Resource and Energy Economics 49 (2017) 165–185

Contents lists available at ScienceDirect

Resource and Energy Economics

journal homepage: www.elsevier.com/locate/ree

Alerts work! Air quality warnings and cycling☆

Soodeh Saberian[a], Anthony Heyes[a], Nicholas Rivers[b,*]

[a] Department of Economics, University of Ottawa, Canada
[b] Graduate School of Public and International Affairs and Institute of the Environment, University of Ottawa, Canada

ARTICLE INFO

Article history:
Received 24 March 2016
Received in revised form 21 April 2017
Accepted 16 May 2017
Available online 24 May 2017

Keywords:
Information-based regulation
Averting behavior
Urban air quality
Health impacts of air pollution

ABSTRACT

Alert programs are central to strategies to reduce pollution exposure and manage its impact. To be effective alerts have to change behavior, but evidence that they do that is sparse. Indeed the majority of published studies fail to find a significant impact of alerts on the outcome behavior that they study. Alerts particularly seek to influence energetic cardiovascular outdoor pursuits. This study is the first to use administrative data to show that they are effective in reducing participation in such a pursuit (namely cycle use in Sydney, Australia), and to our knowledge the first to show that they are effective in changing any behavior in a non-US setting. We are careful to disentangle possible reactions to realised air quality from the 'pure', causal effect of the issuance of an alert. Our results suggest that when an air quality alert is issued, the amount of cycling is reduced by 14–35%, which is a substantial behavioral response. The results are robust to the inclusion of a battery of controls in various combinations, alternative estimation methods and non-linear specifications. We develop various sub-sample results, and also find evidence of alert fatigue.

1. Introduction

Managing the impact of pollution exposure – particularly in big cities – is a key policy priority in many countries. In addition to efforts to reduce pollution levels directly, policy-makers put increasing faith in information-based programs that enable individuals to engage in avoidance behavior to alleviate the negative effects of pollution.

A prominent example of this is the air quality 'alert' schemes that are now in operation in many cities across North America and elsewhere.[1] When air quality is forecast to be poor – fall below some established threshold – an alert or advisory is issued and people are encouraged to change behavior in order to reduce exposure. Typically alerts focus in particular on encouraging people to avoid strenuous outdoor activities.[2]

☆ Heyes is also a part-time Professor of Economics at the University of Sussex. We are grateful to Pierre Brochu, Maya Papineau, Matthew Neidell, Brandon Schaufele, Joel Bruneau, participants at the 2014 Meeting of the CREE and two referees from this journal for very constructive comments. Heyes and Rivers both hold Canada Research Chairs and acknowledge the financial support of the Social Science and Humanities Research Council Canada Research Chairs (CRC) program. Errors are ours.

* Corresponding author.
E-mail addresses: saberian.soodeh@gmail.com (S. Saberian), Anthony.Heyes@uottawa.ca (A. Heyes), nrivers@uottawa.ca (N. Rivers).

[1] For two examples amongst many, Toronto started an alert program in 2005, Hong Kong in 2013.

[2] Avoiding such activity is crucial in reducing the health risk to an individual of poor air quality. Carlisle and Sharp (2001) and Atkinson (1997) are among many studies that link exercising in polluted air to a variety of elevated health risks.

http://dx.doi.org/10.1016/j.reseneeco.2017.05.004
0928-7655/

The evidence that alerts work, however, is thin. Our paper is the first to use administrative data to link air quality alerts to the avoidance of a strenuous outdoor activity. In particular, fine-grained administrative bicycle-count data from the cycle path network of Sydney, Australia allows us to investigate the impact of air quality alerts on cycling behavior in that city. To the best of our knowledge, there are only two existing papers that link alerts to directly-observed avoidance behavior using administrative data. One is Zivin and Neidell (2009) who use turnstile data to show that alerts impact attendance at two popular outdoor venues in Los Angeles (Los Angeles Zoo and The Griffith Observatory) especially amongst those with children. The other is Noonan (2014) who uses data from a small-scale survey of people passing two park benches in a 35 day period in Piedmont Park in Atlanta. He gets mixed results, finding no impact of alerts on aggregate use but evidence consistent with reduced use by older people and joggers.

We estimate the causal effect of air quality alerts on cycling behavior using a regression-based approach that relates daily cycling counts at each cycling counter on the Sydney bicycle network with a dummy variable indicating whether an air quality alert was in place. Recognizing that cyclists may decide whether or not to cycle based on the actual pollution level in addition to whether an alert is in place, we also include covariates to control for actual (concurrent) level of air quality (as well as other determinants of cycling behavior). However, this raises a concern, since air quality is potentially endogenous in our setting.

In fact, estimating the effect of air quality alerts on individuals' behavior is challenging for at least three reasons. First, because of variation in pollution across regions, assigning pollution and weather variables to individuals based on individual and monitor locations could lead to measurement error. Second omitted variable bias could arise due to confounding environmental factors. Third, the level of ambient pollution may be endogenous if individuals shift their outdoor activities toward emission-producing substitute activities (for example the presence of an air quality alert may induce some cyclists to drive). To accommodate this, we instrument for 'air quality' using bushfire activity.

It is important to clarify that our focus in the paper is on estimating the impact of air quality alerts on cycling behavior. Air quality alerts are established the day prior to the alert being issued (based on the *forecast* air quality on the day of the alert), are not revised after being set (to correct for forecast errors), and are city-wide. These conditions ensure that there is no measurement error or endogeneity directly associated with our main variable – the dummy variable for alerts. However, alerts are correlated with actual air quality, which is potentially endogenous, and which can also affect cycling behavior. We show that neglecting to address endogeneity in the air quality variable will lead to bias in our estimate of the effect of alerts on cycling behavior, and thus we use bushfires that occur throughout neighboring regions of Australia as an instrument for air quality in Sydney.

Three characteristics of bushfire activity point to it being a good instrument in this context. First, bushfires have a significant negative influence on air quality in Sydney. Smoke from bushfires consists of carbon dioxide, carbon monoxide, fine particulate matter, and oxides of nitrogen and can also increase ozone concentrations in the presence of sunlight. Because of hot dry conditions, particles from bushfires can be transported several thousand kilometers, and bushfire smoke from distant fires regularly impacts the air quality in the city (Confalonieri et al., 2007). Second, the only channel through which bushfires can sensibly be expected to affect cycling behavior is through their impact on air quality. Third, the timing of bushfires is quasi-random. Although periods of hot and dry weather may create preconditions for fires, their occurrence cannot be perfectly timed.

Bushfire activity is introduced in combination with distance from city and size of fire, though results across the specifications prove similar. The reduction implied in cycle use in response to an alert is not just statistically significant but substantial in size – around 14% under OLS estimation and 35% under the preferred IV specification. We also explore the *dynamics* of response, finding evidence consistent with 'alert fatigue'. More concretely, when alerts are issued for two successive days, the second day response is much smaller (2% in the preferred IV specification) and no longer statistically significant, albeit in a much smaller sample.

The results presented prove robust in sign – and fairly robust in magnitude – to inclusion of alternative combinations of controls for weather, temporal factors, etc. We recognize the risk of omitted variable bias, and estimates from a 'stripped down' version of the model excluding all pollution and weather controls point to a statistically significant 30% fall in cycle use in response to a single-day alert, suggesting the strength of our approach in controlling for potential environmental confounders. We also allow for the possibility of nonlinear effects of concurrent air quality on demand for cycling which, and in that case we find that air quality alerts cause a 15% and 26% reduction in cycling under OLS and IV estimation, respectively.

In addition to our main results, we also use the data to determine whether the response is greater for leisure or commuting cyclists. We conduct this analysis in two ways. First, we divide the data into weekdays and weekends, and find that the cyclists respond more to an air quality alert on weekends than weekdays (49% versus 30% in the preferred IV specification). Second, we categorize the cycle-counter locations according to two criteria – one a measure of the relative density of use of a particular route across days of the week (weekdays versus weekends), the other the "strength" of the peak in usage of a particular route during normal travel-to-work windows on an average weekday. Each criteria are designed to disentangle commuting from non-commuter traffic (counters provide a count of the number of bicycle passing – no information on the purpose of the trip). While neither of these proxies are perfect, they both suggest a stronger response to air quality alerts of leisure cyclists relative to commuter cyclists.

The layout of the rest of the paper is as follows. The next section summarizes the pertinent research from a number of streams of research in air quality, behavior and the impact of alerts. Section 3 describes data sources. Section 4 lays out