WORKING PAPERS

N° 1453

June 2023

# The (Ir)Relevance of the Cooperative Form

Paul-Henri Moisson, Pierre Dubois and Jean Tirole

Toulouse School of Economics

# The (Ir)Relevance of the Cooperative Form[†]

Paul-Henri Moisson[*] Pierre Dubois[**] Jean Tirole[***]

June 28, 2023

**Abstract**

It is puzzling that cooperatives, which stand for the interests of their users, do not occupy more space in the market for corporate forms. This paper unveils a new impediment to their formation. It shows that equilibrium free-riding handicaps cooperatives in their competition with alternative institutions, notably the for-profits. The irrelevance of cooperatives is a remarkably robust result. The paper then analyzes desirable government interventions in the corporate market.

*JEL numbers*: D23, D71, D8, L22.

*Keywords*: Cooperatives, free-riding, competing corporate forms.

[†]The authors gratefully acknowledge funding from the Agence Nationale de la Recherche under grant ANR-17-EURE-0010 (Investissements d'Avenir program), funding under the "PSPC" call for projects operated on behalf of the French government by Bpifrance as part of the "investments for the future" program (PIA) ARPEGE and funding from the TSE-P Health Center whose lists of sponsors can be found at https://www.tse-fr.eu/health.

[*]Toulouse School of Economics (TSE), paulhenri.moisson@tse-fr.eu

[**]Toulouse School of Economics (TSE), pierre.dubois@tse-fr.eu

[***]Toulouse School of Economics (TSE) and Institute for Advanced Study in Toulouse (IAST), jean.tirole@tse-fr.eu

# 1 Introduction

Suppose that multiple users would benefit, possibly to a varying degree, from the development of a new technology or from the production of a public good: A group of countries may have an urge for a new antibiotic, a diagnostic or a vaccine, want to "re-shore" personal protective equipment or wish to cooperate in the financing of green R&D or learning-by-doing on renewable energy. A consortium (of car manufacturers) may need a new infrastructure (a new battery for electric vehicles or a network of charging stations). A coalition of cities and builders in a metropolitan area would like to co-finance the investment in a local green cement factory. Or a crowdfunding platform may harness users' interest in a product to raise funds for its development.

The technology or infrastructure may be provided by a for-profit, i.e. a third-party supplier who has no in-house use for the technology and receives funding from the capital market. Alternatively, concerns about market power and under-inclusiveness may trigger the creation of a cooperative of users. Cooperative members can allocate funding duties among themselves, assign usage rights, and split the cash-flow rights on the revenue from selling access to non-members, subsequent innovations or other derivative decisions. This paper asks a simple question: In a world in which there is no governance cost to forming a cooperative, should we expect the cooperative form to (a) be viable, and if so, (b) win the corporate-form competition against for-profits? One may conjecture that the higher social surplus created by the cooperative form gives it a decisive advantage. This paper argues the contrary.

Section 2 introduces the baseline model of the development of a technology with a known fixed cost. The knowledge to build this technology is widely shared and so there is no barrier to entry into its development. (Potential) users differ in their willingness to pay for using the technology.[1] To counter for-profit companies, a cooperative organizer ("ringmaster") can offer at any time a financing arrangement cum usage and ownership rights to the community (or a subset) of users. Regardless of its corporate form, the first entity to invest enjoys de facto (although not de jure) monopoly rights on the technology, as we provide a condition under which a second entrant, by triggering Bertrand competition, would not be viable even if financed by users eager to create competition. This first entity sets the terms and conditions for non-members to have access to the technology ("non-members" are all users in the

[1] As we show, there can more generally be a public signal concerning each given user's willingness to pay, in such a way that our model accommodates the full range from fully-private information to common-knowledge valuations.

case of a for-profit).

We assume that whoever develops the technology will pursue its own interests in a time-consistent manner when exercising ownership rights. In particular, if a coalition of users develops the technology, it cannot commit to a time-inconsistent policy of exclusion of non-members. The corollary of time consistency is that users who stay out of the coalition for technology development may nonetheless later benefit from the technology.

Section 3's main result is that under *laissez-faire* the payoff outcome is the same whether or not cooperatives can compete in the corporate-form market: Cooperatives are irrelevant. The intuition is that users can hold out and let others invest in the technology, to later purchase access to it. The cooperative's strength – a broader base of users – is also its weakness, as the extra users are in the end reached through low prices, that apply not only to late adopters, but also to the founders who always have the option to be holdouts.[2]

Section 4 demonstrates the robustness of this irrelevance result. Section 4.1 extends the irrelevance result to the presence of externalities. Section 4.2 supposes that after an entity, for-profit or cooperative, has developed the technology, a principal (e.g., a government) maximizing the users' welfare Nash-bargains over access prices (as is often the case for drugs). We show that cooperatives remain irrelevant in this setting. Section 4.3 enables anyone who has developed the technology to sell access at multiple dates, after demand has arisen. The irrelevance result remains valid. Section 4.4 introduces repeat purchases and tacit collusion, delineating cases in which the cooperative form remains irrelevant.

Section 5 studies public intervention. The government (or alternatively, private donors) may co-finance the project for a return below the going market rate ("cheap funding"); the government may choose to restrict its funding to pure cooperatives (i.e. cooperatives entirely owned by users). Unsurprisingly, we show that for a cost of funds below some threshold, the government (or a philantropic donor) subsidizes a cooperative to help it form and pre-empt for-profits. We then study when such interventions bring the most "bang for the buck".

*Related literature.* Several literatures speak to the focus of this paper, starting with the literature on cooperatives. For example, Innes-Sexton (1994) shows how a for-profit supplier benefits from price discriminating among otherwise identical buyers when a coalition of buyers can develop the fixed-cost technology themselves so as to bypass the supplier. Innes and Sexton however do not look at the emergence of the for-profit form in the first place.

[2]We conclude Section 3 by showing the importance of the time consistency assumption for the irrelevance result.

Furthermore, and unlike in this paper, the potential for entry of a cooperative matters for equilibrium outcomes.

The literature on cooperatives has stressed two obstacles to their formation: the cash constraints of the users at the moment of investment, and the governance issues that arise when members have non-congruent objectives (Hansmann 1996). We purposely assume away user cash constraints. The other obstacle to the formation of a cooperative is also absent in our model: Differences in willingnesses to pay for usage is the only possible heterogeneity among potential users in our model. Once cooperative members have secured their own access to the technology, they all have the same objective of maximizing the revenue from licensing the technology to other users (in the absence of externalities). The incentive alignment of the cooperative's members makes our irrelevance result surprising and powerful. The literature on cooperatives also emphasizes that free-riding across generations of users may arise as new generations free-ride on the investments made by their predecessors. Rey-Tirole (2007) analyzes the role of the cooperatives' charter for the stability of such cooperatives. They do not consider for-profit alternatives. Also, in our paper, all potential users are present when investment decisions are made, so intergenerational free-riding is not an issue.

This paper connects to the theory of clubs initiated by Buchanan (1965). Indeed, we show that in our environment, when facing for-profit rivals, clubs of users can exist only if they can be *exclusive*, even though such exclusivity will go against their interest in the future.

Our analysis is further related to the literatures on funding and governance of R&D,[3] and on crowdfunding, starting with Admati-Perry (1991).[4] A cooperative may indeed be interpreted as the outcome of an equity crowdfunding. Our paper differs from this literature by introducing (i) for-profits along users' cooperatives, and (ii) preemption concerns, and showing that they may make (even costless and infinitely efficient) crowdfunding irrelevant.

Lastly, our analysis relates to the literature on the role of time consistency in collective decision-making. Notable contributions include Battaglini-Harstad (2016, 2020), who study how incomplete contracts can reduce the incentives to free ride on collective agreements, thereby enabling larger participation than complete contracts, and how domestic political

[3] Aghion-Tirole (1994) studies the financing of innovation and looks at the allocation of ownership rights between user and innovator (property rights contingent on the nature of the innovation; trailer clauses; shop rights which confer ownership to the innovator while at the same time allocating a nonexclusive, non-assignable, and royalty-free license to use the innovation to the financier).

[4] Among several interesting recent contributions, Strausz (2017) emphasizes that crowdfunding helps entrepreneurs screen projects when they face uncertainty on the scale of aggregate demand. Strausz's model differs from ours in several ways: a finite number of agents, moral hazard, and no competition from for-profits. It would be interesting to add the possibility of preemption in his environment.

economy motives may generate "weak" international treaties. However, while these works focus on non-excludable common goods (e.g., clean air, low GHG emissions), contributors in our setting can exclude others from access to the contributions' outcome (e.g., new technology, drug or infrastructure). In fact, all else being equal, the excludability assumption limits free riding, making our irrelevance result all the more surprising.

## 2 Model

A community of users needs a technology (or infrastructure, drug, innovation) at a given date (but is around earlier).[5] We normalize this date to be date 0 and count time backwards: Let $t \in (0, +\infty)$ denote the time up to the date of demand realization.[6] The rate of interest is denoted by $r$. There is a mass 1 of atomistic potential users, whose (date-0) willingnesses to pay for the technology, $\theta$, are i.i.d. distributed according to a c.d.f. $F(\theta)$ with full support on $[0, +\infty)$ and increasing hazard rate $f/(1-F)$. Users are not constrained by cash. Willingnesses to pay (i.e., "types") are private.

The technology can be developed at any time $t \geq 0$ before the usage date (0), either by a for-profit or a cooperative of users. If they do so, they immediately and publicly incur the investment cost $I < \displaystyle\int_0^{\infty} \theta dF(\theta)$. There cannot be a credible investment until it is sunk. The marginal cost of production is equal to 0. Any entity which has developed the technology can sell access to it at any time and any price in a time-consistent way.

*Corporate entities.* A corporate entity can receive its funding from two sources: the issuance of shares/cash-flow rights to pure investors, and the sale of access/usage rights to "founding users", perhaps bundled with cash-flow rights. We focus on pure for-profits financed only by pure investors, and on pure cooperatives financed only by founding users.[7]

Let us describe these two polar arrangements. A *for-profit* entity is one that is funded solely by pure investors: To invest at date $t$, it must either use its retained earnings or issue a unit mass of cash-flow rights at (date-0) equivalent unit price $s$ each, such that $s = Ie^{rt}$. We assume that there are at least two for-profits.[8] A (pure) *cooperative* is in contrast funded by founding users, and organized by one cooperative ringmaster (having more than one would

[5] This version of the model thus presumes that demand grows over calendar time. Assuming instead that the cost of investment decreases over time (or a smoother process for demand growth) delivers the same results.

[6] Section 4.3 allows for demand not to be fulfilled at date 0, but rather differed to ulterior calendar time, at the cost of discounting.

[7] As will be clear shortly, our ignoring hybrid entities is without loss of generality as users are not cash-contrained (see also Online Appendix B for details).

[8] A single for-profit would not change the analysis, but the exposition is simpler with competing for-profits.

not affect the results). Without loss of generality, bundled usage rights and (equal) cash-flow rights on future profits are granted to founding members against a payment $a_t$ set by the ringmaster. The cooperative ringmaster has no endowment and has the same information as the market (namely, it knows only the distribution $F(\theta)$ of willingnesses to pay for usage, but not individual valuations).

We can entertain various assumptions regarding the goal of the cooperative ringmaster. For concreteness, we assume lexicographic preferences: first, the ringmaster wants to conduct a successful fundraising, enabling investment by a cooperative, and second, that the resulting cooperative be the largest possible. A number of alternative assumptions lead to the same equilibrium outcome (although not necessarily the same off-path behavior).[9]

While a corporate entity can form at any date $t > 0$, the entity will also offer at date 0 access at a price of its choosing to unattached users (users who have not become founding members of a cooperative and therefore do not yet enjoy usage rights).[10] The profit thus realized is distributed as a dividend to holders of cash-flow rights.

A corporate entity's investment ("entry") and the size of its user membership (0 for a for-profit) are publicly observable.

*Timing.* It is easier to picture the timing in discrete time, even though we will present the continuous-time results to alleviate notation.

*Investment stage* ($t > 0$). Let $h_t$ denote the history of entry by date $t$, recording who has entered by date $t$ and with what user membership size (for a cooperative, 0 for a for-profit). At date $t$,

(i) The for-profits that have not yet invested decide whether to invest ($x_{jt}(h_t) = 1$ if for-profit $j$ invests and $x_{jt}(h_t) = 0$ otherwise). For-profit $j$ sinks its investment immediately if $x_{jt}(h_t) = 1$.

(ii) If the cooperative has not yet invested, the cooperative ringmaster makes an offer of a bundled ownership-cum-usage right at price $a_t$ to users. Each (yet unattached) user $\theta$ selects a conditional acceptance stragegy $\sigma_t(\theta | h_t, (x_{jt})_j, a_t) \in \{0, 1\}$, that is, each user accepts to become a founding member or not. We rule out coordination failures among

[9] Other possible assumptions are the maximization of users' welfare (in this model all users have aligned incentives as the arbitrage condition will imply that they pay the same net price for obtaining access). Still another possible assumption is that the ringmaster has material incentives and levies a fee $w$ for organizing the cooperative, in which case total investment cost becomes $Ie^{rt} + w$; the ringmaster then maximizes its discounted fee.

[10] In fact, once funded at date $t$, there is no benefit, and even a cost for a corporate entity to offer (further) access before date 0, as it would move down the demand curve, reducing its ability to charge a high price.

unattached users (in a sense that we clarify below). If the cooperative collects enough cash to invest, i.e. $a_t \mathbb{E}_\theta [\sigma_t(\theta | h_t, (x_{jt})_j, a_t)] \geq I$, investment takes place. Otherwise, no cooperative emerges at date $t$ and subscribing users are refunded.[11]

At date 0, "unattached users" denote the users who are not founding members of a cooperative that has invested prior to that date.

*Licensing stage* ($t = 0$). Corporate entities that have invested set a price for these unattached users (a monopoly price if there is a single entity, Bertrand prices if there are multiple ones). Unattached users choose whether to license the technology or not; if they license, they do so at the lowest available price.

We assume that users' strategies are monotonic: $\sigma_t(\theta | h_t, (x_{jt})_j, a_t) = 1$ implies that $\sigma_t(\theta' | h_t, (x_{jt})_j, a_t) = 1$ for $\theta' > \theta$. So, the highest types will become the founding users if a cooperative emerges. As we will note, the intertemporal arbitrage condition implies that final users are indifferent between becoming a founding member and acquiring usage rights at date 0. The monotonicity assumption could be micro-founded as in Tirole (2012): a vanishingly small probability of delay in acquiring usage rights at date 0 or of a breakdown in the granting of access later on would make higher types more eager to acquire usage rights today.

Let us make two observations at this stage.

**Observation 1.** *Previous entry precludes any future investment.*

For, suppose that at least two entities have invested by date 0. Then, they compete à la Bertrand to attract unattached users and so offer access for free. Thus there is no possible dividend, and no pure investor would want to invest in a second (or third, etc) entity. Furthermore, no unattached user is interested in acquiring usage rights to fund a new entity, as such a user knows that she will be able to obtain access for free at date 0 if this entity is successful in raising the funds for investment.

**Observation 2.** *When a cooperative attracts all users with $\theta \geq \theta^*$, the cutoff type $\theta^*$ (and more broadly all users that in equilibrium end up using the technology) must be indifferent between joining the cooperative as a founding member and acquiring a license at date 0.*

Let $p^m(\theta^*)$ and $\pi^m(\theta^*)$ denote the optimal date-0 access price charged to unattached users and the resulting monopoly profit for such a cooperative in the absence of entry by a

[11] This timing would seem to favor for-profits by giving them a Stackelberg advantage. Note however that we are taking the limit as the time difference between periods tends to 0. Indeed, reversing the timing would not affect the results.

for-profit:

$$\pi^m(\theta^*) \equiv \max_p p[F(\theta^*) - F(p)] = p^m(\theta^*)[F(\theta^*) - F(p^m(\theta^*))].$$

Letting $t$ be the cooperative's investment date and $a_t$ the proposed founding membership fee, the cutoff $\theta^*$ thus satisfies the arbitrage condition:

$$\begin{aligned} \theta^* - a_t + \frac{\pi^m(\theta^*)}{1 - F(\theta^*)} &= \theta^* - p^m(\theta^*) \\ \iff \quad p^m(\theta^*)[1 - F(p^m(\theta^*))] &= a_t[1 - F(\theta^*)] \end{aligned} \tag{1}$$

Building on these two observations and to give the cooperative form its best chance, we make the following *no-coordination-failure assumption* regarding the users' acceptance strategies of the ringmaster's offers: Let $a_t$ be the ringmaster's price at time $t \leq t^m$, after a history $h_t$ in which no other entity has yet developed the technology. If there exists a cutoff $\theta^*$ satisfying the financing condition ($a_t[1 - F(\theta^*)] = Ie^{rt}$) and arbitrage condition (1), then all users with type $\theta \geq \theta^*$ accept the ringmaster's offer and a pure cooperative with cutoff $\theta^*$ successfully forms at date $t$.

# 3 The irrelevance of the cooperative form under *laissez-faire*

We say that *the cooperative form is irrelevant* if and only if the ability to form a cooperative – regardless of whether a cooperative actually forms on an equilibrium path – does not alter equilibrium users' welfare with respect to the outcome with for-profits alone.[12]

Our main result is contained in the following proposition:

**Proposition 1.** ***(The irrelevance of the cooperative form)*** *Under laissez-faire, the cooperative form is irrelevant.*

*Proof.* Let $\pi^m = \pi^m(+\infty)$ denote the monopoly gross profit, and $p^m = p^m(+\infty)$ the monopoly price:

$$\pi^m = \max_p p[1 - F(p)] \equiv p^m[1 - F(p^m)],$$

Suppose first that $\pi^m \geq I$ (*financial viability* case) and let $t^m$ be given by $e^{rt^m}I = \pi^m$. Hence, a for-profit cannot develop the technology more than $t^m$ before the usage date and

[12]Because of competition, corporate entities do not make a profit in equilibrium.

earn a (weakly) positive payoff. Let us start with a thought experiment: suppose there are only for-profits and thus no cooperative. The analysis is then identical to that in Fudenberg-Tirole (1985). There is preemption and investment at $t = t^m$, the earliest date at which a for-profit becomes viable. Furthermore, only one for-profit invests. The reason for this is that near $t^m$, the intertemporal profit is almost nil and so the probability that more than one firm invests simultaneously must in equilibrium become vanishingly small as $t$ goes to $t^m$.[13] For $t \in (0, t^m)$, there can be simultaneous investments,[14] but all (off-path) continuation equilibria have the property that for any given time interval of real length $\varepsilon > 0$, the probability that at least one for-profit invests by the end of the interval is equal to 1.

Now add the cooperative ringmaster. Suppose that the cooperative offers at some date $t$ founding membership at price $a_t$ and attracts mass $1 - F(\theta^*)$ of founding users, that is all users with $\theta \geq \theta^*$, and that only the cooperative invests. The financing condition ($a_t[1 - F(\theta^*)] = Ie^{rt}$) and the arbitrage condition (1) together imply that

$$Ie^{rt} = p^m(\theta^*)\left[1 - F(p^m(\theta^*))\right].$$

The RHS of this equality is smaller than $p^m[1-F(p^m)]$, strictly so if $\theta^* < +\infty$ (the $\theta^* = +\infty$ case corresponding to a for-profit). Hence, no cooperative can develop the technology before the for-profits.

Suppose next that $\pi^m < I$ (*no financial viability*). Then, neither a for-profit, nor a fortiori a cooperative find it profitable (feasible for a cooperative) to ever develop the technology. Public intervention is thus needed to bring about investment. □

*Inefficiency.* In the financial viability case ($\pi^m \geq I$), the outcome is inefficient for two reasons. First, preemption leads to early investment ($t^m > 0$). Second, there is under-inclusiveness. Only types $\theta \geq p^m$ end up using the technology, while (in the absence of government transfer) the social optimum would involve a cooperative with all types $\theta \geq \hat{\theta}$ where $\hat{\theta} < p^m$ is given by:

$$\hat{\theta}[1 - F(\hat{\theta})] = I.$$

When the technology is not financially viable ($\pi^m < I$), it is not introduced despite the fact

[13] This can be shown more formally either in the discrete time framework when the time length between periods becomes small or in the continuous-time formalism that captures the limit of the discrete-time framework. We refer to Fudenberg-Tirole (1985) for the formal proof.

[14] In these subgames there are multiple equilibria: for example, a symmetric equilibrium in which the for-profits play a time-contingent mixed strategy and simultaneous investments occur, and asymmetric ones in which only one for-profit invests and there are no simultaneous investments.

that the investment cost lies below total willingness to pay.

*Extension to a public signal.* When a public signal $s$ about a user's type $\theta$ is available, yielding conditional distribution $F(\theta|s)$ (an extreme case of this involves symmetric information: $s = \theta$), both a for-profit and a cooperative ringmaster segment the demand into "$s$-markets" for each realization of the signal. Within each $s$-market, types are private (with belief described by $F(\cdot|s)$), and both a (monopolistic) for-profit and a cooperative try to raise as much funds as possible. Yet, as we have just described, the fees a cooperative can collect from "$s$-members" are again constrained by arbitrage. Hence a for-profit always raises more funds and can invest earlier than a cooperative, strictly so unless types are public (in which case a cooperative behaves exactly as a for-profit): The cooperative form is again irrelevant (see Online Appendix A for details). This logic motivates our focusing on private types in the rest of the paper. All results extend to the existence of a public signal.

**Proposition 2.** ***(Public signals)*** *The irrelevance result applies more generally when public signals $s$ on individual preferences are available, leading to conditional beliefs $F(\theta|s)$.*

**Discussion: Time inconsistency and the relevance of the cooperative form.** The time-consistency requirement is necessary for the irrelevance of the cooperative form under *laissez-faire*. Indeed, the cooperative form may become relevant if a cooperative can commit not to supply technology access to non-members.

Assume that upon paying the investment cost $I$, the developers (whether a for-profit or a cooperative) are able to commit to (possibly time-inconsistent) caps on their supply of technology access. The commitment power may for instance stem from a purposedly limited production capacity (such that any additional capacity is exceedingly costly).[15]

Let the technology be financially viable ($\pi^m \geq I$). If a for-profit has already developed the technology at a prior date, a cooperative's viability requires committing to a limited access to the technology for non-members. As an illustration, by denying future access, a cooperative solves its free-riding problem. It avoids competing à la Bertrand with the incumbent for-profit for non-members, letting the for-profit (if any) charge non-members the monopoly price conditional on non-membership.

Building on this observation, suppose that a for-profit has entered prior to date 0, and that a pure cooperative forms just before date 0 with members $\theta \geq \theta^*$, and commits to ex-

[15]The insight would go through if a producer faced capacity constraints per unit of time, so that the cost of not being a cooperative member and yet buying from the cooperative would be a (sufficiently long) delay.

clude non-members. The for-profit thus charges non-members $p^m(\theta^*)$, yielding the following arbitrage condition for cooperative members:

$$\theta^* - \frac{I}{1 - F(\theta^*)} = \theta^* - p^m(\theta^*), \qquad \text{i.e.} \qquad p^m(\theta^*)\left[1 - F(\theta^*)\right] = I. \tag{2}$$

There exists such a $\theta^*$ if and only if $I$ is sufficiently low.[16]

Therefore, whenever a cooperative can commit not to sell technology access to non-members, the cooperative form is relevant for $I$ sufficiently low, and the ability to form such a cooperative increases the users' welfare.

*Remark: Most-Favoured-Nation clauses and cooperatives.* A cooperative is unable to commit to high prices via an MFN clause as the reimbursements specified by such a clause accrue to the cooperative members.

*Remark: Screening investors.* Corporate entities can screen investors even if they cannot directly tell users and pure investors apart. Indeed, users value the bundle of usage and cashflow rights strictly more than pure investors do as the latter have no personal use for the technology. Conversely, even if users can coordinate, it is an equilibrium for users not to "invade" a for-profit selling pure cashflow rights and take a voting majority of shares to direct the latter to charge non-monopoly access charges.[17]

# 4 Robustness and Extensions

## 4.1 Externalities

This subsection establishes the robustness of the irrelevance result under positive or negative externalities from technology adoption. Such externalities arise in various environments. They can be negative, as when the use of antibiotics generates antimicrobial resistance or when polluting technologies generate environmental harm. Conversely, positive externalities arise when diagnostics allow healthcare systems to save on antibiotic consumption and reduce antimicrobial resistance, the use of a vaccine limits the spreading of a pandemic, or

[16]If there exist two solutions, the ringmaster selects the largest feasible cooperative, and hence the lowest solution yields the cutoff.

[17]In practice, users may not be able to invade all for-profits anyway. Even leaving aside coordination problems, they cannot easily acquire the shares of private equity firms or listed firms with large block shareholders. But for the sake of the argument, we show in Online Appendix B that, even when users can coordinate and take a control majority in a for-profit by paying the equilibrium price for the shares, there exists an equilibrium in which (actual) users fail to "invade" a for-profit and direct it to charge non-monopoly prices.

the adoption of green technologies reduces environmental harm. Usage may also generate a product market externality among competing entities: positive in the case of complements, and negative for substitutes. Furthermore, the externalities are borne either solely by technology adopters or by non-adopters as well.

We provide an intuition and refer to Online Appendix C for details. Unless externalities are sufficiently negative, a (monopolistic) cooperative sells at date 0 access to non-members. Hence, it faces the usual arbitrage constraint, which hampers its ability to raise funds and invest early with respect to a for-profit. As a result, no cooperative emerges in equilibrium. By contrast, when externalities are sufficiently negative, a (monopolistic) cooperative does not sell access to non-members, and thus finances the investment cost solely via its members' fees. Hence, a (monopolistic) cooperative then behaves exactly as a (monopolistic) for-profit. While a cooperative may emerge in equilibrium, the cooperative form remains irrelevant as it does not change users' welfare.[18]

**Proposition 3.** ***(The irrelevance of the cooperative form, externalities)*** *With externalities either on actual users only or on the whole population of users, and either positive or negative, the cooperative form is irrelevant.*

### 4.2 Price bargaining

We tacitly assumed that the technology developer, whether a for-profit or a cooperative, makes take-it-or-leave-it price offers to users. Proposition 1 still holds if, as is the case in the health sector, the access price results from Nash-bargaining between the technology developer and a principal (e.g., a government) who stands for the interests of all users (founders or not), as long as a cooperative does not have a larger bargaining power than a for-profit. The intuition again relies on free-riding. The government's bargaining power leads to a lower price for the technology developer. While this reduces the profit of a for-profit, it also reduces that of a cooperative and worsens its free-riding problem.

More formally, suppose that after a for-profit or cooperative has developed the technology, it Nash-bargains at date 0 with the government over the price it can charge (remaining) users if it has monopoly power at date 0. Let $\alpha \in (0,1)$ be the developer's bargaining power – the previous analysis corresponds to $\alpha = 1$. Let $[\theta^*, +\infty)$ denote the founding types (with $\theta^* = +\infty$ for a for-profit and $\theta^* < +\infty$ for a cooperative). The government

[18] In fact, with large negative externalities, a cooperative (with sufficiently high membership cutoff) may still sell access to non-members and enter on an equilibrium path. Yet, in any such equilibrium, the cooperative sells access to non-members at a price equal to the one of a (monopolistic) for-profit, and due to the arbitrage condition, charges its members a fee equal to that price.

maximizes aggregate user welfare $\displaystyle\int_p^{\theta^*}(\theta - p)dF(\theta)$ and the technology developer maximizes $p[F(\theta^*) - F(p)]$. Nash-bargaining amounts to selecting a price $p$ that maximizes $\Big(p[F(\theta^*) - F(p)]\Big)^{\alpha}\Big(\displaystyle\int_p^{\infty}(\theta - p)dF(\theta)\Big)^{1-\alpha}$.

A corporate entity with membership cutoff $\theta^*$ charges non-members a price such that

$$\alpha\frac{F(\theta^*) - F(p) - pf(p)}{p[F(\theta^*) - F(p)]} = (1-\alpha)\frac{F(\theta^*) - F(p)}{\int_p^{\theta^*}(\theta - p)dF(\theta)}.$$

Consequently,[19] for a given bargaining power $\alpha$, the prices $p^m_{NB}$ and $p^m_{NB}(\theta^*)$ respectively charged by a monopoly for-profit and by a monopoly cooperative with membership cutoff $\theta^* < +\infty$ when Nash bargaining (NB) with the government satisfy: $p^m_{NB}(\theta^*) < p^m_{NB} < p^m$. Quasi-concavity implies that $p^m_{NB}(\theta^*)[1 - F(p^m_{NB}(\theta^*))] < p^m_{NB}[1 - F(p^m_{NB})]$, and thus in equilibrium, cooperatives are always preempted by for-profits.[20,21]

**Proposition 4.** ***(The irrelevance of the cooperative form, Nash-bargained prices)*** *The cooperative form remains irrelevant when prices are Nash-bargained with a principal maximizing users' welfare.*

### 4.3 Intertemporal price discrimination

In this subsection and in the next, we switch back to the standard convention of counting time in a forward way. We have so far assumed that all sales of access occur at date 0. Suppose to the contrary that entities that have developed the technology prior to date 0 can sell access to it at later dates $0, 1, 2, \ldots$ (The lag between the periods can be as small as desired. The rationale for the discrete-time formalism after date 0 is to create frictions that maintain some monopoly power if there is a single entity; the Coase conjecture – the absence of profit as time converges to continuous time – is a limit case of this framework). Both a for-profit and a cooperative maximize their profit on non-members (which are all users in

[19]Since $F$ has an increasing hazard rate, for all $p$,

$$1 - \frac{pf(p)}{1-F(p)} > 1 - \frac{pf(p)}{F(\theta^*) - F(p)}, \qquad \text{and} \qquad \frac{p[F(\theta^*) - F(p)]}{\int_p^{\theta^*}(\theta - p)dF(\theta)} > \frac{p[1-F(p)]}{\int_p^{\infty}(\theta - p)dF(\theta)}$$

and both sides of the first, resp. second, inequality strictly increase, resp. decrease with $p$.

[20]The higher the government's bargaining power, the later the technology is developed (if at all) in equilibrium (but still before date 0), and the higher the users' aggregate welfare.

[21]If for-profits and cooperatives' bargaining powers differed, a cooperative could be successful in preempting the for-profits only if its (Nash-bargained) price to non-members were such that $p^m_{NB}(\theta^*) > p^m_{NB}$. This is the case if and only if a cooperative's bargaining power $\alpha_c$ is sufficiently larger than a for-profit's bargaining power $\alpha$ – e.g. with an election-wary government if a cooperative regroups users with political power, while for-profits are foreign firms.

the case of a for-profit).

**Assumption.** ***(Coasian dynamics)*** *Suppose that prior to date* 0*, users with* $\theta \geq \theta^*$ *have secured usage rights while those with* $\theta < \theta^*$ *have not. Then the Coasian equilibrium from date* 0 *on under monopoly (for-profit or cooperative) exhibits a date-*0 *price* $p_0(\theta^*)$ *that is weakly increasing in* $\theta^*$*. Furthermore, the date-*0 *continuation profit* $\pi^m(\theta^*)$ *satisfies* $d\pi^m(\theta^*)/d\theta^* = f(\theta^*)p_0(\theta^*) > 0$*.*

This natural assumption[22] is satisfied for example in the classic equilibria studied by Stokey (1981) and Sobel-Takahashi (1983), and also by the (unique) equilibrium in Fudenberg et al (1985).

As earlier, the for-profit corresponds to $\theta^* = +\infty$, while a cooperative satisfies $\theta^* < \infty$. The amount of money that can be raised by an entity characterized by a cutoff $\theta^*$ is

$$\pi^m(\theta^*) + p_0(\theta^*)[1 - F(\theta^*)]$$

using the arbitrage condition.[23] Taking the derivative with respect to the cutoff:

$$\frac{d}{d\theta^*}\Big(\pi^m(\theta^*) + p_0(\theta^*)[1 - F(\theta^*)]\Big) = [1 - F(\theta^*)]\frac{dp_0}{d\theta^*} \geq 0.$$

**Proposition 5.** ***(The irrelevance of the cooperative form, intertemporal price discrimination)*** *The irrelevance result still obtains when sales can occur after date* 0*.*

## 4.4 Repeat purchases and collusion

Consider a rental good or service offered to non-members at (calendar) dates 0, 1, 2, .... Suppose that sinking the investment cost $I$ once allows an entity to produce the good (or

[22] As a (very informal) motivation, consider the pricing problem at date 0:

$$\max_{p_0}\; p_0\big[F(\theta^*) - F(\theta_1(p_0, \theta^*))\big] + \delta V(\theta_1(p_0, \theta^*), p_0, \theta^*),$$

with $\delta \in (0, 1)$ the seller's discount factor and $V(\theta, p_0, \theta^*)$ its continuation value when types $\theta' \in [\theta, \theta^*]$ have bought access at price $p_0$. In a "Markovian" world, the continuation value $V$ depends only on the lowest type who has already bought access, i.e. on the cutoff $\theta_1 \leq \theta^*$. As a consequence, the pricing problem at date 0 for the prices $p_0$ that generate sales ($\theta_1(p_0) < \theta^*$) writes as

$$\max_{p_0}\; p_0\big[F(\theta^*) - F(\theta_1(p_0))\big] + \delta V(\theta_1(p_0)).$$

The envelope theorem gives the Assumption.

[23] The membership price $a$ satisfies

$$\theta^* - a + \frac{\pi^m(\theta^*)}{1 - F(\theta^*)} = \theta^* - p_0(\theta^*).$$

deliver the service) at zero marginal cost at any future date. Let $\delta \in (0,1)$ be the discount factor (common to users and pure investors).

We distinguish three cases:

- *Neglected market:* $\pi^m/(1-\delta) < I$,
- *Natural monopoly:* $\delta < 1/2$ or $\pi^m/2(1-\delta) < I \leq \pi^m/(1-\delta)$ (only monopoly is viable),
- *Viable oligopoly:* $\delta \geq 1/2$ and $I \leq \pi^m/2(1-\delta)$ (perfect collusion by $n \geq 2$ for-profits is viable).

**Proposition 6.** ***(Rental good and tacit collusion)*** *With a rental good and tacit collusion, the cooperative form is irrelevant in the neglected market and natural monopoly cases, but it is relevant in the viable oligopoly case.*

We refer to Online Appendix D for details. Intuitively, in the viable oligopoly case, collusion among for-profits generates higher profitability, hence attracting several for-profits and leading to late entry. By contrast, the cooperative's free-riding problem is unchanged (the arbitrage condition remains that the membership fee net of dividend be equal to $p^m(\theta^*)$). Hence, the cooperative can preempt the for-profits while still investing later than a monopolistic for-profit would.

## 5 Public funding and the empowerment of users

Would a utilitarian government intervene in favor of the cooperative form? Intuitively, the government or private donors may want to promote a wide access to the technology and therefore subsidize the cooperative form.

We assume that the donor can tell apart for-profits and cooperatives.[24] Let $\lambda > 0$ be the government's cost of public funds, so that a subsidy $T \geq 0$ costs $(1+\lambda)T$. The government knows the distribution of types $F$ and calendar time, but, like corporate entities, does not observe individual types. As discussed above, the government observes the investors' corporate form. The government maximizes the users' welfare minus the cost of public funds. We assume that at any date the government can offer a subsidy $T$ for immediate investment. The government, like the other players, cannot commit for the longer term.[25]

[24] See Online Appendix E for a mechanism enabling the donor to do so, while requiring no superior information.

[25] If the government could avail itself of "quantitative instruments", i.e. could set the price to users (or equivalently a level of membership) conditional on receiving the subsidy, it would erase the distinction between for-profits and cooperatives, as this distinction operates through different price-setting incentives.

Let $\underline{I}$ denote (the monetary equivalent of) the principal's benefit from *replicating* the technology at date 0 and competing with an incumbent for-profit:

$$\underline{I} \equiv \frac{\pi^m + \int_0^{p^m} \theta dF(\theta)}{1+\lambda} = \frac{S(0) - S(p^m)}{1+\lambda}$$

where $S(p) \equiv \displaystyle\int_p^{\infty} (\theta - p) dF(p)$ is the users' net surplus at price $p$. Similarly, for a given $\theta^A$, (the monetary equivalent of) the principal's benefit from *creating* the technology (when it would not have existed otherwise) and giving access to users $\theta \geq \theta^A$ is equal to

$$\frac{\int_{\theta^A}^{\infty} \theta dF(\theta) + \lambda\theta^A[1 - F(\theta^A)]}{1+\lambda} = \frac{S(\theta^A)}{1+\lambda} + \theta^A[1 - F(\theta^A)]$$

It reaches its unique maximum for $\theta^A = p^\dagger$ where $p^\dagger$ is given by the Ramsey condition: letting $\eta(p) \equiv pf(p)/[1 - F(p)]$ denote the elasticity of demand,

$$\eta(p^\dagger) = \frac{\lambda}{1+\lambda}. \tag{3}$$

Hence, let $\overline{I}$ denote the (monetary equivalent of the) principal's maximum benefit from creating the technology and then optimally giving access to users $\theta \geq p^\dagger$:

$$\overline{I} \equiv \frac{S(p^\dagger)}{1+\lambda} + p^\dagger[1 - F(p^\dagger)].$$

For any $\lambda < +\infty$, $\overline{I} > \underline{I}$ and $\overline{I} > \pi^m$, yet $\underline{I} \lesseqgtr \pi^m$ ($\underline{I} > \pi^m$ for any $\lambda$ below a threshold, and $\underline{I} < \pi^m$ for any $\lambda$ above).

The optimal intervention thus depends on the investment cost $I$. At most four main regions can exist:

(1) *(No technology development)* If $I > \overline{I}$, for-profits are not willing to enter, but the investment cost is strictly higher than the principal's maximum benefit from creating the technology. Hence, the principal does not offer any subsidy and the technology is not developed.

(2) *(No for-profit competition and public subsidy to develop the technology)* If $\pi^m < I \leq \overline{I}$, for-profits are still unwilling to enter, but now the principal's maximum benefit from creating the technology exceeds the investment cost. Hence, the principal offers at date 0 a subsidy $I - p^\dagger[1 - F(p^\dagger)]$, which ensures technology development and access to all users $\theta \geq p^\dagger$ (the cooperative's membership cutoff is given by $\theta^\dagger$ such that $p^m(\theta^\dagger) = p^\dagger$).

(3) *(For-profit competition and public subsidy to preempt for-profits)* If $\underline{I} < I \leq \pi^m$, for-profits are willing to enter, and while the principal is unwilling to duplicate the technology once already developed by a for-profit, it is now willing to preempt for-profits. Hence, the principal offers at date $t^m$ a subsidy $I - p^\dagger[1 - F(p^\dagger)]$, which has date-0 value $(\pi^m/I)\big[I - p^\dagger[1 - F(p^\dagger)]\big]$ and which ensures access to all users $\theta \geq p^\dagger$. [This region is empty whenever $\underline{I} \geq \pi^m$, i.e. whenever $\lambda$ is below a threshold.]

(4) *(For-profit competition and public readiness to duplicate the technology, thereby deterring for-profit entry)* If $I \leq \min(\underline{I}, \pi^m)$, the principal is willing to duplicate the technology and compete with an incumbent for-profit, thus yielding zero profits for the latter. Anticipating this, no for-profit enters on path. Hence, the principal *de facto* guarantees $I$ (as an off-path subsidy) in case a for-profit deviates and enters, while two subcases arise regarding the principal's (on-path) subsidy:

(4.a) *(Public subsidy to reach the Ramsey size)* If $p^\dagger[1 - F(p^\dagger)] < I < \min(\underline{I}, \pi^m)$, the principal makes at date 0 a transfer (on path) equal to $I - p^\dagger[1 - F(p^\dagger)]$, which ensures access to all users $\theta \geq p^\dagger$.

(4.b) *(No public subsidy)* If $I \leq \min(\underline{I}, p^\dagger[1 - F(p^\dagger)])$, the principal makes zero transfer (on path) and a cooperative with membership cutoff $\theta^*$ such that $p^m(\theta^*)\big[1 - F(p^m(\theta^*))\big] = I$ emerges at date 0, granting access to users $\theta \geq p^m(\theta^*)$, and thus in particular a wider access than under the Ramsey condition (as $p^m(\theta^*) \leq p^\dagger$).

**Discussion: Efficiency.** Figure 1 depicts the marginal value of public funds (MVPF) of such targeted subsidies, in the spirit of Hendren (2016), Finkelstein-Hendren (2020) and Hendren-Sprung-Keyser (2020). For $I \leq \overline{I}$ (regions 2-4 with public intervention), the targeted subsidy's MVPF is given by

$$MVPF \equiv \begin{cases} +\infty & \text{if } I \leq \min(\underline{I}, p^\dagger[1 - F(p^\dagger)]), \\ \dfrac{S(p^\dagger) - S(p^m)}{(1+\lambda)(I - p^\dagger[1 - F(p^\dagger)])} & \text{if } p^\dagger[1 - F(p^\dagger)] < I < \min(\underline{I}, \pi^m), \\ \dfrac{S(p^\dagger) - S(p^m)}{\dfrac{\pi^m}{I}(1+\lambda)(I - p^\dagger[1 - F(p^\dagger)])} & \text{if } \underline{I} < I \leq \pi^m, \\ \dfrac{S(p^\dagger)}{(1+\lambda)(I - p^\dagger[1 - F(p^\dagger)])} & \text{if } \pi^m < I \leq \overline{I}. \end{cases}$$

To go further, one will need to recognize that the regulator may have less information

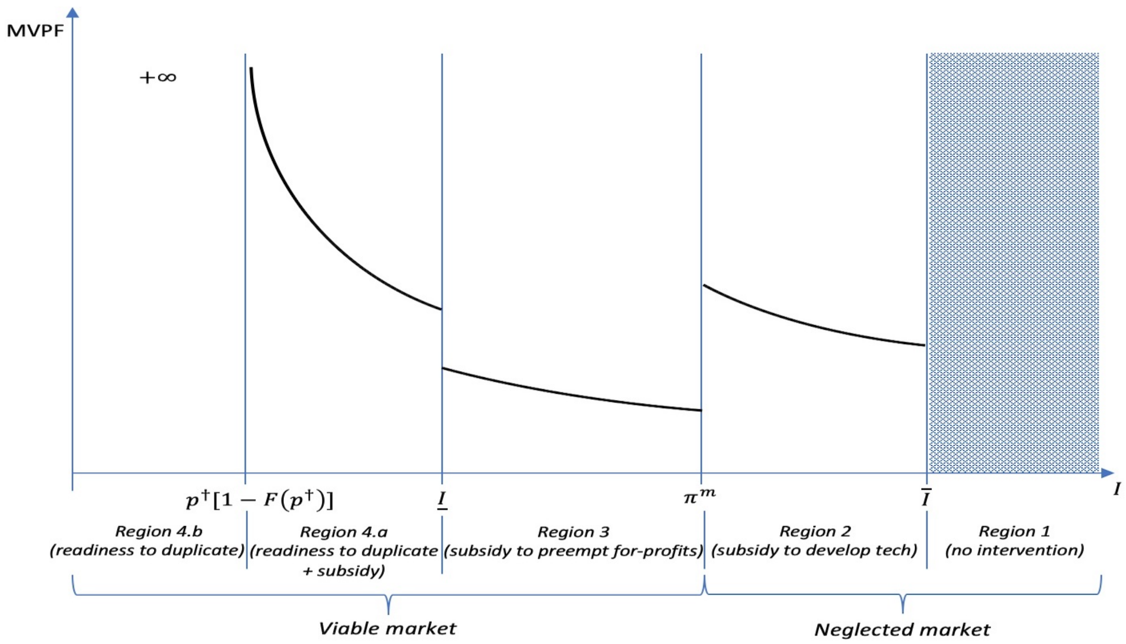


Figure 1: MVPF of the optimal cooperative subsidy as a function of investment cost $I$ (case $p^\dagger[1 - F(p^\dagger)] < \underline{I} < \pi^m$).

about the demand curve and/or the investment cost than the industry. The regulator's information will be partly endogenous: The regulator may infer that the market is neglected from the absence of entry. Some information will be obtained through a market test, using the investors' or users' willingness to co-finance the infrastructure. Such market tests may help identify white elephants (tell regions 1 and 2 apart), or not invest more public money than is needed in regions 3 and 4. We leave this important topic for future research.

# 6 Conclusion

The paper makes two take-home points. Firstly, cooperatives of users or consortia of polities aiming at procuring a commonly desired innovation or a particular good or service are at a competitive disadvantage relative to for-profits. They will be outperformed if the market is financially viable and will not be able to supply neglected (i.e., non-financially viable) markets. This is due to their inferior funding ability, even if their members individually face no financial constraint. Secondly, and relatedly, disinterested (but benevolent) third parties who are neither users nor financial investors may have a key role in promoting a wide access to the technology. These disinterested third parties may be a government when users are a private parties or regional authorities, or private donors or multilateral organizations when users are countries.

These two points do not answer the policy question of where to focus the necessarily limited resources of these third parties. We initiated the study of the marginal value of public funds in this context, but much more is needed to make the analysis operational. This question is essential in a context in which industrial policy to solve climate and health challenges and cooperative forms of procurement are both gaining in importance.

## References


Admati, A. R. and Perry, M. (1991). "Joint Projects without Commitment". *Review of Economic Studies*, 58(2):259–276.

Aghion, P. and Tirole, J. (1994). "The Management of Innovation". *Quarterly Journal of Economics*, 109(4):1185–1209.

Battaglini, M. and Harstad, B. (2016). "Participation and Duration of Environmental Agreements". *Journal of Political Economy*, 124(1):160 – 204.

Battaglini, M. and Harstad, B. (2020). "The Political Economy of Weak Treaties". *Journal of Political Economy*, 128(2):544 – 590.

Buchanan, J. M. (1965). "An Economic Theory of Clubs". *Economica*, 32(125):1–14.

Fudenberg, D., Levine, D., and Tirole, J. (1985). "Infinite-Horizon Models of Bargaining with One-Sided Incomplete Information". In Roth, A., editor, *Game Theoretic Models of Bargaining*. Cambridge University Press.

Fudenberg, D. and Tirole, J. (1985). "Preemption and Rent Equalization in the Adoption of New Technology". *Review of Economic Studies*, 52(3):383–401.

Hansmann, H. (1996). *"The Ownership of Enterprise"*. Harvard University Press.

Hendren, N. (2016). "The Policy Elasticity". *Tax Policy and the Economy*, 30.

Hendren, N. and Sprung-Keyser, B. (2020). "A Unified Welfare Analysis of Government Policies". *Quarterly Journal of Economics*, 135(3):1209–1318.

Hendren, N. and Sprung-Keyser, B. (2022). "The Case for the MVPF in Empirical Welfare Analysis". mimeo.

Innes, R. and Sexton, R. J. (1994). "Strategic Buyers and Exclusionary Contracts". *American Economic Review*, 84(3):566–84.

Rey, P. and Tirole, J. (2007). "Financing and access in cooperatives". *International Journal of Industrial Organization*, 25(5):1061–1088.

Sobel, J. and Takahashi, I. (1983). "A Multistage Model of Bargaining". *Review of Economic Studies*, 50(3):411–426.

Stokey, N. (1981). "Rational Expectations and Durable Goods Pricing". *Bell Journal of Economics*, 12(1):112–128.

Strausz, R. (2017). "A Theory of Crowdfunding: A Mechanism Design Approach with Demand Uncertainty and Moral Hazard". *American Economic Review*, 107(6):1430–76.

Tirole, J. (2012). "Overcoming Adverse Selection: How Public Intervention Can Restore Market Functioning". *American Economic Review*, 102(1):29–59.

# Online Appendix

# The (Ir)Relevance of the Cooperative Form

Paul-Henri Moisson Pierre Dubois Jean Tirole

## A Public signals

As mentioned in the text, when a public signal is available (i.i.d. for agents of the same type), sellers segment the market according to the realized signals. Within each sub-market, types are private and the analysis of the private-types case applies.

Formally, suppose that a signal $s \in S$ is available for each agent, with $S$ the set of potential signals. We denote by $F(\cdot|s)$ the cdf of WTP conditional on signal $s$, and by $G(\cdot)$ the cdf of the signal's marginal distribution.

A cooperative's membership is now described by a set of cutoffs $\Theta \equiv (\theta^*(s))_{s\in S}$ such that for each possible signal $s \in S$, all types with WTP $\theta \geq \theta^*(s)$ and signal realization $s$ join the cooperative. By convention, we denote $\theta^*(s) = +\infty$ if no agent with signal $s$ joins the cooperative.[26]

For any $s \in S$, the monopoly profit from sales to (non-attached) agents with signal $s$ is given by

$$\pi^m(s) = \max_p \; p[1 - F(p|s)]$$

for a for-profit, and by

$$\pi^m(\theta^*(s), s) = \max_p \; p\big[F(\theta^*(s)|s) - F(p|s)\big],$$

for a cooperative with membership profile $\Theta = (\theta^*(s))_{s\in S}$. We denote by $p^m(s)$ and $p^m(\theta^*(s), s)$ the associated (monopoly) prices.

For any $s$ such that $\theta^*(s) < +\infty$, let $a(s)$ denote the membership fee for agents with signal $s$. The arbitrage condition for a (monopolistic) cooperative with membership profile

[26] We assumed monotonic acceptance strategies for cooperative membership: $\sigma_t\big(\theta, s|h_t, (x_{jt})_j, a_t\big) = 1$ implies that $\sigma_t\big(\theta', s|h_t, (x_{jt})_j, a_t\big) = 1$ for $\theta' > \theta$.

$\Theta$ requires that for any $s$ such that $\theta^*(s) < +\infty$,

$$a(s) = p^m(\theta^*(s), s).$$

As a consequence, for any $s \in S$, the total amount of funding raised by a monopolistic cooperative from agents with signal $s \in S$ (both members, if any, and non-members, if any) is equal to

$$\begin{aligned} &[1 - F(\theta^*(s)|s)]a(s) + p^m(\theta^*(s), s)[F(\theta^*(s)|s) - F(p^m(\theta^*(s), s)|s)] \\ &= p^m(\theta^*(s), s)[1 - F(p^m(\theta^*(s), s)|s)] \leq \pi^m(s), \end{aligned}$$

with equality if and only if either $\theta^*(s) = +\infty$, i.e. no agent with signal $s$ joins the cooperative ($\theta^*(s) = +\infty$), or signal $s$ perfectly reveals that the agent has WTP $\theta^*(s)$ (and thus $p^m(\theta^*(s), s) = p^m(s) = \theta^*(s)$). Hence, there is equality if and only if the cooperative behaves in exactly the same way as a for-profit.

The result then obtains by summing over all possible signals $s \in S$. The cooperative form remains irrelevant when public signals on individual preferences are available.

# B Users' acquisition of a control stake in a for-profit

Suppose that users can coordinate and take a control majority in a for-profit by paying the equilibrium price for the shares. We show that there exists an equilibrium in which users fail to "invade" a for-profit and direct it to charge non-monopoly prices. We only sketch the proof – in particular, we gloss over uniqueness when indifferences are involved; we however do not rely on a coordination failure to rule out invasions.

For the sake of exposition, suppose there is a single for-profit. Suppose this for-profit issues at date $t^m$ a mass 1 of shares without usage right, and that shareholders vote on access prices at date 0. Majority rule prevails. The corporate entity sets at date 0 two prices for usage rights: $a_0$ for insiders and $a_1$ for unattached users. Arbitrage requires that $a_0 \leq a_1$.

Suppose that types $\theta \geq \theta^*$ each acquire at least one of the for-profit's shares. Let $\tau \geq 1 - F(\theta^*)$ denote the fraction of shares held by users with types $\theta \geq \theta^*$, and $1 - \tau$ the fraction of shares held by pure investors. Consider a type-$\theta$ user holding $k \geq 1$ shares.[27] Conditional on buying access, this shareholder's preferred values for the insider and outsider

[27] We here implicitly take the limit as the number of shares and users are finite and go to infinity.

prices are $a_0 = 0$ and $a_1 = p^m(\theta^*)$ if $k[1-F(\theta^*)] < 1$, and $a_0 = a_1 = p^m$ if $k[1-F(\theta^*)] > 1$.[28] Conditional on not buying access, its preferred values are $a_0 = a_1 = p^m$. A type-$\theta$ user with $k \geq 1$ shares thus prefers $a_0 = 0$, $a_1 = p^m(\theta^*)$ to $a_0 = a_1 = p^m$ if and only if $k[1-F(\theta^*)] < 1$ and

$$\theta + kp^m(\theta^*)[F(\theta^*) - F(p^m(\theta^*))] \geq k\pi^m,$$

i.e. if and only if $k[1-F(\theta^*)] < 1$ and $(\theta/k) \geq \theta^\sharp \equiv \pi^m - p^m(\theta^*)[F(\theta^*) - F(p^m(\theta^*))]$.

Let this for-profit offer shares at time $t^m$ at unit price $e^{-rt^m}\pi^m = I$, thereby preempting all other entities if its fundraising is successful. Two cases can arise.

*Case I.* Pure investors and users with type $\theta$ and $k$ shares such that $k[1-F(\theta^*)] > 1$ or $(\theta/k) < \theta^\sharp$ buy the majority of shares. Then, $a_0 = a_1 = p^m$, and the outcome is thus observationally equivalent to a for-profit.

*Case II.* Users with type $\theta$ and $k$ shares such that $k[1-F(\theta^*)] < 1$ and $(\theta/k) > \theta^\sharp$ buy the majority of shares. Then, $a_0 = 0$ and $a_1 = p^m(\theta^*)$, which generates a dividend strictly lower than the shares' price.[29] This has two consequences: (a) pure investors would strictly prefer to stay out, (b) all users who buy shares would strictly prefer to buy exactly one share ($k = 1$) rather than several ($k > 1$). The entity becomes observationally equivalent to a pure cooperative, thus unable to invest at time $t^m$.

Therefore, it is an equilibrium for the entity to sell its shares at time $t^m$ at price $I$, for pure investors to subscribe and charge the monopoly prices.

# C Proof of Proposition 3

Whenever several equilibria coexist (due to buyers' coordination), we assume that the selected equilibrium is the (monopolistic) seller's preferred one.

[28] Conditional on buying access, a type-$\theta$ shareholder with $k \geq 1$ shares solves

$$\max_{a_0 \leq a_1} \left[\theta - a_0 + k\left(a_0[1-F(\theta^*)] + a_1[F(\theta^*) - F(a_1)]\right)\right],$$

which yields $a_0 = 0$, $a_1 = p^m(\theta^*)$ if $1 > k[1-F(\theta^*)]$, and $a_0 = a_1 = p^m$ if $1 < k[1-F(\theta^*)]$. [If $1 = k[1-F(\theta^*)]$, the user is indifferent over all prices $(a_0, a_1)$ such that $a_0 \in [0, p^m(\theta^*)]$ and $a_1 = p^m(\theta^*)$.] Similarly, conditional on not buying access, a type-$\theta$ shareholder with $k \geq 1$ shares solves

$$\max_{a_0 \leq a_1} k\left(a_0[1-F(\theta^*)] + a_1[F(\theta^*) - F(a_1)]\right),$$

which yields $a_0 = a_1 = p^m$ and payoff $\pi^m$.

[29] Namely, the dividend has date-$t^m$ value $e^{-rt^m}p^m(\theta^*)[F(\theta^*) - F(p^m(\theta^*))] < e^{-rt^m}\pi^m$.

**Externalities on actual users only.** Let us first consider externalities accruing to users only – e.g. due to technology adoption by product-market complementors/competitors, network effects, user-based innovations, etc. Denote by $e \lesseqgtr 0$ the unit externality induced by each user on each other user.

The monopoly pricing problem of a for-profit thus writes as:

$$\max_p \; p[1 - F(\theta^i(p))] \qquad \text{s.t.} \quad \theta^i(p) = \max\{0,\; p - e[1 - F(\theta^i(p))]\}$$

where the superscript $i$ stands for "investor". Let $\pi^m(e)$ and $p^m(e)$ denote respectively the corresponding profit and price.

Let $[\theta^*, +\infty)$ be the set of cooperative members for a cutoff $\theta^*$ (to be determined below). The cooperative's access policy for non-members satisfies

$$\max_p \; (p + e)\big[F(\theta^*) - F(\theta^c(p))\big] \qquad \text{s.t.} \quad \theta^c(p) = \min\{\theta^*,\; \max\{0,\; p - e[1 - F(\theta^c(p))]\}\}$$

where the superscript $c$ stands for "cooperative".

Let $p^c(\theta^*, e)$ be the price that maximizes the above objective, with $p^c(\theta^*, e) = \theta^* + e[1 - F(\theta^*)]$ if the cooperative does not sell to non-members, and $\pi^c(\theta^*, e)$ the corresponding profit. When the cooperative sells to non-members, the cutoff $\theta^*$ satisfies the arbitrage condition:

$$\theta^* + e\big[1 - F(\theta^c(p^c(\theta^*, e)))\big] + \frac{\pi^c(\theta^*, e) - Ie^{rt}}{1 - F(\theta^*)} = \theta^* + e\big[1 - F(\theta^c(p^c(\theta^*, e)))\big] - p^c(\theta^*, e),$$

i.e.

$$p^c(\theta^*, e)\big[1 - F(\theta^c(p^c(\theta^*, e)))\big] - Ie^{rt} = 0 \;\Leftrightarrow\; (\theta^c + e[1 - F(\theta^c)])[1 - F(\theta^c)] - Ie^{rt} = 0.$$

When the cooperative does not sell to non-members, which happens only for sufficiently large negative externalities, the arbitrage condition becomes:

$$(\theta^* + e[1 - F(\theta^*)])[1 - F(\theta^*)] - Ie^{rt} = 0.$$

With positive externalities ($e \geq 0$), $p^c(\theta^*, e)\big[1 - F(\theta^c(p^c(\theta^*, e))))\big] < \pi^m(e)$, and a cooperative thus never emerges on an equilibrium path as it is always preempted by a for-profit. With strictly negative externalities ($e < 0$), there exist equilibria such that a cooperative emerges on path if and only if externalities are sufficiently negative ($e$ sufficiently low). In any such equilibrium, the cooperative has membership cutoff $\theta^* \geq \theta^i(p^m(e))$, and charges a (net) membership fee to its members and a price to non-members both equal to $p^m(e)$. Hence, when it emerges on path, the cooperative provides access (to its members and possibly to non-members) at the same price as a (monopolistic) for-profit. Therefore, the cooperative form remains irrelevant.

**Externalities on the whole population.** Let us now consider externalities accruing to the whole population of agents – e.g. as with vaccines, antibiotic, diagnostic tests, etc. Denote by $e \lesseqgtr 0$ the unit externality induced by each user on all other users, whether the latter use the technology or not.

Hence, as agents are atomistic, the monopoly pricing problem of a for-profit is given by:

$$\max_p \; p[1 - F(p)]$$

Let $[\theta^*, +\infty)$ be the set of cooperative members for a cutoff $\theta^*$ (to be determined below). The cooperative's access policy $p^m(\theta^*)$ solves:

$$\max_p \; (p + e)[F(\theta^*) - F(p)]$$

Letting $\pi^m(\theta^*) \equiv p^m(\theta^*)[F(\theta^*) - F(p^m(\theta^*))]$ denote the access revenue, the cutoff $\theta^*$ satisfies the arbitrage condition:

$$\theta^* + e[1 - F(p^m(\theta^*))] + \frac{\pi^m(\theta^*) - Ie^{rt}}{1 - F(\theta^*)} = \theta^* + e[1 - F(p^m(\theta^*))] - p^m(\theta^*, e),$$

i.e.

$$p^m(\theta^*, e)[1 - F(p^m(\theta^*, e))] - Ie^{rt} = 0,$$

Because $p^m(\theta^*)[1 - F(p^m(\theta^*))] \leq \pi^m$, either a cooperative either never emerges on an equilibrium path, or, for sufficiently large negative externalities, a cooperative with cutoff $\theta^* \geq p^m$ emerges and sets a membership fee and price $p^m(\theta^*, e)$ to non-members equal to $p^m$, in which case the cooperative form remains irrelevant.

# D Repeat purchases and collusion

Consider a rental good or service offered to non-members at (calendar) dates 0, 1, 2, .... Suppose that sinking the investment cost $I$ once allows an entity to produce the good (or deliver the service) at zero marginal cost at any (future) calendar date. Let $\delta \in (0,1)$ be the discount factor (common to users and pure investors). For simplicity, suppose that two corporate entities, but not three, can collude: $1/2 < \delta < 2/3$ (see generalization below).

Collusion between two for-profits is viable if and only if $\pi^m/2(1-\delta) \geq I$, where $\pi^m$ is the flow monopoly profit. If users with $\theta \geq \theta^*$ have acquired a usage right, optimal collusion occurs at price $p^m(\theta^*)$. Hence, the coexistence of a cooperative with members $\theta \geq \theta^*$ and a for-profit is viable if and only if $p^m(\theta^*)[F(\theta^*) - F(p^m(\theta^*))]/2(1-\delta) \geq I$, i.e. if and only if $\theta^* \geq \theta^d$.

We label an innovation as *financially viable* if $\pi^m/(1-\delta) \geq I$, and focus on this case henceforth. The case $\pi^m/(1-\delta) < I$ corresponds to a neglected market, which is covered by our previous analysis in the absence of collusion (no entity develops the technology).

*Case A: Viable oligopoly.* Suppose that the collusion between two for-profits is viable, i.e. $\pi^m/2(1-\delta) \geq I$. Would entry by two for-profits at $t^d$, given by $\pi^m/2 = Ie^{t^d}$, occur or would a cooperative step in just before?

Suppose a cooperative with members $\theta \geq \theta^*$ enters at date $t^d + \varepsilon$.

*Case A.1:* $\theta^* \geq \theta^d$, i.e. $p^m(\theta^*)[F(\theta^*) - F(p^m(\theta^*))]/2(1-\delta) \geq I$. Then, the cooperative is followed by a single for-profit. The arbitrage condition is

$$a = \frac{p^m(\theta^*) + \dfrac{p^m(\theta^*)[F(\theta^*) - F(p^m(\theta^*))]}{2[1-F(\theta^*)]}}{1-\delta}$$

and the financing condition is

$$a[1-F(\theta^*)] \geq Ie^{t^d} = \frac{p^m[1-F(p^m)]}{2(1-\delta)}.$$

Hence, the cooperative can preempt the two colluding for-profits if and only if

$$p^m(\theta^*)[1-F(p^m(\theta^*))] + p^m(\theta^*)[1-F(\theta^*)] \geq \pi^m.$$

The above inequality is satisfied in particular for any $\theta^*$ sufficiently high.[30]

*Case A.2:* $\theta^* < \theta^d$, i.e. $p^m(\theta^*)[F(\theta^*) - F(p^m(\theta^*))]/2(1-\delta) < I$. Then, the cooperative is

[30]For $\theta^*$ sufficiently high, the LHS strictly decreases with $\theta^*$, with $\lim_{\theta^* \to +\infty} LHS = \pi^m$.

not followed by a for-profit. The arbitrage condition is

$$a = \frac{p^m(\theta^*) + \dfrac{p^m(\theta^*)[F(\theta^*) - F(p^m(\theta^*))]}{[1 - F(\theta^*)]}}{1 - \delta}$$

and the financing condition is

$$a[1 - F(\theta^*)] \geq Ie^{t^d} = \frac{p^m[1 - F(p^m)]}{2(1 - \delta)}.$$

Hence, the cooperative can preempt the two colluding for-profits if and only if[31]

$$2p^m(\theta^*)[1 - F(p^m(\theta^*))] \geq \pi^m.$$

*Case B: Natural monopoly* ($\pi^m/2(1 - \delta) < I$). Then, neither collusion between two for-profits nor collusion between a cooperative and a for-profit is viable. As a consequence, our previous analysis (in the absence of collusion) applies.

The analysis generalizes. Let us assume there is a large number of for-profits (and as before, that entry is free). For any $\delta \in [1/2, 1)$, let $N_\delta$ denote the highest number of for-profits who can collude together ($N_\delta - 1/N_\delta \leq \delta < N_\delta/(N_\delta + 1)$). Then, a cooperative still enters in equilibrium whenever $I \leq \pi^m/2(1-\delta)$, followed by a (weakly positive) number of for-profits which (weakly) increases with the discount factor $\delta$.

Summarizing, our former analysis in the absence of collusion and/or with one-shot purchases remains valid when $\delta < 1/2$ or $I > \pi^m/2(1 - \delta)$, i.e. in the neglected market and natural monopoly cases. By contrast, when $\delta \geq 1/2$ and $I \leq \pi^m/2(1 - \delta)$, i.e. in the viable oligopoly case, a cooperative always enters in equilibrium, followed by zero, one or several for-profits with whom it colludes. Whenever a cooperative enters, equilibrium prices are below the monopoly level.

# E Screening investors

To screen for-profits out and cooperatives in when awarding a subsidy, the donor can require the subsidy recipient to define "shares" such that each share entitles its owner to

[31] Fixing $\theta^*$, case A.2 has a weaker condition on $\theta^*$ than case A.1 as the cooperative does not have to collude/share profit $\pi^m(\theta^*)$). Nonetheless, cases A.1 and A.2 are exclusive.

a usage right plus a cash flow right (equal for all shares). Shares are sold to the highest bidders.

Suppose a mass $\mu$ of such shares is issued at date $t$. Let $p(\mu)$ be the market-clearing price for these shares, and $d(\mu)$ their dividend. An agent's willingness-to-pay for one share is equal to

$$\begin{cases} \theta + d(\mu) - p(\mu) & \text{for a type-}\theta\text{ user when this is the first share for that user,} \\ d(\mu) - p(\mu) & \text{for an investor or a user who already has a share.} \end{cases}$$

Denote by $\theta^*(\mu)$ the cutoff such that all users with type $\theta \geq \theta^*(\mu)$ buy at least one share.

Two cases may arise. Either the subsidy creates a monopoly ("monopoly case") and then $S(t) < Ie^{rt}$ with $t$ the investment date, or the subsidy creates competition with another entity who also develops the technology ("competition case") and then $S(t) = Ie^{rt}$.

*Monopoly case.* Suppose the entity is the only seller of technology access at date 0. The dividend $d(\mu)$ associated with each share is given by

$$d(\mu) = \frac{p^m(\theta^*(\mu))\big[F(\theta^*(\mu)) - F(p^m(\theta^*(\mu))\big]}{\mu}.$$

The users' arbitrage condition yields that

$$p(\mu) - d(\mu) = p^m(\theta^*(\mu)).$$

As a consequence, if $\theta^*(\mu) > 0$, $d(\mu) - p(\mu) < 0$, and thus the only buyers of shares are users with types $\theta \geq \theta^*(\mu)$ who buy exactly one share each (no investor buys any shares). Then, $\mu = 1 - F(\theta^*(\mu))$.

The entity's investment constraint for entering at date $t$ then writes as

$$\mu p(\mu) + p^m(\theta^*(\mu))\big[F(\theta^*) - F(p^m(\theta^*(\mu))\big] = Ie^{rt} + \mu d(\mu) - S(t),$$

with $S(t)$ the subsidy at time $t$. Therefore,

$$p^m(\theta^*(\mu))\big[1 - F(p^m(\theta^*(\mu))\big] = Ie^{rt} - S(t).$$

Finally, the donor selects the proposal with the highest number of shares $\mu$, which ensures the lowest cutoff $\theta^*$.[32]

*Competition case.* Suppose another entity has already developed the technology. Then, the dividend associated with each share is nil: $d(\mu) = 0$. The users' arbitrage condition yields that $p(\mu) = 0$. (And the entity's investment constraint for entering at date $t$ then writes as: $Ie^{rt} = S(t)$.) As a consequence, users are indifferent between buying a share (or several) from the subsidized entity, or buying technology access from the other entity (which is sold at price zero). While the donor is unable to screen for-profits and cooperatives, it is now indifferent with respect to the nature of shareholders in the subsidized entity (be they investors or users).

[32] In the monopoly case, setting $S(t) = Ie^{rt}$ is never optimal for the donor (as $\lambda > 0$), and thus $\theta^*(\mu)$ is always strictly positive.