Subsidies, Caps, and Self-Funding*

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Abstract

Empirical studies of R&D grants find both crowding in and crowding out of private R&D. This paper develops a theory of how the interaction between a funding rate and a maximum grant can generate these patterns. For recipients already able to finance projects receiving the maximum grant, a higher funding rate reduces private R&D, while a higher cap can increase it by enabling more costly projects. When recipients choose project size, a grant can induce expansion of a project that would proceed without support while reducing the recipient's private expenditure. Consistent with this project-size prediction, application and award records from a Spanish R&D grant programme show a concentration of reported project budgets near the cost at which the grant reaches its maximum, including among unsuccessful applications. In the welfare analysis, we show that support can be valuable because it induces projects with benefits to others or replaces recipient finance that is socially more costly than grant finance. With the programme budget unchanged, reallocating it towards a lower rate and higher cap can support more projects and improve welfare even when private R&D falls. The same comparison determines whether an additional unit of programme funding has greater welfare value when used to raise the cap or the rate. Whether grants crowd in or crowd out private R&D therefore does not by itself reveal how much R&D they induce or whether they improve welfare.

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1 Introduction

Innovation grant programmes often state support in two familiar terms, a percentage of eligible project cost and a maximum grant. An applicant proposes a project budget, and the funding agency applies the funding rate to eligible cost up to that maximum. The funding rate determines how much the grant rises as project cost increases. The cap fixes the largest public contribution to any one project. Together they determine the project cost beyond which further expenditure no longer increases the grant.

Several programmes make this distinction observable. The EIC Accelerator combines a percentage funding rate with a maximum grant component (European Innovation Council, 2026). MIT Zuid held its project funding rate at 35 per cent from 2015 to 2016 while raising the maximum project grant from EUR 200,000 to EUR 350,000. Twelve of the 38 R&D collaborations approved in 2016 received more than EUR 200,000, and the programme limited the share of its total R&D budget available for these larger awards (Provincie Noord-Brabant, 2015, 2016; Stimulus Programmamanagement, 2017). NYSERDA has likewise combined cost-sharing requirements with maximum awards (New York State Energy Research and Development Authority, 2012). These programmes show that the rate, cap, and total budget are separate programme choices.

Why does this distinction matter? An agency with limited funds must decide whether to raise the percentage funded or the maximum grant. Either change can reduce what recipients pay for projects they could finance under the initial funding terms. Only the instrument that relaxes their relevant financing requirement can also enable additional projects. Private R&D can rise when enough projects become affordable and their recipients' contributions outweigh the reduction in spending on projects that would proceed under the initial terms. The relevant comparison therefore concerns both the funding instrument and the population of potential projects, not simply the amount of the grant.

These distinctions help organize two recurring findings in the empirical literature. Some studies find that grants stimulate additional private expenditure, while others find substitution between public and private funds, and additionality can weaken as support becomes larger.[1] Effects also differ across recipients, with stronger responses often found among smaller or financially constrained firms.[2]

This paper develops a theoretical framework for understanding how the funding rate and maximum grant can generate these patterns. Recipients decide whether to undertake indivisible projects with different approved eligible costs, and each has a maximum amount it is willing and able to finance. A higher funding rate reduces the required private expenditure while the grant is calculated as a percentage of project cost. This can make more projects feasible. For a project that would receive the maximum grant, however, a higher rate provides no further funding. A higher cap can instead make a costly project affordable by increasing the largest public contribution. The analysis separates the private expenditure associated with additional projects from the private expenditure replaced by larger grants, allowing the distribution of project costs to take a general form.

Recipients' financing capacity explains why these effects can differ within a programme. Recipients with little self-funding may be unable to undertake any project large enough to qualify for the maximum grant. A higher rate can help them undertake projects previously unaffordable, whereas a higher cap leaves

[1] Görg and Strobl (2007) find that small grants raise private R&D among domestic Irish plants, while sufficiently large grants may crowd it out. Marino et al. (2016) find little additionality on average in French data and stronger crowding out at medium and high levels of support. Dimos and Pugh (2016) document substantial heterogeneity across the broader evaluation literature.

[2] Lach (2002) finds strong additionality among small Israeli firms but little evidence of additionality among large firms. Bronzini and Iachini (2014) find no significant average investment effect in an Italian programme, but a positive effect among small firms. Howell (2017) finds stronger effects of U.S. R&D grants among financially constrained firms. Bajgar and Srholec (2025) find crowding in among Czech small and medium-sized enterprises and crowding out among large firms, with financing constraints accounting for an important part of the difference.

their required percentage contribution unchanged. Recipients with greater self-funding can undertake some projects receiving the maximum grant. For them, a higher cap can make still more costly projects feasible. A higher rate cannot do this, but it reduces their private expenditure on less costly projects that would proceed anyway. Raising the funding rate can therefore increase private R&D in one group and reduce it in another.

The main model holds each project's approved cost fixed. Allowing recipients to choose project size reveals a further distinction between induced R&D and private additionality. A grant can induce expansion of a project that would proceed without support while reducing its recipient's contribution. This occurs when the increase in total expenditure is smaller than the grant. Once the proportional grant reaches its maximum, the recipient must finance the full cost of further expansion. Applicants with different projects, returns, and financing conditions can therefore prefer exactly that expenditure, allowing the funding schedule to generate concentration even in a heterogeneous applicant population.

The project-size result gives an observable prediction that we examine using NEOTEC, a Spanish R&D grant programme for young technology-based firms. For the 2019 call, the published application-level records include reported project budgets and the agency's evaluation information for unsuccessful as well as funded applications. This allows us to ask whether the concentration in reported budgets is confined to projects selected for funding and whether it coincides with a change in assessed merit. NEOTEC combines a percentage funding rate with a maximum grant, making the project cost at which the grant first reaches its maximum directly observable. Reported project budgets concentrate near that cost, including among unsuccessful applications. Among applications that passed the initial technology assessment and received a full assessment, there is no statistically detectable discontinuity in mean evaluation scores at the same threshold. These patterns are consistent with reported project size responding to the funding schedule and help distinguish that response from award selection or a corresponding change in assessed merit.

These recipient responses also matter for welfare. A grant can be valuable because it induces projects with benefits to others or because it replaces recipient finance that is socially more costly than grant finance. Private R&D is therefore an outcome to interpret rather than the funding agency's welfare criterion. The agency chooses its funding terms anticipating both participation and expenditure, while holding underlying project opportunities fixed. At unchanged public spending, a lower rate can discourage expansion among recipients whose grants remain below the maximum, releasing funds for a higher cap that enables additional projects and expansion elsewhere. A higher rate and lower cap can instead reduce expenditure at the concentration point, but sacrifice some participating projects and encourage expansion below the maximum. We establish when each direction improves welfare, accounting for the benefits to others from additional projects and the expenditure choices of existing participants.

These comparisons also give a formal reason not to rank programmes by private additionality. At unchanged public spending, a lower rate and higher cap that enable additional projects without increasing aggregate private expenditure strictly improve welfare under the maintained assumptions. The same marginal comparison ranks two ways of spending the same additional programme funding, although it does not imply that either use of those funds raises welfare. At an interior optimum the marginal welfare changes per unit of grant expenditure are equal across the two instruments. The model therefore does not impose a general prediction that both rise with the programme budget.

The ordering of the analysis follows this economic sequence. Section 2 reviews empirical evidence and related theory. Section 3 introduces the model and explains the recipient responses that grant schemes can affect. Section 4 derives the effects of the funding terms on project implementation, private R&D, heterogeneous financing capacity, and expenditure chosen within projects. Section 5 examines grant applications and project budgets in NEOTEC. Section 6 studies grant design under a limited programme budget, with recipients choosing both participation and expenditure. Section 7 concludes. Proofs, data construction, and robustness analysis are in the appendices.

2 Empirical evidence and related theory

2.1 Empirical evidence

A large empirical literature asks whether public R&D support adds to private expenditure or replaces spending recipients would otherwise undertake. Reviews by David et al. (2000) and Dimos and Pugh (2016) document substantial variation across studies. Effects also vary with grant size and recipient characteristics: Görg and Strobl (2007) and Marino et al. (2016) find weaker additionality or crowding out at higher levels of support, while Lach (2002) and Bronzini and Iachini (2014) find stronger responses among smaller firms. Financing conditions are an important source of heterogeneity in Hyytinen and Toivanen (2005), Howell (2017), and Bajgar and Srholec (2025), while Meuleman and De Maeseneire (2012) show that public support can also improve access to external finance. These findings motivate our focus on how the funding rule interacts with the recipient's own financing capacity.

Related evidence shows that programme design can change spending and selection in ways that are not captured by grant amount alone. Baker et al. (1999) study the introduction of a cap in a Canadian matching programme, and Baicker (2005) distinguishes responses to different dimensions of U.S. federal matching rules. Santamaría et al. (2010) examine subsidy and credit decisions in Spanish cooperative R&D programmes, while Giebe et al. (2006) test alternative allocation procedures experimentally. Studies of R&D tax incentives also show that expenditure responds to eligibility and incentive rules (Guceri and Liu, 2019; Agrawal et al., 2020; Dechezleprêtre et al., 2023), and Chen et al. (2021) distinguish real investment from relabelling of expenditure. The NEOTEC records in Section 5 let us examine whether project budgets reported for applications align with the smallest project cost that qualifies for the maximum grant.

2.2 Related theoretical work

Theories of public support for R&D emphasize incomplete appropriability and knowledge spillovers (Nelson, 1959; Arrow, 1962; Martin and Scott, 2000). Other work brings financing frictions into the subsidy problem. Takalo et al. (2013) combine fixed R&D costs, costly external finance, spillovers, and a shadow cost of public funds with a subsidy rate, and show that additionality and welfare need not move together. Lach et al. (2021) study optimal government financing of R&D with positive externalities, adverse selection, moral hazard, and a social cost of public funds. These contributions establish that spillovers, private financing conditions, and the cost of public finance can all matter for programme design.

We distinguish the social cost of recipient finance from that of grant finance and study how this difference interacts with a common funding rate, an absolute grant cap, recipient responses, and a programme budget. The agency anticipates changes in both participation and expenditure. Our contribution concerns how these responses determine the welfare comparison between the rate and cap, rather than the general observation that private additionality and welfare need not coincide.

The public-finance literature has long studied grants that pay a fixed share of expenditure up to a maximum amount, often called closed-ended matching grants (Wilde, 1968, 1971). We use this structure to analyse recipients deciding whether they can finance indivisible R&D projects. The maximum amount they can finance themselves determines whether an increase in the percentage funded or in the maximum grant allows additional projects to proceed. Scotchmer (2013) studies matching requirements and crowding out in research expenditure, while Kleer (2010) develops a signalling role for subsidies. Our recipients face announced funding terms, with eligible cost observable, rather than a signalling or mechanism-design problem.

3 Model

Grant programmes are intended to affect R&D that recipients might otherwise be unwilling or unable to finance. They may matter because R&D creates benefits recipients do not capture, because recipient finance is costly or limited, or both. Sections 3 and 4 take the funding terms as given and ask what they change. We first study which approved projects proceed and how much recipients finance themselves, then allow recipients to adjust expenditure within projects. Section 6 asks when these responses make public support socially valuable.

Each potential recipient has an indivisible R&D project and decides whether to undertake it. We study this financing decision after the project's scope and eligible cost have been approved. In the main model, the recipient cannot change that cost. The population of potential projects has mass one, and eligible cost c is measured in units that put its range at $[0, 1]$. Projects differ in the expenditure they require. The function $F(y)$ gives the fraction with costs no greater than y, including projects that may not be undertaken. Its continuous density $f > 0$ describes how many potential projects fall within a narrow cost range. The funding agency knows this distribution when it announces the programme, and recipients learn their own project cost before deciding whether to proceed.

A recipient is willing and able to finance at most $b \in (0, 1)$. We call b its self-funding limit. Initially, this limit is the same across recipients. It can reflect both the project's private value and the recipient's ability to raise funds. For example, let v be the project's private value, let $\rho \geq 0$ be the financing cost per unit of private expenditure, and let w be the maximum amount of private finance available. Then

$$b = \min\left\{\frac{v}{1+\rho}, w\right\}.$$

Spending more than $v/(1+\rho)$ would cost the recipient more than the project is worth to it. Spending more than w is not possible. The smaller amount is therefore its self-funding limit. Private finance can include borrowing as well as internal funds. Without a public grant, the recipient undertakes the project if and only if it can finance the entire cost, $c \leq b$.

The funding agency announces a funding rate $\alpha \in [0, 1]$ and a maximum grant $K \in [0, 1]$. For a project costing c, the grant offered if the project is undertaken is

$$g(c; \alpha, K) = \min\{\alpha c, K\}.$$

The grant is the smaller of the stated percentage of eligible cost and the maximum amount. The recipient must finance the expenditure not covered by this grant,

$$x(c; \alpha, K) = c - g(c; \alpha, K) = \max\{(1-\alpha)c, c - K\}. \tag{1}$$

When $\alpha c < K$, the recipient pays $(1-\alpha)c$, the share of cost not covered by the funding rate. When $\alpha c \geq K$, it pays $c - K$. Thus the required expenditure x depends on the project's cost and funding terms, while b describes the recipient's willingness and ability to pay. The project proceeds when $x \leq b$.

The agency has a total grant budget $B \geq 0$. Aggregate grants cannot exceed this amount. We first examine recipients' responses to given funding terms, holding the other instrument fixed. Such a change need not leave total grant expenditure unchanged. Section 6 studies the agency's choice of terms under its budget constraint.

Let $q(\alpha, K)$ be the highest project cost for which the required private expenditure does not exceed b. A project costing less than q also requires no more than b. The following result therefore identifies which recipients undertake their projects.

Lemma 1 (Project implementation)**.** *A recipient undertakes its project if and only if $c \leq q(\alpha, K)$, where*

$$q(\alpha, K) = \min\left\{1, \frac{b}{1-\alpha}, b + K\right\}. \tag{2}$$

For $\alpha = 1$, the second term is interpreted as infinity.

The financing requirement in (1) has two parts. The recipient must be able to pay its percentage share, $(1-\alpha)c \leq b$, and the expenditure left after the maximum grant, $c - K \leq b$. These imply maximum project costs $b/(1-\alpha)$ and $b + K$, respectively. Both requirements must hold, and no project costs more than one. Their minimum gives q. An increase in q means that additional recipients can undertake their previously specified projects, not that each recipient chooses a larger project.

We suppress dependence on the funding rate and cap when it is clear. The fraction of projects undertaken is $N = F(q)$. Adding expenditure over these projects gives total project expenditure T, the part financed privately by recipients P, and public grant expenditure G,

$$T = \int_0^q c \;\mathrm{d}F(c), \qquad P = \int_0^q x(c)\;\mathrm{d}F(c),$$
$$G = \int_0^q g(c)\;\mathrm{d}F(c).$$

The identity $T = P + G$ divides total expenditure between private and public finance. Without public grants, only projects costing no more than b proceed and all expenditure is privately financed. Denote that expenditure by $P^0 = \int_0^b c \;\mathrm{d}F(c)$.

We measure input additionality by $P - P^0$, the difference between recipients' total private R&D expenditure with the programme and what they would spend without grants. A positive difference is crowding in of private expenditure, and a negative difference is crowding out. This comparison is distinct from a change between two programmes that both offer grants. It is also distinct from a change in total project expenditure, which includes public funding.

4 Programme rules and private R&D

Private R&D is often used to assess input additionality, but it is an outcome of the funding rule rather than the agency's objective. A change in private expenditure combines recipient spending on projects made possible by support with recipient spending replaced by larger grants on projects that would proceed anyway. We first separate these effects, then ask how the funding rate and cap affect each one.

4.1 Inducement and replacement

Consider a change in the funding rate, grant cap, or both that offers at least as large a grant for every project cost. We compare what recipients spend under the more generous funding terms with what they would spend under the initial funding terms, holding project costs and self-funding limits fixed. Subscripts

I and M denote the initial and more generous funding terms. Thus $g_I(c)$ and $g_M(c)$ are the two grants offered for a project costing c, and q_I, q_M are the costs of the most costly projects that can proceed under the two sets of funding terms. Every project feasible under the initial terms remains feasible under the more generous terms, giving $q_M \geq q_I$.

Let P_I and P_M be total privately financed R&D under the initial and more generous funding terms. The change $P_M - P_I$ consists of private expenditure on projects made feasible by the change, less the reduction in private expenditure on projects that would proceed under the initial terms. This accounting decomposition is

$$P_M - P_I = \int_{q_I}^{q_M} \{c - g_M(c)\} \, \mathrm{d}F(c) - \int_0^{q_I} \{g_M(c) - g_I(c)\} \, \mathrm{d}F(c). \tag{3}$$

Projects costing more than q_I but no more than q_M could not be financed under the initial terms. Their recipients' expenditure under the more generous terms is therefore additional. We refer to this as inducement. Projects costing no more than q_I would proceed under the initial terms. For each of these, an increase in the grant reduces the recipient's payment by the same amount. We refer to this as replacement. Private R&D increases after the change only when the additional private expenditure exceeds the expenditure replaced by larger grants. Both effects must be considered whether the agency raises the rate, the cap, or both.

The same comparison can be expressed for a small change in one instrument. Let t denote either the funding rate or the grant cap, with the other held fixed. Suppose $q < 1$ and the expenditure response is differentiable. At the cost q of the most costly project that can proceed, the recipient uses its full self-funding limit, $q - g(q) = b$. A slightly more costly project would require more than it can finance. Thus each project made feasible by a small increase in support brings approximately b of private expenditure. Since $N = F(q)$ is the fraction of projects undertaken,

$$\frac{\mathrm{d}P}{\mathrm{d}t} = b\frac{\mathrm{d}N}{\mathrm{d}t} - \int_0^q \frac{\partial g(c;t)}{\partial t} \, \mathrm{d}F(c). \tag{4}$$

The change in the number of feasible projects creates private expenditure through the first term. The increase in grants to projects feasible under the initial terms reduces their recipients' expenditure through the second. Appendix A.2 derives (3) and (4).

To compare the programme with no public grants, set $g_I(c) = 0$ and $q_I = b$. Expenditure under the initial funding terms P_I then equals private expenditure without grants, P^0, giving

$$P - P^0 = -\int_0^b g(c) \, \mathrm{d}F(c) + \int_b^q \{c - g(c)\} \, \mathrm{d}F(c).$$

Projects costing no more than b would proceed without grants, since recipients can finance their entire cost. Grants to those projects reduce what recipients pay. Projects costing more than b, but no more than q, proceed only with the programme. Any private expenditure on these projects is additional to what would occur without grants.

4.2 Funding rates and grant caps

For a project costing c, applying the funding rate gives αc. With a positive rate, this equals the maximum grant when $c = K/\alpha$. This is the smallest project cost that qualifies for grant K. For lower costs, the agency pays αc. For higher costs, it pays K, and a further increase in project cost must be financed entirely by the recipient.

To understand which instrument can make additional projects feasible, consider the two financing requirements in (2). If $b/(1-\alpha) < b+K$, the recipient cannot cover the required percentage of expenditure for any project costing more than $b/(1-\alpha)$. Its most costly project that can proceed satisfies $(1-\alpha)q = b$ and receives less than the maximum grant. A higher rate lowers the required private share and makes more projects affordable. A higher cap does not change that share and has no effect.

If $b + K < b/(1-\alpha)$, the most costly project that can proceed instead uses both the full grant K and the recipient's maximum expenditure b. Its cost is $q = b + K$. A higher cap increases this sum and can make still more costly projects affordable. The funding rate does not enter $b + K$, since the grant is already at its maximum for those projects. Raising the rate cannot make another project feasible in this case.

We consider positive rates below one and positive caps, with some projects still infeasible. The following comparisons concern small changes that do not reverse the order of the two implied maximum project costs.

Proposition 1 (Funding rate and grant cap)**.** *If $q = b/(1-\alpha) < b + K$, raising the funding rate makes additional projects feasible, while raising the cap has no effect. If $q = b + K < b/(1-\alpha)$, raising the cap makes additional projects feasible, while raising the rate leaves implementation unchanged and reduces privately financed R&D.*

Even when a rate increase makes no additional project feasible, it can change private expenditure. Recipients with less costly projects may still receive grants below the maximum. Raising the rate increases their grants and reduces what they pay. The aggregate effect therefore depends on both changes in implementation and payments for projects that were already feasible.

To calculate this effect, recall that P is total expenditure financed by recipients. An increase in the rate raises each uncapped grant in proportion to project cost. We therefore need to add up the costs of the projects concerned. Write

$$H(y) = \int_0^y c \, \mathrm{d}F(c)$$

for total eligible expenditure on projects costing no more than y. In particular, total implemented expenditure is $T = H(q)$.

When $q = b/(1-\alpha)$, the effects on private expenditure are

$$\frac{\partial P}{\partial \alpha} = q^2 f(q) - H(q), \qquad \frac{\partial P}{\partial K} = 0.$$

A small rate increase makes projects with costs just above q feasible. The density $f(q)$ describes how many potential projects lie there, and each recipient whose project enters at q spends b. Multiplying these amounts by the change in q, $\partial q/\partial \alpha = q^2/b$, gives $q^2 f(q)$. The amount replaced on projects already feasible is the rate increase multiplied by their total cost, $H(q)$. Private R&D rises when the private expenditure associated with the additional projects is larger than the expenditure replaced on projects already feasible.

When $q = b + K$, the responses are

$$\frac{\partial P}{\partial \alpha} = -H\left(\frac{K}{\alpha}\right) < 0, \qquad \frac{\partial P}{\partial K} = bf(q) - \left\{F(q) - F\left(\frac{K}{\alpha}\right)\right\}.$$

The negative rate effect follows because $q = b + K$ is unchanged. Only grants for projects costing less than K/α increase, and their recipients spend less by the same amount. A small cap increase instead raises by an equal amount the cost of the most costly project that can proceed. The associated private spending gives $bf(q)$. It also raises grants for projects already receiving the maximum. Their fraction is

$F(q) - F(K/\alpha)$, and the additional grant replaces recipient expenditure on each of them.

These formulas show why the distribution of potential project costs matters when a policy change makes additional projects feasible. What matters is how many projects lie just above the cost of the most costly project recipients can finance under the existing funding terms. Each newly feasible project brings additional recipient spending. At the same time, the more generous terms reduce what recipients pay for projects that would already proceed. If many projects lie just above the cost of the most costly project recipients can finance under the existing terms, the additional recipient spending is more likely to dominate. If relatively few projects lie there compared with the number of cheaper projects already receiving support, replacement is more likely to dominate. If the density of project costs is nondecreasing, private R&D rises when a higher funding rate or cap makes additional projects feasible. Appendix A.3 gives the formal bounds.

The density comparison is needed only when the policy change makes additional projects feasible. When $q = b + K$, a higher funding rate makes no additional project feasible. It only reduces what recipients contribute to projects that would already proceed, and private R&D necessarily falls.

4.3 Funding rates and input additionality

Holding the cap fixed, an increase in the funding rate can initially make additional projects feasible and thereby raise private R&D. This possibility ends once the maximum grant determines the cost of the most costly project that can proceed. For $\alpha > K/(b + K)$, that cost is $q = b + K$. A further increase in the rate then makes no additional project feasible and only reduces what recipients pay for less costly projects. Private expenditure is therefore strictly decreasing in the funding rate over this range.

If private expenditure exceeds what recipients would spend without grants when the maximum grant first determines which projects can proceed, but falls below that amount when $\alpha = 1$, the programme crosses exactly once from crowding in to crowding out as the funding rate rises. A higher cap behaves differently. When the maximum grant determines the most costly project that can proceed, raising the cap can still make more costly projects feasible, and its effect on private R&D continues to balance spending on those additional projects against recipient finance replaced on projects already receiving the maximum grant.

To determine whether private expenditure at $\alpha = 1$ is above or below what recipients would spend without grants, keep a cap that leaves some projects infeasible. A rate of one does not fully finance every project. Projects costing no more than K receive their entire cost, while more costly projects receive K and require the recipient to pay the difference.

The programme can therefore remove all private expenditure from some projects that would proceed without grants. It also makes projects costing between b and $b + K$ feasible, but these generate private expenditure only where their costs exceed K. Whether the additional spending offsets the reductions depends on how many potential projects have costs in these ranges. This comparison gives a sharp implication when the funding rate reaches one.

Corollary 1 (Project costs and input additionality)**.** *Suppose $K < 1 - b$, so that some projects remain infeasible. At $\alpha = 1$,*

$$P(1, K) - P^0 = \int_0^b x\{f(x + K) - f(x)\}\, \mathrm{d}x. \tag{5}$$

Input additionality is negative when $f(x + K) < f(x)$ for $0 < x < b$, zero under a uniform distribution, and positive when $f(x + K) > f(x)$ for $0 < x < b$.

A population with many inexpensive projects that recipients could finance without grants, but relatively few additional projects requiring private expenditure, is conducive to crowding out. The programme then replaces spending on many projects while generating spending on few others. The balance can reverse when sufficiently many potential projects require the higher costs made feasible by support.

The expression in (5) makes this comparison by holding the amount of recipient expenditure x fixed. Without grants, it pays for a project costing x. Under a rate of one and cap K, it pays for a project costing $x + K$. The densities compare the numbers of potential projects in small, equally wide intervals around those costs. If the density declines with cost, there are fewer projects at the higher cost for each such comparison and private expenditure falls. Under uniform costs, equally wide intervals contain equal shares of projects and the expenditure effects exactly offset in this case.

This transition sharpens the interpretation of weaker additionality at larger grant amounts in Görg and Strobl (2007) and Marino et al. (2016). A higher rate can increase observed grants after it has ceased to enable additional projects, at which point further rate increases necessarily reduce private R&D. A higher cap can instead increase grants while continuing to make more costly projects feasible. A negative relationship between grant amount and additionality alone does not distinguish these changes.

4.4 Differences in self-funding capacity

We now ask whether the same rate increase can raise private R&D for recipients with less financing capacity and reduce it for those with more. Consider two groups facing the same funding rate and cap. Group L has self-funding limit b_L and group H has the higher limit b_H. These limits measure what recipients are willing and able to finance, not administrative categories eligible for different grants.

A project costing K/α receives the maximum grant K and requires the recipient to finance the difference. Denote this requirement by

$$\bar{b}(\alpha, K) = \frac{K}{\alpha} - K = \frac{1-\alpha}{\alpha} K. \tag{6}$$

The self-funding limit b_j is a recipient characteristic. In contrast, $\bar{b}$ is determined by the programme terms. It is also the recipient contribution at the project cost where the proportional grant first reaches the maximum grant. In Figure 1, this is the height of the bend in each required-contribution curve for the corresponding funding terms.

Suppose $b_L < \bar{b} < b_H$, and neither group can finance every potential project. Group L cannot finance a project large enough to receive the maximum grant. The most costly project it can finance costs $q_L = b_L/(1-\alpha)$. A higher rate reduces the percentage contribution and permits additional projects, while a higher cap does not change which projects the group can finance. Group H can reach projects for which the grant has already reached its maximum. The most costly project it can finance costs $q_H = b_H + K$. A higher cap permits more costly projects, while a higher rate does not increase the maximum grant and therefore adds no project for this group.

Figure 1 shows the difference. Each curve gives the private expenditure required at every project cost, and its intersection with a group's self-funding limit gives that group's most costly project that can proceed. A higher rate moves this intersection for group L but not group H. A higher cap does the reverse.

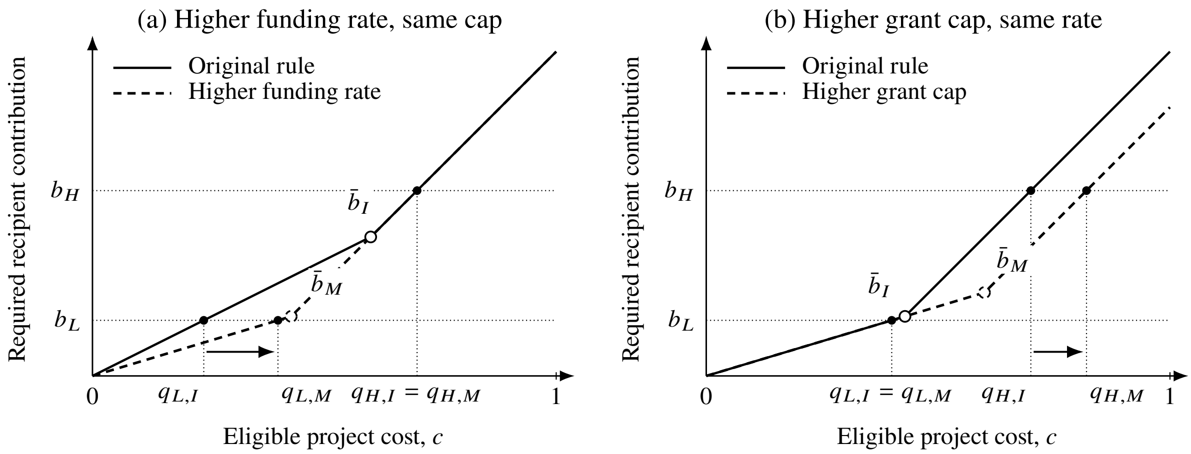

Figure 1: How the funding rate and grant cap affect project feasibility

Notes: A project proceeds when its required contribution does not exceed its self-funding limit. The bend height $\bar{b}$ is the contribution required where the grant first reaches its maximum. In both panels, $b_L < \bar{b} < b_H$. Panel (a) raises α from 0.5 to 0.7 at $K = 0.3$; panel (b) raises K from 0.3 to 0.42 at $\alpha = 0.7$. Both use $b_L = 0.12$ and $b_H = 0.4$. Subscripts I and M denote the initial and more generous terms, and arrows show the increase in the most costly project that can proceed.

Implementation is only one part of the change in private expenditure. For group L, a higher rate creates private spending on projects that were infeasible under the initial terms but reduces recipients' spending on projects that would proceed under those terms. For group H, there are no additional projects. Its less costly projects still receive percentage grants, however, and a higher rate increases those grants and reduces what their recipients pay.

Proposition 2 (Opposite responses across recipient groups)**.** *Suppose $b_L < \bar{b} < b_H$ and $q_L, q_H < 1$. A small increase in the funding rate, holding the cap fixed, makes additional projects feasible only for group L. If private expenditure on those projects exceeds the reduction on projects already feasible in group L, its private R&D rises while group H's falls.*

Let F_j and f_j describe the distribution of project costs in group j and define $H_j(y) = \int_0^y c \, \mathrm{d}F_j(c)$. The rate effects are

$$\frac{\partial P_L}{\partial \alpha} = q_L^2 f_L(q_L) - H_L(q_L), \qquad \frac{\partial P_H}{\partial \alpha} = -H_H\left(\frac{K}{\alpha}\right) < 0. \tag{7}$$

The sign for group L depends on how many potential projects lie near its financing limit relative to the projects on which larger grants replace recipient expenditure. If the density of project costs is nondecreasing over that range, its private expenditure rises. Group H's private expenditure falls for every cost distribution because the rate increase adds no project. A cap increase reverses which group can add projects. It leaves the projects group L can finance unchanged while allowing group H to undertake more costly projects, with its effect on private expenditure again balancing spending on those additional projects against replacement on projects already receiving the maximum grant.

This comparison gives a specific interpretation to evidence of stronger responses among smaller or financially constrained firms, including Bronzini and Iachini (2014) and Bajgar and Srholec (2025). Financing capacity matters relative to the recipient contribution required by the rate and cap. Identifying that comparison requires the applicable funding terms and information on recipients' financing capacity before the award, rather than firm size or the eventual grant alone.

4.5 Choosing project size

The preceding results concern recipients deciding whether to undertake projects with given costs. We now ask how the funding terms affect the size a recipient chooses, conditional on undertaking a project. Below total cost K/α, the recipient finances the fraction $1-\alpha$ of additional expenditure. Above that cost, it finances the entire increase. Required private expenditure is continuous, but the recipient's marginal financing requirement rises at the point where the grant reaches its maximum.

Suppose the project initially requires eligible expenditure $c_0 < K/\alpha$ and the recipient can add expenditure $d \in [0, \bar{d}]$. Total cost is $c_0 + d$. Let $h(d)$ be its increasing, strictly concave private return from that expenditure. With the same financing cost ρ as before, the incremental payoff is

$$h(d) - (1+\rho)\{d - [g(c_0+d) - g(c_0)]\}.$$

The grant increase lowers the recipient's cost of expansion before the cap is reached. Each additional unit costs it $(1+\rho)(1-\alpha)$ below this project cost and $1+\rho$ above it.

Once total project cost reaches K/α, the recipient's incentive to expand changes sharply. Below that cost, an additional unit of eligible expenditure raises the grant by α, leaving the recipient to finance only the remaining share. Above it, the grant has reached its maximum and the recipient must finance the full additional cost. A recipient therefore stops at K/α when further expansion is worthwhile while it still receives proportional support, but not once the maximum grant has been reached.

Let $D = K/\alpha - c_0$ be the additional expenditure needed to reach the project cost at which the grant reaches its maximum. The concentration result can be stated directly.

Proposition 3 (Concentration at the maximum-grant threshold)**.** *Suppose $D \in (0, \bar{d})$ and the recipient can finance total project cost K/α. It chooses $c_0 + d^* = K/\alpha$ whenever*

$$(1+\rho)(1-\alpha) \le h'(D) \le 1+\rho.$$

The condition covers an interval of marginal returns rather than a knife-edge equality. Recipients can therefore differ in their projects, returns, and financing conditions while many choose the same project cost. A positive mass of recipients satisfying the condition creates a concentration of applications at K/α. Appendix A.6 gives the exact choice and financing conditions.

The result also clarifies how this response relates to input additionality. Let d^0 be the additional expenditure the same recipient would choose without a grant, conditional on undertaking the project. Without support, an additional unit costs the recipient $1+\rho$. Proposition 3 requires $h'(D) \le 1+\rho$. Since marginal returns decline with d, the no-grant choice therefore satisfies $d^0 \le D$. A recipient that chooses K/α with the grant therefore chooses weakly more total eligible expenditure than it would without the grant.

For a project undertaken both with and without support, the change in private expenditure is the increase in total expenditure minus the grant, $d^* - d^0 - g(c_0 + d^*)$. For a recipient choosing the threshold, this equals $D - d^0 - K$. The project therefore expands while private expenditure falls whenever $0 < D - d^0 < K$. Allowing recipients to choose project size thus adds a second way in which support can increase total R&D: recipients may expand projects they would already undertake, in addition to projects becoming feasible only because of support.

5 Grant applications and project budgets in practice

Section 4.5 shows how applicants who can adjust project size can concentrate reported project budgets at K/α, where the proportional grant reaches its maximum. Applicants can differ in their projects, returns, and financing conditions and still choose the same threshold. NEOTEC, a Spanish R&D grant programme for young technology-based firms, provides application-level records containing project budgets and evaluation information for unsuccessful as well as funded applications. The unsuccessful applications show whether concentration is confined to proposals selected for funding, while the evaluation scores provide a separate measure of assessed merit. Input-additionality studies estimate how private R&D differs from the expenditure that would have prevailed without support (e.g. Görg and Strobl, 2007; Marino et al., 2016; Bajgar and Srholec, 2025). The NEOTEC records complement that evidence by showing how reported project budgets align with the funding schedule, including among unsuccessful applications, and whether that concentration coincides with a change in assessed merit.

For each project with identified funding terms, we record the funding rate α_i, maximum grant K_i, and reported project budget c_i. Applying the programme formula, the recipient contribution implied if that budget were funded on those terms is $c_i - \min\{\alpha_i c_i, K_i\}$. This is not observed private expenditure, and the reported budget need not equal the eligible cost used to calculate the award. The comparisons below therefore keep reported project budgets, implied recipient contributions, and observed grants distinct.

5.1 Funding terms and awards

NEOTEC supports young technology-based firms. The 2018–2020 calls financed up to 70 per cent of eligible project cost, subject to a EUR 250,000 cap. From 2021, projects involving the recruitment of at least one qualifying doctorate holder could receive up to 85 per cent, subject to a EUR 325,000 cap (CDTI, 2018, 2019, 2020, 2021). We call these the ordinary and enhanced schedules. The ordinary schedule continued alongside the enhanced one. Eligibility for enhanced support can affect both the types of firms applying and their expenditure. Comparing the schedules therefore does not hold recipient characteristics fixed.

Table 1 reports the funding terms and award counts. The ordinary schedule gives the maximum grant at a project cost of about EUR 357,143. The enhanced schedule does so at about EUR 382,353. The funding formula implies a recipient contribution of $\bar{b} = (1 - \alpha)K/\alpha$ at these threshold budgets, as defined in (6). It falls from about EUR 107,143 to EUR 57,353. The enhanced combination therefore permits a larger project at the threshold with less recipient finance. This illustrates why neither the rate nor the cap alone describes the funding requirement.

The archive contains 873 funded projects from the 2018–2025 calls, including awards following appeals or the allocation of remaining funds. We identify the rate and cap for 865 projects, comprising 431 ordinary and 434 enhanced awards. Eight remain unclassified. Appendix B documents the classification, including the treatment of separately reported training support and exceptional observations.

Among the classified awards, 613, or 70.9 per cent, equal the maximum base grant for the project's assigned schedule. Reported budgets are at or above that schedule's cost threshold for 617, or 71.3 per cent. The four additional budgets exceed the threshold but have grants below the maximum. We retain these discrepancies rather than assume that every reported budget equals the eligible cost used in the grant calculation. In the 2019 final awards, the mean grant is about EUR 239,300 against a EUR 250,000 cap. The cap is thus central to observed awards, while similar grants can accompany substantially different reported project budgets and implied recipient contributions.

Table 1: NEOTEC schedules, maximum grants, and concentration of reported budgets

Panel A. Funding schedules

Schedule	Rate	Maximum grant	Cost at maximum grant	Implied recipient contribution	Projects
Ordinary	70%	250,000	357,143	107,143	431
Enhanced	85%	325,000	382,353	57,353	434

Panel B. Awards at the maximum and budgets near each schedule's threshold

Call	Schedule	Projects	At maximum grant (%)	Within EUR 500	Within EUR 1,000
2018	Ordinary	101	51.5	4	8
2019	Ordinary	104	61.5	6	8
2020	Ordinary	103	68.9	8	9
2021	Ordinary	42	61.9	1	2
2021	Enhanced	81	69.1	4	7
2022	Ordinary	25	72.0	0	1
2022	Enhanced	90	76.7	4	9
2023	Ordinary	24	75.0	0	1
2023	Enhanced	105	79.0	3	8
2024	Ordinary	11	100.0	2	2
2024	Enhanced	52	76.9	3	7
2025	Ordinary	21	76.2	1	2
2025	Enhanced	106	84.0	4	9
All calls	Both	865	70.9	40	73

Notes: Monetary amounts are in euros. In Panel A, the proportional grant first reaches the maximum at project cost K/α, and the recipient contribution implied by the formula at that cost is $K/\alpha - K$. The share of projects receiving the maximum grant compares the published base project grant with the assigned cap, allowing EUR 1 for rounding. Distance is reported project budget minus K_i/α_i. Eight of 873 awards remain unclassified. Separately reported training support is removed from the total grant before comparison with the project cap. Enhanced support requires qualifying doctoral recruitment. Sources are CDTI call rules and award resolutions for 2018–2025 (CDTI, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025).

5.2 Project budgets and the grant threshold

For each project with an identified schedule, subtract the cost needed to obtain its maximum grant from its reported budget,

$$z_i = c_i - \frac{K_i}{\alpha_i}.$$

A value of zero means that the reported budget is exactly sufficient for the grant to equal its cap. Negative and positive values indicate smaller and larger reported budgets. Figure 2(a) pools these distances across the eight calls. Forty projects lie within EUR 500 of zero and 73 within EUR 1,000.

To gauge the size of the concentration, we compare the observed counts near zero with a smooth distribution fitted to nearby budget counts outside that interval, following the bunching literature (Saez, 2010; Chetty et al., 2011; Kleven, 2016). With EUR 500 bins and an excluded interval of EUR 1,000 on either side of zero, the fitted distribution predicts 21.5 projects where 73 are observed. The estimated excess is 51.5 projects, with a bootstrap standard error of 8.5, and is also positive when the ordinary and enhanced schedules are analysed separately. Appendix B.2 reports the estimation details and sensitivity checks. The estimate measures local concentration relative to a smooth benchmark rather than the project budgets that would have been reported under another funding rule.

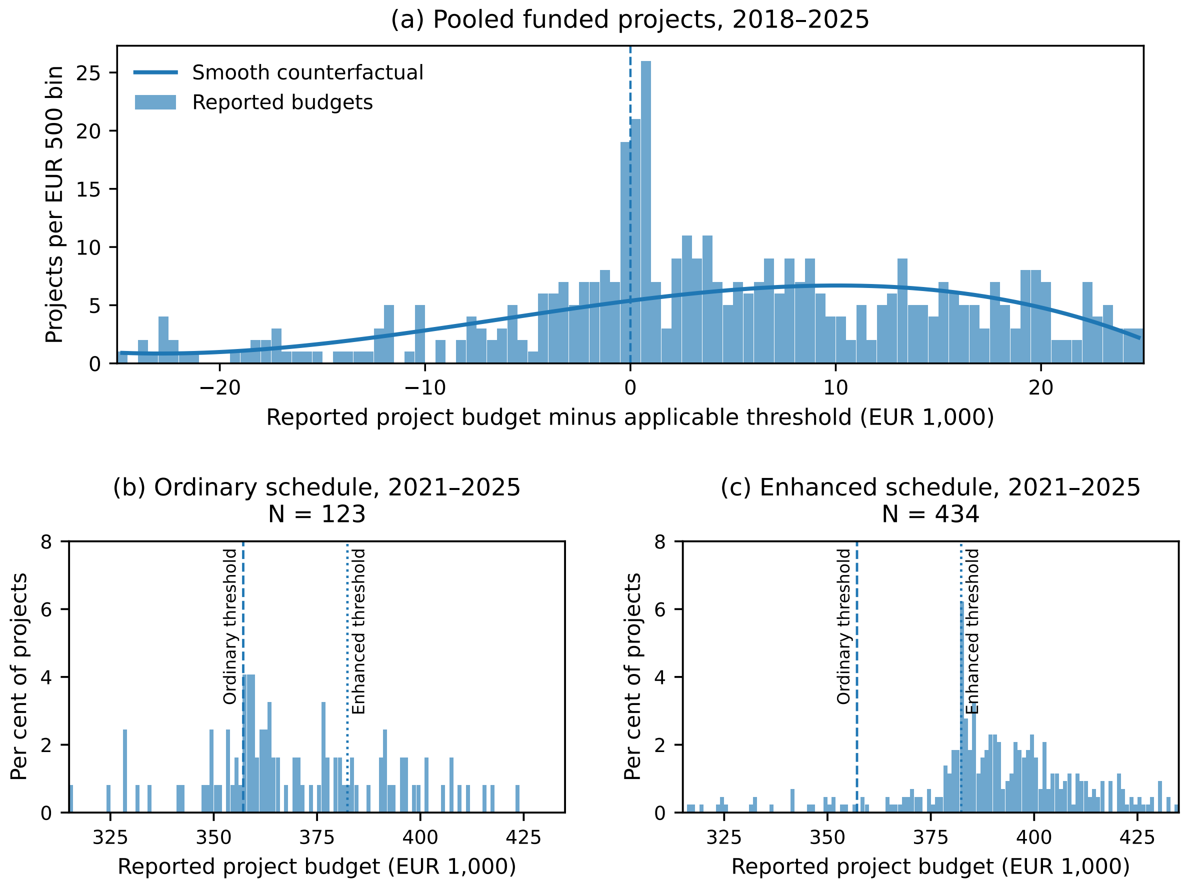

Figure 2: Reported project budgets and the cost at which the grant is capped

Notes: Panel (a) uses the 865 classified funded projects from 2018–2025 and displays distances within EUR 25,000 of each project's own threshold. Bars are EUR 500 bins. The line is a cubic count polynomial fitted outside $|z_i| <$ EUR $1,000$. Panels (b) and (c) compare coexisting schedules in the 2021–2025 calls on identical axes for nominal project budgets and EUR 1,000 bins. Percentages use all 123 ordinary and 434 enhanced projects in those calls, respectively, including projects outside the displayed range. The dashed line marks EUR 357,143 and the dotted line EUR 382,353. Eight unclassified awards are omitted.

Panels (b) and (c) show the two schedules' budgets without subtracting their thresholds, using the calls in which both operate. They have the same budget axis, allowing the two locations to be compared directly. Budgets concentrate near each schedule's own threshold. There are fewer ordinary-schedule projects in these later calls. Across the full period, 33 ordinary and 40 enhanced projects lie within EUR 1,000 of their respective thresholds. The alignment with different project costs is more informative than a peak at one fixed nominal budget, although the schedules differ in eligibility as well as in funding terms.

This alignment with each schedule's own threshold is consistent with the expenditure choices described in Section 4.5. It is not mechanical. Larger projects receive the same maximum grant, and applicants remain free to propose them if they are willing and able to finance the additional cost. The concentration therefore concerns reported project size, not simply the calculation of grant amounts. The two NEOTEC schedules differ in eligibility as well as in their rates, caps, and thresholds. Their comparison is therefore descriptive rather than a policy experiment.

5.3 Unsuccessful applications and evaluation scores

A pattern among funded projects might arise because the agency selects proposals with particular budgets. The 2019 records allow us to examine that possibility. CDTI reports 300 submissions, and the provisional decision tables contain budgets for 293 applications. Of these, 96 were provisionally funded and 197 were provisionally rejected. The published tables contain a score entry for most applications, but the entries are not all comparable total evaluation scores. The call evaluates technology and innovation first and does not assess the remaining criteria when an application scores below the threshold on that criterion. We therefore exclude technology-only scores and administrative zeros from comparisons of total evaluation scores. This exercise uses the provisional decisions. Eight additional projects that were provisionally rejected later received final awards and are linked separately, and provisional and final scores are not combined.

Panel (a) of Figure 3 shows the budgets in all 293 applications. Of the fifteen within EUR 500 of the threshold, five were provisionally funded and ten were provisionally rejected. Within EUR 1,000, the corresponding counts are seven and twelve. For each group and both interval widths, the interval centred on the threshold has the largest count among the shifted intervals used in the diagnostic. The concentration is therefore not confined to applications provisionally selected for funding and cannot be explained solely by the provisional funding decision. The published budgets may reflect applicant choices, revisions made during assessment, or both. This comparison does not identify when the reported amounts were determined.

Panel (b) plots total evaluation scores against reported project budget, relative to the threshold, for applications within EUR 50,000 that passed the initial technology assessment and received a full assessment. Scores show no visible break where reported budgets concentrate. Separate local linear fits give an estimated discontinuity in mean score of about -1.23 points, with a robust standard error of 2.02. There is therefore no statistically detectable discontinuity in mean evaluation scores among applications that passed the initial technology assessment and received a full assessment. Across the full sample with comparable assessments, larger reported budgets are weakly associated with higher scores, a broader relationship reported in Appendix B.4. The local comparison does not imply that assessed merit is unrelated to project size overall, nor does it establish identical proposal quality on either side of the threshold.

Reported project budgets therefore concentrate where the proportional grant reaches its maximum, including among provisionally rejected applications. The concentration is thus not generated solely by the provisional funding decision, and it is not accompanied by a statistically detectable discontinuity in the agency's own measure of assessed merit among applications with comparable full assessments. Taken together, these findings strengthen the interpretation that reported project size responds to the funding schedule rather than merely reflecting award selection or a corresponding discrete change in assessed merit.

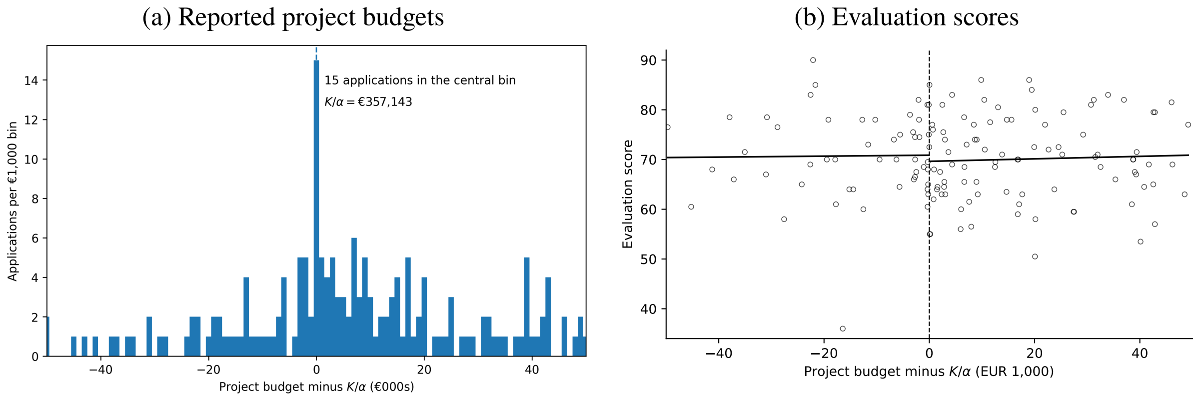

Figure 3: Project budgets and evaluation scores around the 2019 project cost at which the grant reaches its maximum

Notes: Panel (a) uses the 293 applications in the provisional decision tables and EUR 1,000 budget bins. Fifteen applications lie within EUR 500 of the threshold, of which five were provisionally funded and ten were provisionally rejected. Panel (b) uses the 141 applications within EUR 50,000 of the threshold that passed the initial technology and innovation assessment and received a full assessment. Points are individual applications, and solid lines are separate local linear fits on either side of the threshold. In both panels, the vertical line marks K/α = EUR 357, 143. The score comparison is descriptive, not a regression-discontinuity design.

Section 6 turns to grant design when the funding terms affect both participation and expenditure.

6 Grant design

Once recipients choose expenditure, the funding terms affect not only which projects proceed and how they are financed, but also how much existing participants spend. The agency must therefore compare changes in participation with changes in expenditure below and at the maximum grant. Public support can be valuable because additional projects create benefits recipients do not capture or because grant finance is socially less costly than recipient finance. We first compare reallocations of a fixed budget, then ask which instrument gives greater value when additional programme funds become available.

6.1 The agency's problem

Each project initially requires eligible expenditure c_0, distributed according to F_0 with continuous positive density f_0 on $[0, 1]$. Recipients share private value v, financing cost ρ, and a strictly increasing, strictly concave return $h(d)$ from additional expenditure, with $h(0) = 0$. Only the initial requirement differs across recipients. The distribution F_0 and these returns and financing conditions remain unchanged across policies. Final expenditure $c_0 + d^*$ is chosen by the recipient and need not lie below one.

Assume $h'(0) \leq 1 + \rho$. Without support, recipients would not expand, since every additional unit would cost at least as much as its marginal return. They can raise finance at cost ρ, without a separate limit on available funds. After the agency announces α and K, each recipient chooses $d \geq 0$ to maximize

$$v + h(d) - (1 + \rho)\,[c_0 + d - \min\{\alpha(c_0 + d), K\}], \tag{8}$$

and undertakes the project only if the maximized payoff is nonnegative. The quantity $b = v/(1 + \rho) \in (0, 1)$ describes willingness to finance the initial expenditure without expansion. It is not imposed as an unchanged limit on payments after expansion adds value $h(d)$.

If initial expenditure already qualifies for the maximum grant, additional expenditure receives no further support and the recipient does not expand. Below that point, it may choose no expansion, stop before obtaining the maximum grant, or expand until the grant reaches its maximum. A positive choice that stops before the maximum satisfies

$$h'(d^*) = (1+\rho)(1-\alpha).$$

Recipients in the last case choose total expenditure $c_0 + d^* = K/\alpha$. A higher rate can therefore encourage expansion among recipients whose grants remain below the maximum, but reduce expenditure among recipients who continue to choose the point where that maximum is first reached. A higher cap moves that point upward. The two instruments therefore affect expenditure differently even among projects that proceed under either policy. A higher rate encourages expansion while the grant remains proportional to expenditure, but lowers the project cost at which the maximum grant is reached. A higher cap raises that project cost without changing the share of marginal expenditure financed publicly below it. Appendix A.7 gives the exact choice and participation conditions, including zero support and $\alpha = 1$.

The recipient considers the returns it can obtain from its project. The agency also values benefits the recipient cannot capture. Research may, for example, generate knowledge that other firms can use without compensating its producer. Let $e \geq 0$ denote this expected benefit to others when a project is undertaken. It is a benefit of the research, not of receiving a grant, and also arises when the project proceeds without support. We take e to be common across projects and hold it fixed when a recipient adds expenditure. Expansion generates $h(d)$ but no further external benefit in this version of the model. This restriction isolates the benefit of getting an additional project undertaken from the return to expanding a project that already proceeds.

Interpret ρ as a real resource cost of recipient finance, and let $\gamma \geq 0$ be the social financing cost per unit of grant expenditure. The restriction on $h'(0)$ does not make expansion socially worthless. Its marginal return can exceed $1+\gamma$ while remaining below $1+\rho$. Let $q_0(\alpha, K)$ be the largest initial expenditure for which the recipient chooses to proceed. The fraction of projects undertaken is $F_0(q_0)$. The agency solves

$$\max_{0\leq\alpha\leq 1,\ 0\leq K\leq 1} W(\alpha, K) \quad \text{subject to} \quad G(\alpha, K) \leq B, \tag{9}$$

where

$$\begin{aligned} W(\alpha, K) &= \int_0^{q_0} [v + e + h(d^*) - (1+\rho)(c_0 + d^*) + (\rho - \gamma) g(c_0 + d^*; \alpha, K)] \, \mathrm{d}F_0(c_0), \\ G(\alpha, K) &= \int_0^{q_0} g(c_0 + d^*; \alpha, K) \, \mathrm{d}F_0(c_0). \end{aligned}$$

Welfare counts project benefits and expenditure at the cost of recipient finance, then adjusts for expenditure financed publicly. Each unit shifted to grants saves ρ and incurs γ in financing costs. Holding a project and its expenditure fixed, replacing one unit of recipient finance with one unit of grant finance therefore changes welfare by $\rho - \gamma$.

This comparison makes the two reasons for support especially clear. A grant can be valuable even when $e = 0$ and it induces no additional R&D if $\gamma < \rho$, since it replaces more costly recipient finance. Conversely, if $e = 0$ and $\gamma \geq \rho$, positive grants have no strict welfare role in this section. Public finance is then no cheaper, and $h'(0) \leq 1 + \rho$ rules out socially valuable expansion that recipients reject solely because of the cost of their own finance. At least one of $e > 0$ or $\gamma < \rho$ is therefore necessary for a strict welfare gain from support in this version of the model. This is a necessary condition, not a claim that either inequality by itself makes every grant worthwhile. When both are present, the funding terms determine how the programme divides its resources between inducing activity and replacing recipient finance.

Both the objective and the budget use the participation, expenditure, and grants induced by the funding terms. Aggregate private expenditure remains $P = T - G$, where T adds chosen expenditure across participants. As before, recipients receive the announced grant if they proceed. A separate uncertain award decision is not modelled.

6.2 Reallocating a fixed budget

Suppose the agency has used its grant budget and considers lowering the rate to finance a higher cap, or doing the reverse. Hold underlying opportunities, their returns, and financing conditions fixed. Consider terms satisfying

$$0 < \alpha < 1, \qquad 0 < K < 1 - b, \qquad \frac{K}{\alpha} < b + K.$$

Recipients with initial expenditure no greater than $b + K$ can already undertake their projects without expansion under these terms. Allowing expansion cannot lower their payoff. Recipients with higher initial requirements cannot afford their projects even with the maximum grant, and additional expenditure receives no further support. Hence $q_0 = b + K$. A higher cap enables additional projects, whereas a higher rate with the cap fixed changes only existing participants' grants and expenditure.

Suppose also that some recipients choose positive expansion without obtaining the maximum grant, while others expand exactly to it. These choices coexist when $h'(K/\alpha) < (1 + \rho)(1 - \alpha) < h'(0)$. Raising the rate increases grants to the first group, including grants on the expansion it induces. Raising the cap increases payments to existing recipients at the maximum and pays for additional participants. Both instruments therefore increase aggregate grants. At unchanged grant expenditure, a higher cap requires a lower rate. We consider small changes that preserve these financing circumstances.

A lower-rate, higher-cap reform that holds aggregate grants fixed changes activity in three ways. The higher cap enables additional projects. The lower rate reduces expansion among recipients whose grants remain below the maximum, since they finance a larger share of marginal expenditure. Recipients who continue to choose the project cost at which the maximum grant is first reached expand instead, since K/α rises. The agency must account for all three responses.

To state the two expenditure effects precisely, write $s = K/\alpha$ for the project cost at which the maximum grant is first reached. Let $y < s$ be the largest initial expenditure for which a recipient expands but stops below s, so that

$$h'(s - y) = (1 + \rho)(1 - \alpha).$$

Let

$$\kappa = - \left. \frac{\mathrm{d}\alpha}{\mathrm{d}K} \right|_{G=B} > 0$$

be the reduction in the funding rate required per unit increase in the cap to keep aggregate grants unchanged. Under the smoothness conditions used in Appendix A.8, the social saving from reduced expansion below the maximum, net of benefits forgone, per additional project enabled by the reform is

$$A = \frac{(1 + \rho)^2 \alpha \kappa F_0(y)}{-h''(s - y) f_0(q_0)},$$

and the social cost of additional expansion at the maximum, net of benefits gained, per additional project is

$$C = \frac{1 + s\kappa}{\alpha f_0(q_0)} \int_y^s \{1 + \rho - h'(s - c_0)\} \, \mathrm{d}F_0(c_0).$$

Both are nonnegative. A favours the cap because the accompanying lower rate curbs expansion among recipients whose grants remain below the maximum. It is larger when more recipients are in this group, when their expenditure responds more strongly to the funding rate, or when keeping grants fixed requires a larger rate reduction. C favours the funding rate because the higher cap raises expenditure among recipients who continue to stop where the maximum grant is first reached. It is larger when the reform moves that threshold further and when these recipients' marginal returns are further below $1 + \rho$.

With aggregate grants unchanged, a reduction in total expenditure reduces aggregate recipient finance by the same amount. Each unit saved releases one unit of resources and avoids financing cost ρ, giving a social saving of $1 + \rho$ before accounting for benefits forgone. Below the maximum grant, the marginal return is $(1 + \rho)(1 - \alpha)$, leaving a net saving of $(1 + \rho)\alpha$ per unit forgone. For recipients expanding at the maximum, marginal returns are no greater than $1 + \rho$, giving the nonnegative net cost summarized by C.

An additional participant undertakes a project requiring initial expenditure $b + K$ and contributes b. Its private value $v = (1 + \rho)b$ offsets the resource and financing cost of that contribution. The grant finances the remaining K of resources. Since aggregate grants are held fixed, this public finance must be offset by lower grants elsewhere, which shifts the same amount back to recipient finance in aggregate and adds financing cost ρK. The remaining social cost associated with the additional participant is therefore $(1 + \rho)K$, against its expected benefit e to others. The terms A and C account separately for the changes in existing recipients' expenditure.

Proposition 4 (Reallocating the programme budget)**.** *Under these conditions, reducing the funding rate slightly and increasing the cap enough to leave aggregate grant expenditure unchanged raises welfare if and only if*

$$e + A > (1 + \rho)K + C.$$

Increasing the funding rate slightly and reducing the cap enough to leave aggregate grant expenditure unchanged raises welfare if and only if the inequality is reversed.

At equality, a marginal reallocation has no welfare effect. Strict inequalities give improvements for sufficiently small reforms, not a ranking of all possible funding terms. Appendix A.8 derives the expressions for A and C and proves the result. The public financing cost γ cancels from this comparison because total grants are unchanged. The comparison therefore turns on which projects proceed and how much existing recipients spend, not simply on replacing one source of finance with a cheaper one.

The condition can also be read as the sum of two comparisons. The term $e - (1 + \rho)K$ is the net welfare contribution of the additional projects enabled by the higher cap. The term $A - C$ is the net welfare effect of the expenditure changes among projects that already proceed. Endogenous project size therefore need not favour either instrument. It shifts the comparison towards the cap when $A > C$, and towards the funding rate when $C > A$.

The expressions for A and C also show why concentration at the maximum-grant threshold is not itself sufficient to rank the instruments. The cost C depends on the marginal returns to the additional expenditure of recipients at that threshold, not only on their number. Likewise, A depends on how strongly expenditure below the maximum responds to the funding rate.

Endogenous project size also changes what can be inferred from private expenditure. A lower rate can reduce expansion on some existing projects sufficiently that aggregate private R&D does not rise even while the higher cap enables additional projects.

Corollary 2 (Private R&D and welfare)**.** *Consider a lower-rate, higher-cap reform that leaves aggregate grant expenditure unchanged and enables additional projects. If aggregate private R&D does not increase, welfare strictly rises.*

At unchanged public spending, nonincreasing private expenditure also means nonincreasing total expenditure. Reduced expansion must therefore release enough expenditure to cover both expansion elsewhere and the initial expenditure of the additional projects. The expansion forgone has marginal returns no greater than those on expansion added elsewhere. For a project entering at $b + K$, private value v also exceeds $(1 + \rho)(1 - \alpha)(b + K)$, the benefit forgone if its entire initial expenditure were released from expansion below the maximum. The additional projects therefore more than compensate for those forgone benefits, even before counting benefits to others. Appendix A.9 establishes the welfare bound and shows that the same conclusion applies to finite reforms satisfying $K/\alpha < b + K < 1$ under both programmes.

Since private expenditure without grants is unchanged, any decline in private R&D also reduces input additionality. A programme with higher welfare can therefore generate less private additionality than another using the same public budget. This does not necessarily mean crowding out relative to no grants. Private expenditure can fall between programmes while remaining above what recipients would spend without support. Private additionality therefore does not rank programmes when the funding terms also change which projects proceed and how much recipients spend on them.

6.3 Additional programme funds

Proposition 4 also answers a different question. Suppose the agency receives a small increase in its programme budget and can spend the same additional amount through either a higher funding rate or a higher cap. We compare these two uses of the additional funds at the original funding terms.

Corollary 3 (Using additional programme funds)**.** *Under the conditions of Proposition 4, for the same small increase in aggregate grant expenditure, raising the cap gives the larger welfare change if and only if*

$$e + A > (1 + \rho)K + C.$$

Raising the funding rate gives the larger welfare change if and only if the inequality is reversed. At equality, the two changes have the same marginal welfare effect.

The same condition therefore answers two questions. Proposition 4 compares reallocating an unchanged grant budget between the rate and cap. Corollary 3 compares spending an additional unit of grant funding through one instrument or the other. Starting from additional spending through the rate, redirecting that spending to the cap produces exactly the unchanged-budget reallocation studied in Proposition 4. Appendix A.10 gives the short calculation.

Corollary 3 has the same two-part interpretation. For the same additional grant expenditure, the cap's relative welfare advantage consists of the net value $e - (1 + \rho)K$ from the additional projects it enables, together with $A - C$, the difference in how the two instruments change expenditure on projects that already proceed. If project expenditure is held fixed, $A = C = 0$, and the cap gives the larger welfare change exactly when $e > (1 + \rho)K$.

Corollary 3 ranks the two marginal uses of additional grant expenditure. It does not establish that either use raises welfare. Nor does it imply that a larger programme budget must raise the rate, the cap, or both after the agency fully reoptimizes. At an interior optimum with a binding budget, the marginal welfare changes per unit of grant expenditure are equal across the two instruments.

7 Conclusion

A funding rate and a maximum grant are not interchangeable forms of generosity. The rate can make additional projects feasible for recipients with limited self-funding capacity, while for recipients already able to finance projects receiving the maximum grant it mainly changes how much they pay. A higher cap can instead make more costly projects feasible. This distinction helps explain why the same programme can generate different private R&D responses across recipients and why monetary grant size alone is an incomplete measure of support.

The funding terms can also affect the projects applicants propose. When project size is adjustable, the point at which the proportional grant first reaches its maximum changes the recipient's marginal cost of further expansion, and heterogeneous applicants can concentrate their proposed project costs there. NEOTEC exhibits this pattern. The concentration appears among unsuccessful applications as well as awards. Among 2019 applications that passed the initial technology assessment and received a full assessment, there is no statistically detectable discontinuity in mean evaluation scores at the threshold. Together, these observations support treating reported project budget as an outcome that can respond to the funding schedule.

The welfare comparison between the funding instruments depends on both the activity they induce and how that activity is financed. At unchanged public spending, a lower rate and higher cap can improve welfare by enabling additional projects and reducing some subsidized expansion. The reverse reform can be preferable when reducing expenditure at the concentration point saves enough resources to outweigh the projects lost and the expansion encouraged elsewhere. A programme with higher welfare can consequently generate less private additionality than another using the same budget. When additional funds become available, the same marginal comparison ranks spending them through the cap or the funding rate, without establishing that either use is welfare-improving. Taken together, the rate and cap affect both the R&D that takes place and how it is financed. Private additionality therefore does not by itself reveal either how much R&D grants induce or whether they improve welfare.

A Proofs and supporting derivations

A.1 Proof of Lemma 1

The recipient undertakes its project when the required expenditure in (1) does not exceed b. The condition $(1-\alpha)c \leq b$ gives $c \leq b/(1-\alpha)$, while $c - K \leq b$ gives $c \leq b + K$. Both conditions must hold because the recipient contribution is the larger of the two amounts. Including the highest possible cost of one gives (2). □

A.2 The expenditure decomposition

For the initial and more generous funding terms, aggregate privately financed expenditure is

$$P_r = \int_0^{q_r} \{c - g_r(c)\}\, \mathrm{d}F(c), \qquad r \in \{I, M\}.$$

Since $q_M \geq q_I$, split the first integral at q_I:

$$P_M - P_I = \int_0^{q_I} \left[g_I(c) - g_M(c)\right]\, \mathrm{d}F(c) + \int_{q_I}^{q_M} \{c - g_M(c)\}\, \mathrm{d}F(c).$$

Rearranging gives (3).

For a small change in the rate or cap, represented by t, write

$$P(t) = \int_0^{q(t)} \{c - g(c;t)\}\, \mathrm{d}F(c).$$

When $q < 1$, the recipient of the most costly project that can proceed spends its full self-funding limit, $q - g(q; t) = b$. Leibniz's rule gives

$$\frac{\mathrm{d}P}{\mathrm{d}t} = bf(q)\frac{\mathrm{d}q}{\mathrm{d}t} - \int_0^q g_t(c; t)\ \mathrm{d}F(c).$$

Since $N = F(q)$, one has $\mathrm{d}N/\mathrm{d}t = f(q)\,\mathrm{d}q/\mathrm{d}t$, which gives (4). □

A.3 Proof of Proposition 1

Maintain $q < 1$ and positive rates and caps. Suppose the percentage contribution gives the tighter financing requirement,

$$q = \frac{b}{1-\alpha} < b + K.$$

This inequality is equivalent to $q < K/\alpha$, which means that every implemented project receives a grant below the cap. Private expenditure is

$$P = (1-\alpha)H(q).$$

Since $\partial q/\partial\alpha = q^2/b$, differentiation gives

$$\frac{\partial P}{\partial \alpha} = -H(q) + (1-\alpha)qf(q)\frac{q^2}{b} = q^2 f(q) - H(q).$$

The grant cap does not affect any implemented project's grant and does not change which projects proceed, giving $\partial P/\partial K = 0$.

Suppose instead that the most costly project that can proceed receives the maximum grant. Then $q = b + K$. Let $s = K/\alpha$ be the cost at which the grant becomes capped, with $s < q$. Public expenditure is

$$G = \alpha H(s) + K\{F(q) - F(s)\},$$

and private expenditure is $P = H(q) - G$. Holding K fixed, differentiation with respect to α gives

$$\frac{\partial G}{\partial \alpha} = H(s).$$

The terms generated by the movement of s cancel because the grant is continuous there, $\alpha s = K$. Since q is fixed, $\partial P/\partial\alpha = -H(s)$.

Holding α fixed, differentiation with respect to K gives

$$\frac{\partial G}{\partial K} = Kf(q) + F(q) - F(s).$$

Total project cost changes by $\partial H(q)/\partial K = qf(q)$. Hence

$$\frac{\partial P}{\partial K} = qf(q) - Kf(q) - F(q) + F(s) = bf(q) - \{F(q) - F(s)\}.$$

The changes in q follow directly from (2). □

If f is nondecreasing over the relevant costs, then

$$H(q) \le f(q)\int_0^q c\ \mathrm{d}c = \frac{q^2 f(q)}{2},$$

which makes the rate effect positive when $q = b/(1-\alpha)$. When $q = b + K$,

$$F(q) - F(s) \le (q - s)f(q) = \left\{b - \frac{1-\alpha}{\alpha}K\right\} f(q).$$

The cap response is therefore at least $[(1-\alpha)K/\alpha]f(q)$, which is strictly positive for $0 < \alpha < 1$ and $K > 0$. At $\alpha = 1$ it is nonnegative, with the exact offset under uniform costs. These bounds establish the sufficient conditions in Section 4.2.

A.4 Proof of Corollary 1

At $\alpha = 1$ and $K < 1 - b$, the most costly project that can proceed has cost $b + K$. Projects with cost no greater than K are fully publicly funded, while projects with cost between K and $b + K$ require recipient finance. Thus

$$P(1, K) = \int_K^{b+K} (c - K)f(c)\, \mathrm{d}c.$$

Substituting $x = c - K$ gives

$$P(1, K) = \int_0^b x f(x + K)\, \mathrm{d}x.$$

Without public grants,

$$P^0 = \int_0^b x f(x)\, \mathrm{d}x.$$

Subtracting yields (5). The sign statements follow from the pointwise comparisons between $f(x + K)$ and $f(x)$. □

A.5 Proof of Proposition 2

For group j, affordability requires both $c \le b_j/(1-\alpha)$ and $c \le b_j + K$. The percentage contribution gives the tighter financing requirement if and only if

$$\frac{b_j}{1-\alpha} < b_j + K,$$

which rearranges to $b_j < \bar{b}$. With $b_L < \bar{b} < b_H$ and the costs of the most costly projects that can proceed in both groups below one, $q_L = b_L/(1-\alpha)$ and $q_H = b_H + K$. Proposition 1 then gives the two derivatives in (7). If the additional private spending in group L exceeds replacement there, its derivative is positive. The derivative for group H is negative regardless of the shape of its cost distribution. □

A.6 Proof of Proposition 3 and expenditure comparisons

This subsection studies the expenditure chosen by a recipient that undertakes a project and can finance the expenditures being compared. It develops Section 4.5 without changing the implementation decision in the main model. The project initially requires approved eligible expenditure c_0 and the recipient can add eligible expenditure $d \in [0, \bar{d}]$. Total eligible cost is $c_0 + d$, and the government applies the grant rule to this amount. The recipient obtains private return $h(d)$, where

$$h(0) = 0, \qquad h'(d) \ge 0, \qquad h''(d) < 0.$$

Relative to undertaking the project without the additional expenditure, the increase in its grant is

$$\Delta g(d) = g(c_0 + d) - g(c_0),$$

and the added private payoff, after expenditure and financing costs, is

$$h(d) - (1 + \rho)\{d - \Delta g(d)\}.$$

Let

$$D = \frac{K}{\alpha} - c_0$$

be the additional expenditure needed for total project cost to equal K/α. At this cost, the grant stops rising with expenditure and the slope of the required private payment increases. Suppose $D \in (0, \bar{d})$. For $d < D$, the marginal payoff from additional expenditure is

$$h'(d) - (1 + \rho)(1 - \alpha).$$

For $d > D$, it is

$$h'(d) - (1 + \rho).$$

The recipient therefore chooses total eligible cost exactly equal to K/α when the left derivative at D is nonnegative and the right derivative is nonpositive, or equivalently when

$$(1 + \rho)(1 - \alpha) \le h'(D) \le 1 + \rho.$$

This proves Proposition 3. The interval has width $(1 + \rho)\alpha$. It can contain recipients with different initial project costs and marginal returns. They may therefore choose the same total cost K/α, rather than the different project sizes they would choose if grants continued to rise at rate α.

For the comparison with no grant in Section 4.5, let d^0 maximize $h(d) - (1 + \rho)d$ over $[0, \bar{d}]$, conditional on undertaking the project. Proposition 3 implies $h'(D) \le 1 + \rho$. Since h' is decreasing, the no-grant choice satisfies $d^0 \le D$. Thus a recipient that chooses total project cost K/α under the grant chooses weakly more eligible expenditure than it would without the grant. This comparison concerns total project expenditure. It does not determine the sign of private additionality because the grant can also replace recipient finance.

This conclusion is neutral about the content of the additional expenditure. It may expand the productive scope of the project, shift the timing or composition of expenditure, or include lower-value items that remain formally eligible. The observed concentration alone does not distinguish these interpretations. It also does not establish that the final published budget was chosen solely by the applicant, since an agency may adjust eligible expenditure during assessment.

When the recipient can provide at most w in finance, total expenditure must also satisfy $x(c_0 + d; \alpha, K) \le w$. Since x is nondecreasing, the feasible choices of d form an interval. Choosing project cost K/α remains optimal whenever its derivative condition holds and $w \ge x(K/\alpha) = (1 - \alpha)K/\alpha$. Willingness to expand is determined by h here, rather than by treating the self-funding limit b in the main model as unchanged when project value varies with scale.

The derivative condition describes an interval of normalized returns, $h'(D)/(1 + \rho) \in [1 - \alpha, 1]$. Heterogeneity in c_0, h, and ρ can leave many recipients inside this interval. A positive mass at project cost K/α requires positive probability of this event together with sufficient available finance. The funding rule alone does not impose that probability.

For the separate changes in the rate and cap described in Section 6.1, suppose $0 < \alpha < 1$, $D \in (0, \bar{d})$, and

$$(1 + \rho)(1 - \alpha) < h'(D) < 1 + \rho, \qquad w > \frac{K}{\alpha} - K.$$

The initial eligible expenditure c_0, the return function h, the financing cost ρ, and available finance w are held fixed. Continuity preserves these strict inequalities and feasibility for sufficiently small policy changes. Strict concavity of the recipient's payoff then implies that its unique choice remains $c = K/\alpha$. Holding the rate fixed gives

$$\frac{\partial c}{\partial K} = \frac{1}{\alpha}, \qquad \frac{\partial g}{\partial K} = 1, \qquad \frac{\partial x}{\partial K} = \frac{1 - \alpha}{\alpha} > 0.$$

The recipient's expenditure rises because total expansion exceeds the increase in the grant. Holding the cap fixed instead gives

$$\frac{\partial c}{\partial \alpha} = -\frac{K}{\alpha^2}, \qquad \frac{\partial g}{\partial \alpha} = 0, \qquad \frac{\partial x}{\partial \alpha} = -\frac{K}{\alpha^2} < 0.$$

The reduction in private expenditure is entirely a reduction in total project expenditure. Neither comparison alone establishes a welfare ranking when project benefits change with expenditure.

A.7 Recipient expenditure and participation

This subsection develops Section 6.1. Maintain $b = v/(1 + \rho) \in (0, 1)$ and a continuous positive density f_0 on $[0, 1]$. The return function is twice continuously differentiable, with $h(0) = 0$, $h'(d) > 0$, $h''(d) < 0$, and $h'(0) \leq 1 + \rho$. Assume also $\lim_{d \to \infty} h'(d) = 0$. This last condition ensures a finite unconstrained choice at every funding rate below one. At a rate of one, the cap itself limits subsidized expenditure.

For $0 < \alpha < 1$ and $c_0 < K/\alpha$, the derivative of the payoff in (8) below the maximum grant is $h'(d) - (1 + \rho)(1 - \alpha)$. After the grant reaches its maximum, it is $h'(d) - (1 + \rho)$, which is strictly negative for $d > 0$. Strict concavity therefore gives the following exhaustive choices. If $h'(0) \leq (1 + \rho)(1 - \alpha)$, the recipient chooses $d^* = 0$. If $h'(0) > (1 + \rho)(1 - \alpha)$ but $h'(K/\alpha - c_0) < (1 + \rho)(1 - \alpha)$, its unique positive choice satisfies

$$h'(d^*) = (1 + \rho)(1 - \alpha), \qquad 0 < d^* < K/\alpha - c_0.$$

If $h'(K/\alpha - c_0) \geq (1 + \rho)(1 - \alpha)$, it chooses $d^* = K/\alpha - c_0$. Equality is included in this last case. For $c_0 \geq K/\alpha$, it chooses zero additional expenditure. At $\alpha = 0$ or $K = 0$, all recipients choose $d^* = 0$. At $\alpha = 1$ and $K > 0$, the choice is $K - c_0$ for $c_0 < K$ and zero otherwise. These choices maximize payoff conditional on undertaking a project. Participation is determined separately by whether that payoff is nonnegative.

For fixed d, increasing c_0 weakly raises the required contribution. The maximized payoff is strictly decreasing in c_0 when $\alpha < 1$. At $\alpha = 1$, recipients with $c_0 \leq K$ have positive payoff, and for $c_0 > K$ their payoff is $v - (1 + \rho)(c_0 - K)$. In all cases, participation is ordered by initial expenditure. The upper endpoint q_0 is the root of the maximized payoff, or one if every initial expenditure is affordable. An indifferent recipient proceeds, which does not affect aggregates under a continuous distribution.

Under $K/\alpha \leq b + K < 1$, both $(1 - \alpha)c_0 \leq b$ and $c_0 - K \leq b$ hold for $c_0 \leq b + K$. These recipients can proceed with $d = 0$, and choosing expansion cannot lower their payoff. For $c_0 > b + K$, initial expenditure exceeds K/α and the grant is already at its maximum. No expansion is attractive and payoff is negative. Thus $q_0 = b + K$ under the stated terms. More generally, concavity implies $h(d) \leq (1 + \rho)d$. For any policy, payoff is consequently bounded above by $v - (1 + \rho)(c_0 - K)$, and no recipient with $c_0 > b + K$ can participate. Below the rate considered in the main text, participation must nevertheless be determined from maximized payoff and need not extend as far as $b + K$.

These assumptions also make the agency's problem well defined. For $\alpha \le 1/2$, any positive expansion stops by the expenditure at which h' falls below $(1+\rho)/2$. For $\alpha > 1/2$, chosen expansion cannot extend beyond $K/\alpha \le 2$. Choices are therefore uniformly bounded over the allowed policies. Their uniqueness and continuity, together with the continuous distribution of initial expenditure, imply continuity of aggregate grants and welfare. The feasible policies form a nonempty closed subset of $[0,1]^2$, and a welfare-maximizing policy exists.

A.8 Reallocation and proof of Proposition 4

Maintain the strict financing inequalities in Section 6.2. Write $s = K/\alpha$ for the expenditure at which the maximum grant is first reached. Let y denote the largest initial expenditure for which a participant chooses a grant below K. It satisfies

$$h'(s-y) = (1+\rho)(1-\alpha), \qquad 0 < y < s < q_0 = b + K < 1.$$

Recipients with $c_0 < y$ choose positive expansion and stop below the maximum. Their common choice satisfies $d^* = s - y$. Recipients with $y < c_0 < s$ choose final expenditure s, and recipients with $s < c_0 < q_0$ do not expand. These groups are outcomes of recipient choices and change with the funding terms. The maintained inequalities give strictly positive masses in all three groups.

For recipients whose grant remains below K, differentiating $h'(d^*) = (1+\rho)(1-\alpha)$ gives

$$\frac{\partial d^*}{\partial \alpha} = \frac{1+\rho}{-h''(d^*)} > 0.$$

When differentiating aggregate expenditure, moving boundaries between these groups contribute no jump terms. Chosen expenditure, benefits, and grants are continuous at y and s. In particular,

$$\begin{aligned} G_\alpha &= \int_0^y \left[c_0 + d^* + \alpha \frac{\partial d^*}{\partial \alpha} \right] \mathrm{d}F_0(c_0) > 0, \\ G_K &= K f_0(q_0) + F_0(q_0) - F_0(y) > 0. \end{aligned}$$

The rate derivative includes both higher grants on existing expenditure and grants on the expansion induced. The cap derivative includes grants to new participants and increased payments to every existing recipient receiving the maximum. It includes recipients whose initial expenditure exceeds s, even though they do not expand.

An unchanged aggregate grant budget requires

$$\frac{\mathrm{d}\alpha}{\mathrm{d}K} = -\kappa, \qquad \kappa = \frac{G_K}{G_\alpha} > 0, \qquad \left.\frac{\mathrm{d}s}{\mathrm{d}K}\right|_{G=B} = \frac{1+s\kappa}{\alpha}.$$

Here κ is the reduction in the rate needed to finance a marginal increase in the cap. Additional participation per unit increase in the cap is $f_0(q_0)$. The terms defined in the main text are

$$\begin{aligned} A &= \frac{(1+\rho)\alpha\kappa}{f_0(q_0)} \int_0^y \frac{\partial d^*}{\partial \alpha} \mathrm{d}F_0(c_0) = \frac{(1+\rho)^2 \alpha \kappa F_0(y)}{-h''(s-y) f_0(q_0)}, \\ C &= \frac{1+s\kappa}{\alpha f_0(q_0)} \int_y^s \{1 + \rho - h'(s-c_0)\} \, \mathrm{d}F_0(c_0). \end{aligned}$$

They are nonnegative. For recipients below the maximum, reducing expenditure saves $(1+\rho)\alpha$ per marginal unit after crediting the benefit forgone. For those expanding at s, marginal return lies between

$(1 + \rho)(1 - \alpha)$ and $1 + \rho$. Their expansion has a nonnegative net cost when total grants are unchanged. Dividing by $f_0(q_0)$ expresses both effects per additional project undertaken.

At fixed $G = B$, the financing adjustment $(\rho - \gamma)B$ in welfare is constant. A new participant chooses no expansion, since $q_0 > s$. Its contribution to the remaining welfare terms per marginal unit of cap is

$$\{v + e - (1 + \rho)q_0\} f_0(q_0) = \{e - (1 + \rho)K\} f_0(q_0).$$

Together with the expenditure adjustments, this gives

$$\left.\frac{\mathrm{d}W}{\mathrm{d}K}\right|_{G=B} = f_0(q_0)\{e - (1 + \rho)K + A - C\}. \tag{10}$$

Positivity of $f_0(q_0)$ establishes the two directions in Proposition 4. At equality the derivative is zero. Strict signs establish improvements for sufficiently small finite changes by continuity, without ranking programmes beyond this neighbourhood. □

A.9 Proof of Corollary 2

First consider a marginal increase in the cap with the rate reduced to preserve grants. Write L for the aggregate contraction of expansion below the maximum per unit increase in the cap, and R for the expansion at the maximum,

$$L = \kappa \int_0^y \frac{\partial d^*}{\partial \alpha} \, \mathrm{d}F_0(c_0), \qquad R = \frac{1 + s\kappa}{\alpha}\{F_0(s) - F_0(y)\}.$$

The derivative of private expenditure equals that of total expenditure at unchanged grants,

$$\left.\frac{\mathrm{d}P}{\mathrm{d}K}\right|_{G=B} = q_0 f_0(q_0) - L + R.$$

The first term is expenditure on additional projects, the second expenditure forgone by existing participants, and the last their induced expansion. For a recipient choosing s, the marginal net cost of expansion is at most $(1 + \rho)\alpha$. Applying this bound to (10) yields

$$\left.\frac{\mathrm{d}W}{\mathrm{d}K}\right|_{G=B} \geq \{e + (1 + \rho)(\alpha q_0 - K)\} f_0(q_0) - (1 + \rho)\alpha \left.\frac{\mathrm{d}P}{\mathrm{d}K}\right|_{G=B}.$$

The first term is strictly positive because $q_0 > K/\alpha$ and $e \geq 0$. Nonincreasing private expenditure therefore suffices for a positive welfare derivative. This establishes the local claim.

For the finite comparison, let subscripts I and R denote the initial and reformed programmes. Suppose $\alpha_R < \alpha_I$, $K_R > K_I$, identical aggregate grants, and $K/\alpha < b + K < 1$ under both. Then $q_{0,R} > q_{0,I}$ and $N_R > N_I$. The additional expenditure chosen by any recipient without reaching the maximum is weakly smaller under the lower rate. The expenditure at which the maximum is reached is larger.

For an existing recipient whose expansion increases, marginal returns on the added units are at least $(1 + \rho)(1 - \alpha_R)$. For one whose expansion falls, the recipient stops before the revised maximum, and marginal returns on the units forgone are no greater than this value. Expansion by a new participant also has average return at least this value. Consequently, the change in aggregate expansion benefits is at least $(1 + \rho)(1 - \alpha_R)$ times the change in aggregate additional expenditure. This comparison allows recipients to change which part of the grant schedule determines their expenditure.

Only new participants add initial expenditure. The increase in that expenditure is no greater than

$q_{0,R}(N_R - N_I)$. Since $T_R - T_I = P_R - P_I$ and $v = (1+\rho)b$, the same accounting gives

$$W_R - W_I \geq \{e + (1+\rho)(\alpha_R q_{0,R} - K_R)\}(N_R - N_I) - (1+\rho)\alpha_R(P_R - P_I).$$

The coefficient on $N_R - N_I$ is strictly positive. Thus $P_R \leq P_I$ implies $W_R > W_I$, which establishes the finite comparison. □

A.10 Proof of Corollary 3

The derivatives G_α and G_K in Appendix A.8 are strictly positive. If an increment $\mathrm{d}B$ of additional grant expenditure is used only to raise the funding rate, then $\mathrm{d}\alpha = \mathrm{d}B/G_\alpha$. The resulting welfare change is

$$\frac{W_\alpha}{G_\alpha}\,\mathrm{d}B.$$

If the same amount is used only to raise the cap, then $\mathrm{d}K = \mathrm{d}B/G_K$ and the welfare change is

$$\frac{W_K}{G_K}\,\mathrm{d}B.$$

Their difference has the same sign as

$$G_K\left(\frac{W_K}{G_K} - \frac{W_\alpha}{G_\alpha}\right) = W_K - \frac{G_K}{G_\alpha}W_\alpha = \left.\frac{\mathrm{d}W}{\mathrm{d}K}\right|_{G=B}.$$

By equation (10), this expression is positive if and only if $e + A > (1+\rho)K + C$, and negative if and only if the inequality is reversed. This proves Corollary 3. □

B NEOTEC data construction and robustness

B.1 Sources, award decisions, and assignment of funding terms

The archive of funded projects is assembled from the official CDTI call rules and award resolutions for 2018–2025, including later awards following appeals or the allocation of remaining funds (CDTI, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025). Each of the 873 rows records the project identifier, reported project budget, published grant, award decision, and the source used to verify the observation. We refer to this assembly of project-level records from the published resolutions as the reconstruction. The replication package preserves the original archival file as well as the revised classification and scripts generating the tables and figures for funded projects.

ChatGPT (OpenAI) was used during data construction to assist in locating public CDTI documents, translating Spanish-language material, and extracting and organizing information. All observations, programme rules, and classifications used in the analysis were checked against the underlying official sources, and the authors made the final data-construction decisions.

The 2018–2020 schedule is assigned directly from the statutory rule. From 2021, the ordinary and enhanced schedules coexist, and we assign a schedule using the reported project budget and published base grant. Separately reported training support is removed from the total grant from 2022 onward. We assign a schedule when the grant implied by that schedule differs from the published base grant by no more than EUR 2, allowing for rounding. For one project assigned to the enhanced schedule, the difference is instead EUR 14.80. We retain this assignment in the main sample and exclude the project in a sensitivity check. Its reported budget is not within EUR 1,000 of the applicable threshold.

Eight awards remain unclassified. In particular, SNEO-20211428 has a reported budget of EUR 345,694 and grant of EUR 194,298.65 in the 2021 definitive resolution (p. 14). Neither standard formula matches. Its earlier enhanced assignment has no independent support and is not used. The row remains in the full archive, with its source values unchanged. This gives 865 classified awards, comprising 431 ordinary and 434 enhanced awards. Excluding the project with the EUR 14.80 discrepancy leaves the counts near the threshold unchanged and changes the estimated excess mass only from 51.5 to 51.6 projects, with the standard error remaining 8.5.

We distinguish two indicators: whether the reported budget is at or above the assigned threshold K_i/α_i, and whether the published base grant equals the assigned maximum K_i. These indicators identify 617 and 613 projects, respectively. We classify a project as receiving the maximum grant when its published base grant is within EUR 1 of the maximum for its assigned schedule, allowing for numerical rounding. This classification gives the shares reported in Table 1. Four projects have reported budgets at or above the applicable threshold but published base grants below the maximum. All four occur in the 2018–2020 calls, when the statutory funding schedule is unambiguous. We retain the reported budgets and published grants as they appear in the official records rather than alter either value to make the two conform to the standard funding formula.

Table 2 compares the sums of the project-level records with the annual totals published by CDTI. The grant totals agree to the reported precision, and the budget totals differ only by rounding in 2018.

Table 2: Project-level reconstruction and published call totals

Call	Projects	Project-level budget sum	Published budget total	Project-level grant sum	Published grant total
2018	101	38,530,143.14	38,530,143	23,579,675.51	23,579,676.00
2019	104	39,732,353.00	39,732,353	24,887,784.10	24,887,784.00
2020	103	40,926,716.00	40,926,716	24,969,565.50	24,969,566.00
2021	125	50,952,656.00	50,952,656	36,460,000.00	36,460,000.00
2022	115	50,393,368.00	50,393,368	34,992,654.50	34,992,654.50
2023	131	53,056,682.00	53,056,682	40,000,000.00	40,000,000.00
2024	64	26,061,209.00	26,061,209	20,000,000.00	20,000,000.00
2025	130	53,221,491.00	53,221,491	40,000,000.00	40,000,000.00

Notes: Monetary amounts are in euros. Project-level sums add the values reported for individual awards in the official resolutions. Reported budgets and grants are not altered to force agreement with the published call totals.

The 2019 comparison instead uses the provisional award and rejection tables, which report budgets for 293 of the 300 submissions reported by CDTI. The tables contain 96 provisional winners and 197 rejections, with scores for 281 applications. The budget headings are *Presupuesto* and *Presupuesto Total*. Annex 2 of the call, p. 24, permits unsupported expenditure to be removed from the financeable budget and states that the budget stated in the application form prevails when it differs from the business plan. The headings alone do not establish whether the published amounts precede such adjustments. We use "project budgets reported for the applications" and do not attribute the reported amounts exclusively to applicants.

B.2 Smooth-density excess-mass estimates

Let $z_i = c_i - K_i/\alpha_i$. We count projects in equally spaced bins over a symmetric range around zero. A polynomial in the bin centre is fitted by ordinary least squares after excluding a symmetric interval around zero. This is equivalent to including a separate indicator for each excluded bin and using only the polynomial component as the counterfactual count. The approach follows the smooth counterfactual construction in the bunching literature (Saez, 2010; Chetty et al., 2011; Kleven, 2016).

Let n_j be the observed count in bin j and $\widehat{n}_j$ the count predicted by the fitted polynomial without the bin indicators. Denote the excluded bins by $\mathcal{J}$. Estimated excess mass is the sum of observed counts less predicted counts in these bins. Dividing it by their mean predicted count expresses the excess relative to the local density,

$$\widehat{E} = \sum_{j \in \mathcal{J}} (n_j - \widehat{n}_j), \qquad \widehat{E}_{\text{norm}} = \frac{\widehat{E}}{|\mathcal{J}|^{-1} \sum_{j \in \mathcal{J}} \widehat{n}_j}.$$

The quantity $\widehat{E}_{\text{norm}}$ measures excess mass in units of the mean predicted bin count. It helps compare concentration in samples with different underlying densities, but is not an expenditure elasticity. The primary specification fits a cubic over plus or minus EUR 25,000, with EUR 500 bins and an excluded interval of plus or minus EUR 1,000. This local cubic has positive fitted counts throughout the fitting interval in the pooled and each full sample for each funding schedule. Wider-range and nonnegative alternatives are reported in the replication files.

For the bootstrap, we resample projects with replacement separately within every call and assigned funding schedule, keeping each combination's full sample size fixed. Each of 1,999 replications reconstructs the counts and refits the polynomial. Observations outside the fitting range remain part of the resampling population. Reported standard errors are the standard deviation of the resulting estimates, conditional on the observed calls and schedule assignments.

Table 3: Excess mass within EUR 1,000 of the applicable threshold

Sample	Projects	Observed	Counterfactual	Excess	Std. error	$\widehat{E}_{\text{norm}}$
Pooled	865	73.0	21.5	51.5	8.5	9.6
Ordinary	431	33.0	9.6	23.4	5.9	9.7
Enhanced	434	40.0	11.9	28.1	6.3	9.4

Notes: Cubic polynomial, EUR 500 bins, fitting range of plus or minus EUR 25,000. The bootstrap uses 1,999 resamples within call-by-schedule cells. The final column normalizes excess by the mean counterfactual count across the four excluded bins.

The primary estimates give 23.4 excess projects under the ordinary schedule and 28.1 under the enhanced schedule. Relative to the smooth expected mass, both are substantial. The estimates normalized by the predicted local density are similar despite different raw counts and marginal financing costs. Nothing in the model ranks the size of the concentration under the two schedules without further restrictions. Doctoral recruitment, project costs, financing constraints, and recipient characteristics can all differ between the two schedules. The ordinary-schedule sample from calls in which both schedules were available is much smaller, which is visible in Figure 2(b).

The primary estimate remains positive under changes in bin width, polynomial order, and fitting range, including a nonnegative cubic fitted over a wider interval. Changing the excluded interval changes the amount of concentration being measured rather than providing an alternative estimate of the same quantity. Full sensitivity results are provided in the replication files.

The observed density can be higher to the right of the threshold than to the left even if some projects reduce expenditure towards the threshold. The relevant missing mass would be measured against the unobserved distribution without that response, not against the observed density on the other side. We do not assume that every excess project at the threshold was moved there from immediately above it, or impose a matching right-hand deficit. The comparison estimates local concentration relative to a smooth fitted distribution. It does not identify the distribution that would prevail without grants or a causal elasticity of total project cost. In Section 4.5, the adjustable choice is d, while the project's initial cost c_0

is held fixed. Translating concentration into an elasticity of $c_0 + d$ would require further restrictions on both that decomposition and heterogeneous returns or financing constraints. This distinction is consistent with the identification concerns in Blomquist et al. (2021).

B.3 Shifted-window and leave-one-call-out diagnostics

As a descriptive check that does not use the fitted polynomial, we compare the number of projects in an interval centred on each project's own threshold with counts in 101 intervals of the same width whose centres are shifted in EUR 1,000 steps over plus or minus EUR 50,000. The threshold interval is uniquely densest for half-widths through EUR 1,000. These comparisons are descriptive rather than randomization-based tests, and wider intervals are less distinctive because they include more of the broader region in which project budgets are concentrated.

The concentration is also not driven by any single call. After omitting each call in turn, the EUR 500 interval remains uniquely densest, and the estimated excess mass within EUR 1,000 ranges from 43.8 to 46.1 projects. Full shifted-window and leave-one-call-out results are provided in the replication files.

B.4 The 2019 application records

Table 4 reports the application counts at the two narrow intervals used in the main text. For all applications and for the provisionally funded and rejected groups separately, the interval centred on the threshold is uniquely densest among the 101 shifted intervals at both widths. Full shifted-window results are provided in the replication files.

Table 4: Concentration of project budgets among 2019 applications

Sample	Applications	Within EUR 500	Within EUR 1,000
All applications	293	15	19
Provisionally funded	96	5	7
Provisionally rejected	197	10	12

Notes: For each sample and interval width shown, the interval centred on the threshold is uniquely densest among the 101 shifted intervals.

The concentration is not driven by the two applications reporting budgets exactly equal to EUR 357,143. Excluding them leaves thirteen applications within EUR 500 of the threshold, and that interval remains uniquely densest. Nor is the pattern explained by general rounding to thousands: excluding every budget divisible by EUR 1,000 leaves fourteen applications within EUR 500 and again leaves the threshold interval uniquely densest.

The published budget headings are *Presupuesto* and *Presupuesto Total*. They do not establish that each amount is the applicant's unchanged original submission. The call permits unjustified items to be removed from the financeable budget (CDTI, 2019, Annex 2, p. 24). The reported amounts may therefore reflect applicant choices, revisions made during assessment, or both. Project budget is not itself a formal scoring criterion or tie-breaker, and the call assigns no score or selection threshold to the project cost K/α (CDTI, 2019).

The call evaluates technology and innovation first, with a threshold of 21 points on that criterion. Applications below the threshold are rejected without evaluation of the remaining criteria. We therefore exclude technology-only scores and administrative zeros before comparing total evaluation scores. This leaves 230 applications with comparable full assessments. Among the 141 fully assessed applications within EUR 50,000 of the project cost at which the maximum grant is reached, separate local linear fits on either side imply a difference of -1.23 points at the threshold, with a robust standard error of 2.02. This is a descriptive local comparison, not a regression-discontinuity estimate.

Across all 230 comparable assessments, the Pearson correlation between score and reported project budget is 0.16 ($p = 0.018$), and the Spearman rank correlation is 0.13 ($p = 0.053$). A simple linear regression gives an increase of 1.22 score points per EUR 100,000 of reported project budget, with a heteroskedasticity-robust standard error of 0.58. Assessed merit is therefore weakly positively associated with project size over the full comparable-score sample, while the local comparison shows no statistically detectable discontinuity at the funding threshold.

Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work, the authors used ChatGPT (OpenAI) to assist with manuscript organization, revision, and language. The authors reviewed and edited the output and take full responsibility for the article.

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