Penalty Lottery

Duk Gyoo Kim

SKKU

Oct 5, 2022
Internal Department Seminar

Purposes

Sell a new idea. If a ‘day fine’ system makes sense to you...

BUSINESS

Finland, Home of the $103,000 Speeding Ticket

Most of Scandinavia determines fines based on income. Could such a system work in the U.S.?

JOE PINSKER MAR 12, 2015

(If time permits, introduce a new project *Grant Lottery*.)

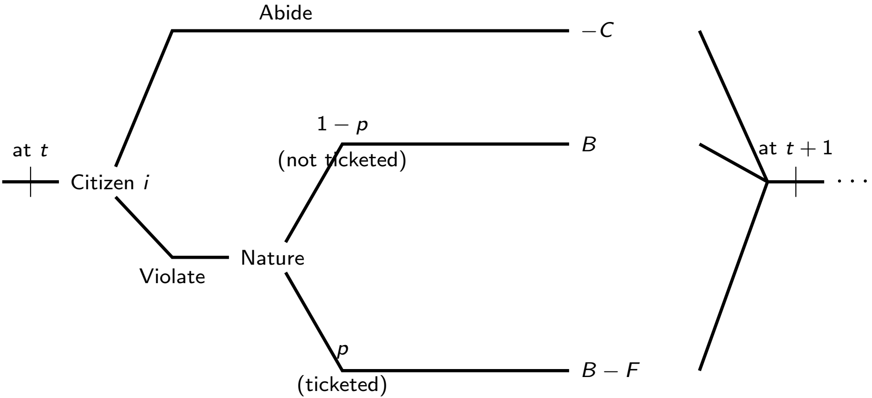
Question

Consider a sequential public bad production under imperfect monitoring for punishment.

- A person in the queue decides whether to produce a public bad for his own sake (B), or not ($-C$).
- The probability that his action is monitored is $p \in (0, 1)$.
- Since public bad production incurs some negative externality, the person who produced a public bad and got monitored must pay the fine (F) that compensates the social costs induced by the negative externality.
- If $B - pF > -C$, everyone is better off by wrongdoing. (Needless to mention Becker (1968).)

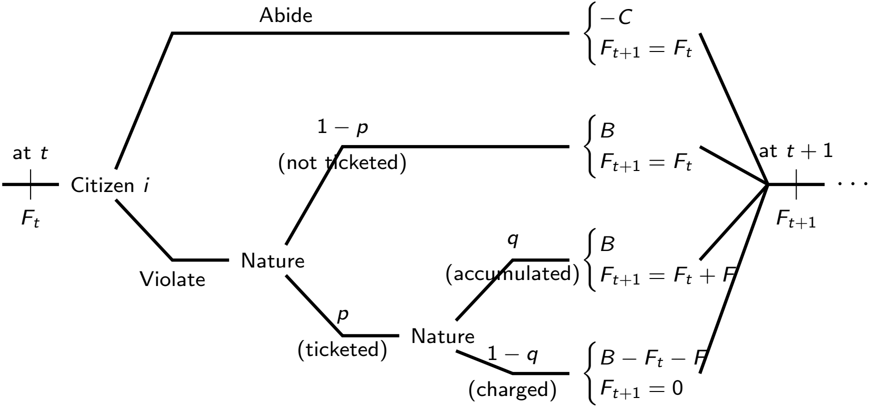
Q) Given (i) p cannot be easily changed, and (ii) changing F is unjustifiable, is there a way to control public bad productions?

Illustration: Current Rule of the Game



Note) Consider misdemeanors from now on. "Violators" are a proper subset of "Wrongdoers".

Suggestion: Penalty Lottery



Note) The current rule of the game is nested as a special case with $q = 0$. F_t is commonly known. $F_0 = 0$.

Preview of the Results

- With prob. 1, the proportion of wrongdoers approaches 0. This is *neither* the main advantage of the penalty lottery *nor* the main claim that I want to raise.
- The more heterogeneous the population is, the slower such a proportion approaches 0. (not reaching 0 when the support is unbounded.)
- **A citizen with a higher willingness to produce a public bad self-selects a larger ex-ante expected fine.**
  - "Evil pays more" does not hold under the penalty lottery.
  - A day fine system can be endogenously induced.
- It is related to joint and several liability in tort claims.
- The local government's loss, if any, is always finite.

Literature

- Alternative fine: Hillsmann (1990, A day fine system)
- Institutional changes: Gerardi et al. (2016, Turnout lottery), Duffy and Matros (2014, Turnout lottery+fines)
- Imperfect public monitoring on producing public bad: Ambrus and Greiner (2012)
- Lotteries in a non-standard setting: Morgan (2000) and Morgan and Sefton (2000) using lotteries for voluntary contributions of public goods. Kearney et al. (2010) and Filiz-Ozbay et al. (2015) using lotteries for boosting savings.

Model

- Consider a society with n citizens indexed by $i \in \{1, \ldots, n\}$.
- Each citizen sequentially faces a problem of wrongdoing for his/her own benefit at time $t = (\tau - 1)n + i, \tau \in \mathbb{N}_+$.
- Call those who violate the law as "wrongdoers", and some wrongdoers who got caught by a police officer as "violators".
- B_i benefit from wrongdoing, C_i cost to abide by the law, and F the amount of the fine.
- Assume $(1 - p)u_i(B_i) + pu_i(B_i - F) > u_i(-C_i)$, where $p \in (0, 1)$ is the common probability of getting caught, and $u_i(\cdot)$ is an increasing, weakly concave utility function of i.

Model

- With probability q, a violator is *not* asked to pay the fine, and the fine is accumulated to a public account. F_t is the accumulated fines at time t. $F_0 = 0$.
- With probability $1 - q$, the violator pays $F_t + F$.
- At t, a citizen faces a problem of choosing B_i or C_i, with knowing that the probability of paying $F_t + F$ is $p(1 - q)$.
- The typical rule of the game is nested as a special case with $q = 0$.
- I assume here that the local government's goal is to minimize public bad production.*
- For any $q \in (0, 1]$, $p(1 - q) < p$, so it gives more incentives to violate the law in the beginning.**

(*,** will be discussed later.)

Willingness to violate the law, k_i

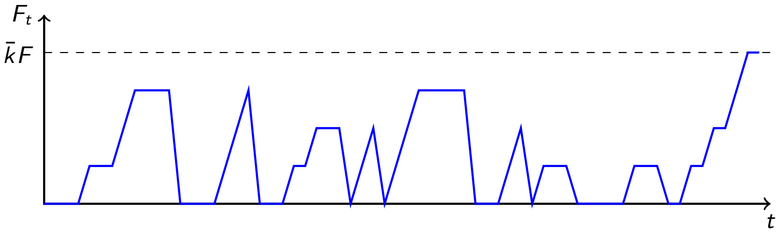
- For any τ such that $(1-p+pq)u_i(B_i)+p(1-q)u_i(B_i-F_\tau-F)\leq u_i(-C)$, citizen i won't violate the law.
- $k_i=\left\lceil \frac{B_i+C_i}{p(1-q)F}\right\rceil-1$, where $\lceil x\rceil$ is the smallest integer larger than x, is the upper bound of citizen i's threshold. If $F_t\geq k_iF$, i won't violate the law.
- k_i is interpreted as a degree of willingness to produce public bads for the private sake, or simply put, willingness to violate the law.
- $\bar{k}=\max_i k_i$. $G(k)$ is the distribution of k_i.

Violations are completely eliminated in the long run

Proposition

Let $P(V|t)$ be the ex-ante probability that a violation is observed after t periods. For $q \in (0, 1)$, $P(V|t)$ is monotone decreasing in t. If $q = 0$ or $q = 1$, $P(V|t) = 1$ for any t.

- In words, the society will *consecutively* accumulates $\bar{k}$ fines eventually.
- Randomization is required: Neither $q = 0$ nor $q = 1$ works.



Why focus on short-run dynamics?

Because the "long-run" comes a LOOOOONG way (or doesn't come at all.)

Proposition

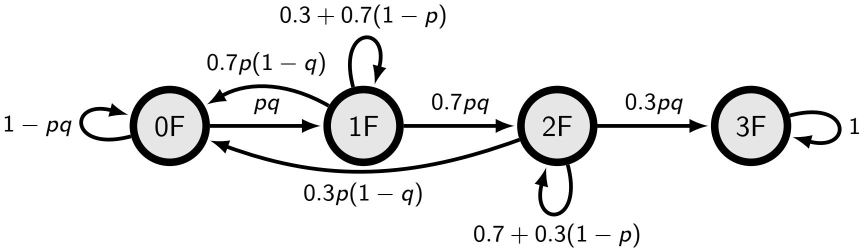
The expected number of time periods reaching the steady state starting from zero fine accumulations is

$$\frac{1}{pq}\sum_{i=0}^{\bar{k}-1}\frac{1}{(1-G(i))q^i}.$$

- If $\tilde{G}(k)$ is the mean-preserving spread of $G(k)$ with a larger $\bar{k}$, and $\tilde{P}_{\tilde{G}}(V|t) \geq P_G(V|t)$.
- A thinner upper tail makes it longer. That is, even if the society's overall willingness to produce public bads decreases, it is possible that the time to reach the steady state can be substantially longer.

Intuition: Prop 2

Figure: Finite-State Absorbing Markov Chain, $g_1 = 0.3, g_2 = 0.4, g_3 = 0.3$



- Consider instead $g_1 = 0.4, g_2 = 0.2, g_3 = 0.4$. It takes slightly shorter time to reach the absorbing state.
- Consider instead $g_1 = 0.4, g_2 = 0.3, g_3 = 0.2, g_4 = 0.1$. It takes significantly longer time to reach the state.

Self selection

Corollary

Let $\phi(k_i)$ be the ex-ante expected fines for an individual with k_i. $\phi(k_i)$ is increasing.

- Citizens "reveal" their true willingness to violate the law. The penalty lottery induces endogenous price discrimination.
- More risk seeking $\Rightarrow$ Larger k_i
- More B_i $\Rightarrow$ Larger k_i
- More inequity averse $\Rightarrow$ Smaller k_i
- (A day fine system, F_i) Larger B_i/F_i $\Rightarrow$ Larger k_i

Experiments

- Why experiments? As a testbed.
- Abstract framing: I avoid using "wrongdoing", "violations", "fines", "misdemeanors", etc.
  - To minimize an experimenter-demand effect (Zizzo, 2010).
  - To shut down heterogeneous internalizations of social norms (Kimbrough and Vostroknutov, 2016).
- Red ball (=abiding by the law), Blue ball (=violating the law), Black sticker (=fine).

Procedure

1. 60 rounds. Everyone is endowed with 100 tokens.
2. Randomly assigned to groups of four. One member makes a decision in each round.
3. A subject in his turn chooses either a red or blue ball, with knowing how many black stickers are in the common pool.
4. A red ball: Turn ends.
5. A blue ball: With prob. 0.7, turn ends. With prob. 0.3, a black sticker is followed. The black sticker is added to the common pool with probability q. With the other probability $1 - q$, he keeps all the black stickers including all the black stickers in the common pool.
6. A red ball$=-1$ token. A blue ball$=+5$ tokens. A black sticker$=-8$ tokens.

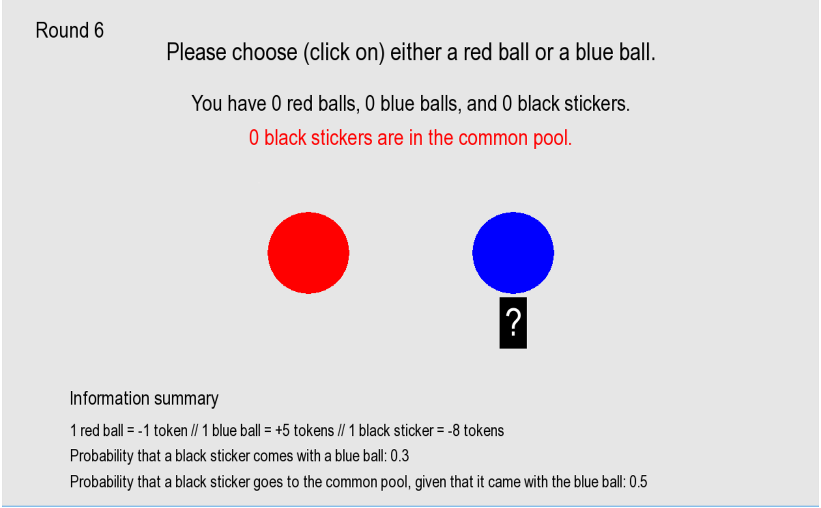
After the main experiment, risk preference is measured.

Experimental Design and Summary of Hypotheses

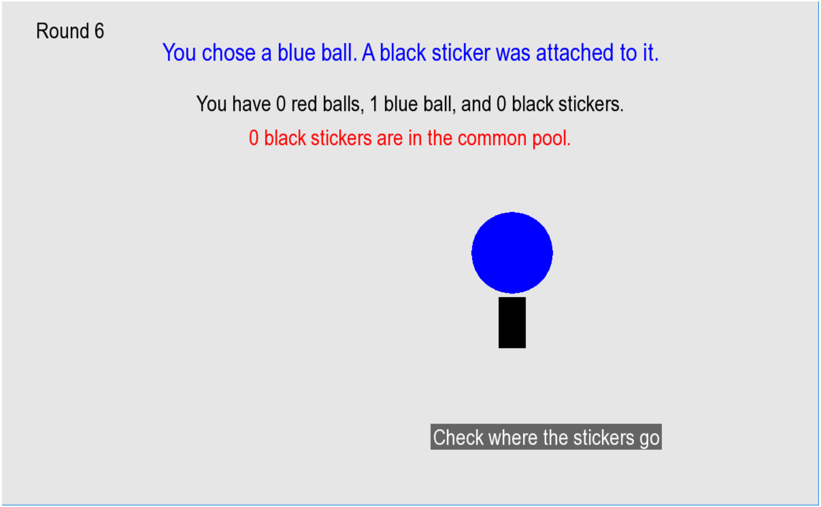
Treatment	p	q	$p(1-q)$	k	$P(\text{V} \mid t = 60)$
Mq	0.3	0.5	0.15	4	56.19%
Lq	0.3	0.1	0.27	2	85.44%

- More treatments/sessions may be followed.
- Two treatments that I didn't/won't do: (1) $q = 0$, (2) Public Information on how others do.

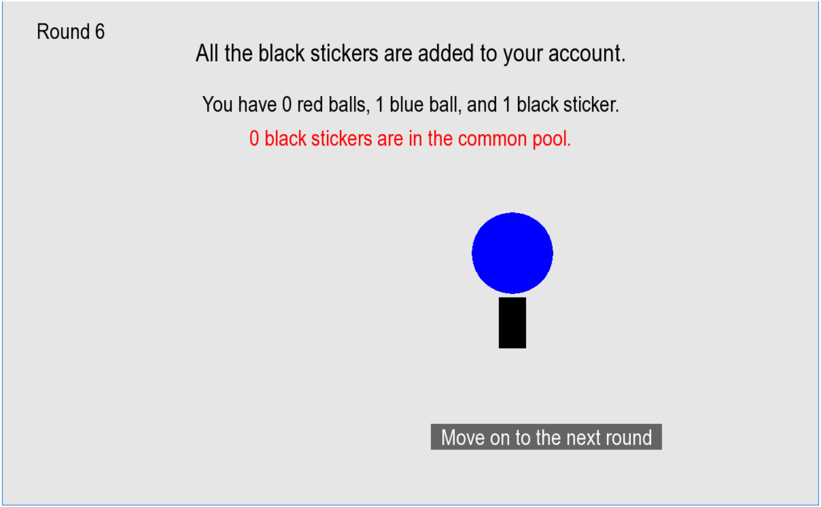
Screenshot 1



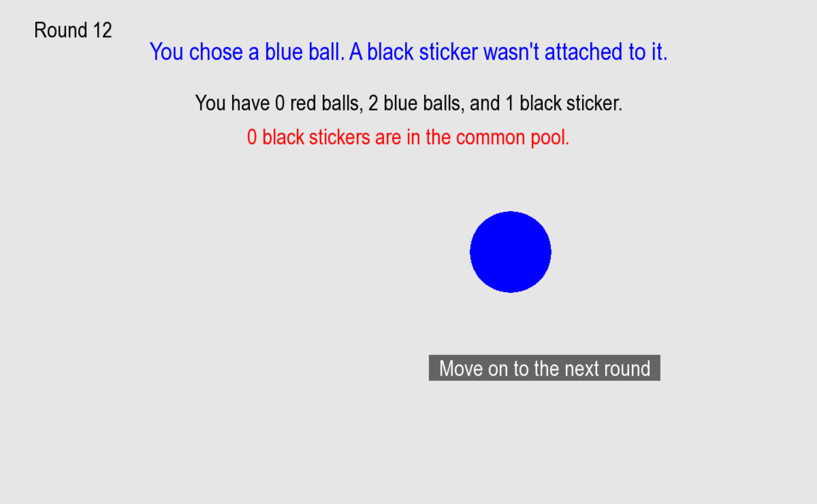
Screenshot 2



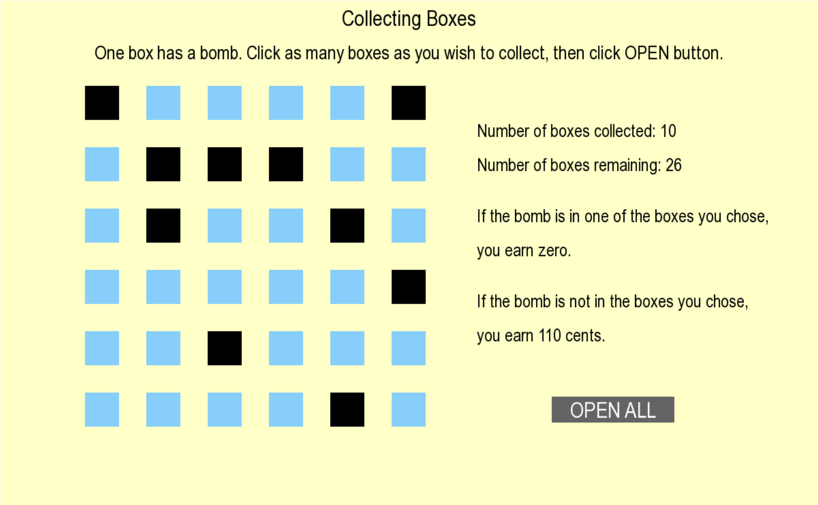
Screenshot 3



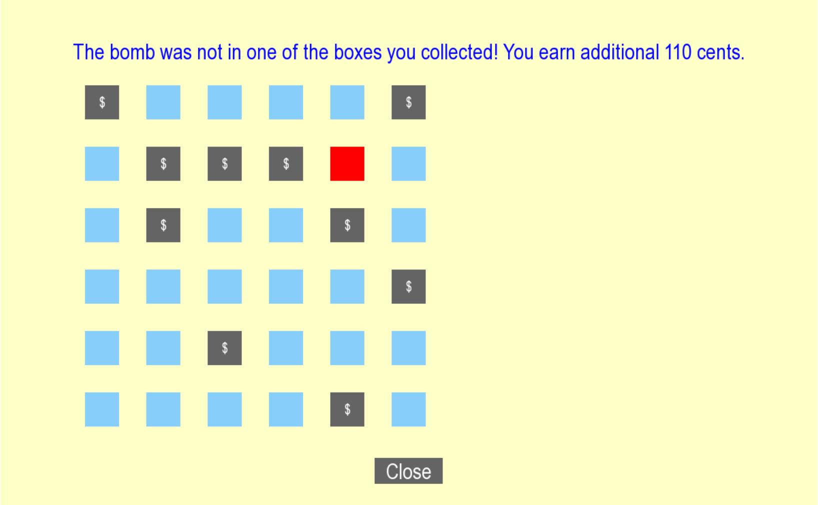
Screenshot 4



After the main experiment, BRET



After the main experiment, BRET



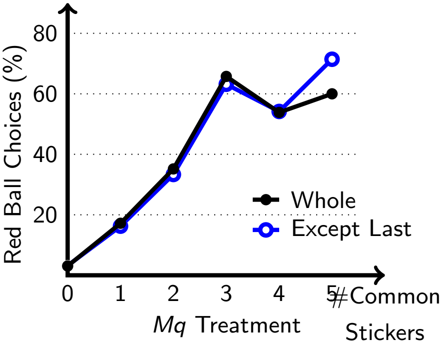
Results - Data summary

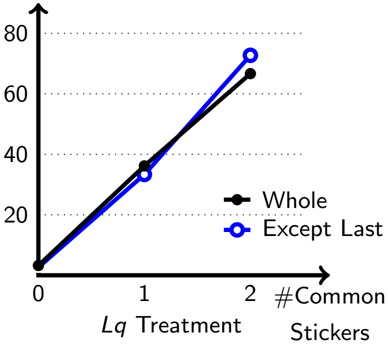
Nothing seems wrong.

Treatment	Number of Subjects	Red Balls (%)	Blue Balls (%)		
			w/o Sticker	Common	Subject
Mq	64	18.33	58.75	10.21	12.71
Lq	64	8.85	64.17	3.02	23.96

In *Mq* treatment, red balls were chosen more.

Results - Responses to penalty accumulations





In both treatments, #of black stickers in the common pool strongly affects the frequency of red ball choices. No 'last-round effect' was found.

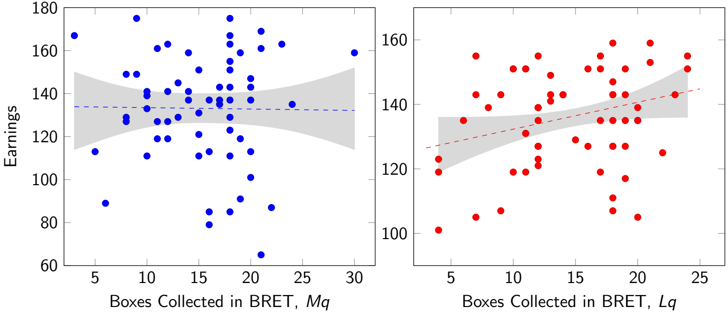
Results - Responses to penalty accumulations

	LPM			Logit	
	(1)	(2)	(3)	(4)	(5)
ComBlack	0.2961***	0.2953***	0.2253***	2.2648***	1.9263***
	(0.0413)	(0.0421)	(0.0403)	(0.3253)	(0.3344)
SubjBlack	−0.0182*	−0.0188*	−0.0127	−0.1557	−0.1072
	(0.0086)	(0.0091)	(0.0072)	(0.0834)	(0.0717)
Mq	0.0012	0.0051	−0.0008	0.5629	0.4694
	(0.0258)	(0.0261)	(0.0185)	(0.4520)	(0.3502)
ComBlack × Mq	−0.1459**	−0.1463**	−0.1039*	−1.3319***	−1.1249**
	(0.0466)	(0.0476)	(0.0414)	(0.3829)	(0.3612)
DRound	0.0113***	0.0115***	0.0080**	0.1142***	0.0730**
	(0.0028)	(0.0029)	(0.0023)	(0.0271)	(0.0246)
prevRed			0.3238***		1.8969***
			(0.0597)		(0.3535)
prevBCom			0.0325		0.4166
			(0.0403)		(0.3087)
prevBSubj			0.0036		−0.3458
			(0.0133)		(0.3596)
cons.	−0.0190	−0.1970	−0.1066	−5.9808***	−5.0881***
	(0.0148)	(0.1559)	(0.1095)	(1.7613)	(1.3167)
Indiv.Chars.	Excluded	Included	Included	Included	Included
R^2	0.2711	0.2866	0.3651	0.3036	0.3657
N	1,920	1,920	1,664	1,920	1,664

Dep.Var: Red Ball Choices. ComBlack: #black stickers in the common pool. SubjBlack: #black stickers that the subject has kept. Mq: =1 if the treatment was *Mq*. DRound: decision round varying 1 to 15. prevRed: =1 if subject previously chose a red ball, prevBCom: =1 if subject previously chose a blue ball followed by a black sticker added to the common pool. prevBSubj: =1 if subject previously chose a blue ball followed by a sticker and kept all the stickers including ones in the common pool. Standard errors clustered at the subject level are in parenthesis. *, **, and *** indicate statistical significance at the 5% level, 1% level, and 0.1% level.

Results - Risk seeking doesn't pay

Risk Preferences and Earnings



This figure shows scatter plots and fitted lines of earnings on the number of boxes collected in BRET. In *Mq* treatment, there is no linear relationship between earnings and the number of boxes collected in BRET. In *Lq* treatment, however, those who are more risk-seeking are paid more.

Results - Risk seeking doesn't pay

- B_i, C_i, and F are controlled. So the main heterogeneity comes from risk preferences.
- More risk seeking $\Rightarrow$ More willing to violate the law $\Rightarrow$ More volatile earnings
- In Mq, the variance of the subjects whose risk preferences are in the top half is significantly larger than the variance of those in the bottom half. In Lq, such a difference in variances is not found.
- With the penalty lottery, a high risk brings even a higher volatility in payoffs.

F test of equality of variances

Mq		Lq	
St.dev.(Earnings —$B_i < \mathrm{Med}(B_j)$)	St.dev.(Earnings —$B_i > \mathrm{Med}(B_j)$)	St.dev.(Earnings —$B_i < \mathrm{Med}(B_j)$)	St.dev.(Earnings —$B_i > \mathrm{Med}(B_j)$)
19.49	28.33	15.22	16.60
$F_{29,28}(2.1117) = 0.0256^{**}$		$F_{31,29}(1.1888) = 0.3211$	

Conclusions

- I know policymakers won't/can't adopt the penalty lottery right away.
- Yet it is simple for citizens to understand, and easy to implement. It doesn't require a huge structural change. It's at least better than the day fine system.
- Even if the society doesn't reach the steady state, the penalty lottery is still good in that citizens reveals their willingness to produce public bad and (expected) fines increases in their willingness.

Discussions: Common knowledge of F_t?

- The number of accumulated fines, F_t, is assumed to be common knowledge.
- With harnessing existing information technologies, it is not practically hard to provide such information.
- Electronic signboards on highways display
- Cramton et al. (2018) claims the dynamic price of the road usage using GPS data.
- Shoup (2017) recommends that cities should charge fair market prices for on-street parking, which dynamically respond to demands.
- At the very least, it is easier to have common knowledge in a smaller group, e.g., a messy kitchen shared by five roommates.

Discussions: Objective of the Local Government?

- Social welfare maximization vs. Tax revenue maximization?
- Garrett and Wagner (2009), Makowsky and Stratmann (2011): "tax revenue decline or budgetary shortfalls in $t-1$ $\Rightarrow$ more citations in t"
- Makowsky and Stratmann (2009): Using speeding tickets as a source of tax revenues from the outside.

Discussions: Has it ever been considered?

- Not really...
- But at least it is worth discussing in academia.
- Under *Joint and several liability* in tort claims, a plaintiff may recover all the damages from any of the defendants regardless of their individual share of the liability. In the sense that the winner of the penalty lottery takes the whole accumulated fines, the idea is understood as one particular rule of joint and several liability.

Discussions: Budget constraint of the poor violator?

"What if I am poor and face a huge fine that I cannot afford?"

- Provided that the concerns for common knowledge are cleared, the budget-constrained agent won't produce a public bad from the point it is not worth doing so. Thus, more accumulated fines *do not* affect the budget-constrained agent at all.
- Consider this analogy: A longer prison sentence for a felony does not affect ordinary people's ordinary lives as they do not commit a crime. "What if I commit a crime and face a longer sentence that I cannot bear?" is a concern for naught.

Regarding an unfortunate nature of a pure mistake, no penalty system can be free from such a concern.

Discussions: Why not just multiple the fine? (1/2)

- Imposing a massive fine for complete deterrence brings distorted incentives on the margin (Stigler, 1970), which are much smaller under the penalty lottery.
- Consider a fine changed from F to kF with $k \in (1, \bar{k}]$. A significant fraction of citizens $(G(k) - G(1))$ is "on the margin," that is, many citizens' incentives are distorted.

- Another practical issue: Policymakers do not observe k_i. Which k is appropriate? What if new citizens (e.g., immigrants or newborns) bring heterogeneities to a greater extent?
- Under the penalty lottery, the policymaker does neither need to know $\bar{k}$ nor need to track the changes in $\bar{k}$.

Discussions: Why not just multiple the fine? (2/2)

- Multiplying the fine by k will deter wrongdoings of citizens whose willingness to violate the law is *relatively small*.
- Roughly speaking, better citizens are distorted more.
- Those with $k_i \leq k$ will earn $u(-C_i)$.
- Those with $k_i > k$ will earn the expected utility from producing public bads, which is greater than their $u(-C_i)$.

Discussions: Sincere vs. Rational non-violators?

Relax $B_i > C_i > 0$ and $(1-p)u_i(B_i) + pu_i(B_i - F) \geq u_i(-C_i)\ \forall i$

- $\exists$citizens who don't violate the law when $q = 0$.
- Citizen i with $u_i(B_i) \leq u_i(-C_i)$ is a *sincere* non-violator.
- Citizen j with $u_j(B_j) > u_j(-C_j)$ and $(1-p)u_j(B_j) + pu_j(B_j - F) \leq u_j(-C_j)$ is a *rational* non-violator.
- For a rational non-violator j, $\exists q_j \in (0,1)$ such that $\forall q \geq q_j$, $(1-p+pq)u_j(B_j) + p(1-q)u_j(B_j - F) \geq u_j(-C_j)$.
- The rational non-violators will again abide after $\lceil q/(1-q) \rceil$ fines are accumulated. If $q \leq 0.5$, $\lceil q/(1-q) \rceil = 1$.
- It is not bad to distinguish sincere non-violators from those who strategically choose not to violate the law.

A new project
Grant Lottery

- Many applicants complain randomness of a selection process.
- Many reviewers find it costly to correctly evaluate two projects of similar quality. At least, the noise of their evaluation increases with the density of the true quality distribution.
- Many employers claim that performance in evaluation criteria is not related to work performance (e.g., Korean History Proficiency test and government officials).
- Random selection is used in many forms. Random selection from those above a bar (e.g., KATUSA and Nigerian start-ups YouWiN), from those within a subgroup (e.g., AEA CESWEP), or from those who are excluded by the merit-based selection (e.g. public *Jeonse*).

A new project
Grant Lottery

Literature:

- There are some studies!!
- Frank (2016) claims luck attributes to success more than people think.
- Pluchino et al. (2018) mathematically show why success most often goes not to the most talented people, but instead to the luckiest. (2022 Ig Nobel Economics winner)
- Pluchino et al. (2010) show that random promotion can be more efficient in a hierarchical organization.
- Moreira and Prez (2021) examine the changes in cost-effectiveness before and after the introduction of mandated exams for selecting civil servants.

A new project

Grant Lottery

The grant lottery would be ideal when

- the evaluations are costly and noisy,
- evaluation criteria are less related to performance criteria, and
- the quality distribution is dense.

Questions:

- When should we change the merit-based grant to the lottery-based grant?
- Which form of lottery should be considered?
- What's the distributional outcomes?
- Would (and how severely) the grant lottery mechanisms distort the applicants' behaviors?
- Randomization as a source of revenue?