point 2: On the TTEP in general: You say that it is there and you describe its goals, but you don't say what it prescribes. (This is one of the data obscurities criticised above)

Response 2: Reviewers have repeatedly pointed out that the article's description of the policy background information is vague. This will make readers have difficulty understanding the policy variables in the empirical analysis later. We have added an explanation of the policy background information as follows:

“The TTEP policy requires the selection of key energy consumption units (mainly industrial enterprises, the selection criterion of industrial enterprises is 10,000 tons standard coal) with a total energy consumption of more than 10,000 tons of standard coal in 2010. As there are about 17,000 enterprises nationwide, it is called “Ten-Thousand Enterprises”. Therefore, the

implementation of the TTEP is an important support and guarantee for achieving a 16% reduction in the energy consumption per unit of GDP during the “Twelfth Five-Year Plan” period and a 17% reduction in carbon dioxide emission per unit of GDP. The TTEP policy requires all local energy conservation authorities to break down the energy conservation targets during the “Twelfth Five-Year Plan” period in the regions into the targets for each of the “Ten-Thousand Enterprises” and report them to National Development and Reform Commission for record and assessment. In order to maintain the continuity of the TTEP policy, major changes will not be made to the list of “Ten-Thousand Enterprises” during the “Twelfth Five-Year Plan” period in principle. The policy’s implementation cycle is the entire “Twelfth Five-Year Plan” period, and its stability provides an institutional guarantee for assessing various impacts of the policy scientifically. The State Council requires the completion of energy conservation targets and the implementation of energy-saving measures of the ten thousand enterprises to be included in the provincial government’s responsibility assessment system of energy-saving target. The results of assessing the completion of local Ten-Thousand Enterprises’ energy-saving targets will be summarized and published every year, mainly including the overall Ten-Thousand Enterprises’ energy-saving target assessment in all provinces, autonomous regions and municipalities, the completion of state-owned enterprises’ energy-saving targets, and the list of enterprises that fail to complete annual energy-saving targets. The assessment results will be sent to relevant departments such as State-owned Assets Supervision and Administration Commission of the State Council. The above measures also ensure that the TTEP policy serves as a rigid restraint on the enterprises’ energy consumption decision. ”

Point 3: Section 2.2 (Data...), “two databases”: This is definitively too little description of your input data. Please quote exactly the original sources (even if these may be not be publicly available); further, please provide more information for assessing how trustworthy these sources are (data collection, quality control, data polishing procedures etc.).

Response 3: We have adjusted the presentation of the data introduction part so that readers can understand our data more clearly. As follows:

“The data used in this paper consist of two parts: The first part is the 2010–2013 China Industry Business Performance Data. The statistical caliber of this database changed in 2011. Before the year, the survey targeted at all state-owned enterprises and non-state-owned enterprises of CNY5 million and above; whereas, after the year, the target is all state-owned enterprises and non-state-owned enterprises of CNY 20 million and above. Therefore, from 2010 to 2011, a part of enterprise samples are not included in China Industry Business Performance Data because of the change in statistical caliber. According to the data, the number of enterprise samples included in the 2010–2013 databases is 348,536, 303,392, 311,557 and 345,101.

The second part is the list of enterprises and energy-saving targets of the “Ten Thousand Enterprises Energy Conservation and Low Carbon Action” published by the National Development and Reform Commission. The enterprises in the implementation of TTEP all meet the requirement of total energy consumption standing at 10,000 tons standard coal and above in the base period (2010). In 2011, a total of 16,076 enterprises were included in the TTEP. Considering that the policy was introduced and put into effect in 2011, the first year of the “Twelfth Five-Year Plan,” the time when the Ten Thousand Enterprises was recorded and reported by local energy conservation authorities was earlier than 2011, it is possible that the Ten Thousand Enterprises had taken actions in the starting year of the policy (2011),

and enterprises' core variables should not be used as matching variables to weaken the selection bias. Based on this, the empirical analysis below uses enterprises' key characteristics in 2010 as the matching variables of GPSM and the supplementary report in the robustness test is based on the empirical results with 2011 as the base period.

Several points need to be explained when matching the data of the Ten Thousand Enterprises announced by the National Development and Reform Commission with the industrial enterprise database from 2011 to 2013. First, although the National Development and Reform Commission required the list of the Ten Thousand Enterprises during the 12th Five-Year Plan to remain stable, businesses were still added after 2011. We removed the enterprises that were added to the list in 2012 and 2013 in order to ensure that enterprises in the control group during the base period would not appear in the treatment group (in the later period). Second, matching the list of Ten Thousand Enterprises announced in 2011 with the enterprise data of 2010 would result in a sample loss (i.e., a loss of approximately 16% of the Ten Thousand Enterprises) due to the entry and exit of the enterprises and the changes in statistical caliber. Third, we selected manufacturing enterprises among industrial enterprises as research targets and eliminated non-manufacturing enterprises during the matching of both databases. In the end, we successfully matched 7,880 out of the Ten Thousand Enterprises.”

Point 4: Section 2.3.1. (Definition and Estimation of Variables/Core Variables): Again, none of the two “core variables” is described unequivocally. Something called “energy consumption scale” is used as a “basis”, but something called “output scale” is then used as a proxy. While I do understand the reasons for using a proxy and the data transformations described later, I do not understand at all which data you are talking about. For one thing, I presume the variables you mean are simply “energy consumption” and “output” rather than “...scale” (or: the amount of energy consumed). But how is “output” measured? (Money? Weight? Some index of productivity? Else?) And in which units (per year? Per unit of product? Else?)

Response 4: The reviewer pointed out that the definition of variables and the calculation process are vague. We re-elaborated as follows:

“(1) Gross output value (labeled as Output, measured as RMB). This variable accurately gauges businesses' production scale and can be directly obtained from the enterprise data. We derived this variable's natural logarithm to eliminate the effects of dimension and outliers. (2) Enterprises' TFP in the base period (labeled as TFP_0). On the one hand, the higher an enterprise's initial TFP, the more this helps to reduce factor inputs and hence lower energy consumption. On the other hand, it is necessary to effectively deal with differences that exist before a policy is implemented. Therefore, we added the enterprises' initial TFP to the covariates of this study. (3) Capital per capita (labeled as Cap, measured as RMB/ Per-capita). An enterprise's capital density may influence both its TFP and energy consumption. We divided the net fixed assets by the number of employees, then took natural logarithm of the results. (4) R&D investment (labeled as R&D, a binary variable). We distinguished R&D investment during the base period from enterprises' innovative spirit. While innovation may affect energy consumption and TFP, we also expected that innovation would be an important transmission mechanism for the ECCR policy's impact on the enterprises' TFP. R&D is a binary variable, coded 1 if an enterprise having a positive R&D investment value in the initial period, and 0 otherwise. (5) Subsidy income (labeled as Sub, measured as RMB). We calculated this variable's natural logarithm¹ using the enterprise' subsidy income, reported in the data. As an additional source of income for businesses, subsidies can offset costs arising from the ECCR policy, thereby weakening the negative

¹ If an enterprise's subsidy income is zero, we added 1 and took the natural logarithm of the results.

impact of energy consumption regulations. Subsidies also reflect the “government-enterprise relationship,” thus affecting the ECCR policy’s impacts across the enterprise. (6) *Financial situation* (labeled as *Fina*, it’s a ratio). We measured this variable by determining the ratio of an enterprise’s total liability to its total assets (i.e., the debt-to-asset ratio). (7) *An enterprise’s export characteristics* (labeled as *EX*, a binary variable). This variable is a binary one, defined based on the enterprises’ export value during the base period, coded 1 if the value greater than 0, and 0 otherwise. Further, we controlled for the enterprise’ age (labeled as *Age*, measured as year), property rights features (label state-owned enterprises and private enterprises as *Domestic*, a binary variable)², industry characteristics (a group of dummy-variables for the four-digit industry codes), and location (a group of dummy-variables for the province codes). We divided the enterprise samples into two groups based on whether a company was one of the **Ten Thousand Enterprises**. Table 1 summarizes the descriptive statistics of the main variables.”

Table 1. Descriptive statistics of major variables.

Var. Name	Units	Ten Thousand Enterprises group				Non-Ten Thousand Enterprises group			
		Mean	Std.	25 th	75 th	Mean	Std.	25 th	75 th
<i>ECCR</i>	ton/RMB	0.031	0.084	0.002	0.025				
<i>TFP₀</i>	-	7.991	1.289	7.135	8.779	6.332	1.109	5.588	7.025
<i>Output</i>	RMB	13.552	1.702	12.468	14.639	11.170	1.334	10.337	11.986
<i>Cap</i>	ln(RMB/#)	4.678	1.507	3.594	5.639	3.281	1.409	2.295	4.077
<i>Fina</i>	-	0.915	0.634	0.543	0.925	0.844	0.603	0.485	0.928
<i>Age</i>	year	11.701	13.489	3	13	7.155	7.944	3	9
<i>EX</i>	-	0.605	0.489	0	1	0.427	0.495	0	1
<i>R&D</i>	-	0.385	0.487	0	1	0.171	0.377	0	0
<i>Sub</i>	ln(RMB)	2.735	3.741	0	6.479	0.868	2.113	0	0
<i>Domestic</i>	-	0.313	0.464	0	1	0.493	0.499	0	1

And, the range of variables in the form of natural logarithm is explained in the footnote.

Point 5: ECCR and TFP definition problem

Response 5: ECCR and TFP are the key variables of this article. The reviewer pointed out that the definition and calculation process of these two variables are vague in the article. We made corrections:

The ECCR policy (labeled as *ECCR*), and the enterprises’ TFP performance (labeled as *TFP*) are the core variables of concern to us. The basis for determining the target scale of the “energy conservation and carbon reduction” for each of the Ten Thousand Enterprises during the 12th Five-Year Plan is their carbon consumption in 2010. In fact, the reduction percentage is more accurate to measure the policy impact of ECCR on the enterprises. But, we don’t have data on the carbon consumption of each Ten Thousand Enterprises in the base period. For enterprises, the carbon consumption is closely related to the output level. Given other conditions unchanged, the higher the output is, the more the carbon consumption is. The same “energy conservation and carbon reduction” target represents different impacts of the environmental regulation policy on the enterprises with various output levels ^[30]. Thus, we divided the ECCR target (measured as ton) of the Ten Thousand Enterprises during the 12th Five-Year Plan by their gross output values (measured as RMB) during the base period (2010) to gauge the treatment levels of the ECCR policy.

For non-Ten Thousand Enterprises, the treatment levels of the ECCR policy equal to zero. Since non-Ten Thousand Enterprises constitute the vast majority of the enterprise samples, we employed

² The data we used provides the registration type codes for each enterprise, which provides information to identify the type of the enterprise property.

the fractional logit model to estimate the conditional distribution function of treatment variable ECCR. The fractional logit model requires the domain of treatment variable to fall within the range [0,1]. Based on the method we defined, the values of the treatment variable basically meet this requirement, whereby only 36 of the Ten Thousand Enterprises had a treatment level greater than 1. These 36 samples represented a negligible proportion in the 7880 Ten Thousand Enterprises, and we deleted these samples.

We tested for the ECCR policy's impact on enterprises' TFP. Hence, it was necessary to define the changes in their TFP after the ECCR policy was executed. First, we employed the Olley and Pakes (1996) approach ^[31] (hereafter the OP) to calculate the TFP of all sample enterprises. Consider a standard Cobb-Douglas production function:

$$\ln VA_{jt} = \gamma_k \ln K_{jt} + \gamma_l \ln L_{jt} + x_{jt} + \xi_{jt} \quad (11)$$

Where, VA_{jt} is the value-added output of enterprise j at year t ; K is the net fixed assets; L is the employment. The conventional measure of productivity is to take the difference between log value-added output and log factor inputs times their estimated coefficients³:

$$TFP_{jt} = \ln VA_{jt} - \hat{\gamma}_k \ln K_{jt} - \hat{\gamma}_l \ln L_{jt} \quad (12)$$

Point 6: References section: Something seems to have gone wrong with the numbering (see above). What are the letters in square brackets [R, M, J] good for? Please stick to the Journal's formatting rules. Some of the literature entries are prepared rather carelessly. E.g. entry 24: the journal is "Biometrika" rather than "Literature Review"; entry 25: 2 misprints, editors are missing

Response 6: We have revised the References part and kept it consistent with the order of appearance in the paper.

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³ In fact, TFP has no measure unit. The difference in TFP values between enterprises reflects their productivity ranking.

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