Hidden Costs of the Great London Smog: Evidence from Missing Births

Alastair Ball*

Abstract

This article measures the effect of the Great London Smog on fetal loss by testing for missing births in the subsequent nine months, using newly available data. Results show the five day smog resulted in a 3.5% reduction in the size of the cohort affected in the third trimester, and a 1.5% reduction in the size of the cohort affected in their first trimester.

1 Introduction

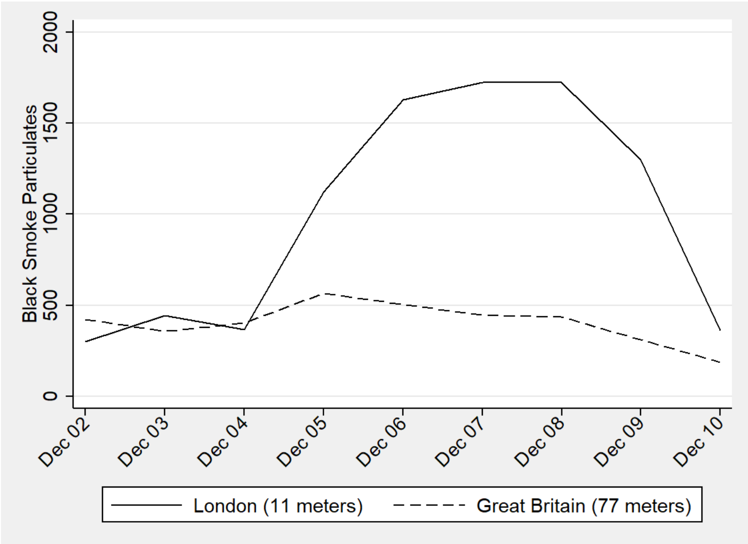
Over 12,000 people lost their lives prematurely after exposure to the Great London Smog of 1952 (Bell *et al*, 2004). This paper tests whether the five-day Smog also caused mortality among those who were *in utero* at the time. To my knowledge, this is the first paper studying a possible link between fetal loss and exposure to a short urban smog[1].

For long-term pollution exposures over the pregnancy, there is good evidence in health economics that a number of proxies for fetal health are affected, including birthweight, prematurity, and neonatal mortality (Currie *et al*, 2014). Within epidemiology, Siddika *et al* (2016) perform a meta-analysis of 13 studies of pollution and stillbirths, finding a suggestive link between the two. There is much less evidence about fetal loss and short exposures to pollution, such as found in urban smogs. An exception is Pereira *et al* (1998), who use two years of daily data on late fetal loss (after 28 weeks) from Sao Paolo, linked to daily data on five pollutants. They find a significant association between births and a summary measure of pollution, up to a lag of five days.

*Birkbeck, University of London. Address for correspondence: Alastair.Ball@bbk.ac.uk. Mailing address: Department of Economics, Mathematics and Statistics, Birkbeck, University of London, Malet Street, Bloomsbury, London WC1E 7HX.

[1]The review below relates to evidence about fetal loss. However, for recent studies of the effects of London's Smogs on mortality among adults and infants, see Clay and Troesken (2011), Beach and Hanlon (2018), and Hanlon (2018).

Figure 1: Black Smoke Particulates ($\mu g/m^3$) in London and Great Britain during the 1952 Smog. Data from the Fuel Research Board.



The estimates above are likely to be lower-bounds as fetal loss is only ordinarily recorded in later pregnancy, after around twenty weeks. Jayachandran (2009) circumvents this, and other data challenges, by observing 'missing births' in the 2000 Indonesian census following a large wildfire, finding a 1.2% reduction in the size of the affected cohort. Sanders and Stoecker (2015) take another approach, measuring the effects of the 1970 Clear Air Act on birth ratios, finding that a standard deviation increase in TSP particulates reduced the percentage of male live births by 3.1%.

2 Background and Data

The Great London Smog began on the 5th of December 1952 and lasted five days. During these days, the level of average Black Smoke particulates was 1,500 $\mu g/m^3$, with a peak daily average of 1,720 $\mu g/m^3$ on the 8th of December. In terms of modern measures, these figures correspond roughly to 500 and 720 $\mu g/m^3$ PM2.5[2]. The Smog was caused by an atmospheric temperature inversion that prevented the normal dispersion of pollution. As shown in Figure 1, other areas of the U.K. were not affected.

Following Jayachandran (2009), this paper tests for 'missing births' in London in the nine months following the Great London Smog. Information on quarterly births from 1948-1965 in London and England & Wales comes

[2]Conversion of Black Smoke measures to PM2.5 is imprecise. Bell *et al* (2004) convert London's 1952 Black Smoke measures to TSP at (1:1). Cao *et al* (2011) convert TSP to PM2.5 at a ratio of (3:1) in the context of the P.R. China.

Table I: **Summary Statistics:** Birth data from the Registrar General, Weather data from the MET Office, Pollution data from the Fuel Research Board.

VARIABLES	(1) mean	(2) sd	(3) min	(4) max
Quarterly Births, London	16,012	1,534	13,462	19,103
Quarterly Births, England and Wales	154,814	15,451	127,288	187,674
Quarterly Minimum Temprature	0.318	1.891	-3.600	4.300
Quarterly Average Black Smoke	150.8	33.36	100.6	218.7

from the records of the Registrar General for Births, Deaths, and Marriages and can be seen in Figure 2. This is the official record of births for the United Kingdom, and should contain the universe of registered births[3]. Data on weather conditions comes from the U.K. Meteorological Office. Data on black smoke particulates comes from the official publications of the Fuel Research Board[4]. The series for London spans from 1950-1958 and is based on data from fifteen meters. Summary statistics for the main variables can be seen in Table I.

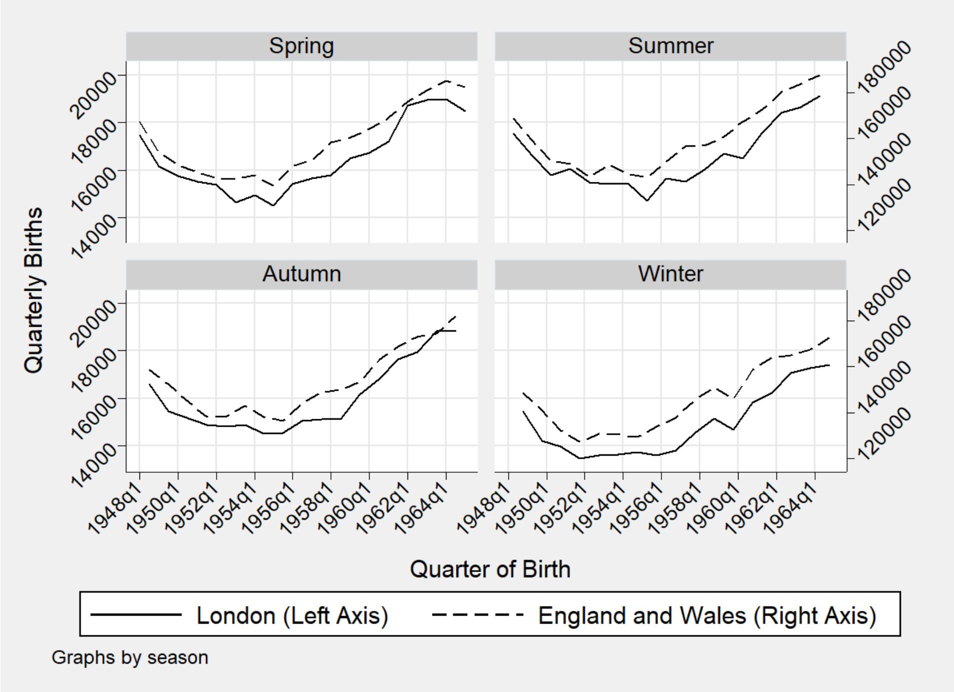
3 Statistical model and estimation

The aim of the statistical model is to compare actual births in 1953 - when children affected *in utero* would be born - to a counterfactual capturing expected births in the absence of the Smog. The dependent variable is log births in London ($BIRTHS^L_{ts}$) in quarter t and season s. The overall trend of log births between 1948 and 1965 is captured with a polynomial $\phi(\tau)$ of degree τ, and three seasonal dummies D_s. Log births in the rest of England and Wales ($BIRTHS^E_{ts}$) - which was unaffected by the Smog - are included to capture deviations from this trend due to unobserved economic, environmental, or other nation-wide factors. Additional data relating to environmental exposures is available from 1950-1958, and are included for some specifications as E_t. This contains the average pollution exposures and minimum temperatures during the nine months prior to the quarter of birth. Lastly, the model contains dummies for quarters following Smog events D^{Smog}_t. The coefficients of interest are γ, the difference in log births

[3]Registration of births has been compulsory in the U.K. since the Births and Deaths Act of 1874.

[4]Available in the UK National Archives. Conversion of BS to a gravimetric measure such as TSP is not precise. In the context of the Great London Smog, Bell *et al* (2004) use a 1:1 conversion.

Figure 2: Quarterly Births in London and England and Wales, by season. Data from the Registrar General.



in London following the Smog, relative to the modelled counterfactual.

$$BIRTHS^L_{ts} = \alpha + \beta_1\phi(\tau) + \beta_2 D_s + \beta_3 BIRTHS^E_{ts} + \beta_4 E_t + \gamma D^{Smog}_t + \epsilon_{ts} \quad (1)$$

Estimation of the model is by ordinary least squares. Newey-West standard errors are used, with a lag-length determined by the automatic procedure suggested in Newey & West (1994). Results will be shown for polynomials $\phi(\tau)$ of different degrees, and a preferred specification will be chosen using the reported AIC and BIC.

4 Results and Discussion

Estimated coefficients from Equation 1 can be seen in Table II. Columns (A1)-(A5) are from the complete series of birth data from 1948-1965. The AIC and BIC both suggest adjusting for long-run trends with a fifth order polynomial, seen in the top half of Figure 3. Discussion will focus on this specification (A5). Much of the variation in the London birth series was shared with the England and Wales series, and the associated coefficient is highly significant in all specifications. This relationship also captured most of the seasonality in the data. Of the seasonal controls, only the winter dummy was significant, indicating that although births are lowest in the Winter in England and Wales, they are 3-4% more so in London.

The dummy for Winter 1952 in (A5) includes the period of the Smog, and shows 1.1% fewer births, significant at the 1% level. The dummy for Spring 1953 captures those affected by the Smog while in the third trimester, and indicates a 3.5% drop in births, significant at the 1% level. This estimate corresponds to 540 missing births, relative to the counterfactual. The dummy for Summer 1953 captures those affected in the second trimester, and shows a 1.1% drop, or 171 missing births, though this estimate is not statistically significant. The dummy for Autumn 1953 captures those in the first trimester during the Smog; the coefficient suggests a 1.5% drop in births, or 223 missing births, significant at the 1% level. The dummy for Winter 1953 captures those who were conceived too late to be affected by the Smog. The coefficient is negative but not significantly different from zero. For this longer series, two additional dummies were included for the three quarters following the 1948 and 1962 Smogs. The estimated coefficients showed a 4% decline in births against expectations in the three quarters following the 1948 Smog, significant at the 1% level, but no change after the (less severe) 1963 smog.

Columns (B1)-(B4)[5] were estimated on data from 1950-1958, and include additional controls for average levels of pollution exposure and minimum temperatures in the three quarters prior (the period during which a child would be in utero.) The length of polynomial lag suggested by AIC and BIC is sensitive to the number of impact dummies included, but is always (B1) or (B3). With the five impact dummies, (B1) is selected, and discussion will focus on this specification. In terms of results, much of the discussion above holds. The added controls for temperatures and particulates had estimated coefficients with the expected (negative) sign but very small magnitudes that were not statistically significant. This is most likely because the fitted line, the seasonal dummies, and the idiosyncratic shocks picked up by the England and Wales series had already picked up much of the variation in births due to environmental causes. The estimated impacts in (B1) were generally larger, and more likely to be statistically significant than those in (A5).

The results for the third trimester were robust to choice of specification and controls. For other results, the specification of the polynomial trend was important for the longer series. In particular, the effect relating the first trimester was significant only with a first and fifth order polynomial. All estimates in the shorter series including environmental information were robust to the specification of the polynomial. This is unsurprising because the long-trend in the shorter series is broadly linear.

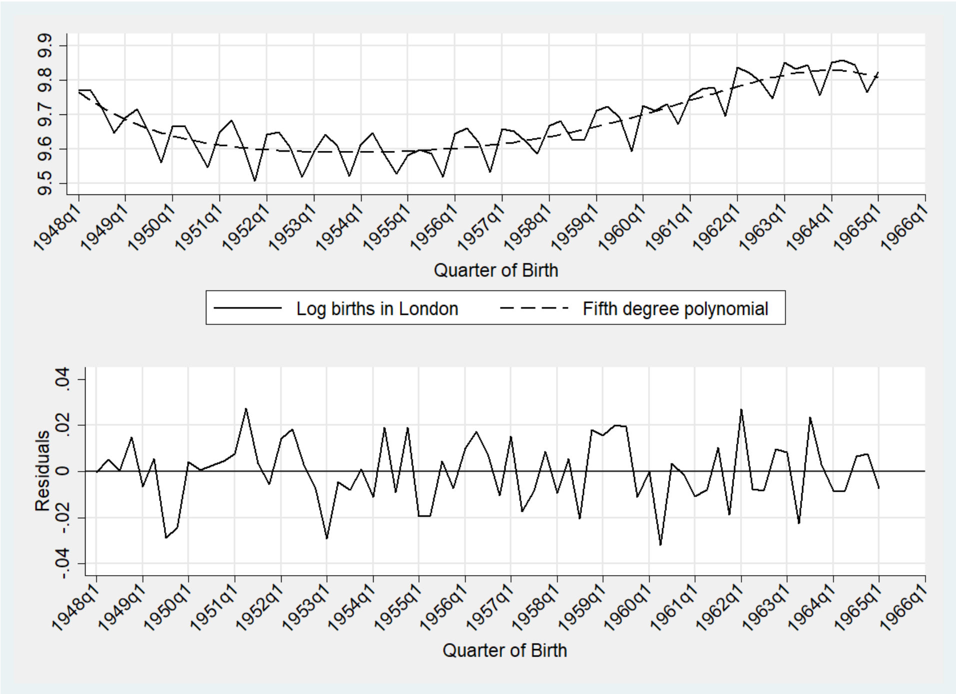
[5] The fifth order polynomial term in what would be specification (B5) was omitted due to collinearity.

Table II: **Estimated coefficients from Equation 1:** Log quarterly births in London regressed on a polynomial trend, seasonal dummies, and dummies for quarters following the 1952 Smog. Regressions reported in columns A1-5 include data form 1948-1965, AIC and BIC select column A5. Columns B1-4 include environmental and pollution controls, and include data from 1950-1958, AIC and BIC select column B1. Newey-West standard errors. Birth data from the Registrar General, Weather data from the MET Office, Pollution data from the Fuel Research Board.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	(A1)	(A2)	(A3)	(A4)	(A5*)	(B1*)	(B2)	(B3)	(B4)
1952, Winter (Smog)	0.003	-0.002	-0.001	-0.005	-0.011***	-0.011***	-0.012***	-0.017***	-0.016***
	(0.008)	(0.004)	(0.005)	(0.006)	(0.002)	(0.004)	(0.004)	(0.004)	(0.004)
1953, Spring (T3)	-0.022**	-0.025***	-0.024***	-0.028***	-0.035***	-0.030***	-0.031***	-0.035***	-0.034***
	(0.008)	(0.004)	(0.006)	(0.004)	(0.003)	(0.004)	(0.004)	(0.005)	(0.003)
1953, Summer (T2)	-0.007	-0.004	-0.002	-0.004	-0.011	-0.016***	-0.018**	-0.022***	-0.019**
	(0.010)	(0.007)	(0.011)	(0.007)	(0.007)	(0.004)	(0.008)	(0.008)	(0.008)
1953, Autumn (T1)	-0.015**	-0.009	-0.006	-0.008	-0.015***	-0.014***	-0.017**	-0.020***	-0.016**
	(0.006)	(0.006)	(0.008)	(0.007)	(0.004)	(0.003)	(0.006)	(0.005)	(0.007)
1953, Winter	0.010	0.006*	0.007	0.008	-0.002	0.000	-0.001	-0.003	0.001
	(0.009)	(0.004)	(0.004)	(0.005)	(0.002)	(0.003)	(0.004)	(0.003)	(0.006)
L(births), Eng+Wales	0.947***	0.685***	0.641***	0.654***	0.657***	0.749***	0.785***	0.829***	0.810***
	(0.060)	(0.099)	(0.085)	(0.072)	(0.069)	(0.083)	(0.112)	(0.124)	(0.133)
Summer	-0.005	-0.000	0.000	-0.001	-0.001	0.005	0.005	0.003	0.004
	(0.006)	(0.007)	(0.006)	(0.006)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)
Autumn	0.005	-0.002	-0.004	-0.004	-0.004	-0.000	0.001	0.002	0.001
	(0.006)	(0.007)	(0.006)	(0.005)	(0.004)	(0.006)	(0.007)	(0.006)	(0.007)
Winter	-0.021***	-0.041***	-0.045***	-0.046***	-0.045***	-0.033**	-0.030**	-0.026*	-0.028*
	(0.007)	(0.011)	(0.009)	(0.008)	(0.008)	(0.012)	(0.014)	(0.014)	(0.015)
Ave Pollution, in utero						-0.000	-0.000	-0.000	-0.000
						(0.000)	(0.000)	(0.000)	(0.000)
Min Temp, in utero						-0.001	-0.000	-0.001	-0.001
						(0.001)	(0.001)	(0.001)	(0.001)
Observations	68	68	68	68	68	34	34	34	34
AIC	-328	-346	-344	-356	-367	-186	-185	-185	-185
BIC	-299	-315	-311	-323	-334	-167	-163	-162	-162
Deg. of Polynomial Trend	1	2	3	4	5	1	2	3	4
Environmental Controls	no	no	no	no	no	yes	yes	yes	yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 3: Expected Quarterly Births in London: The upper figure shows the log births data fitted with the fifth degree polynomial chosen by the AIC and BIC. The lower figure shows the residuals from Equation 1, excluding the 1953 impact dummies. Birth data from the Registrar General.



5 Conclusion

This paper estimated the effect of the Great London Smog on fetal loss by testing for 'missing' births in the subsequent nine months. Results show around a 3.5% reduction in births among the cohort affected by the Smog in their third trimester, and a 1.5% reduction in births among those affected in their first trimester. Some specifications also showed around a 1% reduction in births among those affected in the second trimester, though this result was statistically significant in only some models. The Great Smog was a particularly severe event, and the last major smog event in London was in 1962. However, smogs have been recorded in India and China in recent years in which measures of particulates have reached daily peaks of 600 $\mu g/m^3$ PM2.5 or higher[6][7]. An interesting question for future research is whether exposure to these short smogs also have 'hidden' effects for fetal mortality.

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