Towson University
Department of Economics
Working Paper Series

Working Paper No. 2017-02

Medium- and Long-run Consequences of Pollution on Labor Supply: Evidence from Indonesia

by Younoh Kim, James Manley and Vlad Radoias

March 2017

Medium- and Long-run Consequences of Pollution on Labor Supply: Evidence from Indonesia

Younoh Kim
Sam Houston State University
younoh@shsu.edu

James Manley
Towson University
jmanley@towson.edu

Vlad Radoias
Sam Houston State University
radoias@shsu.edu

January 2, 2017

Abstract

We use a natural experiment in Indonesia to study the medium- and long-run effects of air pollution on labor supply. We find that exposure to air pollution reduces hours worked and while the medium-run effects are larger in magnitude, some effects do persistent in the long run. More interestingly, we are able to provide some insight regarding the underlying channels that contribute to the reduced labor supply. Own health seems to be the only responsible channel in the long-run, while in the medium-run an additional channel based on dependent care-giving is also important.

Keywords: Air Pollution; Working Hours; Indonesia.

JEL Classification Numbers: J22, Q53.

1 Introduction

A vast medical literature exists that links air pollution, especially fine particulate matter, to health[1]. Better air quality reduces infant mortality (Chay and Greenstone 2003a, 2003b, Currie and Neidell 2005, Bobak and Leon 1992, Loomis et al. 1999), respiratory problems in both infants and adults (Emmanuel 2000, Romieu et al. 2002, Chauhan and Johnston 2003), and can even improve mental health and cognition (Peterson et al. 2015).

From an economic perspective, pollution has social costs that go beyond the direct costs associated with these negative health consequences. Having health problems, even transitory ones, not only imposes a direct cost on those affected, but also can lead to further social losses stemming from reduced productivity or reduced labor activity of those affected. There is ample evidence in the literature that shows negative consequences of pollution on labor supply (Hausman et al. 1984, Hanna and Oliva 2015, Aragon et al. 2016) and on worker productivity (Graff Zivin and Neidell 2012, Chang et al. 2014).

Most of the existent evidence focuses however, only on the short-term impact of pollution and there is extremely limited research on its long-term effects. Studying the effects of pollution over longer time horizons is extremely important as some of its negative effects could be persistent over time and harder for exposed individuals to recover from. Among the few recent studies that try to address the issue in the long-run, Kim et al. (2016) show negative effects of pollution on a range of health measures that persist even ten years post exposure, while Isen et al. (2016) show negative effects on labor supply and earnings for those who were exposed to pollution during their early childhood.

This paper proposes to study the medium- and long-run effects of air pollution on labor supply, using data from Indonesia and taking advantage of a natural experiment that offers the unique opportunity of having a truly randomly assigned pollution shock. In the fall of 1997, large parts of Indonesia were engulfed in forest fires that originated with slash-and-burn practices commonly used by farmers as a cheap way of clearing land, but were aggravated by the especially dry and windy season caused by El Niño. This episode has been widely used in the literature to study a variety of issues surrounding air pollution (see for instance Jayachandran 2009, Kunii et al. 2002 or Heil 2000).

[1]See Pope (2000) for a literature review on the negative consequences of pollution on health.

Our paper adds to the very limited evidence by studying the issue at the aggregate population level and by using a fully exogenous pollution shock, rather than achieving identification through some policy change that might be suffering from other confounders. The closest paper to our study that we are aware of is Isen et al. (2016). However, they only focus on the early childhood exposure and use a policy change in the 1970s to identify the effect of pollution exposure, which is overall less persuasive than the direct evidence of pollution exposure our study uses. We find that higher pollution reduces the hours worked in both the medium- and the long-run. We capture medium-run effects three years past exposure, and long-run effects ten years past exposure. The medium-run effects are larger in magnitude, which is consistent with a hypothesis of recovery over time, but some effects still persist ten years after exposure.

2 Data and Methodology

We use data from the Indonesia Family Life Survey (IFLS). IFLS is a longitudinal survey containing a sample of households that is representative for over 80% of the Indonesian population. The first wave of the survey was fielded in 1993, with subsequent waves in 1997, 2000, 2007, and 2015[2]. The attrition rates are very small in IFLS and most households can be successfully tracked from one wave to another. This is ideal for our study, as we use data from all four waves to estimate our main econometric models.

Our dependent variable is hours worked. Respondents are surveyed on the numbers of hours they work during a typical week, which is a good proxy for the respondents' labor supply decision. We collect this information from all waves of IFLS and use the data from 2000 and 2007 as dependent variables to study the medium-, and respectively long-run effects of air pollution. The data from the 1993 wave is used as a control variable proxying for the initial labor supply decision. We do not use the data from 1997 since the data collection process overlapped with the smoke months and hence the data from 1997 could already include the population response to pollution, rather than just the initial labor supply information.

The explanatory variable of interest is the pollution level that respondents were exposed to during

[2]IFLS 5 was fielded in 2014-2015, with data being made available during 2016. Due to certain data limitation problems, IFLS 5 data is not included in the current study.

the 1997 fires. Following Kim et al. (2016), we interpolate the Total Ozone Mapping Spectrometer (TOMS) data described in Jayachandran (2009) using Global Positioning System (GPS) coordinates for each community provided by IFLS. We then compute the monthly pollution as the median of the daily values, and average over the September, October, and November months of 1997 to construct the pollution variable used in all our regressions.

We argue that pollution exposure was due to a wholly exogenous phenomenon, as the spread of fires was mainly due to El Niño and not to anything else that could be correlated with individual or household specific socio-economic factors. We therefore treat the pollution shock as a natural experiment and simply estimate the effect of the pollution level on respondents' hours worked, three and respectively ten years past exposure. We nevertheless control for initial hours worked and for other socio-economic factors that could affect hours worked. We collect extensive control data on respondents' age, education level, tenure at current job, sex, household size, whether they live in an urban setting, and whether their dwelling has an outdoor kitchen and water supply. Formally, the reduced form models can be written as follows:

$$HoursWorked_{ij}^{t} = \alpha HoursWorked_{ij}^{1993} + \beta Pollution_{j}^{1997} + \gamma X_i + \varepsilon_{ij}$$

where t represents the year (2000 and 2007) for our two separate estimations, i denotes the respondent, j denotes the community, X is the vector of individual and household level control variables mentioned above, and ε_{ij} is the error term representing unobservables uncorrelated with the regressors. We estimate these equations with Ordinary Least Squares (OLS) with robust standard errors.

3 Results

We start with presenting the long-run results. Table 1 presents the results of the effects of the 1997 pollution shock on working hours in 2007. For space considerations we do not report all the coefficients, but our estimations control for age and age squared, tenure at current job and tenure squared, education, sex, urban location, household size, having a kitchen and water source outside of the dwelling, and initial labor supply. For the initial labor supply, we use data on working hours in 1993, to avoid all possible contaminations with the pollution episode in 1997. We dropped observations that were most likely mis-measured, such as those who reported working more than 168 hours per week.

Table 1: Long Run Regression Results - Full Sample Analysis
Dependent Variable: Working Hours (as measured in 2007)

Explanatory Variables	Coefficient	Robust Standard Error
Pollution in 1997	-0.8005*	0.4555
Education in 2007	-0.2014***	0.0.0633
Urban	5.255***	0.6202
Male	3.2554***	0.5984
Working Hours in 1993	0.1824***	0.0171
Const.	42.186***	5.7115

*-significant at 10% level **-significant at 5% level ***-significant at 1% level
Sample size: 5209

There is a negative and statistically significant effect of pollution on working hours, ten years past exposure. To further investigate the channel that this effect works through, we estimate a similar equation where we control for the general health of respondents. General health status (GHS) is a self-reported measure that aggregates the overall level of health. GHS has been found to be a good proxy and predictor for future health (See Idler and Benyamini 1997, Burstrom and Fredlund 2001, or van Doorslaer and Gerdtham 2003)). Controlling for GHS in our main specification renders the effect of pollution insignificant, which proves that health is the main channel through which pollution negatively affects the labor supply in the long run. This fact is consistent with the findings of Kim et al. (2016) who find that air pollution affects health negatively, and these effects persist in the long run.

We are however interested in studying whether the negative effects of pollution on labor supply decrease over time. We estimate a similar model where we replace the dependent variable working hours with its year 2000 level. We use the same set of control variables and again drop those observations that are likely mis-measured. The results are presented in Table 2.

Table 2: Medium Run Regression Results - Full Sample Analysis
Dependent Variable: Working Hours (as measured in 2000)

Explanatory Variables	Coefficient	Robust Standard Error
Pollution in 1997	-1.5458***	0.3754
Education in 2000	-0.2557***	0.0.0611
Urban	4.659***	0.5919
Male	2.2675***	0.5549
Working Hours in 1993	0.2803***	0.0163
Const.	36.9941***	3.9785

*-significant at 10% level **-significant at 5% level ***-significant at 1% level
Sample size: 6526

The effect of pollution on hours worked is negative, statistically significant, and larger in magnitude than the long-run effect. This is consistent with the hypothesis that the negative effects of pollution are mitigated by the passage of time. The medium-run effects three years post exposure are approximately double in magnitude when compared to the long-run effects. Even more importantly, the medium-run effects do not disappear when controlling for health, which suggests there are additional channels other than health, that can cause diminishing labor supply in the presence of air pollution. One possible explanation is care-giving. Aragon el al. (2016) find that moderately levels of pollution do not have direct effects on labor supply, but they do have indirect effects in households with children and elderly, where working adults take time off from work to care for these dependents. In order to investigate this hypothesis, we disaggregate the sample into two subsamples: households with dependents and households without dependents. We considered all children younger than 16 as dependents. The results are presented in Table 3.

Table 3: Medium Run Regression Results - Sub-Sample Analysis
Dependent Variable: Working Hours (as measured in 2000)

Sample	**Households with Dependents**	**Households without Dependents**
Explanatory Variables	**Coefficient** (Robust St. Error)	**Coefficient** (Robust St. Error)
Pollution in 1997	-1.720***	-0.746
	(0.418)	(0.863)
Education in 2000	-0.263***	0.0.266*
	(0.069)	(0.135)
Urban	4.387***	5.151***
	(0.677)	(1.230)
Male	2.017***	3.166***
	(0.648)	(1.102)
Working Hours in 1993	0.269***	0.313***
	(0.019)	(0.032)
Poor GHS	-0.019	-2.753*
	(0.891)	(1.458)
Const.	36.7194***	44.8031***
	(4.646)	(8.845)
Sample Size	4788	1736

*-significant at 10% level **-significant at 5% level ***-significant at 1% level

As hypothesized, when controlling for health status, air pollution still has a significant negative effect on hours worked for respondents with minor dependents. For those without dependents, the effects of pollution disappear when controlling for health, just as in our long-run analysis. It follows

that, while there are significant negative effects of pollution on labor supply in both the medium and the long run that are driven by health, there are additional effects in the medium-run that are driven by dependent care-giving. The care-giving channel does not play a role in the long run arguably because, as Kim et al. (2016) show, in the long run, young children tend to recover from bad health episodes caused by pollution.

4 Conclusions

In this paper, we study the medium- and long-run consequences of air pollution on labor supply. Using the Indonesian forest fires of 1997 as a natural experiment, we estimate significant negative effects of pollution on hours worked that persist over time. The negative consequences seem to be somewhat mitigated by the passage of time. We find the medium-run effects (three years past exposure) to be approximately double in magnitude when compared to the long-run effects (ten years past exposure) and driven primarily by care-giving. The effects that persist in the long-run seem to be mainly driven by respondents' own health.

A particularly interesting line of future research would be to investigate possible additional channels through which air pollution affects the labor supply in the medium and long run, and also possible effects on earnings and other socio-economic indicators. Our study clearly shows that the economic costs of air pollution go well beyond the well established short-run effects, with some effects persisting even ten years past exposure. This should be extremely relevant to policy-makers, especially in developing countries where air pollution is often times a less important topic of debate and where cost-cutting industry practices are often given priority, at the expense of air quality.

References

[1] Aragon, F., Miranda, J., and Oliva, P., 2016, "Particulate matter and labor supply: evidence from Peru", Simon Fraser University Economics Working Paper.

[2] Bobak, M., and Leon, D., 1992, "Air Pollution and Infant Mortality in the Czech Republic, 1986-1988.", *Lancet* 340:1010-14 .

[3] Burstrom, R., and Fredlund, P., 2001, "Self Rated Health: Is it as Good a Predictor of Subsequent Mortality Among Adults in Lower as well as in Higher Social Classes?", *Journal of Epidemiology and Community Health* 55:836-840.

[4] Chang, T., Graff-Zivin, J., Gross, T., and Neidell, M., 2014, "Particulate pollution and the productivity of pear packers", NBER working paper 19944.

[5] Chauhan, A., and Johnston, S., 2003, "Air Pollution and Infection in Respiratory Illness", *British Medical Bulletin* 68(1):95-112.

[6] Chay, K., and Greenstone, M., 2003a, "Air Quality, Infant Mortality, and the Clean Air Act of 1970.", NBER Working Paper No. 10053.

[7] Chay, K., and Greenstone, M., 2003b, "The Impact of Air Pollution on Infant Mortality: Evidence from Geographic Variation in Pollution Shocks Induced by a Recession.", *Quarterly Journal of Economics* 118(3):1121-67.

[8] Currie, J., and Neidell, M., 2005, "Air Pollution and Infant Health: What Can We Learn from California's Recent Experience?", *Quarterly Journal of Economics* 120(3):1003-30.

[9] Emmanuel, S., 2000, "Impact to Lung Health of Haze from Forest Fires: The Singapore Experience.", *Respirology* 5(2):175-82.

[10] Graff-Zivin, J., and Neidell, M., 2012, "The impact of pollution on worker productivity", *The American Economic Review* 102(7):3652-3673.

[11] Hanna, R., and Oliva, P., 2015, "The effect of pollution on labor supply: Evidence from a natural experiment in Mexico City", *Journal of Public Economics* 122:68-79.

[12] Hausman, J., Ostro, B., and Wise, D., 1984, "Air pollution and lost work". NBER working paper 1263.

[13] Heil, A., 2000, "The 1997-98 Air Pollution Episode in Southeast Asia Generated by Vegetation Fires in Indonesia", *International Forest Fire News* 23:68-71.

[14] Idler, E., and Benyamini, Y., 1997, "Self-Rated Health and Mortality: A Review of Twenty Seven Community Studies", *Journal of Health and Social Behavior* 38(1):21-37.

[15] Isen, A., Rossin-Slater, M., and Walker, W., 2014, "Every breath you take-every dollar you'll make: the long term consequences of the clean air act of 1970", NBER working paper 19858.

[16] Jayachandran, S., 2009, "Air Quality and Early-Life Mortality: Evidence from Indonesia's Wildfires", *Journal of Human Resources* 44(4):916-954.

[17] Kim, Y., Knowles, S., Manley, J., and Radoias, V., 2016, "Long-run health consequences of air pollution: Evidence from Indonesia's forest fires of 1997". Available at SSRN: https://ssrn.com/abstract=2783402 or http://dx.doi.org/10.2139/ssrn.2783402

[18] Kunii, O., Kanagawa, S., Yajima, I., Hisamatsu, Y., Yamamura, S., Amagai, T., and Ismail, T., 2002, "The 1997 Haze Disaster in Indonesia: Its Air Quality and Health Effects", *Archives of Environmental Health: An International Journal* 57(1):16-22.

[19] Loomis, D., Castillejos, M., Gold, D., McDonnell, W., and Borja-Aburto, V., 1999, "Air Pollution and Infant Mortality in Mexico City.", *Epidemiology* 10:118-23.

[20] Peterson, B., Rauh, V., Bansal, R., Hao, X., Toth, Z., Nati, G., Walsh, K., Miller, R., Arias, F., Semanek, D., Perera, F., 2015, "Effects of Prenatal Exposure to Air Pollutants (Polycyclic Aromatic Hydrocarbons) on the Development of Brain White Matter, Cognition, and Behavior in Later Childhood", *JAMA Psychiatry* 72(6): 531-540.

[21] Pope, C., 2000, "Epidemiology of fine particulate air pollution and human health: biologic mechanisms and who's at risk?", *Environmental Health Perspectives* 108(4): 713-723.

[22] Romieu, I., Samet, J., Smith, K., and Bruce, N., 2002, "Outdoor air pollution and acute respiratory infections among children in developing countries.", *Journal of Occupational Environmental Medicine* 44(7): 640-649.

[23] van Doorslaer, E., and Gerdtham, U-G., 2003, "Does Inequality in Self Assessed Health Predict Inequality in Survival by Income? Evidence from Swedish Data", *Social Science and Medicine* 57:1621-1629.