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Higher fuel prices are associated with lower air pollution levels

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ABSTRACT

Air pollution is a persistent problem in urban areas, and traffic emissions are a major cause of poor air quality. Policies to curb pollution levels often involve raising the price of using private vehicles, for example, congestion charges. We were interested in whether higher fuel prices were associated with decreased air pollution levels. We examined an association between diesel and petrol prices and four traffic-related pollutants in Brisbane from 2010 to 2013. We used a regression model and examined pollution levels up to 16 days after the price change. Higher diesel prices were associated with statistically significant short-term reductions in carbon monoxide and nitrogen oxides. Changes in petrol prices had no impact on air pollution. Raising diesel taxes in Australia could be justified as a public health measure. As raising taxes is politically unpopular, an alternative political approach would be to remove schemes that put a downward pressure on fuel prices, such as industry subsidies and shopping vouchers that give fuel discounts.

1. Introduction

Traffic emissions are the major source of air pollution in most urban areas. High levels of traffic pollution are associated with multiple serious health problems, including myocardial infarction (Hart et al., 2013), stroke (Miller et al., 2007), asthma (Modig et al., 2009) and preterm birth (Wilhelm et al., 2011). Traffic emissions are a major contributor to ambient outdoor particulate matter pollution, which is the ninth leading risk factor in the global burden of disease (Lim et al., 2012). Vehicular fossil fuel combustion also makes a substantial contribution to global warming (Smith et al., 2009).

Reducing traffic-related air pollution is difficult as many people contribute to its creation and policies that aim to reduce vehicle usage are met with resistance from the powerful car lobby (Douglas et al., 2011). Congestion charges (where fees are charged in an effort to reduce vehicle use) are generally unpopular with the public and have had mixed results in terms of reducing in traffic-related air pollution (Kelly et al., 2011). Policies that improve fuel and vehicle standards do improve air quality (Giles et al., 2010), but take time to have an impact.

Traffic pollution has many parallels with cigarette smoking as a public health issue (Douglas et al., 2011; Peters, 2009), including that reducing the health impacts can be achieved by reducing consumption. One proven method of decreasing cigarette consumption is to raise prices. We were interested in whether higher fuel prices had a positive effect on air quality. In economics this is known as “price elasticity” and higher fuel prices do reduce vehicle numbers (Hirota and Poot, 2004), but no research has shown if the reduction in vehicle numbers is large enough to impact on air quality. We examined whether higher fuel prices in Brisbane, Australia, were associated with reductions in traffic-related air pollution.

2. Materials and methods

Brisbane is the capital of the state of Queensland and is its most populous city (2.2 million people). We assessed the association between daily fuel prices and daily air pollution levels in Brisbane from July 2010 to June 2013. We examined the most recent three years as this gave us sufficient statistical power, with a greater than 90% power to detect a 10% short-term change in the selected air pollutants for a 10 cent change in price.

We used average daily pollution data from two monitoring stations that are the city's most directly exposed to traffic emissions. These stations are near the city centre and near to major roads and freeways carrying 50,000 to 130,000 vehicles per day (see Appendix A) (Department of Transport and Main Roads, 2011). Both stations are subject to traffic emissions from all wind directions. We examined the following air pollutants that are markers of traffic-related air pollution: carbon monoxide, nitrogen oxides (NO_x) and particulate matter (Ban-Weiss et al., 2008). For particulate matter we examined both $PM_{2.5}$ (<2.5 μm) and PM_{10} (<10 μm).

We obtained average daily price data across Brisbane for unleaded petrol and diesel. Approximately 75% of vehicles in Brisbane are fuelled by unleaded petrol, and 20% by diesel, which covers 95% of vehicles (Australian Bureau Statistics, 2013).

2.1. Statistical methods

We were only interested in the short-term association between fuel price and pollution. Long-term changes in pollution levels are due to

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other factors such as improved combustion technologies, and long-term changes in fuel prices are due to multiple factors including international exchange rates. We removed these long-term trends and the seasonal variation in daily pollution and prices using a natural spline with three degrees of freedom per year (Barnett and Dobson, 2012).

We assumed a linear association between daily fuel price and pollution, and allowed a potentially delayed association, as fuel bought today can be used several days later. We assumed a maximum lag of 16 days between prices and pollution. This was based on local data using: an average fuel tank of 68 l, an average fuel consumption of 13.8 l per 100 km, and average daily distance travelled of 31 km (Australian Bureau Statistics, 2013). Using these figures an average full tank would need refilling in 15.8 days.

We present the results as a percentage change in pollution levels, using the change from the overall pollution averages for 2010 to 2013.

2.2. Missing pollution data

There were some missing pollution data (see Appendix A). We imputed missing daily data from a monitoring station by exploiting the strong correlations between: i) multiple pollutants from the same station (e.g., CO and NO_x at station A), and ii) the same pollutant at other stations (e.g., CO at station A and CO at station B). We tested the accuracy of this imputation by randomly deleting 30 observations and comparing our predicted and observed values. The R-squared values for these predictions were all above 70% for pollutants that were used (see Appendix A). If a pollutant had more than 5% missing data at a given station then we did not use it.

3. Results

Higher diesel prices were associated with statistically significant short-term reductions in NO_x and CO (see Fig. 1). The percentage reductions from the lowest to the highest diesel price were around 30% for NO_x and 70% for CO. There were no statistically significant associations with unleaded petrol prices, as the 95% confidence intervals in Fig. 1 contained 0% for all prices. $PM_{2.5}$ and PM_{10} levels were not associated with either diesel or petrol prices.

4. Discussion

Our results show that concentrations of some traffic-related air pollutants were greatly reduced in the short-term when fuel prices were high in Brisbane. Higher prices reduce the number of vehicles on the road which directly reduces traffic emissions, and fewer vehicles means less congestion which can further reduce emissions. Higher fuel prices may also encourage more people to use public transport, which would also lower pollution levels.

We did not observe an effect of fuel price on $PM_{2.5}$ or PM_{10}. This was consistent with local emission inventories and source apportionment studies, which suggest that traffic emissions contribute a much greater relative proportion of CO and NO_x compared to particulates (Chan et al., 1999; Queensland Government Environmental Protection Agency, 2004).

Pollution levels were dependent on diesel but not unleaded petrol. Local emission inventories suggest that petrol vehicles are the major source of CO and NO_x (Queensland Government Environmental Protection Agency, 2004). The disparity between our results and the emission inventory could reflect to the regional scale of the inventory (hundreds of kilometres) versus our focus on a highly localised scale (less than 10 m), with pollution monitors located immediately proximate to emission sources. While diesel vehicles make up only 20% of the vehicle fleet in Brisbane, overseas studies have shown that they can emit a disproportionate share of the total traffic emissions of NO_x concentrations when measured near the source, such as in road tunnels (Ban-Weiss et al., 2008; Kirchstetter et al., 1999; Kristensson et al., 2004). Studies have also shown that diesel emissions can be reduced by 60–80% on weekends due to reductions in road freight, and this change has been associated with lower NO_x levels (Bahreini et al., 2012; Harley et al., 2005). It is therefore plausible that changes in diesel price have an appreciable impact on air pollution due to the reduction in diesel vehicles on the road.

Another possible explanation for the strong association with diesel is that drivers who are the most price-sensitive are those with the least fuel efficient and most polluting vehicles. This could be because those vehicles most affected by price are medium and large diesel trucks, which are a major source of traffic-related air pollution (Bahreini et al., 2012), or older passenger vehicles and four-wheel drives.

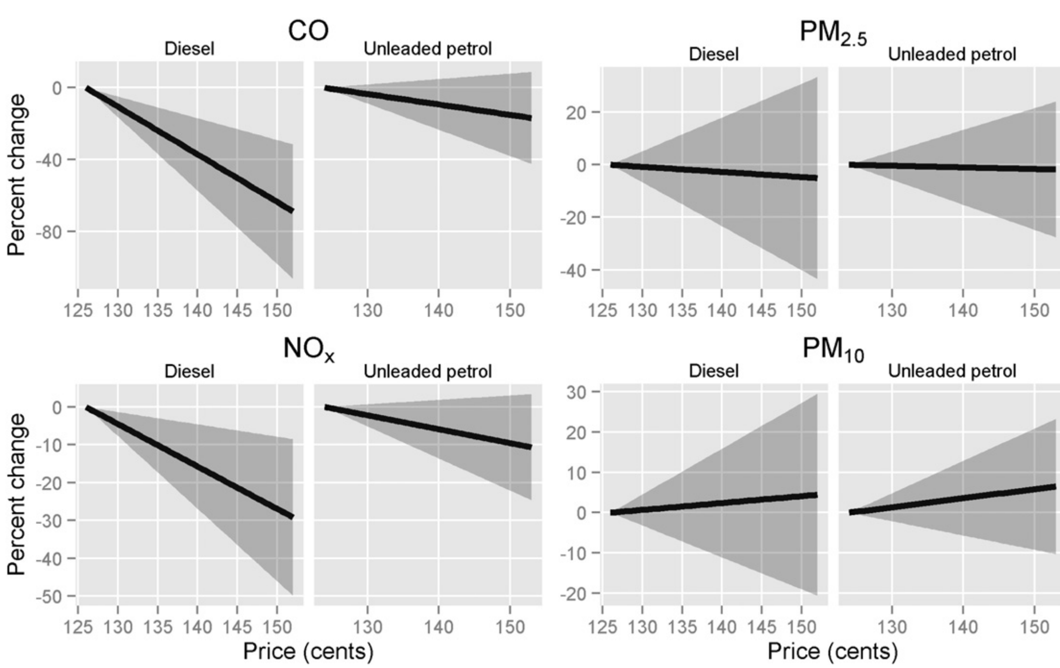

Fig. 1. Changes in percentage air pollution levels associated with changes in fuel prices in Brisbane, 2010–2013. The 0% level on the y-axis is the pollution level for the reference price of 126 cents for diesel and 124 cents for petrol which were the lowest prices during the study period.