Progress

Class 8 - Incentives

Kevin A. Bryan - Toronto Rotman - Nov 5 2025

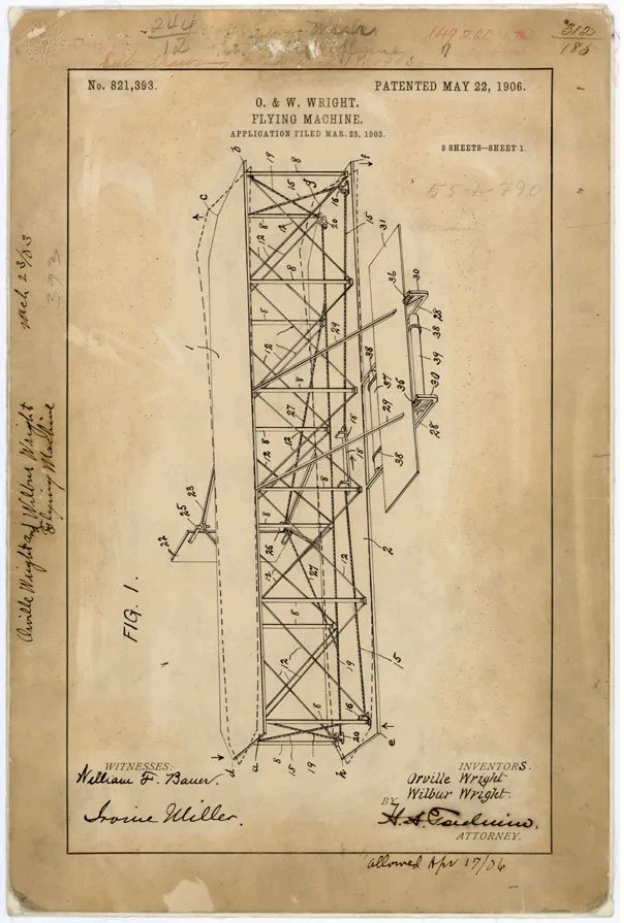
After class notes in Red

If I want more 'directed human action to improve the standard of living', why don't I just pay for it?

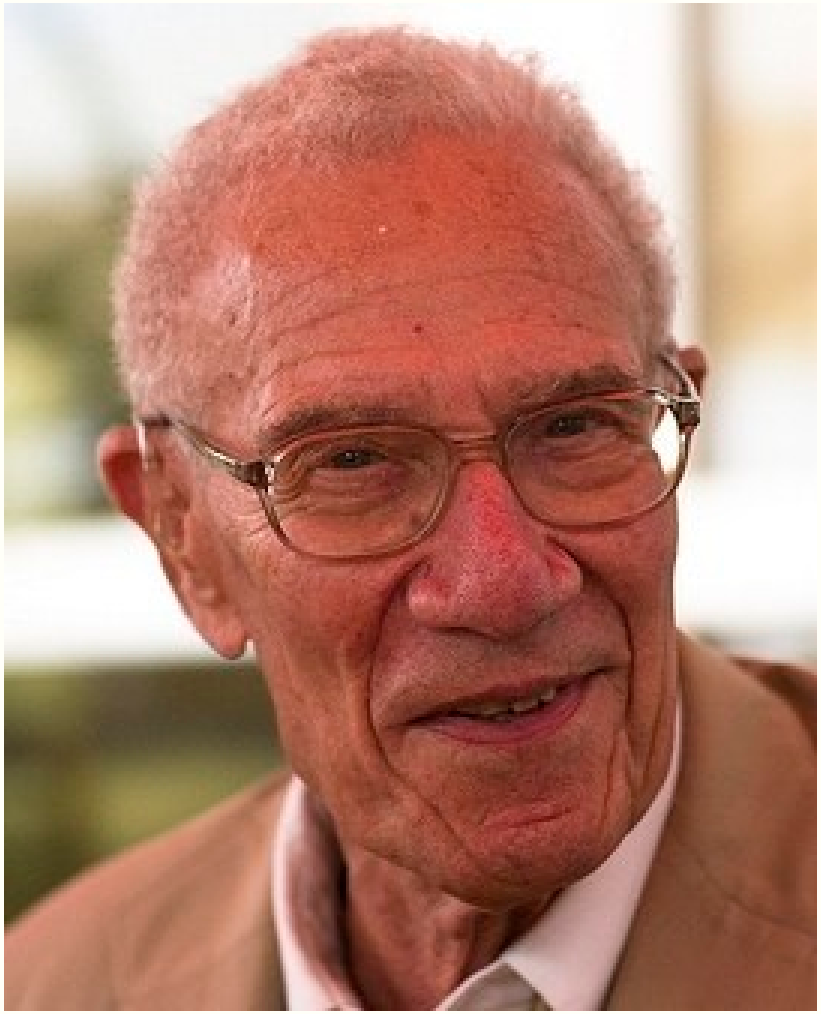
We'll discuss at the end of today's class - are there aspects of progress where "greater financial incentive to do X" is going to be a poor or less effective way of achieving that goal?

What mechanisms can incentivize technical progress, in particular?

Patents, ex-ante prizes, ex-post prizes, R&D subsidies, direct procurement, 'directed' policies like DARPA (we'll discuss the latter much more in class 10). And of course people invent or discover because of curiosity, because their firm has a first-mover advantage or some other way to "appropriate" rents, in order to solve a personal problem, and so on.

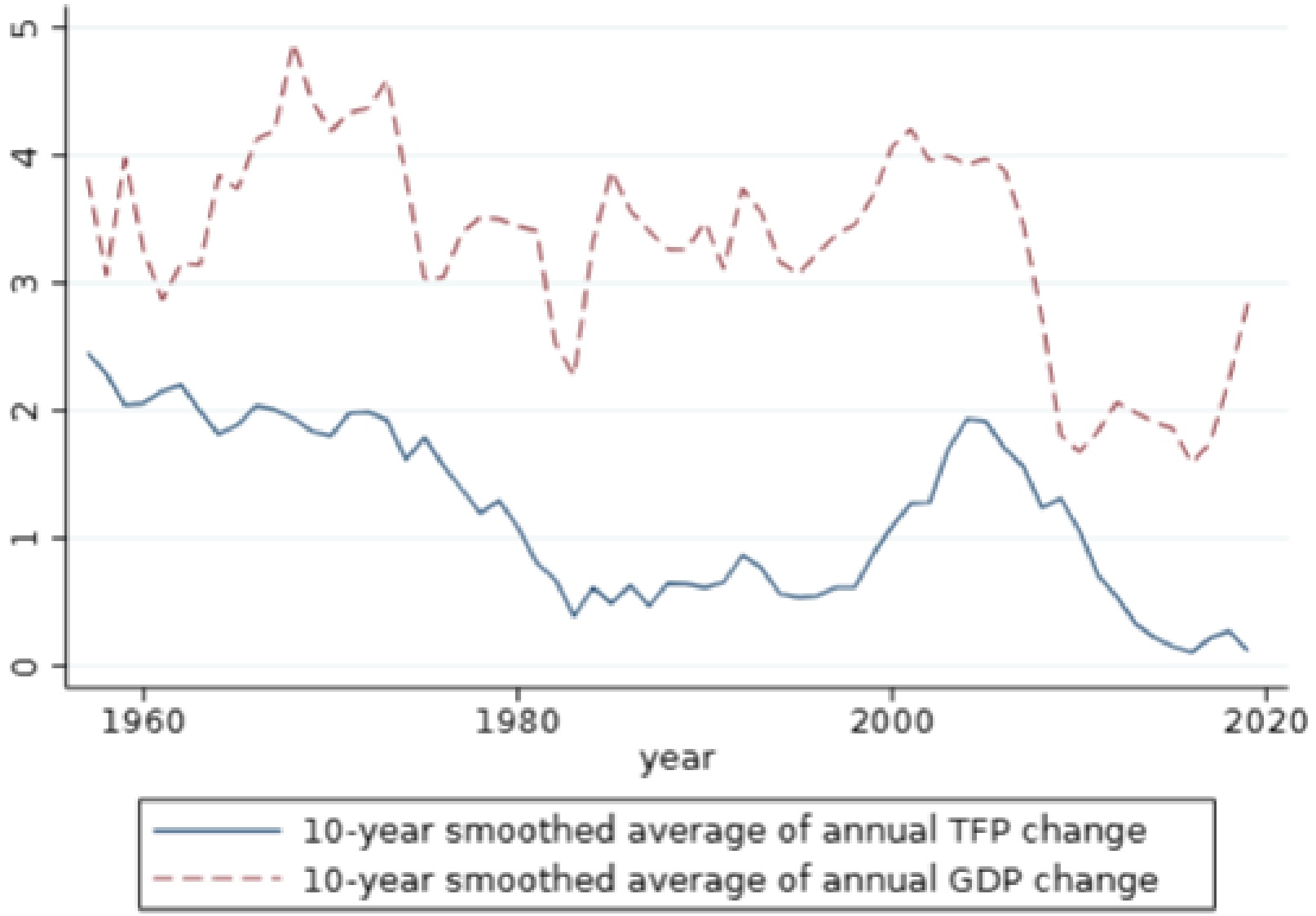


Patents (here, the Wright's famous '393 patent), prizes like the X Prize, and direct procurement of innovation (a la Warp Speed) are the most common



Until the 1950s, there was very little research on innovation that considered it an economic process; Schumpeter (left) being an exception. Only 11 articles in the three most prominent economic journals until 1960 on the topic. Innovation was considered psychology, or history, primarily. Solow (right) in his growth theory paper, however, finds that neither more human labor nor more capital can explain growth patterns - it is a nebulous "total factor productivity".

We now see TFP as primarily being linked to the invention and diffusion of new goods. In the 1960s a ton of research and data collection of whether that invention and diffusion could be affected by economic incentives - answer turned out to be yes.

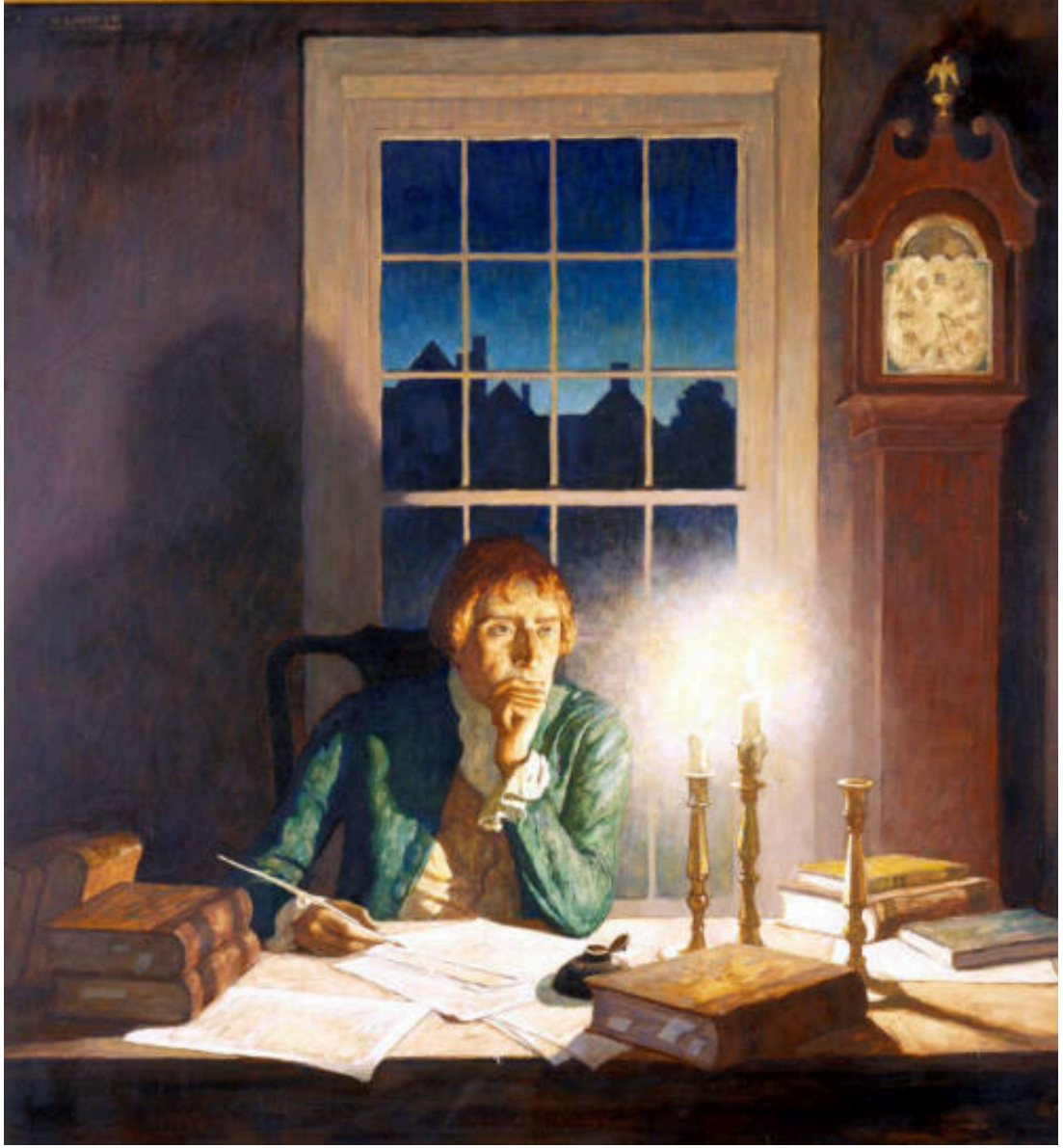


Note the correlation (here in US data) between TFP and overall growth. Worldwide, ~1/2 of long term growth is TFP and roughly half of that is from innovation and diffusion of new goods.

Why do we have 'innovation policies' and not 'car policies' or 'candle policies"?

Arrow (1962): efficiency in general equilibrium requires *convex production functions*, *no externalities*, *hedgable uncertainty*

Our normal arguments for why "markets work" come from general equilibrium theory, where market prices adjust and play the role of incentive and signal to produce optimally. Sometimes we can correct distortions while still using market prices (e.g., taxes on pollution, which are so-called "Pigouvian taxes").
Arrow's 1962 paper argues that new goods possess three features that make it really hard for laissez faire markets to properly incentivize new things.



Convexity: If I can produce 6 of x using 3 of input y, I need to be able to produce at least 2 of x using 1 of input y. But Jefferson: "He who receives an idea from me receives instruction himself without lessening mine; as he who lights his taper at mine, receives light without darkening me."
Ideas are very expensive to produce the first unit, very cheap thereafter. Not convex! And in particular, first production super expensive ONLY for initial inventor.

Alto from "Mother of All Demos", Jobs seed, builds Apple.

Who gets the returns from an invention? Not necessarily the inventor. Spillovers to related products ('sequential invention'), spillovers from failed research (I don't waste time making the same mistakes as you), etc.

Is this guy working hard or asleep? Science is uncertain and effort unobservable. So when research fails, hard to know if researcher was unlucky, if the research proposal was impossible, or if the researcher just shirked and didn't try. While a lot of economic uncertainty can be hedged by risk averse agents (e.g., an airline buys oil futures), moral hazard and adverse selection make it difficult to hedge research uncertainty.

What we need to incentivize

- What inventors to give $
- But how much is the invention worth?

Encourage follow-on work?

- And will cash balance Exploit vs. Experiment

Patents

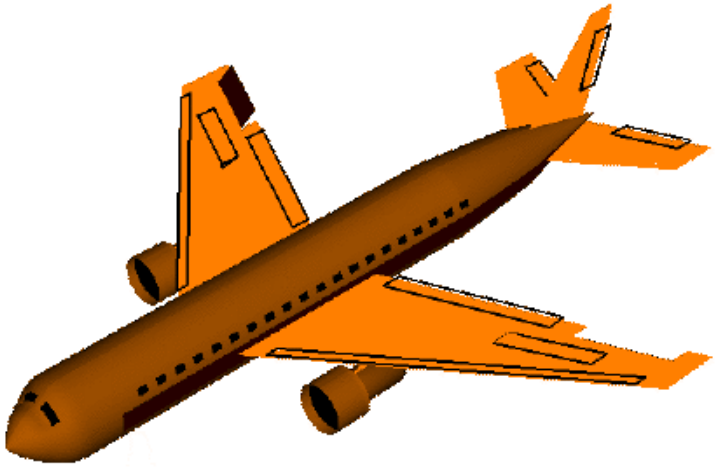
Novel invention (not idea). File paperwork at cost of ~10k. 20 years of protection from application date. Covers "claims".

Patents don't cover an "idea" or even an "invention", but a set of claims. These are often some sub-component of an invention (like wing warping in the '393 airplane patent). How much that covers follow-on is often subjective - look at the famous battle over the Wright patent vs. Curtiss and his alternative method of roll control!
This is one reason patents are likely most used when the invention is very clear and hard to invent around - like a molecule for a drug patent.

Embedded Website:

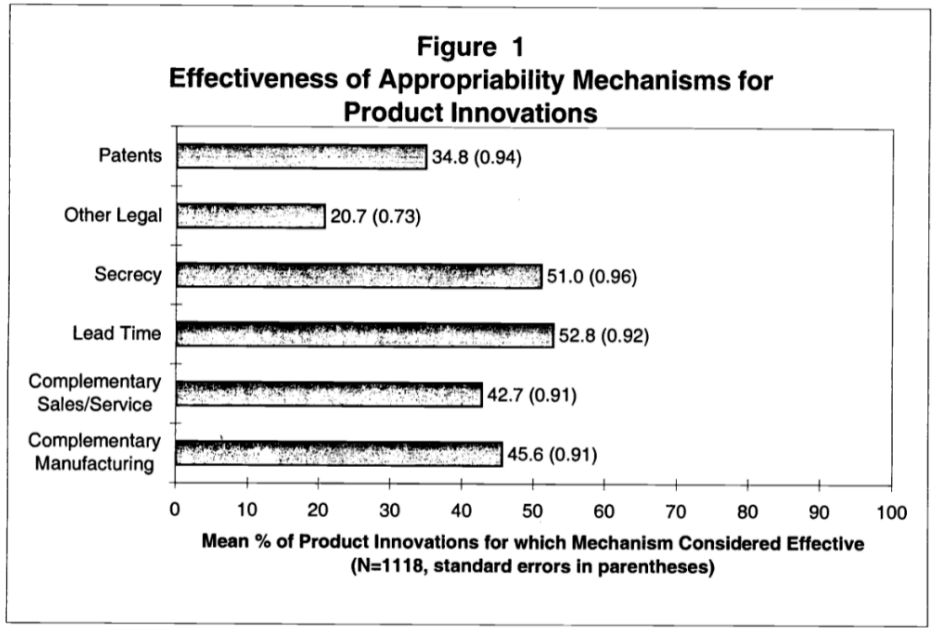
https://patentimages.storage.googleapis.com/1c/17/b5/e1f4968143a568/US821393.pdf

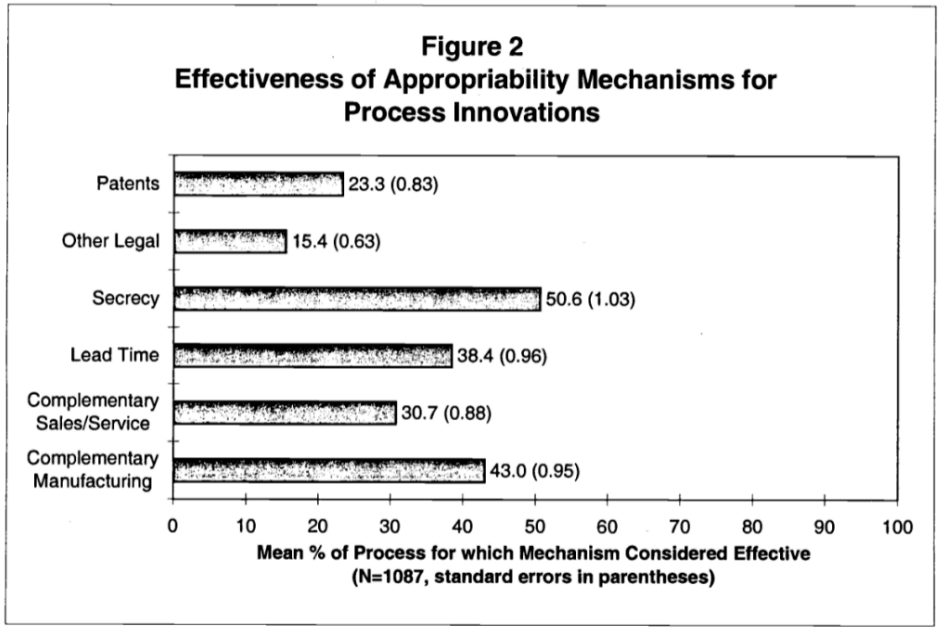
The Wright '393 patent. You can see the "claims" in the last couple pages, after the required description of how the invention works. This description needs to allow someone "trained in the art" to replicate it.



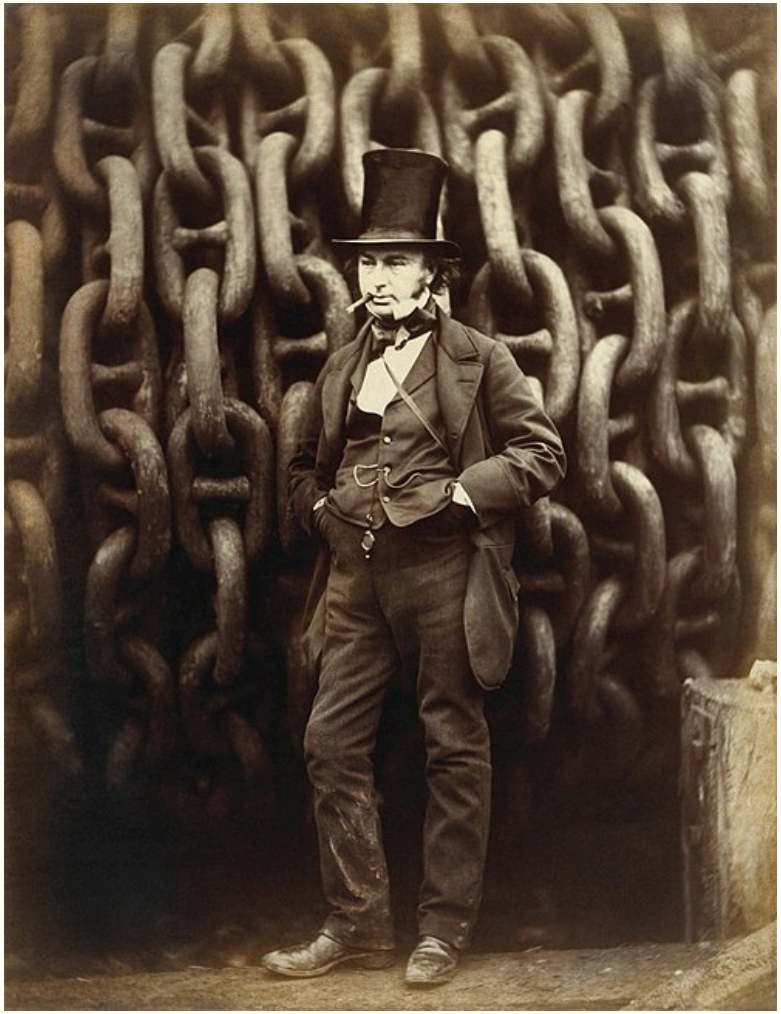
Wrights use "wing warping" for roll control. All practical planes later used ailerons. But did "credit for invention" cause a race to the less practical design? Incentives matter!

Here, the incentive is "credit for being a famous inventor" and it comes from society rather than a principal. So why did the Wrights get all the credit when many inventors were necessary to make a modern airplane? And of course the aileron vs. wing warping battle led to a massive patent dispute between the Wrights and Curtiss - did the Wrights invent 'controlled airplanes' or 'wing warping control'?
Which should they get credit for? Note that the Curtiss designs are what modern airplanes are based on - perhaps getting credit for being first led the Wrights to "race" toward a faster but harder-to-built-on solution. In that case, patents and "credit for the big invention" were a big problem! See my paper here: https://kevinbryanecon.com/EarlyAirplane.pdf



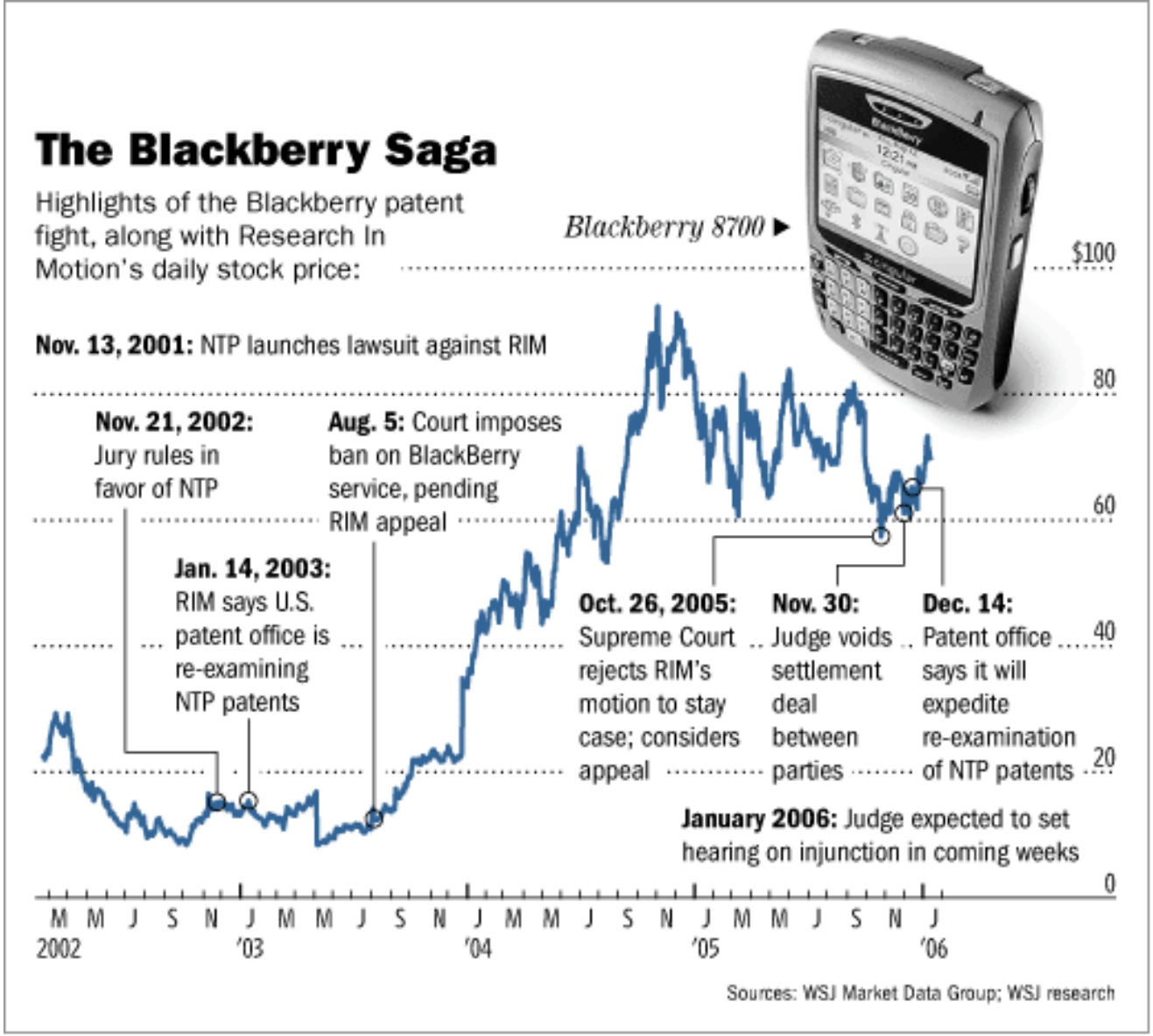


This is from the "Carnegie Survey" of R&D heads. "Yale survey" finds that same - patents are not the main way that firms claim they appropriate value. Only in areas like pharma and chemicals are patents as important as other methods for protecting inventions.



Text: *...it is almost now to introduce the slightest improvement in anything without infringing on some patent, and exposing oneself to be proceeded against by some patentee*
Isambard Kingdom Brunel

The greatest engineer in British history, French-American father, very much opposed to patents. The late 1800s were a very 'free trade' area: Switzerland didn't allow patents at all, the Netherlands got rid of their patents, and the UK almost did as well. The idea was - why are we giving these monopolies out? Of course, patents come from the same history as "royal monopolies" for things other than invention!



And even today, many argue patents are used to just to slow down the "people doing real things" - see the many complaints by RIM/Blackberry's cofounders about how "patent trolls" caused years of delay in their ability to compete with the iPhone.

Patents are a partial *monopoly*, including on *further* inventions.

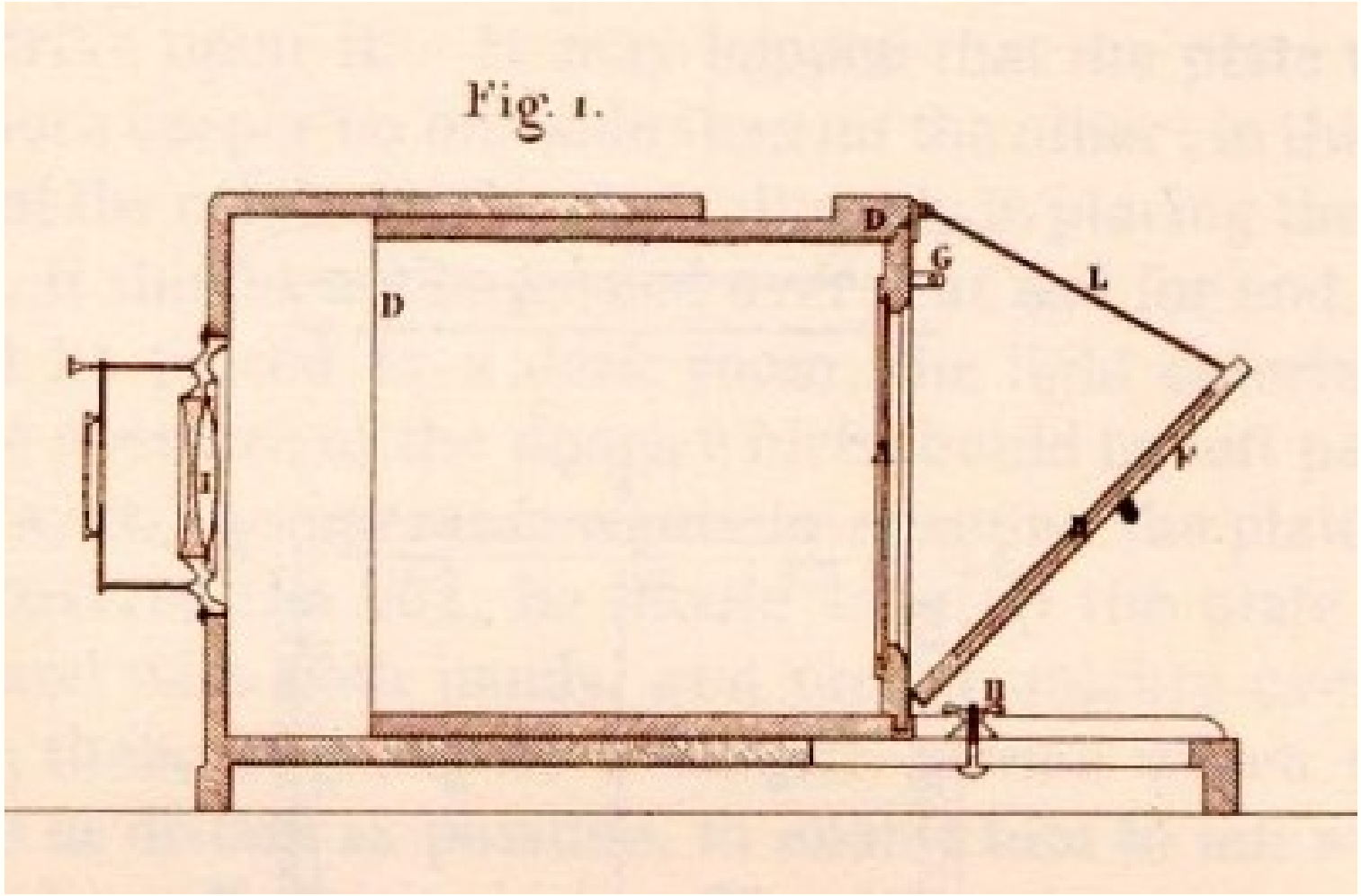
So why do we use them?

"Letters patent" historically were often *literally* monopoly grants, and in England parliament restricted just to invention in the 1600s because the King was giving friends a patent. Now, we exchange monopoly power to inventors plus ability to hold up some follow-on invention in exchange for "better information"/not requiring the planner to know what the great inventions will be?
Zorina Khan finds this especially important: the value of patents determined by the market not by a government or other committee.

Patents are a partial *monopoly*, including on *further* inventions.

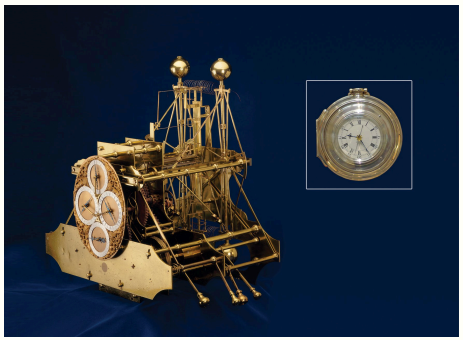
Tell me what the most important inventions of the next decade will be. Go.

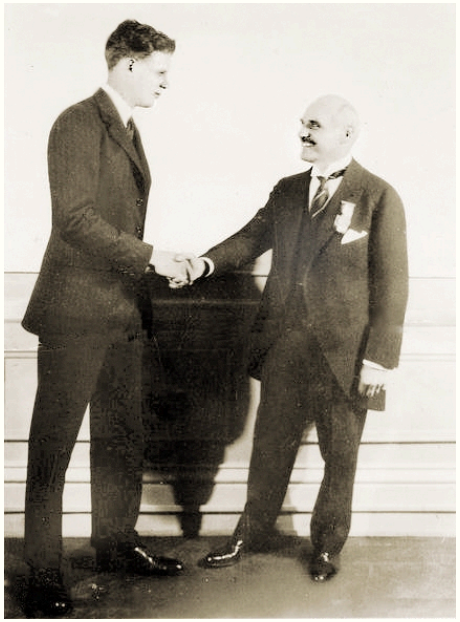
Very hard to predict! Even for government. Who would have predicted peptide-type therapies like Ozempic as the big recent breakthrough - and medicine is easiest!



Daguerrotype buyout in 1839? Can this work?

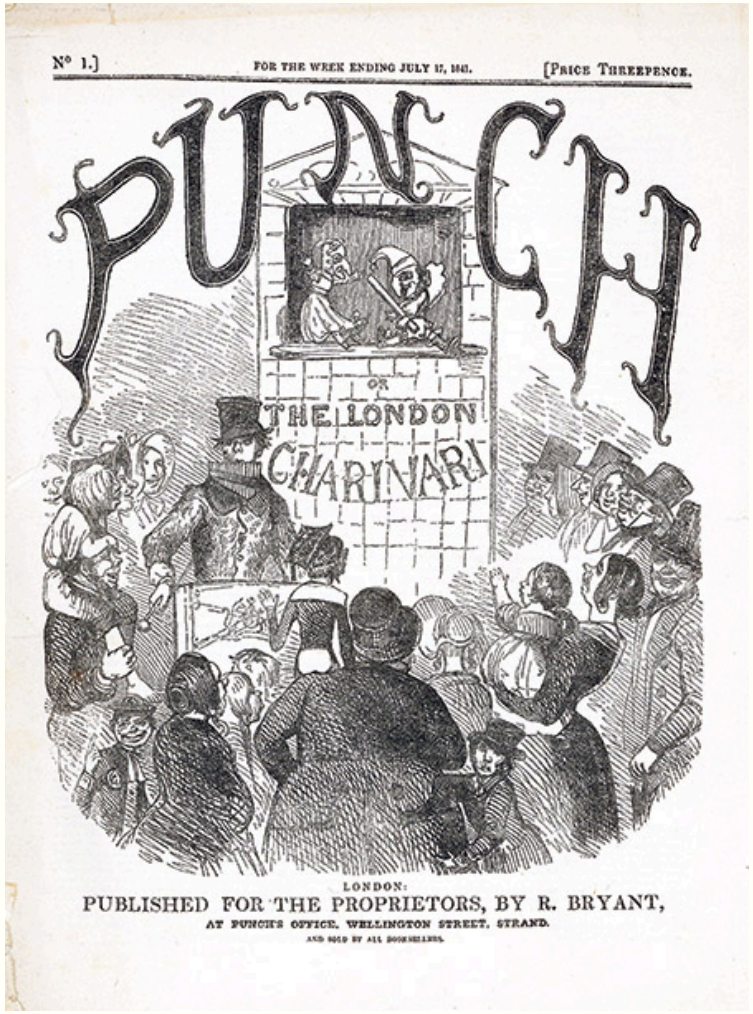
An alternative to patents: just give a cash prize to inventors equal to the monopoly profits, then have the good produced competitively, reducing deadweight loss and the transaction costs of licensing. The story is that this is what happened with the original camera, the Daguerrotype, but note that Khan shows this may be a misleading story.





ANSARI X PRIZE®

Some famous prizes include the Orteig prize 1919 for flying NY to Paris won by Lindbergh in 27, Napoleon's prize that led to canned food, X Prize for going to space in a "build and launch a spacecraft capable of carrying three people to 100 kilometers above the Earth's surface, twice within two weeks", John Harrison's longitude prize for, basically, a clock that works at sea so you can figure out how far East or West you are.



"Deeply impressed as always with the conviction that the progress of invention has been delayed by the lack of encouragement", Punch magazine offered 10,000 pounds for the first aeronaut who goes to Mars and back in a week

Though note that sometimes prizes won't work if the thing we are trying to incentivize isn't feasible, as this satirical comment from Punch in the early 1900s makes clear!

And a *public choice* worry: unlike patents, committees decide who wins (ex-ante prizes) or who should get a prize for the creative (ex-post prizes).

History is full of stratagems here where connected-to-power people got prizes and outsiders like the uneducated John Harrison of the longitude contest got nothing - see Khan! "Public choice" means that governments don't maximize social welfare - rather, they are made up of people who face incentive problems just like firms and individuals do.

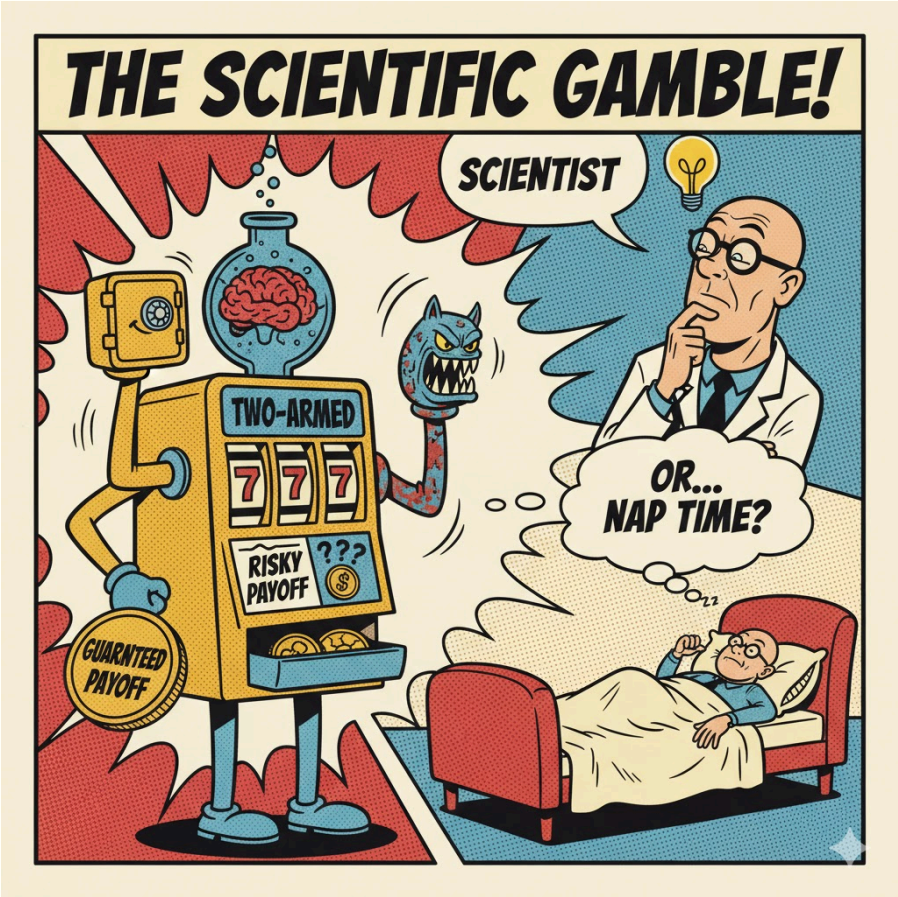
"Advanced Market Committments", a middle ground?

Pneumococcal vaccine, some controversy over the role played by AMCs but generally considered a big success. See Kremer Levin Snyder: https://scholar.harvard.edu/files/kremer/files/amc_pp_20_20_01_13.pdf

Can I spur *creativity* with incentives?

Meaning, even if I can spur invention, can I spur high-variance, high-creativity invention?

How do you get scientists to work on risky things?



The "two-armed bandit":

Pull safe arm, get v.

Pull risky arm, pr(.5) get v'>2v, else 0.

Sleep, get 0.

Pulling arms is costly to scientist and unobserved.

The multi-armed bandit is a mathematical problem where you can do safe or risky things. The risky thing reveals information (the risky arm may best or may not be, and you only learn this over time). Think of incentivizing a researcher who bears a personal effort cost to doing safe or risky research, and can shirk instead of doing either. What to do?

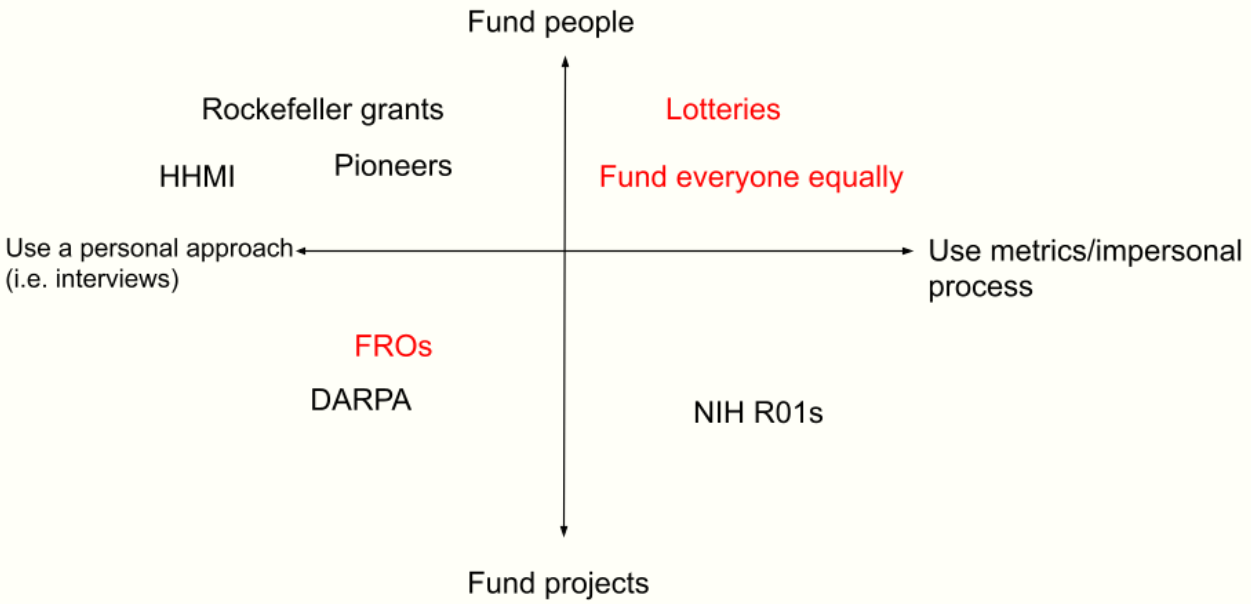
Optimal Manso contract: pay *more* for early failures and later successes.

Pay for early failure: get them to pull risky arm not safe arm.

Pay for later success: get them to pull risky arm not sleep.

Manso's result uses "big pay for later success" to get you to not shirk, and uses "pay for early failure" to get you not to just do the safe, low-variance thing. It turns out to be mathematically optimal. Think about what a "Manso mechanism" looks like for incentivizing an architect, or a government funding body, or a scientist?

HHMI "Fund People Not Projects"



One Manso-type mechanism is to, instead of giving grants to scientists based on their number of past publications and citations, and for the purpose of a short-term new project, instead give them on the basis of the high-variance of their new project, for a longer term, and linked to the "person" not the "project".

Then only renew 7 years later if we made a breakthrough. That is, we don't reward you at all for "small hits" which many people would create, but we also require some big outcome over the 7 year period to get renewed. Manso like! The Howard Hughes institute gave grants in exactly this way.

TABLE 8 Effects of HHMI Appointment on the Direction of Research

Impact of Treatment on:	Dependent Variable	X-Section	ATE	ATT	DD	SDD
Topic novelty	Avg. MeSH keyword age	−0.028**	−0.014	− 0.016†	−0.020	−0.027*
		(0.009)	(0.009)	(0.009)	(0.013)	(0.013)
Change in research direction	Normalized MeSH keyword overlap	−0.258**	−0.206**	−0.259**		
		(0.060)	(0.058)	(0.059)		
Breadth of impact	Citing journal diversity index	0.223**	0.192**	0.231**		
		(0.071)	(0.060)	(0.073)		
No. of scientists		417	417	417	417	417

can I spur creativity?

And the grant recipients, compared to similar folks who got more "traditional grants", did more novel research, with more "duds" but also more very-high-return outcomes. Exactly what we want!

Note that patents and prizes do *not* look like this system - is there a principal-agent issue for patents/prizes?

That is, is it fine to give patents/prizes and then let researcher effort problems happen inside the firm? Maybe government's job is to give the incentive, then firms/orgs try to get the creativity with internal incentives. But note many firms are running "internal prize contests" and the like - are we sure these are "Manso mechanisms"?

Caveat 1: Remember Punch Magazine. When are "not enough incentives" likely to be the main problem?

Perhaps ones where political issues constrain? But see the Mo Ibrahim prize - millions of $ if you step down after losing a democratic election in Africa. Money can work! Perhaps without the right training, education, liberty, science, there is no one who can actually solve the problem even if money is there?
Perhaps aspects of progress that aren't pure invention are harder to solve - e.g., what 'incentives improvement' have led to women's suffrage?

And caveat 2: how important is "Big I" Innovation anyway?

Might we distort effort away from everyday activities that keep up what we already have?

I disagree with essentially the entire Aeon article you read, but of course, we care about more than just "new things". We also want to maintain what we have - the sewer systems, the cultural artifacts, the building facades.
My view is that the status quo bias is so strong, and traditional political and market incentives good enough, that it's not obvious we need *extra* incentives to maintain things. The opposite is true for new things!

Next Week

Organizations for Progress

What organizational features are better for progress than for the status quo? Can we design firms, orgs, universities and governments to be more progress-oriented?