

Loss of labor productivity of manufacturing plants in India attributable to air pollution



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Motivation

- Air pollution health burden in India was estimated to result in a staggering economic loss of 36.8 billion USD, translating to 1.36% loss in the country's gross domestic product (GDP).¹
- Manufacturing sector contributes 16-17% of India's GDP. Several studies were conducted to understand the drivers that affect productivity in manufacturing plants.^{2,3}
- Global literature has established the negative impact of air pollution on growth of the labor productivity across multiple sectors.^{4,5}
- However, the role of environmental factors, notably air pollution, in affecting productivity in this sector has been relatively unexplored in India.

Objective

- To assess the loss in labor productivity in manufacturing plants in India attributable to ambient air pollution.

Data

- Satellite-PM_{2.5} at 1-km spatial scale and 24-hr daily scale.⁶
- Labor productivity data from the Annual Survey of Industries at plant level for 2008-2010.⁷
- Control variables: Temperature, humidity and rainfall from reanalysis data.

Table 1. Distribution of labor productivity. INR is Indian Rupee.

Number of Workers Employed in manufacturing factories	Percentage of manufacturing Plants 2008-09	Percentage of manufacturing Plants 2009-10	Labour Productivity 2008-09 (in INR)	Labour Productivity 2009-10 (in INR)	Annual growth in labor productivity (%)
≤100	65.94	68.37	1344.95	1320.41	1.82
101-500	27.34	25.36	5079.16	5590.88	10.07
501-1000	4.23	3.93	7060.031	6993.98	-0.93
1001-5000	2.34	2.18	7650.50	7601.98	-0.63
5001-10000	0.09	0.11	9263.21	17187.10	85.54
>10000	0.06	0.05	10011.2	40083.27	300.38

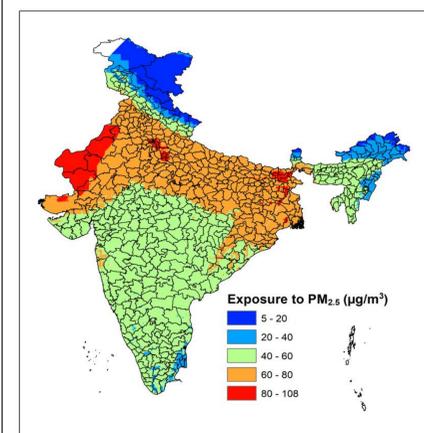


Figure 2. Spatial patterns of ambient PM_{2.5} exposure across the districts averaged over 2008 to 2010.

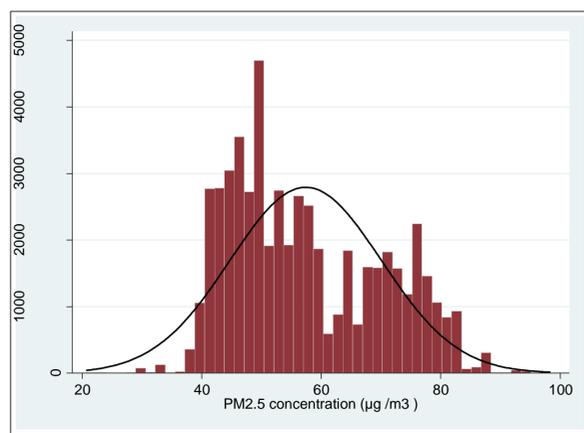


Figure 3. Frequency distribution of ambient PM_{2.5} exposure of laborers across the manufacturing plants during the study period.

Modelling Strategy

$$Productivity_{ijt} = \beta_0 + \beta'X_{it} + \alpha_i + \gamma_t + \varepsilon_{it}$$

$Productivity_{ijt}$ in equation (1) is the labor productivity of the manufacturing plant (i) at the time (t). Labor productivity was estimated by the ratio of the gross value added to the worker employed in the manufacturing plant (i) at the time (t); y_{it}/l_{it} . The total factor productivity was used as an alternative measure of productivity in the analysis.

$$Pr(I = 1|X_1, X_2, \dots, X_k) = \Phi(\beta_1 X_1 + \beta_2 X_2 + \dots + \beta_k)$$

I represent the improvement dummy, and X 's are explanatory variables. It includes PM_{2.5} exposure, annual average temperature, humidity, and the location of the plant (rural vs. urban location). The unobserved state-specific characteristics that may have an impact on the improvement of labor productivity are also controlled for by introducing state dummies. The variable (I) assumes the value 1 if $(\Delta LP_{ijt} = LP_{ijt} - LP_{ijt-1}) > 0$ and 0 otherwise.

References

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Results

Table 2. Impact of air pollution exposure on labor productivity (gross value added/workers). Robust standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1. Note: Location of the Plant Dummy=1 if a plant is in the rural region; otherwise, 0. ®: Industry dummies are defined at the three-digit level National Industrial Classification of 2008 (NIC 2008).

Explanatory Variables	Fixed Effect		Random Effect		System GMM	
	R (1)	R (2)	R (3)	R (4)	R (5)	R (6)
Annual Average PM _{2.5} exposure	-0.060** (0.023)		-0.052** (0.023)		-1.489*** (0.497)	
Annual Average Concentration of PM _{2.5} >40 µg m ⁻³		-0.143*** (0.024)		-0.085*** (0.024)		-2.033*** (0.540)
Annual Average Temperature	-0.857*** (0.072)	-1.017*** (0.076)	-0.705*** (0.069)	-0.863*** (0.074)	1.414*** (0.384)	3.025*** (0.596)
Annual Average Relative Humidity	-1.047*** (0.046)	-1.107*** (0.046)	-0.668*** (0.045)	-0.859*** (0.046)	1.350*** (0.300)	2.105*** (0.371)
Location of the Plant Dummy	-0.029*** (0.010)	-0.020** (0.010)	-0.045*** (0.009)	-0.026*** (0.009)		
(Labor Productivity) _{t-1}					-0.023** (0.009)	-0.024*** (0.009)
Observations	57,447	55,850	57,447	55,850	57,446	55,849
F-statistic and Probability	148 0.000	157 0.000				
Individual Plant Effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry Dummies	Yes	Yes	Yes	Yes	No	No
Time Dummies	Yes	Yes	Yes	Yes	Yes	Yes
WaldChi2 and Probability			9577	10035	1.473e+06	1.304e+06
ProbChi2					0.000	0.000
number of instruments					7	7
Hansen J Statistic					1.133	0.317
Hansen p-value					0.287	0.574
Rho			0.766	0.763		

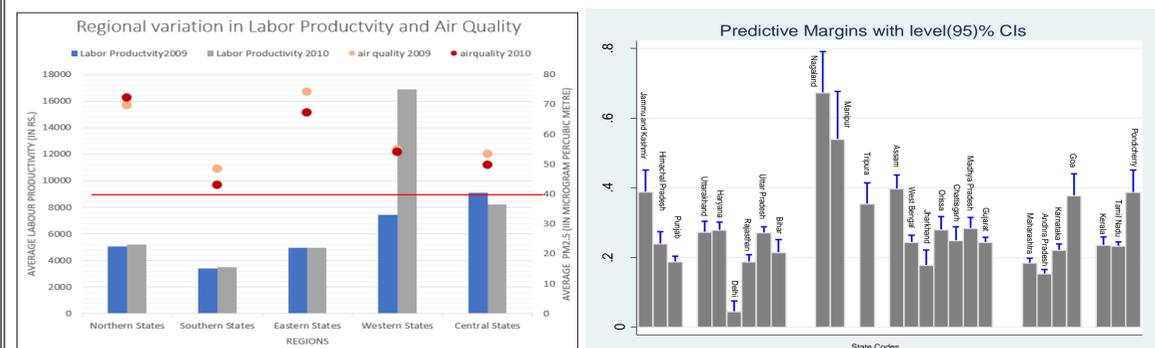


Figure 4. (Left) Regional variations in labor productivity and ambient PM_{2.5} exposure in India. The horizontal line shows the NAAQS. (Right) Probability of improvement in state-level labor productivity.

Table 3. Plant-level characteristics and impact of PM_{2.5} exposure on labor productivity. Dependent Variable: Labour Productivity (Gross value added/workers).

Explanatory Variables	Plants with capital intensity higher than the industry average	Plants with capital intensity lower than the industry average	Plants with blue-collar workers' intensity higher than the industry average	Plants with a supervisor's intensity higher than the industry average
Annual Average PM _{2.5} exposure	0.078* (0.040)	-0.048** (0.023)	-0.139*** (0.029)	-0.016 (0.031)
Annual Average Temperature	-0.104 (0.103)	-0.655*** (0.073)	0.002 (0.079)	-0.181** (0.089)
Annual Average Relative Humidity	-0.055 (0.077)	-0.714*** (0.047)	-0.535*** (0.055)	-0.729*** (0.061)
Location of the Plant Dummy	-0.031** (0.015)	-0.119*** (0.010)	-0.102*** (0.012)	-0.172*** (0.013)
Constant	8.578*** (0.661)	12.88*** (0.448)	10.20*** (0.517)	11.25*** (0.566)
Individual Plant Effect	Yes	Yes	Yes	Yes
Industry Dummies®	Yes	Yes	Yes	Yes
Time Dummies	Yes	Yes	Yes	Yes
Observations	16,647	40,800	16,361	22,451
WaldChi2 and Probability	2835 (0.000)	11282 (0.000)	125950 (0.000)	6525 (0.000)
Rho	0.661	0.744	0.704	0.760

Summary and Way forward

- For every 10 µg/m³ rise in PM_{2.5} exposure, labor productivity decreased by 14.8% after controlling for the confounders. Once exposure crosses NAAQS, the loss is bigger (20%).
- Labor productivity loss was lower for plants using capital intensive production techniques.
- The labor productivity in plants with a higher share of blue-collar workers was more sensitive to ambient PM_{2.5} exposure.

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