Ending Wasteful Year-End Spending: On Optimal Budget Rules in Organizations

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Introduction

- Public sector agencies: budgets expire year-end
  - Use-it-or-lose-it
  - Pentagon: Millions for lobsters and $9000 office chairs
  - Salespeople camping in US ministries last week
  - D: “December fever”, Canada: “March Madness”
- DoD employees estimate 32% of year-end spending is wasted (McPherson, 2007)
- Problems: Waste, but also low quality

Objective in this paper

What can we do about it?

- Model close to application
- What rules can improve on annual expiring budgets?
  - Can roll-over of unused funds be optimal? How much should be rolled-over?
  - Under which conditions should spending be audited?
  - How does roll-over change the optimal audit rules?

Literature

- Liebman & Mahoney (2017, AER):
  - Empirically year end spending surge with low quality spending
  - Theory: Allowing fund roll-over can be beneficial
- Malenko (2019, Restud):
  - Mechanism design: within-firm capital allocation
  - Little structure
- My model in between: Comprehensive analysis of alternatives, but close to application to be useful

The model, players

- **Principal**: taxpayer, Parliament
- **Agent**: bureaucrat, administrative staff
- Goal: maximize principal expected utility

The model, spending needs

- Two years, $y = 1, 2$
- Uncertain state in y: **spending need** θ_y, iid from continuous uniform distribution on $[0, u]$
- Interpretation: replace broken computers
- Realization θ_y learned by agent in y, private information
- θ_y is what principal wants agent to spend in y

The model, agent strategy space and budget

- Agent has budget b_y in year y
- Agent decides on spending amount: $s_y \in [0, b_y]$
- Spending $s_y > \theta_y$ is called **fund misuse**
- Exogenous budget $b > 0$ granted every year
- Unused funds from $y = 1$ may be rolled-over to next year if $\Delta > 0$:

$$\begin{aligned} b_1 &= b, \\ b_2 &= b + \Delta(b - s_1) \end{aligned}$$

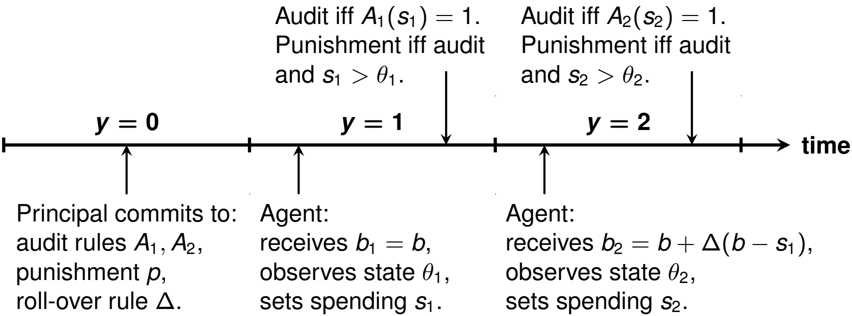
The model, principal strategy space

- Principal commits to $\{\Delta, A_1, A_2, p\}$ in $y = 0$
- **Fund roll-over rule** $\Delta \in [0, 1]$: Unused dollar in $y = 1$ leads to Δ additional dollars in $y = 2$
- **Audit rule** $A_y(b_y)$ maps every possible spending amount into audit or not,

$$A_y : [0, b_y] \to \{0, 1\}$$

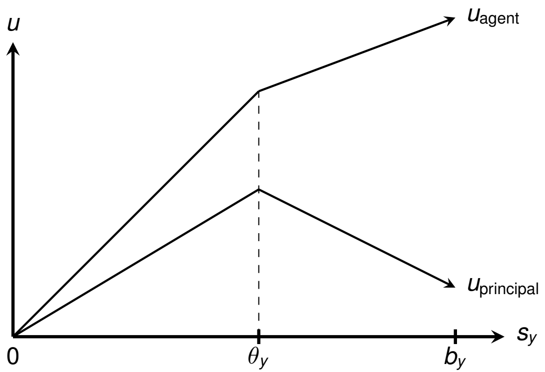
- Audit reveals realization θ_y, costs $c_A > 0$
- **Punishment**: If caught misusing funds, reduce agent utility by $p > 0$. Costs $p \cdot c_p$

Timing and summary



Preferences

- Agent: Marginal utility 1 from fulfilling spending needs, marginal utility $0 < \alpha < 1$ from misusing funds



- Principal:
  - Marginal benefit 1 from getting spending needs fulfilled, marginal benefit 0 from fund misuse
  - Marginal cost of funds: $0 < \lambda < 1$

Optimal punishment

Result

The optimal policy uses a large punishment $p > 2\alpha b$, so that punishment never occurs in equilibrium.

Class of optimal audit rule: Threshold

Result

In $y = 2$ and in $y = 1$ if roll-over is ineffective, the optimal audit rule is a threshold rule.

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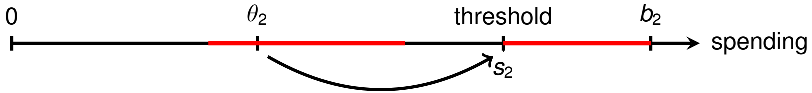
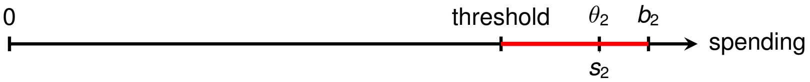
- Not a threshold rule:



- Agent decision equivalent if threshold is largest amount that is not audited here

Class of optimal audit rule: Threshold

- For large spending needs: no fund misuse



Class of optimal audit rule: Interval

Result

In $y = 1$ if roll-over is effective, then the optimal audit rule is an interval rule.

- No auditing, roll-over prevents some fund misuse:

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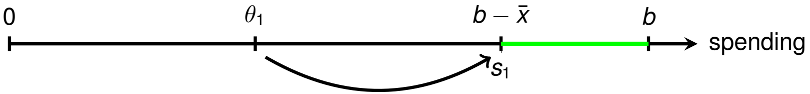
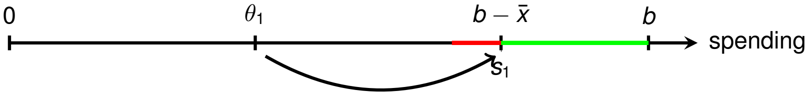


- Add some auditing, no effect:



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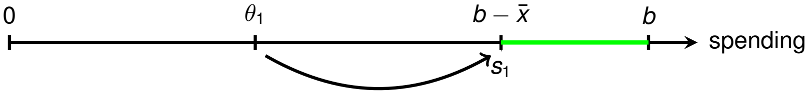
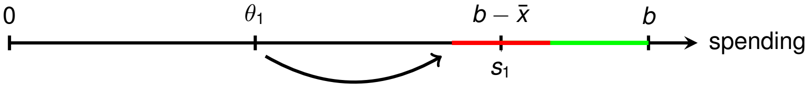


- Interval rule: audit on both sides of $b - \bar{x}$:



Optimal roll-over rule

Result

Depending on conditions, the optimal roll-over rule is either $\Delta = 1$ *or* $\alpha < \Delta < 1$*.*

- So new: $\Delta < 1$ can be optimal
- From perspective of principal, Δ has two purposes:
    1. Use unneeded funds from $y = 1$ in $y = 2$. Best with $\Delta = 1$.
       "Given savings, $\Delta = 1$ is best"
    2. Get agent to save more. Sometimes best with $\Delta < 1$.
       "$\Delta < 1$ **might lead to more savings"**

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    2. Get agent to save more. Sometimes best with $\Delta < 1$.
       “$\Delta < 1$ **might lead to more savings”**
- High cost of funds and small agent utility from fund misuse favor $\Delta < 1$.
- Practice: State of Washington

Optimal threshold rule $y = 2$

Result

The optimal threshold rule either has threshold $\underline{a}_2^* = c_A/\lambda$ or does not audit ($\underline{a}_2^* = b_2$).

- Larger threshold means less auditing, less audit cost, more fund misuse
- Larger audit cost or smaller cost of funds tends to increase audit threshold
- In year 1: threshold the same if b is large, otherwise smaller threshold (more auditing), additional benefit

Extension: Endogenizing the budget

- More budget trade-off: fulfill more spending needs but more fund misuse
- Cost of funds λ is cost of fund misuse
- $1 - \lambda$ is benefit of fulfilling spending needs
- With max budget, agent does not save for roll-over

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Result

1. *If audit costs are small enough, then maximal budget with auditing is optimal.*
2. *If audit costs are large and cost of funds sufficiently small, then maximal budget without auditing is optimal.*
3. *If audit and fund costs are sufficiently large, then budget below maximum is optimal.*

Conclusion

Take home messages:

- “Spend smarter, not harder”
- Allowing fund roll-over is improvement over status quo
- New: finding of partial roll-over being optimal
- New: proving that roll-over and auditing interact: threshold vs interval rules
- In practice: don’t punish savings by cutting future budget (prevent ratchet effect)

Appendix

Utility functions

- Agent:
  - Marginal utility 1 when spending $s_y \leq \theta_y$, marginal utility $\alpha < 1$ when spending $s_y > \theta_y$
  - Punishment if audited and funds misused
- Principal:
  - Marginal utility 1 when spending $s_y \leq \theta_y$, marginal utility 0 when spending $s_y > \theta_y$
  - Cost of funds: Budget b costs $b\lambda$, with $\lambda \in (0, 1)$
  - Implies net marginal utility of fulfilling spending needs is $1 - \lambda$
  - Plus audit costs, punishment costs

Solving, agent reaction, year 2

- Take principal strategy as given
- Assume audit rules are threshold rules, so that $A_y(s_y) = 1$ iff $\bar{a}_y < s_y$
- Assume punishment $p > 2\alpha b$ (to be confirmed later)
- Implies auditing in equilibrium, but no punishment
- Then agent spends

$$s_2(\theta_2) = \begin{cases} \min\{\theta_2, b_2\} & \text{if } \theta_2 \geq \bar{a}_2, \\ \bar{a}_2 & \text{if } \theta_2 < \bar{a}_2. \end{cases}$$

Solving, agent reaction, year 1

- Suppose $\theta_1 < b_1$, ignore auditing for now
- Should agent misuse funds or save and roll-over funds (if $\Delta > 0$)?
- Marginal benefit of saving x, rolling over Δx, is

$$\frac{\partial}{\partial b_2}\Bigg[\int_0^{\bar{a}_2}(\theta_2 + (\bar{a}_2 - \theta_2)\alpha)\mathrm{d}G(\theta_2) + \int_{\bar{a}_2}^{b_2}\theta_2 dG(\theta_2) + \int_{b_2}^{\overline{\theta}} b_2 \mathrm{d}G(\theta_2$$
$$= (1 - G(b_2))\Delta.$$

- This is non-negative and decreasing until $b_2 = \overline{\theta}$
- Equating marginal utility of misusing with saving:

$$\alpha = \Delta(1 - G(b + \Delta x)) \iff \frac{G^{-1}(1 - \frac{\alpha}{\Delta}) - b}{\Delta} = \hat{x}. \quad (1)$$

- Let $\bar{x} = \min\{\max\{\hat{x}, 0\}, b\}$
- Immediately obvious: No $\Delta \leq \alpha$ can induce $\bar{x} > 0$

Principal expected utility given agent reaction

Second year expected utility (EU) as function of second year budget

$$V(b_2) := \int_0^{\underline{a}_2} (\theta_2 + \lambda(b_2 - \underline{a}_2))\mathrm{d}G(\theta_2)$$

$$+ \int_{\underline{a}_2}^{b_2} (\theta_2 + \lambda(b_2 - \theta_2) - c_A)\mathrm{d}G(\theta_2) + \int_{b_2}^{u} (b_2 - c_A)\mathrm{d}G(\theta_2).$$

If $\bar{x} = 0$, the principal uses a threshold audit rule in both years:

$$EU = \int_0^{\underline{a}_1} [\theta_1 + V(b + \Delta(b - \underline{a}_1)) + \lambda(1 - \Delta)(b - \underline{a}_1)]\mathrm{d}G(\theta_1)$$

$$+ \int_{\underline{a}_1}^{b} [\theta_1 - c_A + V(b + \Delta(b - \theta_1)) + \lambda(1 - \Delta)(b - \theta_1)]\mathrm{d}G(\theta_1)$$

$$+ \int_{b}^{u} [b - c_A + V(b)]\mathrm{d}G(\theta_1) - 2\lambda b.$$