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Insights

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RATIONAL RESPONSE TO IRRATIONAL ATTITUDES: THE LEVEL OF THE GASOLINE TAX IN THE UNITED STATES

Thomas L. Brunell and Amihai Glazer

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 (e.g., 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 to compensate for the increased visibility they have incurred. Two patterns might result: relatively few states imposing a tax of exactly 10 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 8 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 it would be necessary to consider not only the usual economic and political explanations, but also the nominal value 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.

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AVOIDANCE OF 10-CENT TAXES

Our test of whether states avoid setting taxes of exactly 10 cents per gallon is given by Table 1, which lists the frequency of taxes. We see, for example, that in 72 cases the tax lay 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 χ^2 test shows that the proportion of integer values within a range differs for 10 cents compared with all other ranges at better than the 1 percent significance level. States avoid a tax of 10 cents far more than they avoid any other integer value.

AVOIDANCE OF DOUBLE-DIGIT TAXES

The data above referred to taxes of exactly 10 cents. To test more generally for avoidance of double-digit taxes we turn to a 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[1] (Benford, 1938; for a recent exposition see Hill, 1998). The Dow-Jones index and the Standard and Poor index fit well the distribution Benford's Law describes. 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). For example, 3.7 percent of the taxes were 2 cents, 0.01 percent were 2.5 cents, and 3.7 percent were 20-something. So in total, in 7.4 percent of the cases the first digit of the tax was 2. Visual inspection suggests that Benford's Law is grossly violated. χ^2 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 20 cents per gallon and are rarely set at 1 cent, the avoidance of taxes with 1 as the most significant digit corresponds to avoidance of double-digit taxes.

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

[1] One way to understand the invariance of the distribution of significant digits when measurement units are changed is to think of a histogram of each of the distributions. They should be identical. 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 by Benford's Law.

Table 1. Distribution of gasoline taxes, 1919–1995, all 50 U.S. 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%
19.5–10.5	50		
20		46	92.00%
Total	3603	2855	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.

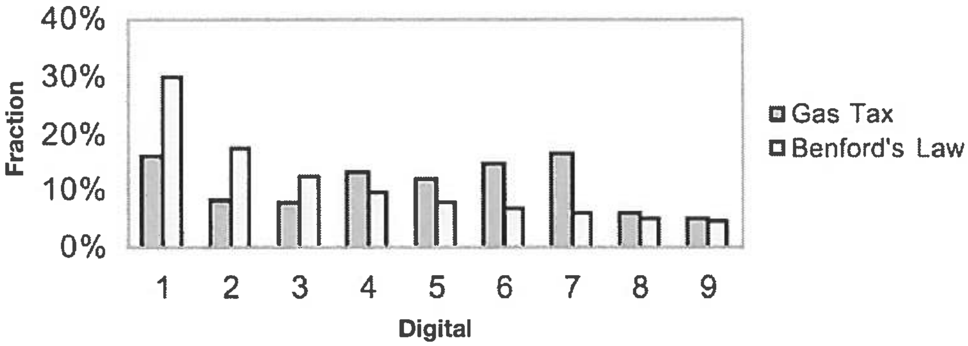

Figure 1. Distribution of the first significant digit of taxes.

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 8 in 27 addresses, and the number 9 in 16 addresses; but he used 10 in only nine addresses, and 11 in only one. 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 1000 students. If the answer is yes, then analyses should note that nominal values constrain public policy.

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