Postprint: Study on the Relationship between Urban Water and Air Pollution Emissions and FDI in the Arid Region of Northwest China

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Abstract

The implementation of the Belt and Road Initiative in the arid and semi-arid regions of northwestern China has raised widespread concerns regarding potential pollution transfer effects in water and air. The scarcity of water resources and fragile ecological environment determine that these regions are unsuitable for introducing pollution-intensive foreign direct investment (FDI). Unlike previous literature that examined the pollution transfer effect of FDI at national or provincial levels, or by categorizing eastern, central, and western regions, this study utilizes city-level data that better captures ecological and economic disparities in arid and semi-arid zones, and applies grey relational analysis and difference-in-differences methods to investigate whether FDI produces pollution transfer effects on urban water and air quality in northwestern China' s arid and semi-arid regions under the Belt and Road Initiative. The findings indicate that since the initiative' s implementation, the degree of association between water and air pollution emissions and FDI has declined in cities of the northwestern arid region; moreover, the substantially larger FDI growth in semi-arid regions compared to arid regions has not resulted in significant differences in water and air pollution emissions between cities in northwestern semi-arid and arid areas.

Full Text

Relationship between Water & Air Pollutant Emission and FDI in Arid Cities in Northwest China

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Abstract: The implementation of the "Belt and Road" policy has raised widespread concerns among experts and scholars regarding whether it will bring about pollution transfer, as the fragile ecological environment in arid and semi-arid areas of northwest China suggests that pollution-intensive foreign direct investment (FDI) should be rejected. Unlike previous studies that focused on pollution transfer effects caused by FDI at the national and provincial levels or across China's eastern, central, and western regions, this study innovatively employs grey correlation and difference-in-differences (DID) methods to examine whether FDI creates pollution transfer effects in cities of arid and semi-arid areas in northwest China under the "Belt and Road" policy. Moreover, grey correlation analysis is used to compare the correlation between FDI and pollution in arid and semi-arid areas before and after policy implementation. The results reveal that the association coefficient decreased after implementing the "Belt and Road" policy, indicating that FDI did not bring pollution transfer effects to cities in arid and semi-arid regions of northwest China. Following policy implementation, FDI in semi-arid areas increased by 107.41% on average, but only by 3.41% in arid areas. Furthermore, the DID method was used to explore whether significant differences existed in pollutant emissions between the two region types. No significant difference in pollutant emissions was found between arid and semi-arid urban areas before and after policy implementation. Therefore, we further verify that FDI did not produce pollutant transfer effects under the "Belt and Road" policy. In addition to policy effects, pollutant emissions from arid and semi-arid regions also relate to many other socio-economic factors. Population growth and transportation development aggravate urban pollutant emissions; tertiary industry development reduces emissions; education can reduce urban pollutant emissions by improving people's awareness of green environmental protection and promoting green technology development. Therefore, implementing the policy in northwest China's arid and semi-arid regions requires greater attention to harmonious development of economy, society, and environment where the ecological environment is relatively fragile. For these regions, the government should promote tertiary industry development, increase education investment, and advance scientific and technological innovation to achieve human-nature harmonious development. The "Belt and Road" policy has provided a good opportunity for development in northwest China's arid and semi-arid regions. The increase in FDI has not resulted in pollution there but has achieved harmonious development of economy and environment.

Keywords: city; water pollution; air pollution; FDI; pollution transfer effect of FDI; the "Belt and Road" Initiative; arid and semi-arid areas

1. Data and Methods

1.1 Study Area and Data Sources

According to the dry-wet climate division standard based on the 200mm annual precipitation line, cities in northwest China are divided into arid and semi-arid areas [21]. The study period covers 2011–2017 based on data availability from the *China City Statistical Yearbook*. Arid area cities include Karamay, Turpan, Hami, Hotan, Aksu, Kashgar, and others; semi-arid area cities include Xi' an, Xining, Lanzhou, Yinchuan, Hohhot, Baotou, and others.

1.2 Variable Selection

The dependent variables are urban pollutant emissions, including industrial wastewater (10 tons), SO (10 tons), and smoke dust (10 tons). The core independent variable is FDI (10 USD). Control variables include: (1) economic factors: GDP per capita (10 yuan), industrial output value (10 yuan); (2) social factors: population density (persons/km^2), education level (proportion of college students); (3) environmental regulation: wastewater treatment rate (%); (4) infrastructure: road area per capita (m^2); (5) industrial structure: proportion of tertiary industry (%); (6) technological innovation: number of patents.

1.3 Grey Correlation Analysis Method

Grey correlation analysis measures the degree of association between factors in a system. The correlation coefficient formula is:

$$\gamma(z_i(k), x_j(k)) = \frac{\min_{i,j,k} \Delta_{ij}(k) + \rho \cdot \max_{i,j,k} \Delta_{ij}(k)}{\Delta_{ij}(k) + \rho \cdot \max_{i,j,k} \Delta_{ij}(k)}$$

where $\Delta_{ij}(k) = |z_i(k) - x_j(k)|$ is the absolute difference between reference sequence $z_i(k)$ and comparison sequence $x_j(k)$ at time k, and ρ is the distinguishing coefficient (typically 0.5). The grey correlation degree is the average of all correlation coefficients.

1.4 Difference-in-Differences Model

To test the pollution transfer effect of FDI, we construct the DID model:

$$Y_{it} = \beta_0 + \beta_1 \cdot place_{it} \cdot time_{it} + \beta_2 \cdot place_{it} + \gamma \cdot time_{it} + X_{1t}, \ldots, X_{nt} + \varepsilon_{it}$$

where Y_{it} represents pollutant emissions, $place_{it}$ is the regional dummy variable (semi-arid area = 1, arid area = 0), $time_{it}$ is the time dummy variable (2014–2016 = 1, 2010–2013 = 0), and $X_{1t}, \ldots, X_{nt}$ are control variables.

2. Empirical Results

2.1 Grey Correlation Analysis Results

shows the grey correlation coefficients between FDI and pollutant emissions in arid and semi-arid cities of northwest China. The correlation coefficients between FDI and industrial wastewater, SO , and smoke dust in semi-arid areas are 0.905736, 0.905820, and 0.905735 respectively, while in arid areas they are 0.893879, 0.893879, and 0.893879 respectively. The correlation coefficients exceed 0.89, indicating strong correlations between FDI and pollutants in both region types. However, the correlation coefficients in semi-arid areas are higher than in arid areas, suggesting that FDI in semi-arid areas is more closely related to pollutant emissions.

After implementing the "Belt and Road" policy, the correlation coefficients between FDI and pollutants decreased. The correlation coefficient between FDI and industrial wastewater in semi-arid areas decreased from 0.918463 to 0.871614, while in arid areas it decreased from 0.873498 to 0.842941. This indicates that the "Belt and Road" policy weakened the correlation between FDI and pollutant emissions, suggesting that FDI did not bring pollution transfer effects.

2.2 Difference-in-Differences Analysis Results

2.2.1 Parallel Trend Test The DID method requires parallel trends between treatment and control groups before policy implementation. We conducted a parallel trend test using data from 2011–2013. The results show that before the "Belt and Road" policy, the trends of pollutant emissions between arid and semi-arid areas were parallel, satisfying the DID model' s prerequisite.

2.2.2 Model Specification To control for heteroskedasticity and autocorrelation, we used cluster-robust standard errors at the city level. The model includes city fixed effects and year fixed effects to control for unobservable factors. The regression was performed using Stata 14.0 software.

2.2.3 Regression Results presents the DID regression results for pollutant emissions in northwest China' s arid and semi-arid areas. For industrial wastewater emissions, the coefficient of the interaction term is -0.11 ($t = 0.84$, $P > 0.1$), indicating no significant difference between arid and semi-arid areas before and after policy implementation. For SO emissions, the coefficient is -5.70 ($t = 4.01$, $P < 0.01$), showing a significant decrease in semi-arid areas compared to arid areas after policy implementation. For smoke dust emissions, the coefficient is -12.00 ($t = 2.45$, $P < 0.05$), also indicating a significant reduction in semi-arid areas.

These results demonstrate that after implementing the "Belt and Road" policy, pollutant emissions in semi-arid areas significantly decreased compared to arid areas, further confirming that FDI did not cause pollution transfer effects.

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3. Discussion and Conclusion

3.1 Discussion

(1) Following the "Belt and Road" policy, FDI in semi-arid areas increased substantially by 107.41%, while arid areas saw only a 3.41% increase. The correlation coefficients between FDI and pollutants decreased after policy implementation, indicating that FDI did not bring pollution transfer effects to northwest China' s arid and semi-arid regions. This occurs for two main reasons: First, FDI in semi-arid areas primarily flows into non-polluting industries such as infrastructure, services, and high-tech manufacturing rather than heavily polluting sectors. Second, the "Belt and Road"policy emphasizes ecological protection and green development, with stricter environmental regulations that prevent pollution-intensive FDI entry.

(2) The DID analysis shows no significant difference in industrial wastewater emissions between region types, but SO and smoke dust emissions decreased significantly in semi-arid areas after policy implementation. This suggests that environmental regulations under the "Belt and Road" policy effectively controlled air pollution. The development of tertiary industry, improvements in environmental awareness through education, and promotion of green technology all contributed to emission reductions.

3.2 Conclusion

This study investigates the pollution transfer effect of FDI in arid and semi-arid cities of northwest China under the "Belt and Road"policy using grey correlation and DID methods. The findings show that: (1) The correlation between FDI and pollutant emissions weakened after policy implementation; (2) FDI growth did not lead to increased pollutant emissions; (3) The policy effectively promoted harmonious economic and environmental development in these regions.

The "Belt and Road" policy provides significant development opportunities for northwest China' s arid and semi-arid regions. Governments should continue strengthening environmental regulations, optimizing industrial structure by developing tertiary industries, increasing education investment, and promoting technological innovation to achieve sustainable development. For regions with fragile ecological environments, balancing economic growth and environmental protection remains crucial.

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Note: Figure translations are in progress. See original paper for figures.