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Rational Response to Irrational Attitudes: The Level of the Gasoline Tax in the U.S. States[1]

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Abstract

Some numerical values are more salient than others to the public, and some particular values carry strong messages. We find that policymakers recognize these principles, with states avoiding setting gasoline taxes at exactly ten cents per gallon. This avoidance appears to be substantively important.

1. Introduction

Retailers often price items at $9.99 rather than $10.00. They may do so to fool consumers into viewing the price as closer to $9.00 than to $10.00, or to signal consumers that the product is on sale (for evidence, see See Stiving and Winer (1997)). Similarly, workers highly desire a six-figure income----a salary of $100,000 sounds much more impressive than a salary of $99,999.

This paper explores related behavior by government. Suppose legislators attempt to reduce the salience of increases in the gasoline tax by avoiding moving gasoline taxes into double digits, and suppose that once taxes are moved beyond the double-digit threshold, legislators might as well raise them a little more than just the threshold increment in order to compensate for the increased visibility they have incurred. We might then see two patterns: relatively few states imposing a tax of exactly ten cents, and a more general avoidance of double-digit taxes. The data confirm this pattern.

Such attention to nominal values can lead to peculiarities. Consider the following thought experiment. A state is observed to impose a tax of eight cents on a gallon of gasoline. But were it forced to specify the tax as so many cents per quart, it would impose a tax not of 2 cents per quart, but of 3 cents per quart. Were such behavior common, then to explain the level of taxes we would need to consider not only the usual economic and political explanations, but also to consider the nominal values of taxes.

In the following we present two different ways of testing for the importance of nominal values. Our focus is on gasoline taxes in the different states in the United States. Such taxes are both substantively important, and well suited for study since much data are available on them.

2. Avoidance of ten-cents taxes

Our test of whether states avoid setting taxes of exactly ten cents per gallon is given by Table 1 below, which lists the frequency of taxes. We see, for example, that in 72 cases the tax lied in the interval of 9.5 cents to 10.5 cents inclusive. Of these, the number of observations with a tax of exactly 10 cents was 30 (41.67 percent of the taxes in the interval between 9.5 and 10.5). Inspection of the table shows that 10 cents was far less likely to be chosen within an interval than any other integer within an interval. The next closest integer to this is 14, in which 58.14 percent were at the integer level. A Chi-square test shows that the proportion of integer values within a range differs for 10 cents compared to all other ranges at better than the one percent significance level. States avoid a tax of 10 cents far more than they avoid any other integer value.

3. Avoidance of double-digit taxes

The data above referred to taxes of exactly ten cents. To test more generally for avoidance of double-digit taxes we turn to a different statistical test, for violations of Benford's Law. This law describes how often we expect the leading digit in a distribution of numbers to take on each value from 1 through 9, showing that for scale invariant measures, or measures where nominal values play no role (that is for measures which can be stated in miles or kilometers, gallons or quarts, and so on) the proportion of numbers beginning with digit *d* is *log(1 + 1/d)*; for example, the digit 1 occurs with a probability of about 30 percent.[2] (See Benford (1938); for a recent exposition see Hill (1998)). The Dow-Jones Index and the Standard and Poor Index well fit the distribution described by Benford's Law. So do populations of the counties in the United States. Indeed, violation of Benford's Law has been used to detect tax fraud (Hill 1998).

Figure 1 shows the distribution of the most significant digits for state gasoline taxes (on the left) and the distribution predicted under Benford's Law (on the right). Visual inspection suggests that Benford's Law is grossly violated. Chi-square tests confirm that the distribution predicted by Benford's Law is violated at better than the 1 percent significance level. Most noticeable is a shortage of taxes that begin with the digit 1. Since the taxes rarely exceed twenty cents per gallon and are rarely set at one cent, the avoidance of taxes with *1* as the most significant digit corresponds to avoidance of double-digit taxes.

4. Conclusion

We demonstrated that states care about nominal values of taxes, showing a strong bias against a gasoline tax of exactly 10 cents, and more generally to double-digit taxes.

Gas taxes can be politically significant (think of the protests against such taxes in Europe in the summer of 2000, or the proposal by congressional Republicans to reduce the federal tax that year). But we also think that the effects can appear in other areas. Consider the content of President Clinton's weekly radio addresses. In them he used the number "eight" in 27 addresses, and the number "nine" in 16 addresses; but he used "ten"

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[2] One way to understand the distribution is to begin with the idea that a histogram of significant digits should remain the same regardless of what unit is used. Consider what happens to the measurements in switching from a tax on half-gallons to a tax on gallons. Under scale invariance, all the taxes should double. This means that all taxes which used to start with 1 will now start with 2 or 3, and all measurements which used to start with 2 will now start with 3, 4 or 5. But measurements which used to start with 5, 6, 7, 8, or 9 will now all start with 1. The only distribution of the most significant digits which is invariant under such a unit transformation is the one described.

in only 9 addresses, and “eleven” in only 1. Successful politicians have divined that the public is sensitive to particular numbers, which students of public policy should heed. And so we might also ask whether new programs are long limited to budgets below $1 billion, or whether high schools avoid enrolling more than 1,000 students. If the answers are yes, then analyses should note that nominal values constrain public policy.

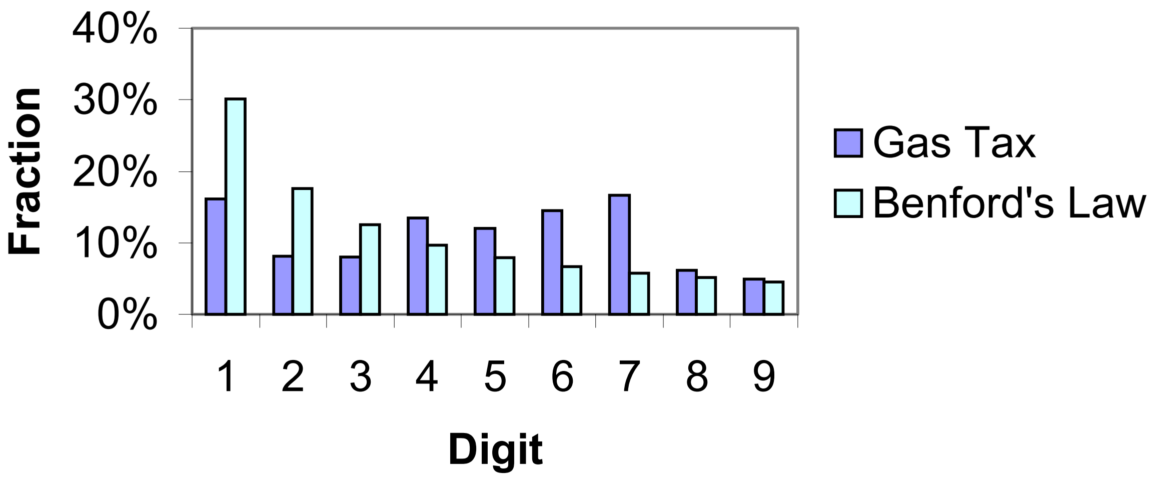
Table 1: Distribution of gasoline taxes, 1919-1995, All 50 US states

Range (cents)	Number of observations		Fraction at integer
2.5-3.5	289		
3		274	94.81%
3.5-4.5	491		
4		462	94.09%
4.5-5.5	446		
5		404	90.58%
5.5-6.5	538		
6		408	75.84%
6.5-7.5	708		
7		529	74.72%
7.5-8.5	289		
8		179	61.94%
8.5-9.5	208		
9		154	74.04%
9.5-10.5	72		
10		30	41.67%
10.5-11.5	95		
11		66	69.47%
11.5-12.5	37		
12		30	81.08%
12.5-13.5	65		
13		54	83.08%
13.5-14+.5	43		
14		25	58.14%
14.5-15.5	66		
15		45	68.18%
15.5-16.5	55		
16		48	87.27%
16.5-17.5	42		
17		31	73.81%
17.5-18.5	71		
18		47	66.20%
18.5-19.5	38		
19		23	60.53%
19.5-20.5	50		
20		46	92.00%
Total	3,603	2,855	79.24%

Note: In addition, in 267 cases the tax was exactly 0, in 64 cases the tax was exactly 1 cent, and in 145 cases the tax was exactly 2 cents.

Source: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics.*

**Figure 1:
Distribution of First Significant Digit
of Taxes**



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