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Marginal reductions in vehicle emissions under a dual-blend ethanol mandate: Evidence from a natural experiment

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ABSTRACT

Among the many reasons policy makers across the world have sought to supplement fuel supplies with ethanol-blended fuels are the cited environmental benefits that come with replacing a fossil-fuel with a cleaner burning alternative. Dual-blend ethanol mandates, in which multiple ethanol blends are simultaneously available, are one way policy markers can move forward with more aggressive mandates more quickly. The recent ethanol mandate in the state of New South Wales, Australia offers a unique natural experiment to quantify the potential environmental benefits and costs of a dual blend ethanol policy. This paper estimates the impact on carbon dioxide (CO_2) emissions from road-activity that are attributable to the implementation of the New South Wales ethanol requirements. We find that there was a decrease in emissions due to the policy, but that the decrease is relatively minor given the size of the market and that it comes at a high cost. The cost was over $1200 per ton of carbon to reduce gasoline emissions by just 1.2%.

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1. Introduction

Policy makers are faced with a variety of goals when confronting the multi-headed Hydra of domestic fuel policy. It is no surprise, then, that many countries have adopted ethanol mandates to confront the pressing issues of energy independence, volatile fuel costs, support of domestic industries and agriculture, and importantly — environmental concerns. As Heal (2010) notes, difficulties can arise when countries promote the use of renewable energy sources before fully analyzing the potential for fulfilling their specific policy objectives and the costs of doing so. Difficulties can compound further the more aggressive the policy objectives and the shorter the timetable for meeting them. To aid policy makers when considering the adoption or reconsideration of an ethanol mandate, this paper seeks specifically to comment on the environmental benefit of an ethanol requirement in terms of carbon dioxide (CO_2) reductions from road activity, relative to the costs of achieving that benefit, in the context of a specific and recent ethanol mandate. To our knowledge, ours is the first to evaluate the environmental effects of a "dual-blend" ethanol mandate — an aggressive type of mandate designed to increase ethanol in the fuel supply relatively more quickly. Ours is one of the few studies able to evaluate the effects of an ethanol mandate in a natural policy experiment setting, with comparable treatments and controls, as the mandate was a state-level and not a national-level mandate.

We examine the emission reductions induced by the ethanol mandate in New South Wales, Australia. Beginning in October of 2007 the state of New South Wales, Australia, required that a target proportion of total gasoline volumes include ethanol fuel. The first iteration of the mandate required 2% of the fuel supply be comprised of ethanol, and successive mandates increased the requirement to 4% and 6% of the total fuel supply.

The NSW mandate was relatively aggressive in the sense that regulators wanted to introduce ethanol blends while there was debate about its safety in about 20% of vehicles on the road. In order to move the mandate forward, regulators adopted a dual blend mandate — i.e. both E10 and a more expensive version of E0 were to remain simultaneously available. In this case, premium fuel would serve as the ethanol-free E0. The design was intended to move consumers whose vehicles could handle E10 onto E10, while ethanol-free fuel would

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remain available, albeit more expensively, only for those vehicles that needed it. The goal of the mandate was to replace all unblended regular gasoline with E10 within five years, while leaving premium fuel unaffected.

This is different from the adoption of E10 in the U.S. where E10 was implemented almost universally and E0 largely disappeared as a choice. It is more similar to the current (slower) transition from E10 to E15 in the U.S. made necessary by increases in the U.S. ethanol targets. As E15 is not suitable for all vehicles, both must remain available, and the cost of a RIN (Renewable Identification Number), paid by producers and blenders, creates a price wedge between E10 and E15 designed to move consumers on to E15 wherever possible. The EPA and automobile manufacturers disagree substantially on the percentage of vehicles that can safely use E15, however. The EPA has certified E15 for all 2001 and later model vehicles (about 70% of the fleet) while automobile manufacturers report that E15 is suitable only in some post-2012 models (about 10%) and that its use may damage engines and void manufacturer warranties. Consumer enthusiasm for E15 has thus been low and adoption has been poor. Further, supply-side issues may also serve to impede E15 adoption because suppliers are unsure if they would be liable for misfueling, or because of the need to balance and conform to Reid Vapor Pressure standards (among other potential concerns).

Unlike many other mandates national in scale, the Australian experience lends itself well to a controlled treatment effect analysis. The NSW mandate was not adopted nationwide, so other states within Australia that sell ethanol-blended fuels can serve as control groups, subject to the same federal policies and global influences, but absent a large scale ethanol mandate. We are thus able to distinguish between the change in emissions directly due to the passing of the ethanol mandate from what might have occurred naturally given existing market forces or relative price fluctuations. From this policy treatment effect analysis, we are able to quantify the amount of emissions that have been abated, or more accurately — avoided, due to the mandate-induced rise in ethanol-blended fuel consumption.

We seek to answer four questions: By how much did CO_2 emissions change in NSW as a direct result of the ethanol mandate? How much was the cost per ton of CO_2 abated? How does this cost compare to original expectations and to costs for comparable reductions in other parts of the world where a universal, rather than a dual-blend, mandate has been used? How does it compare to the cost of alternate methods of carbon reduction?

To preview results, we find that there is a statistically significant but globally small decrease in the amount of vehicle-emissions due to the policy, 14,501 tons of CO_2 per month. The reduction was marginal and well below the carbon reduction goals the state was hoping to achieve. The reduction amounted to 1.2% of monthly New South Wales emissions or about 0.0032% of monthly CO_2 emissions from U.S. energy sources (in 2014). Yet for consumers, the small impact came at a sizable cost. Combining our results with information on the costs of implementation and production from government sources and information on increased pump prices from Noel and Roach (2016), we find that consumers, taxpayers and firms ultimately paid between \$1276.50 and \$1407.53 per ton of CO_2 to make only a dent on emissions from gasoline; an expensive way to achieve a marginal improvement in environmental quality. This figure is substantially higher than that initially expected, higher than comparable international figures, and higher than that attainable from other means of attaining emissions reduction goals.

In particular, we contrast our figures to Meng et al. (2013). Meng simulates carbon reductions from a carbon tax and finds that a \$23 per ton carbon tax in Australia should cause CO_2 emissions to decrease by up to 12%. In our paper, we find that the implementation of the dual blend ethanol mandate resulted in just 1/10th as much emission reductions as that projected by Meng, and did so at a cost 56 to 61 times greater. The \$23 price tag used by Meng derives from the Australian Clean Air Regulator's regulated permit price for releasing a ton of carbon into the atmosphere at \$23 in 2012/2013. We conclude that the NSW ethanol mandate was exceptionally expensive relative to other methods of carbon reduction.

We proceed as follows. Section 2 gives additional background and insights from the recent literature on the costs of ethanol mandates. Section 3 discusses the data and the methodology used in the analysis. Section 4 presents results and Section 5 concludes.

2. Literature and background

Ethanol mandates have become popular over the past decade and over sixty nations have implemented some form of one (GFRA, 2014). Purported benefits include environmental benefits, greater energy independence, and benefits to a domestic ethanol industry. The fact that ethanol production and consumption can affect a variety of industries is one of the reasons for its recent surge in popularity among policy makers (Charles et al., 2007).

However, mandates also come at a cost, a cost that is higher to the extent that there are unintended consequences (Jaeger and Egelkraut, 2011). For example, the passing of an ethanol mandate can potentially lead to higher land and food prices, increased use of water to grow the fuel source, and increased energy-use from polluting sources to process plant materials into fuel (Pimental, 2003; Jaeger and Egelkraut, 2011; Carter et al., 2013; Wu and Langpap, 2014). Griffin (2013) states that it is time to reconsider ethanol mandates in the U.S. because the realized benefits have been minimal. Griffin (2013) and Carter et al. (2013) further note that there are negative spillover effects from the U.S. ethanol mandate in developing countries in the form of higher food prices. Along the same lines, Drabik and De Gorter (2013) show that there is "leakage effect" and that emissions increase elsewhere in the world from U.S. fuel standard policies because oil prices decrease. Grafton et al. (2012) recognize this shift in equilibrium prices and induced demand for fossil-fuels as a green paradox. Charles et al. (2007) mention several potential drawbacks of developed countries championing a biofuels policy, including environmental drawbacks, and find the justification used by these governments to be "questionable".

Only a few other studies have measured the amount of emissions that have been mitigated due to ethanol consumption, though none from a treatment effect point of view. Szklo et al. (2005) find that 5.4 million metric tons of CO_2 emissions per year are avoided in Brazil due to ethanol consumption. Nguyen and Gheewala (2008) find that in Thailand the consumption of biofuels leads to a 4.3% life-cycle decrease in emissions compared to gasoline. Greaker et al. (2014) use a numerical simulation to show that the introduction of a renewable fuel standard slows the rate of oil depletion. The authors also find that even when biofuels are as emissions-intensive as oil a renewable fuel standard may reduce climate costs. Grafton et al. (2012) find that the opposite holds. Namely, that the adoption of new policies hurries the depletion rate of fossil fuels and causes more damage. Grafton et al. (2012) do include the caveat that a "green paradox" is not a general result and that under certain specifications this effect ceases to hold. Given the very long half-life of CO_2 emissions, though, this discrepancy in the delay in emissions is less meaningful in the scope of greenhouse gas accumulation over time. Even the Economist has contributed to the discussion on biofuels and their environmental impact by noting that the "biofuels that can best compete commercially are not, in fact, green", and that "those that are green cannot compete commercially". (Economist, 2015).

Paying attention to the relative costs of passing an ethanol policy Henke et al. (2005) show that the abatement costs of using ethanol in Germany are about ten times the cost of simply purchasing permits on the open market. The authors also note that "with the same economic effort a larger amount of [greenhouse gas] emissions could be avoided elsewhere" (Henke et al., 2005). Jaeger and Egelkraut (2011)