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Population Shifts and Discrete Public Services: Rationing Rules and the Support for Public Goods

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Abstract

Cities with declining populations face increasing per-capita costs to maintain discrete public goods—those with fixed costs that cannot be easily scaled to demand. Likewise, growing cities may face decreasing benefits from congestible public goods. In either case, there are two policy actions: limit access (ration) or expand output (higher revenues per person required). We report the results of a series of experiments designed to investigate the effect of alternative rationing rules on the propensity for individuals to support increases in taxes to overcome congestion externalities or decreases in the tax base.

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While Samuelsonian pure public goods are not subject to congestion, the literature has long recognized the importance of congestion effects in a broad class of public goods (Bergstrom and Goodman 1973; Oates 1988). Congestion—the decline in individual consumption due to an increase in the size of the consuming group—is particularly an issue with discrete quasi-public goods that require large lump-sum investments for increased provision, such as public schools and fire stations/protection. As these discrete or "lumpy" public goods do not scale easily, large changes in the population of users are an important source of congestion effects and present unique challenges for rapidly evolving cities and towns. Previous work has shown that a more populous municipality will offer a wider range of services, which Oates (1988) attributes to the fact that some public goods require a substantial initial investment and therefore a sufficient number of taxpayers. But whereas that issue is concerned with population size and the large initial investment of a single unit of provision (e.g., a zoo and an airport), the questions we pose revolve around population change and the large expenditures necessary for an additional unit (e.g., a school and a fire station).[1]

Consider municipalities with a growing population. The increase in users creates congestion in the services of lumpy public goods, and the municipality must either *ration* the current levels of service or increase the level of service. If the growth in the population is not evenly divisible by the population served by an additional discrete unit of the public good, the municipality must *raise taxes* to increase the levels of service. This was the situation in the fast-growing southwest suburbs of Chicago during the 2000s, Denver in more recent years, and several other urban areas in the southeast and southwest areas in the United States.

In the case of Chicago, the influx of new residents to the area's cities and towns created congestion in schools, among other services, and the construction of new schools required public approval of increased taxes via a referendum. The public initially rejected increases in tax rates, thereby choosing to ration services, but eventually approved higher taxes to maintain per capita levels of services.[2] Now, consider the case of a city or town with a declining population. Again, if the decline is not evenly divisible by the population served by each unit of the discrete good, the reduction in users creates idle capacity, and the municipality must either *increase taxes* to sustain current levels of service or ration lower levels of service. For example, between 1950 and 2008, the population of Detroit, Michigan, declined by 50 percent, and today, nearly a third of housing units are vacant. The severity of the change precluded the option to maintain services with additional public funding, so the city opted to ration by reducing services to sections that comprise over 20 percent of the city (Dolan 2010). Therefore, whether it is rising or falling, a change in population presents similar options for the provision of lumpy public goods: ration services or raise taxes. As in the Chicago suburbs example, the decision can be synthesized with a referendum that determines whether to increase taxes to avoid rationing or ration to avoid higher taxes.[3]

The likelihood that voters will accept rationing to avoid higher taxes may depend on the rationing rule. Consider two types of rationing: *proportional* and *exclusionary*. Purely proportional rationing spreads congestion effects evenly by lowering individual consumption of all users. The overcrowding of schools experienced in the southwestern suburbs of Chicago illustrates this type of rationing. Purely exclusionary rationing alleviates the congestion by restricting access to some users to maintain the individual consumption of other users. Detroit choosing to stop serving specific sections of the city illustrates exclusionary rationing. Of course, rationing often represents a hybrid of each rule, wherein the reduction in quality for some is less than the reduction in quality for others.[4] Standard theory suggests that risk-averse individuals will prefer, ceteris paribus, a proportional loss with certainty over the full loss (exclusion) with a proportional probability. Therefore, one may expect relatively greater support for tax increases aimed at avoiding exclusionary rationing as compared to proportional rationing. Evidence, however, suggests that individuals often exhibit nonstandard preferences, including anchoring on the status quo and overconfidence about their chances for success (Camerer and Lovallo 1999). If the influence of status quo bias and overconfidence is large enough, individuals may prefer to take their chances at maintaining the status quo under exclusion than suffer a certain proportionate loss and will be more likely to support tax increases if rationing is proportional rather than exclusionary.

To examine this question, we develop a theoretical framework that captures congestion with lumpy public goods and test the theoretical implications using experimental methods. While field data exist, it is filled with confounding elements that impede the ability to isolate the behavioral responses to taxes and rationing mechanisms (Oates 1988). The experimental method is particularly useful in public economics because the lab offers control over the heterogeneity and uncertainty with the returns of public goods and direction of tax revenue, while also using induced values that mitigate many of the issues associated with secondary data.[5] We develop a set of experiments that investigate the acceptability of higher taxes under two alternative mechanisms to ration the returns from the public good. We find the standard theory of risk aversion does an inferior job of explaining behavior than nonstandard theories of status quo bias and overconfidence: support for raising taxes is greater when rationing is proportional than exclusionary. Results also corroborate previous studies that show considerable levels of tax aversion—people vote against a tax that is in their financial self-interest (Cherry, Kallbekken, and Kroll 2014; Kallbekken, Kroll, and Cherry 2011).

Theoretical Outline

Consider a town with population P that is served by a lumpy public good at cost C (or on a per-capita tax basis, $t = \frac{C}{P}$, per unit where each unit has an optimal capacity of N users. Let Q represent the number of units of the lumpy public good, and let the per-capita benefit of the good be piecewise, at B up to its optimal capacity, then *proportionally rationed* at $\frac{BN}{P}$ when capacity is constrained at $P > N$. Therefore, for a population, the per-capita benefit is B up until $P = QN$ and then $\frac{BQN}{P}$ thereafter. An example of this type of benefit could be a fire station that can offer sufficient services to a town of 5,000 residents based on residences clustered sufficiently close to the station, uncongested roads at that population, or a sufficiently low likelihood of having more than one simultaneous call. Above 5,000 residents, the fire station still provides services, but these services decline on a per-capita basis as traffic makes responding more difficult, new population is sited further away from the station, and the likelihood of simultaneous calls increases.

It is straightforward to show that the optimal allocation of the lumpy public good occurs where the population is evenly divisible by the capacity of each unit. Our focus is on the suboptimal cases where a population faces the choice between raising taxes to support a suboptimally large number of units or suffering a service level decrease that may either be proportional or exclusionary. This dilemma exists for both increasing and decreasing populations, differing in that an increasing population will default into a service decrease without change in the number of units while a decreasing population will default into an increase in per-capita costs.

Let the initial population, P_0, be evenly divisible by N so that the current allocation of the public good is optimal. For a small ΔP, it will not be worthwhile to add or subtract another discrete large unit of the public good. But as $|\Delta P| \rightarrow N$, the extra cost of overprovisioning the good exceeds the losses from rationing. If $|\Delta P| > N$, at least one unit should be added or subtracted accordingly.

The region of interest is for increases or decreases of population less than N. For an increase in population, voters should support the addition of another unit of the good with the corresponding increase in the per-capita tax basis over a proportional reduction in access if the following condition holds:

$$B\left(\frac{QN}{P_0 + \Delta P}\right) - \frac{QC}{P_0 + \Delta P} < B - \frac{(Q+1)C}{P_0 + \Delta P}.$$

The left-hand side of the inequality is the reduced per-capita benefits from population growth without increasing the amount of the public good less the reduced per-capita cost of supplying the same amount of public good. The right-hand side is the restored per-capita benefit less the increased per-capita cost of supplying an additional unit of the good. Simplifying algebraically, we get the condition:

$$\Delta P > \frac{C}{B}. \tag{1}$$

If the population growth is greater than the costs divided by the per-capita benefits, or in other words if population growth exceeds the number of people it takes receiving per-capita benefits B to exceed the cost C, then another unit of the good should be financed. Otherwise, taxpayers are better off settling for rationing.

For a decrease in population, voters should support the subtraction of a unit of the good with the corresponding decrease in the per-capita tax basis over facing an increase in taxes if

$$B - \frac{QC}{P_0 - \Delta P} < B\left(\frac{(Q-1)N}{P_0 - \Delta P}\right) - \frac{(Q-1)C}{P_0 - \Delta P}.$$

The left-hand side of the inequality is the status quo per-capita benefits less the increased costs of supporting the status quo with a smaller population. The right-hand side is the reduced per-capita benefits after subtraction of a unit of the good less the reduced per-capita costs. This simplifies to

$$\Delta P < \frac{C}{B} - N\,. \tag{2}$$

For *exclusionary rationing*, there is a probability $\frac{QN}{P}$, if $QN < P$, that users will be able to access the good at its full per-capita benefit, B, and a probability $\left(1 - \frac{QN}{P}\right)$ that they will pay for the good but receive no benefit. Therefore, for an increase in population, risk-neutral voters should support the addition of another unit of the good if

$$\frac{QN}{P_0 - \Delta P}B - \frac{QC}{P_0 - \Delta P} < B - \frac{(Q+1)C}{P_0 - \Delta P}.$$

The left-hand side of the inequality is the probability weighted per-capita benefit less the per capita cost. The right-hand side of the inequality is the full benefit less the increased per-capita cost of providing an additional unit of the good. This simplifies for risk-neutral voters to

$$\Delta P > \frac{C}{B}. \tag{3}$$

This is the same as equation (1).

Finally, for a decrease in population with exclusionary rationing, voters should support the reduction of a unit of the good if

$$B - \frac{QC}{P_0 - \Delta P} < \frac{QN}{P_0 - \Delta P}B - \frac{(Q-1)C}{P_0 - \Delta P}.$$

The left-hand side of the inequality is full per-capita benefit of the good less the increased costs from a smaller population supporting the same amount of the good. The right-hand side of the inequality is the probability-weighted benefits of consuming the good less the decreased per-capita costs of providing less of the good. This simplifies to

$$\Delta P < \frac{C}{B} - N. \tag{4}$$

This is the same as equation (2).

Voters with concave utility (i.e., risk-averse voters) will prefer the expected value of a gamble over the gamble itself and should thus prefer proportional rationing with its certain values over equivalent exclusionary rationing.

Experimental Investigation and Hypotheses

How individuals will respond to proportional and exclusionary rationing is ultimately a behavioral question. Because conditions (1) and (3) are the same and conditions (2) and (4) are the same, a risk-neutral, rational agent

Table 1. Treatments and Parameters.

Rationing Rule	Group Size	Tax Level	Multiplier	Final Group Share
Proportional	3, then 9, then 3	2 vs. 2.5	1 vs. 1.4	Everyone consumes 3.2 vs. everyone consumes 4.0
Proportional	9, then 3, then 9	2 vs. 2.5	1 vs. 1.4	Everyone consumes 3.2 vs. everyone consumes 4.0
Exclusionary	3, then 9, then 3	2 vs. 2.5	1 vs. 1.4	2 Consume 4.3, 1 consumes 1.0 vs. everyone consumes 4.0
Exclusionary	9, then 3, then 9	2 vs. 2.5	1 vs. 1.4	6 Consume 4.3, 3 consumes 1.0 vs. everyone consumes 4.0

would respond to proportional and exclusionary rationing equally. However, a longline of behavioral research (see Tversky and Kahneman [1974] for an introduction to this long literature) has shown that individuals are subject to behavioral biases such as risk aversion, loss aversion, implicit anchoring, and status quo bias. Loss aversion and risk aversion would suggest that individuals would choose to provide more of the public good more eagerly under an exclusionary rationing rule, where citizens risk paying taxes and receiving no benefits, than under a proportional rationing rule. However, if citizens anchor on their level of good before the tax, they may be willing to gamble on continuing to receive those same benefits over accepting a guaranteed proportional reduction.

We have designed a set of experiments in which we have a public good provided from an initial tax obligation. After the initial set of individuals has enjoyed the good for a couple of rounds, we announce that the population consuming the good has increased or decreased with a consequent reduction in the multiplier. Thus, we have imposed congestion when the population is increasing and a loss from discreteness when the population is decreasing.[6] Depending on the treatment (see table 1), the resulting rationing takes the form of a reduction in availability of the good to all persons (shares fall for all subjects) or it takes the form of some randomly selected individuals being excluded from access.

The experiment consists of seventy-two subjects in four treatments with eighteen subjects each, with each treatment requiring one session. The treatments are outlined in table 1. Two of the treatments have subjects facing a proportional rationing rule, and two treatments have subjects facing an exclusionary rule. For symmetry, each of the rationing rule has a treatment in which group sizes are first increased before being decreased and one in which group sizes are first decreased and then increased. Specifically, all sessions begin with a baseline in which there are six persons in each group (three groups), and the net return to the public good contribution is 1.2 tokens. This setting is in place for two rounds, although subjects are not informed of this duration. In each of these rounds, there is no decision to be made. Subjects simply click through the instructions and payment screens. The purpose of these rounds is to present the tax payment and public good setting.

Before the third round begins, the treatment is introduced, and the three groups of six are either dissolved and randomized into six groups of three (if group size is decreasing first) or combined and randomized into two groups of nine (if group size is increasing first). The subtraction of subjects consuming the public good results in a lower multiplier from a reduction in economies of scale, while the addition of subjects consuming the public good results in a lower multiplier from congestion. Either way, less of the public good is provided to consumers, given the original tax (required contribution) level. The use of the multiplier and our choice of parameters were designed to make it *clearly superior* to vote for the tax increase. Our variable of interest is the strength of support for that tax increase.

As discussed, there are alternate rationing rules that could be imposed to address the reduction in public good in a naturally occurring setting. We have selected two polar settings for our investigation. All persons in the group may be provided a reduced share of the public good (proportional rationing). Alternatively, the good could be supplied to only some people on a random draw basis (exclusionary rationing). This would be typical of a good that could only be enjoyed if it was discrete and entirely available, such as a park or a fire station, or placing a child in a preferred school, utilities, or access to public health care. These rationing rules are the treatments reported in table 1.

After the rounds in which congestion appears and one of the above rationing rules is applied, all subjects are presented with the following choice setting. They vote whether to maintain the previous level of contribution and accept the lower level of service or whether to increase their contributions to maintain the previous level of service. As just described, the treatments (table 1) are the rationing rules imposed in the event the tax increase is rejected. The votes are tabulated and the results announced.

Subjects face the same choice each round regardless of whether the tax increase was approved in a previous round. After five rounds of voting and results, the group sizes are reset to six, and the game repeats with two rounds of the baseline, followed by one round of a new group size, followed by five more rounds of voting. The group size column of table 1 explains the ordering of group sizes. In groups that decrease from six to three at first, return to six and increase to nine, then return to six and decrease once again to three. The reverse is true for groups that initially increase to size nine. This allows us to tease out any order effects from the changes in group sizes. Appendix lays out the structure of the session.

The game is set up so that expected income is increased when the increased tax is passed (the congestion externality is overcome in the increasing case or the level of good is stepped up in the decreasing case). Our interest lies in how the exclusion rule changes the desire to vote for the tax increase. In the proportional reduction treatment, a subject voting yes is indicating a preference for a payout of 4.0 tokens to a payout of 3.2 tokens. In the exclusionary treatment, a subject voting yes is indicating a preference for a payout of 4.0 tokens to a two in three chance of receiving 4.3 tokens and a one in three chance of receiving 1 token. The expected value of risking exclusion is 3.2—the same as the status quo in the proportional treatment. A risk-neutral voter with no behavioral biases would support the tax increase with equal vigor under either rationing rule.

However, if subjects exhibit risk aversion, loss aversion, or rank-dependent expected utility, we would expect a stronger desire to avoid exclusion than to avoid a proportional reduction. As such, we put forth the following research question to be addressed with the data from the experiments. Does the rationing mechanism affect the likelihood a tax increase will pass under majority rule? Given that people are, on average, risk averse, which was confirmed for this subject pool with our risk-aversion measure, our formal hypothesis is that we would find greater support for the tax under proportional rationing.

Hypothesis 1: Support for the tax will be greater under an exclusionary rationing rule than under a proportional rationing rule.

Hypothesis 2: Support for the tax will be unchanged regardless of whether rationing is required due to an increasing or decreasing population.

Experiment Results

Computerized sessions programmed in Z-Tree (Fischbacher 2007) were conducted at the Appalachian Experimental Economics Laboratory at Appalachian State University.[7] Seventy-two undergraduate students participated in

Table 2. Support for Raising Taxes by Rationing Rule, Group Size, and Risk Preference.

	Proportional	Exclusion	Overall
Total	98.7%	77.0%	87.9%
	(0.5%)	(4.7%)	(2.7%)
	[540]	[540]	[1,080]
Group size			
Nine	98.1%	74.4%	86.3%
	(9.4%)	(5.6%)	(3.2%)
	[270]	[270]	[540]
Three	99.3%	79.6%	89.4%
	(5.0%)	(4.8%)	(2.7%)
	[270]	[270]	[540]
Risk preference			
Averse	99.0%	85.5%	91.6%
	(5.7%)	(4.6%)	(2.7%)
	[300]	[366]	[666]
Loving	98.6%	62.7%	87.0%
	(1.4%)	(11.3%)	(5.0%)
	[140]	[67]	[207]
Neutral	98.0%	57.0%	76.8%
	(1.3%)	(10.1%)	(6.6%)
	[100]	[107]	[207]

Note: Numbers in each cell are the percentages of yes votes, standard errors in parentheses, and the number of observations in square brackets. Standard errors are clustered at the subject level.

sessions lasting approximately one hour and received an average of US$21 for their participation. Each subject participated in one treatment (as listed in table 1). A moderator introduced subjects to the laboratory environment, and subjects participated in [Holt and Laury's (2002) risk preference elicitation game before proceeding to the main experiment.[8] Experimental earnings were denominated in tokens and converted into US dollars at a rate of 1.5 dollars per token at the end of the experiment. Subjects were paid for three rounds selected at random to mitigate risk pooling over periods and to make decisions in each individual round more consequential. At the end of the session, subjects answered a short questionnaire and were paid privately, individually, and in cash before leaving the laboratory.

Table 2 reports the support for increasing taxes (as measured by the proportion of yes votes in the referendum) by rationing rule, group size, and risk preference. The aggregate numbers reveal initial insights to our hypothesis. We observe a significantly higher level of support for higher taxes to alleviate congestion when the congested public good is rationed proportionally rather than with exclusion—98.7 versus 77.0 percent. This is a thorough rejection of our hypothesis. This result is consistent across the two group sizes of three and nine, though the smaller group appears more deterred by the exclusion rationing than proportional (79.6 vs. 74.4 percent). If voters are indeed risk averse, this result is inconsistent with standard expected utility theory or nonexpected utility theories (e.g., loss aversion and rank dependent). To confirm risk aversion, we examine the results from the Holt and Laury's (2002) risk-elicitation test. Approximately 62 percent of voters could be considered risk averse, while only 20 percent could be considered risk loving. These risk preference numbers correspond to those reported in the literature, thereby providing confidence that our voters tend to be risk averse.

Table 2 provides additional evidence on the relative support for higher taxes across rationing rules by risk preferences. In every row of the table, the difference in proportion voting yes between the proportional and exclusionary rationing rule is statistically significant ($p < .006$). While support to avoid proportional rationing is similar across risk preferences, we see support to avoid exclusion rationing is significantly greater among risk-averse individuals. Therefore, risk preferences do not appear to be the underlying determinant of the relative effect of rationing a congested public good with proportional versus exclusion rationing.

We extend these aggregate results with conditional analyses of individual voting decisions using the following linear probability panel model:

$$V_{it} = \beta_i + r_i + \chi_{it} + \eta_{it} + \omega_i + \psi_t + \varepsilon_{it},$$

where the dependent variable, V_{it}, denotes the ith subject's vote to increase taxes (= 1 if yes, 0 if no) in period t; β_i signifies the rationing rule the subject plays under (= 1 if proportional, 0 if exclusion); η_{it} is the group size the subject was in during period t; r_i is the individual's measure of risk aversion as indicated by the Holt–Laury mechanism; χ_{it} represents whether or not the subject was excluded in the previous round (= 1 if yes, 0 if no; always 0 for the proportional treatment); ω_i captures individual subject effects; ψ_t captures period-specific effects on contributions; and ε_{it} represents the contemporaneous error term.[9] In addition to a pooled model that employs all the data, we estimate models using subsamples of the data to isolate any relationships specific to the rationing rules and individual risk preferences. We therefore estimate six models: a pooled

Table 3. Panel Model Results.

	Rationing Rule			Risk Preference		
	Pooled	Proportional	Exclusion	Averse	Loving	Neutral
Proportional	0.232***	—	—	0.137***	0.579***	0.515***
	(.045)			(.052)	(.107)	(.116)
Group size = 3	0.038**	0.012	0.062**	−0.013	0.085**	0.151***
	(.016)	(.010)	(.029)	(.017)	(.037)	(.0045)
Risk aversion	0.044***	0.004	0.125***	0.041**	0.063	—
	(.012)	(.003)	(.026)	(.020)	(.044)	
Excluded	0.002	0.004	−0.004	−0.002	−0.020	−0.023
	(.020)	(.010)	(.049)	(.022)	(.042)	(.055)
Constant	0.704***	0.977***	0.608***	0.778***	0.466***	0.389***
	(.035)	(.008)	(.050)	(.052)	(.106)	(.086)
χ^2	72.00	11.10	62.43	45.01	103.95	61.47
	(.000)	(.851)	(.000)	(.000)	(.000)	(.000)
N	1,080	540	540	666	207	207

Note: The dependent variable is Yes = 1 if the subject voted for the tax increase. Results estimated using a random-effects GLS model. Standard errors are given in parentheses.
*Significant differences from 0 at 10 percent level.
**Significant differences from 0 at 5 percent level.
***Significant differences from 0 at 1 percent level.

model, two rationing rule models (proportional and exclusion), and three risk preference models (averse, loving, and neutral).

Table 3 presents the estimates for our voting models. The conditional estimates corroborate the findings from the aggregate numbers; subjects are significantly more likely to vote for a tax increase if the status quo is a proportional reduction in access to the public good as opposed to a random chance of exclusion ($p = .000$). The estimated coefficient indicates the likelihood of voting for higher taxes is about 23 percentage points higher when congestion is rationed proportional rather than exclusion. As the risk preference models indicate, this finding is consistent whether the subjects are risk averse, risk loving, or risk neutral. We note, however, that risk-averse players exhibit a significantly lower likelihood of voting for higher taxes under proportional rationing. Greater support under exclusion rationing contradicts standard theory and therefore indicates the presence of behavioral influences on managing lumpy public goods. The well-documented behavioral tendencies of status quo bias and overconfidence may lead people to take a chance on maintaining their individual public good services without changes in tax rates.

Estimates indicate that the size of the group matters. From the pooled model, subjects in the larger group size (nine) are significantly less likely to vote for an increase in taxes to alleviate congestion ($p = .014$), but the rationing rule models show these results only hold in the case of exclusion. Further, estimates from the risk preference models indicate that only risk-loving and risk-neutral (not risk-averse) subjects exhibit this behavior. Thus, voting behavior of risk-neutral subjects is unaffected by the size of the group ($p = .448$), which may be due to the fact that voting is more consequential when there is a greater probability of being decisive.

Results concerning the individual risk aversion, as measured by individual choices in the Holt–Laury mechanism, indicate that aversion to risk positively affects the likelihood to vote for higher taxes, but only when rationing is achieved via exclusion. This corresponds to the expectation that individuals who are more averse to risk will be less likely to choose a lottery. Lastly, across all models, we find that being excluded in the previous round has no significant influence on voting behavior ($p > .605$), indicating that recent experience is not a strong predictor of the propensity to vote for a tax increase in our setting.

The aggregate and conditional analyses yield three main findings. First, support for tax increases to alleviate congestion was greater if the congestion was rationed proportionately rather than exclusion, and the magnitude of this preference was much greater among risk-neutral and risk-loving players. Second, group size mattered only for risk-neutral and risk-loving people and only when the congestion was rationed by exclusion. Third, risk aversion influenced voting behavior only when the rationing mechanism entailed risk.

Conclusion

Increasing demand for congestible public goods or changing demand for discrete public goods may cause a demand-driven growth in per-capita government expenditure. Thus, this provides a motive for growth of government spending that is not supply-side driven (e.g., bureaucratic excesses).

We find that the behavioral response, support for tax increases, is determined by the rationing rule imposed to deal with congestion in public goods provision. Contrary to behavior theories of risk-aversion, loss-aversion, or rank-dependent expected utility, we find in scenarios where demand was increasing or decreasing for a quasi-public good that voters were more likely to support a tax increase if the alternative was a small, *guaranteed* reduction access to the good rather than if there was a likelihood of being excluded from consuming the good entirely. This finding is consistent with reports from the behavioral literature that people exhibit status quo bias and overconfidence. Voters may prefer to take a chance on the status quo rather than accept higher taxes to maintain aggregate levels of public good services. If robust, such a result could contribute to explanations of why some people seemingly vote against their own self-interest (voting against tax breaks on the wealthy due to overconfidence about becoming wealthy) or against principles of loss aversion (e.g., opposing health-care reforms that increase access to insurance but increase congestion of medical resources is a case of choosing potential exclusion over a proportional reduction).

Appendix

Experiment Details

Table A1. Structure of a Session.

	9-3-9 Treatment		3-9-3 Treatment	
Period	Group Size	Voting?	Group Size	Voting?
1	6	N	6	N
2	6	N	6	N
3	9	N	3	N
4	9	Y	3	Y
5	9	Y	3	Y
6	9	Y	3	Y
7	9	Y	3	Y
8	9	Y	3	Y
9	6	N	6	N
10	6	N	6	N
11	3	N	9	N
12	3	Y	9	Y
13	3	Y	9	Y
14	3	Y	9	Y
15	3	Y	9	Y
16	3	Y	9	Y
17	6	N	6	N
18	6	N	6	N
19	9	N	3	N
20	9	Y	3	Y
21	9	Y	3	Y
22	9	Y	3	Y
23	9	Y	3	Y
24	9	Y	3	Y

Table A2. Parameters and Results of Risk Elicitation Experiment.

Decision Task	Option A	Option B	CRRA Coefficient of Relative Risk Aversion (*r*)	Proportion of Participants
1	Receive US$3.00	0 Percent chance of US$5.00 100 Percent chance of US$0.50	—	0
2	Receive US$3.00	10 Percent chance of US$5.00 90 Percent chance of US$0.50	$[-\infty, -3.508]$	0
3	Receive US$3.00	20 Percent chance of US$5.00 80 Percent chance of US$0.50	$[-3.507, -2.146]$	0
4	Receive US$3.00	30 Percent chance of US$5.00 70 Percent chance of US$0.50	$[-2.145, -1.336]$	0
5	Receive US$3.00	40 Percent chance of US$5.00 60 Percent chance of US$0.50	$[-1.335, -0.742]$	.097
6	Receive US$3.00	50 Percent chance of US$5.00 50 Percent chance of US$0.50	$[-0.741, -0.250]$	.111
7	Receive US$3.00	60 Percent chance of US$5.00 40 Percent chance of US$0.50	$[-0.249, 0.194]$	.167
8	Receive US$3.00	70 Percent chance of US$5.00 30 Percent chance of US$0.50	[0.195, 0.631]	.250
9	Receive US$3.00	80 Percent chance of US$5.00 20 Percent chance of US$0.50	[0.632, 1.112]	.222
10	Receive US$3.00	90 Percent chance of US$5.00 10 Percent chance of US$0.50	[1.113, 1.758]	.111

(continued)

Table A2. (continued)

Decision Task	Option A	Option B	CRRA Coefficient of Relative Risk Aversion (*r*)	Proportion of Participants
11	Receive US$3.00	100 Percent chance of US$5.00 0 Percent chance of US$0.50	$[1.759, \infty]$	.041

Note: The risk coefficient corresponds to an individual who switches from the certain payoff (option A) and the uncertain payoff (option B) at this task. One individual accepted the US$3.00 certainty equivalent over a 100 percent chance of US$5.00.

Authors' Note

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Notes

1. Brueckner (1981, 57) argues "that increasing a community's population should not greatly reduce the level of fire protection, holding suppression capacity fixed" because of the presence of idle capacity in baseline provision. However, this can only be true to the point at which constraints will increase response times and the potential for simultaneous calls, but it highlights that congestion effects will differ across lumpy public goods. Even so, we therefore focus on cases of substantial changes in population.

2. The southwest suburbs of Chicago refer to the tri-county area of Will, Grundy, and Kendall counties. In the area's Plainfield School District 202, enrollment increased from 3,500 in 1990 to over 28,000 in 2010. A 2006 referendum was approved to build ten new schools.
3. After significant population growth, Houston residents voted in 2010 to impose new taxes on themselves to fund improvements to the city's drainage infrastructure. Conversely, after significant population declines, Detroit faced the prospects of rationing public schools with the budget only able to fully fund a tenth of its 87,000 students.
4. Prior to Detroit's move to exclude parts of the city from receiving services, a planning official hinted at such a hybrid rationing situation by saying, "if we have an honest conversation, we know there are many areas of the city where we are not providing adequate service at this time" (Dolan 2010).
5. Indeed, previous experimental work has provided new insights on the role of voting outcomes on tax compliance and the differential impact of direct and indirect taxes on the likelihood of voting in favor of redistribution (Sausgruber and Tyran 2005).
6. It would have been possible to raise the contributions rather than decreasing the benefits when the group sizes decreased, but as each subject played through both increasing and decreasing group sizes, this would have reduced the symmetry of the game and increased the complexity. The effect on net income is equivalent.
7. The reported computerized version of the experiment followed a "pencil and paper" version conducted the previous year. Results from the pencil and paper version matched the computerized experiments reported here.
8. The Holt–Laury mechanism was implemented as follows. Prior to beginning the public goods experiment, the subjects made selections for eleven binary choices between a lottery gamble and a sure bet. Once the subject decisions were recorded, the public good experiment began. When the public goods experiment was completed, the subjects were shown their choices in the Holt–Laury phase, and the random process of selecting a pair for play and the lottery outcome was completed. In this way, the two phases of the experiment were independent.
9. Due to subjects participating in a single treatment, subject-specific heterogeneity is modeled as random effects.

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