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Precipitation, Profits, and Pile-Ups

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Abstract

In considering the economic impacts of climatic changes, economists frequently use annual national income as a proxy for social welfare. I show that such studies suffer from a significant bias, arising from the fact that such models typically ignore changes in mortality rates. Using panel data from Australia, I show that rainfall lowers traffic deaths, suggesting that the standard approach may underestimate the true economic cost of droughts.

JEL Codes: I12, I31, J17, Q25

Keywords: national income; social welfare; rainfall; traffic fatalities

1. Introduction

Over recent years, a spate of studies have studied the relationship between rainfall and social welfare (eg. Masters and Sachs 2001; Buckle et al 2002; Sica 2005; Barrios, Bertinelli and Strobl 2006). Such models exploit variation in rainfall over time, and across regions, taking advantage of the fact that weather conditions are exogenous with respect to economic conditions. Estimates of the impact of rainfall on social welfare have important policy implications, and are often used to forecast the economic impact of extreme weather conditions, such as drought or climate change.

One factor that is common in most of these models is the use of GDP as a measure of social welfare. While the limitations of GDP have been noted by many economists (see Islam and Clarke 2002 for a review of this literature), researchers have tended to take the view – implicitly or explicitly – that GDP is a sufficient statistic for considering the impact of rainfall on social welfare.

In this paper, I estimate the impact of increased rainfall on traffic accident fatalities. This focus is motivated by two factors. First, in OECD countries, road traffic crashes are the leading cause of death for people aged 15-24. Second, the social welfare cost of traffic deaths is largely ignored in GDP calculations. If rainfall significantly affects traffic deaths, then this should be taken into account in considering the impact of rain on social welfare.

To test this theory, I use data from Australia, a developed country with a significant agricultural sector.[1] Since the relationship between rainfall and GDP is reasonably well established for Australia, this provides a useful benchmark against which the impact of rainfall on road deaths can be compared.

2. Rainfall and Traffic Deaths

In principle, rain will impact road deaths in two ways: it will make driving conditions more dangerous, and it will cause drivers to adjust their behavior. Since these two effects operate in opposite directions, the net effect of rainfall on road deaths is theoretically ambiguous. Although some studies have tended to find that the risk of a road accident is higher on the day that it rains (see eg. Keay and Simmonds 2006 for Australia), these studies often fail to take account of the possibility that rainfall may have a lagged effect on traffic deaths. Using monthly data from US states over the period 1975-2000, Eisenberg (2004) shows that traffic deaths are *lower* in months with higher rainfall – which he attributes to drivers slowing down the day after rain.

The data for this study are drawn from three sources. Rainfall figures are taken from the Bureau of Meteorology, and apply to the closest weather station to the centre of the main city in the state. Rainfall and traffic data do not match perfectly, since rainfall prior to 9am is assigned to the previous day. (Note that rain is the only relevant form of precipitation for Australia, as its major cities are almost never affected by snow.) Road fatalities are from the Australian Transport Safety Bureau. Population statistics are from the Australian Bureau of Statistics. Figures are available for the eight states and territories in Australia over the period

[1] In 2005, 8 out of every 100,000 Australians were killed in a motor accident, a figure that is slightly below the OECD median of 9.5 per 100,000 (ATSB 2007).

from January 1989 to April 2006, and are aggregated to the state-month-year level, giving a sample size of 1664.

The mean monthly rainfall is 0.075 meters, with a standard deviation of 0.095. The mean number of monthly road fatalities in a state is 19.847 with a standard deviation of 18.002. The mean distance travelled per month is 1.801 billion kilometers, with a standard deviation of 1.606. The fact that rainfall is exogenous with respect to traffic deaths obviates the need for additional controls. The estimating equation is:

$$Deaths_{it} = \beta Rainfall_{it} + \rho Distance_{it} + \delta_i + \gamma_t + \varepsilon_{it}$$

Where *Deaths* is the number of traffic deaths per 100,000 people in state i and month-year t, *Rainfall* is total monthly precipitation, *Distance* is the number of kilometers travelled in that state and year, δ is a state fixed effect (capturing state-specific factors affecting rainfall and traffic deaths), and γ is a month×year fixed effect (taking account of changes in vehicle technology and policing that affect road safety in all states simultaneously). Standard errors are clustered at the state level. The equation is estimated using a Poisson model.

Table 1 shows the results, indicating that a 0.1 meter rise in rainfall (about one standard deviation) lowers the number of traffic deaths by 3 percent, a figure very close to the 3.8 percent estimated by Eisenberg (2004) on US data. Daily analysis on Australian data (not shown) indicates a rise in traffic fatalities on the day of rainfall, followed by an even larger fall in fatalities on subsequent days. In the daily specification, both the contemporaneous increase and the lagged decrease are statistically significant. The rise in mortality on the day of rainfall might be caused either by the danger of more slippery roads or by a temporary increase in mileage. The fall in mortality on subsequent days is most likely due to motorists overcompensating in their driving behavior in the days after a downpour.

Table 1: Rainfall and Traffic Deaths
Dependent variable is traffic fatalities in a given month and state

Rainfall	-0.301**
	[0.146]
Distance travelled	0.004*
	[0.002]
Constant	0.788***
	[0.168]
State FE	Yes
Month×Year FE	Yes
Observations	1664

Note: ***, ** and * denote statistical significance at the 1%, 5% and 10% levels respectively. Standard errors, clustered at the state level, in brackets. Rainfall is in meters. Distance travelled is the annual number of motor vehicle kilometers (in billions) travelled in that month, year and state.

The leading estimate of the value of a statistical life in Australia is Abelson (2003), who estimates a figure of $2.5 million for avoiding an immediate death of a healthy individual aged about 40 (approximately the average age of death for motor vehicle accident victims). Assuming that the cost of a traffic accident death is regarded as being incurred in the year of death (rather than being amortized over the potential lifetime), and taking the 2006 road toll of 1601, this indicates that a 0.1 meter drop in rainfall leads to 48 additional road deaths, which is equivalent to an economic cost of $120 million. However, virtually none of this cost will show up in economic output in the year of death, since the victim's lost earnings will be counterbalanced by the costs associated with the death – medical expenses, funeral expenses, coroners' costs, and (in some cases) the judicial system.

Many of the recent the estimates of the relationship between rainfall and income for Australia relate to the 2002 drought, which saw rainfall down by 0.25 meters in the typical Australian state. The 2002 drought is generally estimated to have reduced Australian GDP growth by 1 percentage point (Reserve Bank of Australia 2002; Adams et al 2002; Horridge et al 2003; Lu and David Hedley 2004). With 2002-03 GDP of A$782 billion, this suggests that the impact of the drought on the Australian economy was A$7.8 billion.

However, since these estimates are based on changes in output in the agricultural sector, they do not take account of effects on road fatalities. The estimates in Table 1 suggest that the drought had an additional economic impact – it also led to 120 additional road fatalities. At $2.5 million per life, and assuming that this cost is borne in the same year, this implies a further social welfare loss of $300 million as a result of the 2002 drought, suggesting that the use of GDP understates the true economic cost of drought by 4 percent.

3. Conclusion and Policy Implications

Speaking at the University of Kansas in 1968, Robert Kennedy noted the limitations of national income as a measure of wellbeing: "Gross National Product counts air pollution and cigarette advertising, and ambulances to clear our highways of carnage". In using national income as a measure of social welfare, researchers frequently ignore the economic burden of highway carnage. Furthermore, as the agricultural share of the national economy shrinks, and car commuting rises, the relative importance of traffic accidents can be expected to increase.

With climate change models predicting that global warming will lead to an increase in rainfall in high latitudes, and reductions in rainfall in the subtropics (Stern 2006), accurate modeling of the impact of rainfall on social welfare is of some policy importance. My results (and those of Eisenberg 2004 for the US) therefore imply that global warming will cause traffic deaths to fall in high latitudes, and rise in the subtropics.

For those seeking to model the impact of climatic changes on social welfare, there are two ways of taking road fatalities into account. One is to focus only on GDP, but to explicitly acknowledge its limits as a measure of social welfare. The other is to take a broader approach, considering economic costs such as road deaths that are not fully encapsulated in the national accounts.

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Appendix: Daily Traffic Deaths

To see the effect of current and lagged rainfall on motor accident deaths, I estimate a similar equation to that which is shown in the body of the paper, but on daily data, taking account of lagged effects. Here, the estimating equation is:

$$Deaths_{it} = \sum_{n=0}^{6} \beta_n Rainfall_{it-n} + \rho Distance_{it} + \delta_i + \gamma_t + \varepsilon_{it}$$

Where *Deaths* is the number of traffic deaths per 100,000 people in state i and day t, *Rainfall* is daily precipitation on that day (and the 6 days prior), *Distance* is the number of kilometers travelled in that state and year, δ is a state fixed effect, and γ is a month×year fixed effect. Standard errors are clustered at the state level. The equation is estimated using a Poisson model.

Appendix Table 1 shows the results. On a given day, a centimeter of rain (0.01 meters) boosts the number of traffic deaths by 1.9 percent. However, this is more than offset by a 2.3 percent fall in deaths two days afterwards, and a 1.2 percent fall in deaths three days afterwards. (The insignificant coefficient on day t-1 is most likely explained by two countervailing effects.) Summing the seven rainfall coefficients, the net impact of a centimeter of rain is to lower fatalities by 3.6 percent (significant only at the 14 percent level).

Appendix Table 1: Daily Rainfall and Traffic Deaths
Dependent variable is a state's traffic fatalities on day t

Rainfall t	1.935*
	[1.073]
Rainfall t-1	0.244
	[0.610]
Rainfall t-2	-2.260***
	[0.681]
Rainfall t-3	-1.165***
	[0.316]
Rainfall t-4	-0.702
	[0.553]
Rainfall t-5	-1.026
	[1.219]
Rainfall t-6	-0.645
	[0.659]
Distance travelled	0.004*
	[0.002]
Constant	-2.640***
	[0.186]
State FE	Yes
Month×Year FE	Yes
Observations	50554
Sum of rainfall coefficients (t to t-6)	**-3.619**
	[2.405]

Note: ***, ** and * denote statistical significance at the 1%, 5% and 10% levels respectively. Standard errors, clustered at the state×year level, in brackets. Rainfall is in meters. Distance travelled is the daily number of motor vehicle kilometers (in billions) travelled in that state.