Impact of Urban Environmental Quality on Industrial Total Factor Productivity - Panel Data from 251 Cities in China

Du Chunyan
Business School, Yunnan University of Finance and Economics, Kunming, Yunnan, China
202003110009@stu.ynufe.edu.cn

Abstract
More than 70% of cities in China failed to reach air quality standards in 2017. The continuous deterioration of pollution makes for the great challenge for the reasonable flow of population, which will not be conducive to the stable development of the industrial TFP. This paper analyzes the relationship between urban environmental quality and industrial TFP through panel data from 2006 to 2013 in 251 cities. The regression model results are as follows. Firstly, urban environmental quality promotes the industrial TFP significantly. Industrial TFP of labor-intensive enterprises, non-state-owned enterprises and enterprises in central and western China are more obviously affected by urban environmental quality. Secondly, urban environmental quality generates population flow, which resulting in the change of industrial TFP. That is to say. The 1% rising of urban environmental quality, the net inflow of population will increase by 3.527%, fostering industrial TFP grow by 0.111%.

1. Introduction
The transformation policies such as "Made in China 2025" advocate the creation of industrial enterprises with an international competitive advantage. Under the background of limited resources, it is an effective way to promote the development of the industrial economy to realize the improvement of TFP through rational allocation. The city is the center of economic transformation. In recent years, the urban population has been raising and urbanization has gradually increased by 60.6% in 2019. Urbanization affects urban economic growth in terms of population gathering, industrial upgrading, capital investment, and so on. While urbanization may cause resource shortage, environmental pollution and traffic congestion[1]. These problems would weaken industrial TFP in the long run. So this paper mainly discusses the impact of urban environmental quality on the industrial TFP in 251 cities in detail. More Chinese literature focus on the impact of environmental regulation or city scale on industrial TFP[2-4], and little researches care for urban environmental quality. Discussion on how to evaluate urban environmental quality and how it make a difference to industrial TFP are theoretical and practical worth for improving the quality of urban development.

2. Materials and Methods
2.1. Model construction
This paper constructs two models:

Benchmark model: $\text{TFP}_it = \alpha_0 + \alpha_1 \text{quality}_it + \gamma X_{it} + \lambda_t + \lambda_i + \epsilon_{it}$ (1)

Mediator effect model:

$\text{TFP}_it = \beta_0 + \beta_1 \text{quality}_it + \gamma X_{it} + \lambda_t + \lambda_i + \epsilon_{it}$ (2)
\[ P_{\text{flow}}_i = \theta_0 + \theta_1 \text{quality}_i + \gamma X_i + \lambda_i + \lambda_t + \epsilon_i \]
\[ TFP_i = \delta_0 + \delta_1 \text{quality}_i + \delta_2 p_{\text{flow}}_i + \gamma X_i + \lambda_i + \lambda_t + \epsilon_i \]

where TFP is the industrial TFP level of the ith city in year t; quality is the urban environmental quality of the ith city in the tth year; pflow is the population flow of the ith city in the tth year. X denotes a vector consisting of a series of control variables involved enterprise size, capital density, asset-liability ratio, fixed assets ratio and marketing. \( \lambda_i, \lambda_t \) and \( \epsilon_i \) represent the year fixed effect, city fixed effect and random disturbance respectively. Obviously, we focus on the model coefficients and their significance, which contribute to explore the relationship among variables.

2.2. Variable setting

Explained variable: LP method is usually used for measuring industrial TFP\([5]\), and the formula is:
\[ \text{addvalue} = a_i + b_k (k, m) + \eta_i. \]
Addvalue is industrial value added, 1 is the average number of employees, k is fixed capital and m is the intermediate cost of inputs.

The explanatory variables are as follows: (1) Urban Environmental Quality (quality), which adopts the entropy method to comprehensively measure urban environmental quality system with 6 indicators, including environmental pollution and governance\([6]\). (2) Population flow (pflow), reflected by results of the population in next year minus the population at present and natural increment; if pflow > 0, indicating the net inflow; otherwise net outflow.

Control variables:(1) Enterprise size (size) is determined by the total assets of the enterprise. (2) Capital intensity (kl) is shaped by the fixed assets per employee. (3) Marketing (market) is shown by Fan Gang's market-oriented index. (4) The ratio of assets to liabilities (lev) and the ratio of fixed assets (fix-ass) are the proportion of total liabilities and fixed assets to total assets\([7]\).

2.3. Data description

Data for industrial TFP come from the 2006-2013 Industrial Enterprises Database. Urban environmental quality data and population flow data come from Urban Statistical Yearbook and China Urban Construction Statistical Yearbook. We first need to filter and delete unnecessary and missing data in the industrial enterprises database (the number of TFP, employees and total capital assets is less than 0). In addition, non-opened enterprises (such as closure, preparation, logout) from 2006 to 2013 are excluded. Next, we match the two types, the city statistics data, and the industrial enterprises database so that 605304 valid data from 251 cities are obtained.

3. Results & Discussion

3.1. Impact of urban environmental quality on industrial TFP

3.1.1. Benchmark regression

The regression results of the relationship between urban environmental quality and industrial TFP are shown in Table 1. Model (1) reports urban environmental quality could positively affect industrial TFP, Model(2) shows environmental pollution could negatively affect industrial TFP, and model(3) reflects environmental governance could positively improve industrial TFP, because the worse the urban environmental pollution is, the much more cost industrial enterprises will spend for pollution. All results are still likely to be unable to identify causality or omit important variables. Therefore, all the lag phase of the explanatory and control variables are analyzed for model(4)-(6), as the same result as model(1)-(3), indicating that the urban environmental quality has a direct impact on industrial TFP.
Table 1 Estimation of impact of urban environmental quality on industrial TFP

|      | (1) TFP | (2) TFP | (3) TFP | (4) TFP | (5) TFP | (6) TFP |
|------|---------|---------|---------|---------|---------|---------|
| quality | 0.448*** | (0.012) | 0.449*** | L.quality | 0.283*** | (0.013) | L.quality | -0.660*** | (0.016) |
| pollu | - | - | - | - | 0.703*** | (0.015) | - | L.pollut | -0.660*** | (0.016) |
| gover | - | - | - | 0.449*** | (0.011) | - | L.gover | 0.294*** | (0.012) |
| lnkl | 0.140*** | (0.001) | 0.140*** | (0.001) | 0.140*** | (0.001) | 0.140*** | (0.001) | 0.140*** | (0.001) |
| Insize | 0.459*** | (0.002) | 0.458*** | (0.002) | 0.459*** | (0.002) | 0.459*** | (0.002) | 0.459*** | (0.002) |
| lev | - | - | - | - | - | - | L.lev | -0.028*** | (0.002) | -0.028*** | (0.002) |
| market | 0.033*** | (0.004) | 0.024*** | (0.004) | 0.034*** | (0.004) | 0.034*** | (0.004) | 0.034*** | (0.004) |
| fix-ass | 0.046*** | (0.002) | 0.045*** | (0.002) | 0.046*** | (0.002) | 0.046*** | (0.002) | 0.046*** | (0.002) |
| _cons | 4.763*** | (0.021) | 5.704*** | (0.023) | 4.768*** | (0.021) | 4.768*** | (0.023) | 4.768*** | (0.022) |

Individual fixed Y Y Y Individual fixed Y Y Y
Year fixed Y Y Y Year fixed Y Y Y
City fixed Y Y Y City fixed Y Y Y

N 586278 586278 586278 586278 586278 586278
R² 0.8407 0.8382 0.8380 0.8379 0.8412 0.8408

3.1.2. Analysis of different regions, industries and ownership enterprises

The results of industrial enterprises in different regions, industries and ownership are shown in Table 2. Considering the huge differences of economic efficiency, we divide China into three parts: Eastern China(model7), Central China(model8) and Western China(model9). The results show that the urban environmental quality has the positive impact on industrial TFP in whole China. Whereas the coefficient in Central and Western China is greater than that in Eastern China, indicating industrial TFP in Eastern China get less influence from urban environmental quality. This may be the relatively weak regional economy foundation in Central and Western China. They must have ignored environmental protection in the urbanization development, resulting in serious environmental pollution so that the ecological resilience is lower. Model (10)-(12) report urban environment could promote industrial TFP of resource-intensive, labor-intensive and capital-intensive enterprises. But the coefficient of labor-intensive enterprises is greater than others, lying in the labor mobility. Poor environment is bad for the health, leading more labour flow to other cities in good environmental quality. No matter which kind of ownership of enterprises(model13-state-owned and model14-non-State-owned), the urban environmental quality could shape their industrial TFP. While the coefficient in model(13) is less, because state-owned enterprises are almost controlled by the government, and its operation mostly depends on the interests of the central government and protected by state power. Non-state-owned enterprises face the challenge of financing cost, operating risk, market-depend. Poor urban environmental quality causes the possibility of industrial enterprises migration, which need to...
bear a series of costs (time, land, labor, etc.). Thus it will be not less beneficial for non-state-owned enterprises.

Table 2 Results of impacts in different regions, industries and ownership enterprises

|   | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) |
|---|-----|-----|-----|------|------|------|------|------|
| TFP | TFP | TFP | TFP | TFP | TFP | TFP | TFP |
| quality | 0.100** | 0.432*** | 0.375*** | 0.372*** | 0.477*** | 0.333*** | 0.1* | 0.443*** |
| lnkl | 0.195** | - | - | - | - | - | - |
| lnsize | 0.609** | 0.578*** | 0.555*** | 0.527*** | 0.568*** | 0.650*** | 0.633*** | 0.607*** |
| lev | - | - | - | - | - | - | - |
| market | -0.002 | 0.072*** | 0.013 | 0.009 | 0.005 | 0.005 | 0.023 | 0.003 |
| fix-ass | 0.034** | 0.057*** | 0.015** | - | 0.068*** | 0.04*** | - | 0.136*** |
| _cons | 3.853** | 2.924*** | 3.643*** | 3.823*** | 2.805*** | 2.548*** | 1.308*** | 3.084*** |
| Year fixed | Y | Y | Y | Y | Y | Y | Y | Y |
| City fixed | Y | Y | Y | Y | Y | Y | Y | Y |

N 493059 62045 47275 91923 241953 253458 15233 587146
R² 0.5561 0.5769 0.5333 0.4990 0.5315 0.6081 0.5979 0.5594

3.2. Urban environmental quality, population flow and industrial TFP

The mediator effect of population flow in urban environmental quality on industrial TFP can be expressed in Table 3. Model(15)-(17) and (18)-(20) are the benchmark regression results with unlagging and lagging mediator effect, respectively. Two kinds of results indicate that excellent urban environmental quality will be helpful for population inflow and then improve the industrial TFP without lagging, lagging or lagging two phases. The 1% rising of urban environmental quality, the net inflow of population will increase by 3.527%. The promotion effect of urban environmental quality on industrial TFP partly comes from population flow. That is, urban environment with good quality makes for population inflow and further benefits to industrial TFP. The main reason is that the city with favorable urban environment could get more attraction for people inflow meeting the pursuit of good health, thus sufficient supply of labor force spur industrial TFP.
Table 3: Urban environmental quality, population inflow and industrial TFP

|                | (15)   | (16)   | (17)   | (18)   | (19)   | (20)   |
|----------------|--------|--------|--------|--------|--------|--------|
| TFP            | 0.442*** | 10.70*** | 0.436*** |        |        |        |
| pflow          |        |        | 0.0004*** |        |        |        |
| L.pflow        |        |        | 0.0005*** |        |        |        |
| L.quality      |        |        |            | 3.527*** |        |        |
| L2.quality     |        |        |            |        | 0.111*** |        |
| lnkl           | -0.192*** | 0.169*** | -        | -      | 0.143*** | -1.71*** |
| lnsize         | 0.600*** | -0.049* | 0.612*** | 0.595*** | -0.046 | 0.595*** |
| lev            | -0.218*** | 0.067 | -        | 0.190*** | 0.213*** |        |
| market         | 0.0246** | 2.237*** | 0.026*** | -      | 1.958*** | -0.087*** |
| fix-ass        | 0.0330** | -0.053 | 0.026*** | 0.032*** | -0.03 | 0.032*** |
| _cons          | 3.048*** |        | 2.600*** | 3.736*** | -      | 3.751*** |

3.3. Robustness analysis
In order to make the results more convincing, the robustness test is also required. There are many methods for robustness testing, such as alternative variables, supplementary variables, model substitution, changing the sample size, etc. We select Wooldridge estimation to measure the industrial TFP instead of OP and LP methods, which overcome the potential identification problem proposed by ACF. As the outcome is consistent with the benchmark regression result.

4. Conclusion
At present, there are few empirical studies on the relationship between urban environmental quality, population flow and industrial TFP. This paper significantly explores their relations through panel data form 2006 to 2013 in 251 cities by empirical analysis. Firstly we evaluate the values of environmental quality system by entropy method in different cities. Then models are constructed to analyse whether urban environmental quality do affect industrial TFP, even industrial TFP of labor-intensive enterprises, non-state-owned enterprises and enterprises in central and western regions are tested, which have the greater coefficient. Finally, the moderator effect of population flow is testified. The 1% rising of urban environmental quality, the net inflow of population will increase by 3.527%,
fostering industrial TFP grow by 0.111%. There are also limitations in this research, which deserves further exploration. Firstly, the sample quality needs to be improved with the latest statistical data. Secondly, urban environmental quality system only includes indicators of air and water pollution, which is not enough. Soil and noise pollution could be added in the research framework. Other reactions, facing poor environmental quality, could be considered, such as the rise of management, sales and interest expense. Thirdly, we can discuss their relations in different city scale to find out more breakthroughs for suggestions in the next step.

References
[1] Zhang, Y., Wang, J. (2020) Health Damage of Air Pollution, Labor Mobility and Economic Growth. J. Journal of Shanxi University of Finance and Economics. 42:17-30.
[2] Wang, J., Liu, B. (2014) Environmental Regulation and Enterprises TFP-An Empirical Analysis based on Chinese Industrial Enterprises Data. J. China Industrial Economics. 3:44-56.
[3] Guo, T., Sun, Y. Y. (2021) The Riddle of the Coexistence of Environmental Regulation and High-quality Development of Enterprises-From the Perspective of Heterogeneous Enterprises and Total Factor Productivity Decomposition. J. Jinan Journal (Philosophy & Social Sciences). 43:102-118.
[4] Guo, X. D., Zhang, J., Wu, L. X. (2019) City Size, Advantages of Firm Productivity and Resource Allocation Efficiency. J. Management World. 35:77-89.
[5] Levinsohn, J., Petrin, A. (2003) Estimation Production Functions Using Inputs to Control for Unobservable. J. Review of Economic Studies. 70:317-341.
[6] Xie, R., Chen, Y., Han, F. (2018) Research on Influence and Time-space Effect of New-type Urbanization on Urban Eco-environmental Quality. J. Management Review. 30:230-241.
[7] Hao, W. Y., Wei, W., Wen, J. (2016) How Does Policy Uncertainty Influence Firm Innovation? An Effect Mechanism based on the Real Option Theory. J. Business Management Journal. 10:40-54.