Two Novel Mechanisms for Funding and Discovering Public Goods

Notes on this outstanding presentation by Alex Tabarrok

at AFT 2021, which reveiws the following three papers along with quotes from a Vitalik Buterin blogpost (my own addition);

- [The private provision of public goods via dominant assurance contracts

](https://mason.gmu.edu/~atabarro/PrivateProvision.pdf) Tabarrok, Public Choice 96: 345–362, 1998.

- [Better Crowdfunding

](https://mason.gmu.edu/~atabarro/BetterCrowdfunding.pdf) Cason, Tabarrok, Zubrickas, 2019.

- [A Flexible Design for Funding Public Goods

](https://arxiv.org/pdf/1809.06421.pdf) Buterin, Hitzig, Weyl, 2019.

- [Quadratic Payments: A Primer

](https://vitalik.ca/general/2019/12/07/quadratic.html) Buterin, 2019.

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- Pt. 3 The contribution problem of public goods vs. the Information Revelation problem

Note: each part maps to three papers listed in descending order.

Pt. 1 The Public Good Problem

- Public goods are a challenge to markets
- Consider averting a flood.
- Everyone would be better off if everyone contributed to averting the flood but individual incentives mitigate against everyone contributing.
- Everyone would be better off if everyone contributed to averting the flood but individual incentives mitigate against everyone contributing.

Agent i

/Others

Do not contribute

Contribute

Do Not Contribute

(0,0)

(950,800)

Contribute

(-100,0)

(900,900)

The better off equilibrium is much better.

- There exists the free rider problem
- If other people are contributing then your incentives are not to contribute because other people will contribute to averting the flood. If you do so you don't get an additional benefit no matter what you do the flood will be averted. Therefor it makes sense for you to free ride.

- The other problem is less talked about is the Assurance problem - you are also worried that you might contribute and other people don't so then your contribution is just wasted.
- Now imagine the town's mayor announces that those willing to build the dike meet at Town Hall.
- Work will begin if and only if enough people gather so that the dike can be built high enough to avert the flood.

Agent i

/Others

Do not contribute

Contribute

Do Not Contribute

(0,0)

(950,800)

Contribute

(0,0)

(900,900)

Now you have eliminated the Assurance problem. You know that your contribution is never going to be wasted because you will only ever start building the dam if there are enough people that show up to Town Hall. So you have been given some assurance that your contribution will not be wasted.

We still have the free rider problem, but maybe if people are altruistic or want to be seen (or perceived as) to be altruistic then perhaps the free rider problem can be overcome.

Mayor Game II

- Suppose that the mayor announces that the dike will be built if and only if everyone agrees to contribute.
- The free rider problem has been eliminated because the dike is only going to be built if everyone contributes. If you do not contribute there is no free riding because the public good does not get built
- Everyone's contribution is required so no free riding
- Everyone's contribution is required so no free riding
- Even with both the free rider and assurance problems eliminated there is no guarantee of success.
- Although contribute, contribute is an equilibrium, do not contribute, do not contribute remains a Nash equilibrium.
- If I think that you will not contribute and if I don't contribute then it's rational for you not to contribute. Self-fulfilling prophecy
- Stronger with epsilon cost of contributing
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Crowdfunding

- Crowdfunding (e.g. Kickstarter, IndieGoGo, GoFundMe) use the assurance contract method.
- Nobody pays until total contributions exceed a threshold high enough to assure completion of the goal.
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- Crowdfunding has grown rapidly.
- In 2021 there were over 6.4 million worldwide crowdfunding campaigns which raised over $35 billion
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- There are problems with crowdfunding
- Most campaigns fail
- kickstarter’s success rate is only 37%
- Why?
- Bad Projects
- inefficient coordination - in the assurance contract game there are multiple equilibria and most of them involve a failure to coordinate on the most beneficial contribute/contribute outcomes
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Dominant Assurance Contracts

This is where the dominant assurance contract comes in from the 1998 paper (Refund bonuses)

- Let a crowdfunding entrepreneur offer potential contributors a "refund bonus." if they offer to contribute but the contribution threshold is Not reached then the potential contributor gets their contribution back plus a Bonus.
- Risk free trade
- Risk free trade
- This converts the public goods game by now making it a dominant strategy to contribute to fund public goods
- we've gone from public goods being nearly impossible to fund to a game where its now the dominant strategy to contribute
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Agent i

/Others

Do not contribute

Contribute

Do Not Contribute

(0,0)

(0,Bonus)

Contribute

(Bonus,0)

(900,900)

Imagine you believe other people will not contribute. If you think others will not contribute then you want to contribute to get the bonus.

On the other hand, if you think that other people will contribute then you also want to contribute in order to get the public good produced which still has a private benefit to you.

- In equilibrium, the refund bonuses are never paid. (similar to diamond and dybvig model on deposit insurance. No longer incentive to run to the bank if you think they are running out of money.) Because this is an off the equilibrium path you never have to pay out the refund bonus (in theory), in practice an entrepreneur who offers refund bonuses will still have to pay them some of the time
- one reason- although the only equilibria in this model have the public good being successfully funded there are still multiple successful equilibria when you don't require everyone to contribute. So their can still be some mis-

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- The only Nash equilibrium in the game has the public good funded but if not every player is necessary to reach the threshold then its no longer a dominant strategy to contribute.
- How should refund bonuses be paid?
- Fixed amount?
- proportional to contribution?
- Fixed amount?
- proportional to contribution?
- when should refund bonuses be paid?
- pay only to early contributors?
- pay only to early contributors?
- Refund bonuses lie off-the-equilibrium path: design freedom
- Great in theory, does it work in practice?

Pt. 2 Laboratory Experiments

- Campaigns are run on a lab-based crowdfunding platform developed in Carson and Zubricks (2019) designed to replicate actual crowdfunding institutions.
- asynchronous contributions; upward revisions allowed
- continuous (public) updating of aggregate contributions
- Multiple (2) fundraising campaigns available at same time
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- continuous (public) updating of aggregate contributions
- Multiple (2) fundraising campaigns available at same time

Rules of the game

- 10 subjects per group
- continuous time (2 min), hard close
- Each player has a draw (knows) on the value of the public good known to them only of v_1

~ U[20;100]

- If the threshold (C) is reached each player receives their value
- If the threshold (C) is not reached, each player who agreed to contribute gets a refund bonus in experiments with refund bonuses

A variety of different treatments were observed

- Baseline: contributions are refunded but there are no bonuses
- F3: Fixed refund bonus of z = 3

for any total individual contribution of > gmin = 30

- F6: Fixed refund bonus of z = 6

for any total individual contribution > gmin = 30

- FE30: Fixed refund bonus of z = 6

for first 5

individuals whose total contribution > gmin = 30

- FE50: Fixed refund bonus of z = 6

for first 5

individuals whose total individual contribution > gmin = 50

- PE10: Proportional refund bonus r = 0:10

paid on contributions made during the first half of the contribution period

- PE20: Proportional refund bonus r = 0:20

paid on contributions made during the first half of the contribution period.

- In the baseline treatment only about 1/3 of projects are successfully funded.
- This is in a lab situation by which design all projects are socially valuable, yet only 1/3 are successfully funded
- This illustrates the large amount of equilibrium mis-coordination
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- very close to kickstarter 37% number mentioned previously
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- Any refund bonus scheme increases the success rate by about 20 percentage points or 50%.
- Larger refund bonuses work a bit better
- F6 > F3
- FE50 > FE30
- PE20 > PE 10
- F6 > F3
- FE50 > FE30
- PE20 > PE 10
- In each version the larger refund bonus increases the success rate even more than the smaller refund bonuses. Even thew smaller refund bonuses increases the success rate quite a bit
- You can also see this in another way. In the baseline nearly 20% of individuals don’t contribute at all.
- This halves or quarters when refund bonuses are used. You are bringing more people in with refund bonuses on the extensive and intensive margin
- Illustrates the importance of inefficient equilibrium

Treatment

All Projects

Unsuccessful projects

Successful Projects

Baseline

0.197

0.265

0.061

F3

0.092

0.122

0.062

F6

0.069

0.097

0.053

FE30

0.061

0.091

0.028

FE50

0.112

0.153

0.080

PE10

0.068

0.085

0.050

PE20

0.053

0.069

0.043

Refund bonuses take people from not contributing anything towards contributing something.

One of the versions of the refund bonuses run was inspired by Benjamin Franklin who was known in his days a successful crowdfunder. He was asked how do you do this?

In the first place, I advise you to apply to all those whom you know will give something; next, to those whom you are uncertain whether they will give anything or not, and show them the list of those who have given…

- Benjamin Franklin

Franklin was pointing to the importance of early contributions; “If Thomas Jefferson gave to the project then I should also give to the project”

This may also indicate that this is a project which will be successful or useful and we are all in this together

- Early contributions appear to be especially important in perhaps signaling public spiritedness
- The outcome of a (Kickstarter) campaign can be predicted with 85% accuracy only 15% of its duration (Etter et al., 2013)

- successfully funded projects tend to accumulate contributions quickly from the start of the campaign

Can we use refund bonuses to reduce mis-coordination and increase early contributions?

Maybe we can use them as signaling for public spiritedness impact

- compare two refund bonuses
- P20: proportional refund bonues r = 0.20 paid on contributions made at anytime during the contribution window
- PE20: proportional refund bonus r = 0.20 paid on contributions made during the first half of the contribution window

Treatment

Funding Frequency

Shortfall (std. error)

Baseline

74/170 = 43.5%

86.2 (6.2)

P20

133/220 = 60.5%

29.0(2.9)

PE20

154/230 = 67.0%

49.8 (3.8)

Since you are only paying to the guys in the first half you pay less and save on the refund bonuses paid on the out-of-equilibrium when the fundraise fails

Why do refund bonuses work?

- They make more potential contributors pivotal sooner
- pivotal - a contributor is pivotal when a single contributor would find it profitable, that is in their own self-interest, to push total contributions to the threshold
- In the beginning no one is pivotal because its in the interest of no single individual to fund the public good. But, as more and more people contribute you get to a point where even for a single contributor its worthwhile for them in their private interest to push you over the threshold.
- pivotal - a contributor is pivotal when a single contributor would find it profitable, that is in their own self-interest, to push total contributions to the threshold
- In the beginning no one is pivotal because its in the interest of no single individual to fund the public good. But, as more and more people contribute you get to a point where even for a single contributor its worthwhile for them in their private interest to push you over the threshold.
- In the baseline treatment - the most pivotal contributors comes towards the end
- P20 you get a bigger spike but it is still at the end; there is sniping here and inefficient equillibria which is possible when people become pivotal towards the end
- PE20 makes pivotalness happen much earlier - gives it time to become salient. It may be in your own interest to push this public good to the threshold.

In theory the refund bonuses are never paid. In practice we see even in our very best model 1/3 of the time an entrepreneur has to pay up.

- Thus, entrepreneurs must balance greater campaign success with refund bonuses with greater risk of paying the refund bonus and getting nothing.
- We show that with modest markups (10% or 20%) that refund bonuses are profitable.

- PE20 is especially profitable because it increases success and reduces refund bonuses at the same time
- the extra profit you make on the increase in the number of successful campaigns more than pays for the refund bonuses you have to pay out for unsuccessful campaigns.
- only paying out refund bonuses to those who paid in the first half of the contribution period
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Summary

- Refund bonuses double crowdfunding campaign success
- Refund bonuses pay for themselves
- All kinds f refund bonuses, fixed, proportional, early, constant, work well.

Pt. 3 The contribution problem of public goods vs. the Information Revelation problem

- The refund bonus scheme works well when you know the public good that you want and the problem is gathering enough contributions.
- e.g., lighthouse, public monument, dam
- You know for technological considerations how big the dam should be. Your problem then is just figuring out how to get people to contribute to the dam.
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- The second problem is people not knowing how to value the public good
- What if the problem is that you don’t know how much people value the public good? How much to spend on public parks vs. firework shows?
- Here information revelation mechanisms such as quadratic funding mechanism (Buterin, Hitzig, Weyl 2019) can help to reveal information about which public goods to provide at the expense of requiring subsidies (government or outside funding)
- Refund bonuses get people to contribute but the information revelation mechanism needs to be paid for.
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The Public Good Optima

- To find the optimum for a continuous public good G

we sum the MB

of all individuals and set equal to the MC

.

\sum MB = MC

- G

is the amount of the public goof

- MB

is the marginal benefit

- MC

is the marginal cost

On their own neither individual is even willing to pay for the first unit of the public good because their marginal benefit for even the first unit is less than the marginal cost. But since its a public good we find the optimum by summing up the marginal benefits curves.

- How does the government or subsidizer know how much of the public good to produce - the optimum without knowing the marginal benefit curves?
- The quadratic funding mechanism is a remarkable information revelation mechanism
- What Buterin, Hitzig, and Weyl (2019) show is that if the funder agrees to subsidize contributions to the public good according to the quadratic funding formula (QFF) then individuals will agree to contribute such that the optimum is reached.
- Given the QF formula, the optimum is going to be revealed by individual choices.

So here comes the challenge: how do we aggregate together people's preferences? Some private and public goods are worth producing, others are not. In the case of private goods, the question is easy, because we can just decompose it into a series of decisions for each individual. Whatever amount each person is willing to pay for, that much gets produced for them; the economics is not especially complex. In the case of public goods, however, you cannot "decompose", and so we need to add up people's preferences in a different way.

- Vitalik , Quadratic Payments 2019 (1/3)

But instead of just thinking about one single public good, let's create a mechanism where anyone

can raise funds for what they claim to be a public good project. Anyone can make a contribution to any project; a mechanism keeps track of these contributions and then at the end of some period of time the mechanism calculates a payment to each project. The way that this payment is calculated is as follows: for any given project, take the square root of each contributor's contribution, add these values together, and take the square of the result.

- (2/3)

In any case where there is more than one contributor, the computed payment is greater than the raw sum of contributions; the difference comes out of a central subsidy pool (eg. if ten people each donate $1, then the sum-of-square-roots is $10, and the square of that is $100, so the subsidy is $90). Note that if the subsidy pool is not big enough to make the full required payment to every project, we can just divide the subsidies proportionately by whatever constant makes the totals add up to the subsidy pool's budget; you can prove that this solves the tragedy-of-the-commons problem as well as you can with that subsidy budget

.

- (3/3)

The quadratic funding formula is the sum of the square root of the contributions all squared

G = (\sqrt{c_1} + \sqrt{c2} + ... \sqrt{c_i} +...\sqrt{c_n})^2

(\sum_{i=1}^{n} \sqrt{c_i}^2)

- where c_i

is i's

contribution to the public good.

- When individuals know that the total funding of the public good will be G

, then individuals will contribute such that G = G^*

where G^*

is the optimum level

- Thus, Nash equilibrium has the optimum public good being chosen.

In this example when G = (√c_1 + √c_2)^2

then it is individual 1 and 2's self-interest to choose c_1

and c_2

such that

- c_1 = 45/8, c_2 = 5/8
- G = (√45/8 + √5/8)^2 = 10 = G^*
- Subsidy = 10 - 45/8 - 5/8 = 3.75

The government or someone else has to come up with the subsidy

The Subsidy

- G = (\sum_{i=1}^{n} \sqrt{c_i}^2)
- Subsidy = G - \sum_{i=1}^{n} c_i
- The contributions are the square roots squared
- Total subsidies increase as each individual contribution becomes small relative to the whole.
- If you get very small then the subsidies are huge
- Reflects the logic that in the atomistic world, fewer externalities are internalized so you need bigger subsidies
- Reflects the logic that in the atomistic world, fewer externalities are internalized so you need bigger subsidies
- A public goods funding mechanism where each individual makes a small contribution but this small contribution benefits many other people vs. a mechanism where each individual makes a large contribution that only benefits a small number of people.
- Corollary: If there is only one contributor, then there is no externality and no subsidy
- G = (\sqrt{c_1})^2 = c_1
- G = (\sqrt{c_1})^2 = c_1

Quadratic funding penalizes the oligarchs and benefits the people!

- Lots of people small amount = big subsidy
- Few people large amount = small subsidy

The Logic is the externality logic. This is a consequence of the externality logic, the mechanisms wasn't produced to have these consequences. Its just that you can express the logic of the externality consequence in this language which makes it easier to sell the idea.

Subsidies and Internalizing the Externality

- Essentially what the subsidies do id they internalize the externality or they make up for the externality
- Example: If 1 and 2 cared about one another as much as they care for themselves they would increase their respective contributions and act as if they were a single person.
- The subsidies 2,1 and 1,2 are what are needed to make the total contribution as if 1 and 2 cared for another and "internalized the externality"
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- The subsidies 2,1 and 1,2 are what are needed to make the total contribution as if 1 and 2 cared for another and "internalized the externality"

Sybil Attacks

- If c_1 = 4

, c_2 = 4

then c_1 + c_2 = 8

- G = (\sqrt{4} + \sqrt{4})^2 = 16
- Subsidy = 16 - 8 = 8

Individual 1 contributes 1, individual 2 contributes 4

If c_1

sybils and submits {1,1,1,1} and c_2

submits 4 then the total contributions remain the same

c_1 + c_2 = 8

However if you now put this into the formula then you get

G = (\sqrt{1} + \sqrt{1} + \sqrt{1} + \sqrt{1} + \sqrt{4})^2 = 36

Subsidy = 36 - 8 = 28

- Now the subsidy has increased significantly due to the sybil attack
- Clear incentive to sybil which gets even worse if the donor is also the recipient.
- Sybil attack plus self-dealing will create large incentives to take advantage of the mechanism by grabbing up the subsidy.
- Identity proof is needed to protect the subsidy
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Nash Equilibrium

- The Nash Equilibrium of the quadratic funding mechanism is at the optimum level of public good funding but there isn't a dominant strategy
- In other words, the optimal contribution for 1 depends on how much 2 gives and vice-versa
- Need to grope towards equilibrium
- the quadratic funding formula hasn't been tested in the lab to see how close we get to NE
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Quadratic Funding in Practice

- Gitcoin makes donations to Ethereum projects using the QF mechanism
- Rarely in the history of mechanisms have we seen a mechanism described in theory and then adopted in practice so quickly
- Round x donated $1.38 million to 812 different projects
- $0.880 million from over 12,000 contributors with $0.500 million in subsidies

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- Round x donated $1.38 million to 812 different projects
- $0.880 million from over 12,000 contributors with $0.500 million in subsidies
- Sybil attacks have become common and have become more common over time as people learn about the mechanism
- Some projects promised people who donated to their project that they would get a reward “airdrop” later - element of self-dealing
- Note that a small donation can result in a relatively large reward due to the subsidy - its possible to squeeze the subsidy provider to give back more to people who contribute to your project then they gave and maintain a pot of funds for yourself
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- Note that a small donation can result in a relatively large reward due to the subsidy - its possible to squeeze the subsidy provider to give back more to people who contribute to your project then they gave and maintain a pot of funds for yourself
- Gitcoin has been using a combination of machine and human intelligence to thwart sybil attacks and self-dealing
- Moving towards identity verification with Github accounts
- Making donations impossible to prove
- the donee doesn’t know who gave the money and the donor can’t prove they donated
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- The fundamental problem of collusion - mechanisms that allow unorganized groups to coordinate are vulnerable to organized groups that collude
- when you give people tools to coordinate those tools can inevitably be used to collude.
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Two Mechanisms: Summary

- Refund bonuses improve the crowdfunding contract and can solve the contribution problem
- The Quadratic Funding Mechanism can elicit people’s preferences for public goods using subsidy

Competition is a discovery procedure. But for public goods we have not been able to use competition to discover the most demanded goods produced in the least costly ways.

- Crowdfunding with refund bonuses and the quadratic funding mechanism are two mechanisms that can bring competition to the provision of public goods
- More generally, creating mechanisms that allow entrepreneurs and markets to produce public goods may create more and better public goods.
- for the first time we can use all of the benefits of discovery procedure to figure out what people want and what is the best way of producing what they actually want
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Signal

- An entrepreneur that offers a refund bonus is signaling that they are confident they won't have to pay the refund bonus
- If every entrepreneur with a good project uses refund bonuses then there are incentives for a bad project to offer refund bonuses as well.
- There is a complex signaling game in which you expect some randomization. Most good projects offer refund bonus and most bad ones won't, but there could be a mixed equilibrium where some bad projects offer refund bonuses
- Overall refund bonuses or these types of schemes should expand the amount of public goods that can be produced.
- Since most crowdfunding campaigns fail I think this means there is space for many more of them
- Ideally, If we see more of these types of mechanisms we could see a flowering of public goods provision to do things we never realized were public goods