Optimizing the Allocation of Agricultural R&D Funding:

Is win-win targeting possible?

By Johannes Roseboom, Paul Diederen, and Arie Kuyvenhoven[1]

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ISNAR
P.O. Box 93375
2509 AJ The Hague
The Netherlands

Tel: (31) (70) 3951810
Fax: (31) (70) 3819677
Email: h.roseboom@cgiar.org

[1] Johannes Roseboom is research officer at the International Service for National Agricultural Research (ISNAR), Paul Diederen is senior researcher at the Agricultural Economics Research Institute (LEI), and Arie Kuyvenhoven is professor of development economics at Wageningen University.

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Abstract

Appeals for targeting agricultural R&D in developing countries more explicitly to the needs of poor smallholders in marginal areas are often countered by arguments of efficiency. Others, however, taking a political economy perspective, argue that there is a bias in the selection of agricultural R&D projects towards commercial farmers in the better agricultural areas. In this paper, we try to bring the two perspectives together and illustrate how they interact. We analyze R&D budget allocation assuming two distinct R&D opportunity curves – one for poor smallholders and one for large commercial farmers. We find that, in contrast to the actual allocation of research resources, an efficient allocation (i.e., equalizing the marginal rate of return between the two portfolios) would increase the budget for smallholder projects by 29% and decrease that of commercial farmer projects by 26%. Total economic welfare would increase with 2.1% and there is a modest distributional effect: smallholder welfare increases by 14% and commercial farmer welfare decreases by 11%. In other words, more efficiency in the selection of agricultural R&D projects favors poor smallholders. We also analyze the effects of a premium on research benefits accruing to smallholders and find them to be limited. Rather than trying to shift the R&D opportunity curve artificially, we conclude that policies that can help to increase the profitability of research investments across the board (such as investment in infrastructure, development of markets, and education) and hence shift the R&D opportunity curve for poor smallholders outwards should be pursued more vigorously.

Keywords: Agricultural R&D, S&T policy, returns to research, research intensity

1. Introduction

Appeals for targeting agricultural R&D in developing countries more explicitly to the needs of poor smallholders in marginal areas are often countered by arguments of efficiency – continued investment in agricultural R&D targeting commercial farmers in the better agricultural areas will yield a better return (Byerlee and Morris 1993). Others, however, argue that commercial farmers are better organized and lobby more effectively for their interests than poor smallholders. In this way, they bias the selection of agricultural R&D projects in their favor at the expense of poor smallholders (see e.g., de Janvry, Sadoulet, and Fafchamps 1989; Berdegué and Escobar 2001).[2] In this paper, we try to bring the two perspectives together and illustrate how they interact. To what extent can the low share of R&D aimed at poor smallholders' needs be explained by a selection bias (i.e., distorted equity), and to what extent by more-limited profitable R&D opportunities (i.e., efficiency)? In addition, we would like to know more about the effects of positive discrimination in favor of poor smallholders. Does it really create a great deal of economic inefficiency?

We base our analysis on estimates of two *agricultural R&D opportunity curves* – one for developed countries and one for developing countries (figure 1). These curves were first introduced by Roseboom (2002a,b) and depict the choice sets from which research funding bodies in respectively developed and developing countries selected their research projects in the early 1980s. The distinctive shape and position of both curves reinforce the notion that innovation opportunities differ significantly between developed and developing countries, leading to different levels of both *actual* and *optimal* research intensity.[3]

[2] An interesting reading in this context is the Special Issue of *Food Policy* on Assessing the Impact of Agricultural Research on Poverty Alleviation (Food Policy Vol. 25, No. 4 (2000): 379-530, edited by Douglas Pachico, Reed Hertford, and Alain de Janvry).

[3] In figure 1, we assumed an optimal cutoff rate (i.e., the social rate) of 12% for developing countries and 7% for developed countries.

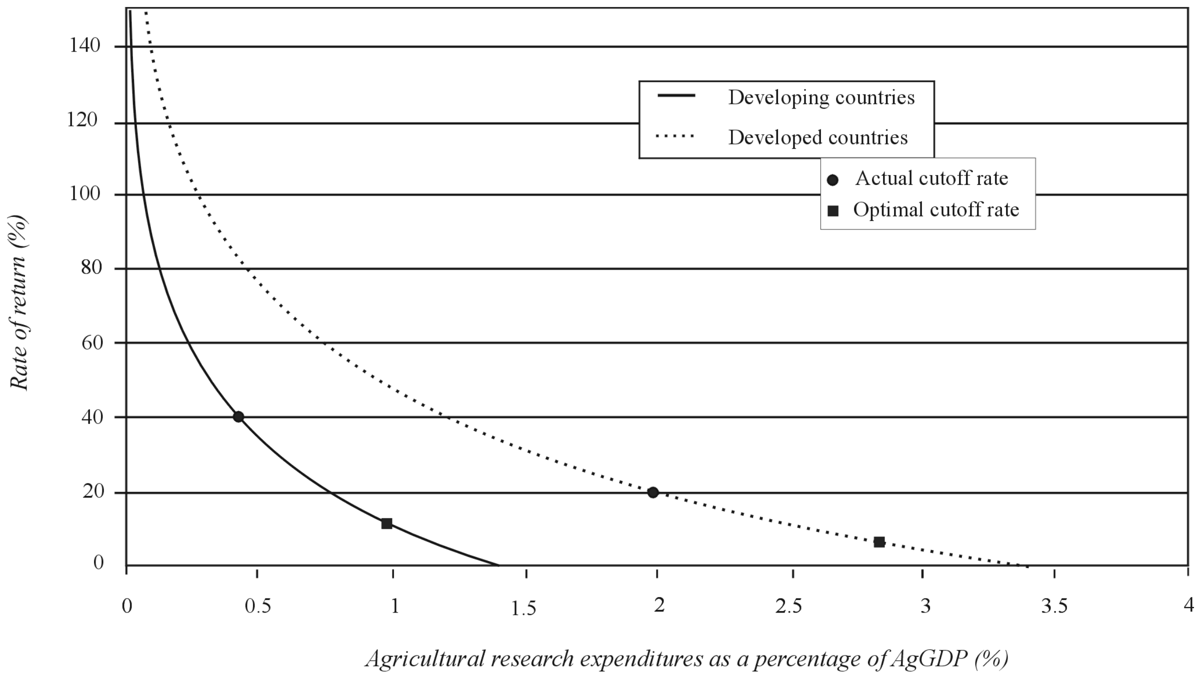

Fig. 1: Agricultural R&D opportunity curves for developed and developing countries, 1981-85

This paper is structured as follows. Section 2 discusses briefly the construction of R&D opportunity curves, while section 3 focuses on the contrasting interests of commercial farmers and poor smallholders and how this may affect the allocation of agricultural research resources. The effects of an active pro-poor policy are reviewed in section 4. Section 5 summarizes the principal conclusions.

2. The construction of agricultural R&D opportunity curves

A prerequisite to say anything about the optimal (or for that matter suboptimal) allocation of agricultural research resources is a notion of the choice set of agricultural R&D projects from which society chooses ex ante. In order to get a grip on this notion, we introduce a simple representation of the choice set as well as of the selection procedure. First of all, we assume that the number of possible agricultural R&D projects increases (and, most likely, exponentially) going from a high to a low expected rate of return (ERR) as depicted by a hypothetical distribution in figure 2a — the exact position and shape of the curve are unknown. Secondly, we assume that optimality is defined strictly in efficiency terms: the research project with the highest ERR should always be selected first. The optimal budget allocation would be such that exactly all R&D projects above the social cutoff rate could be financed (figure 2b).

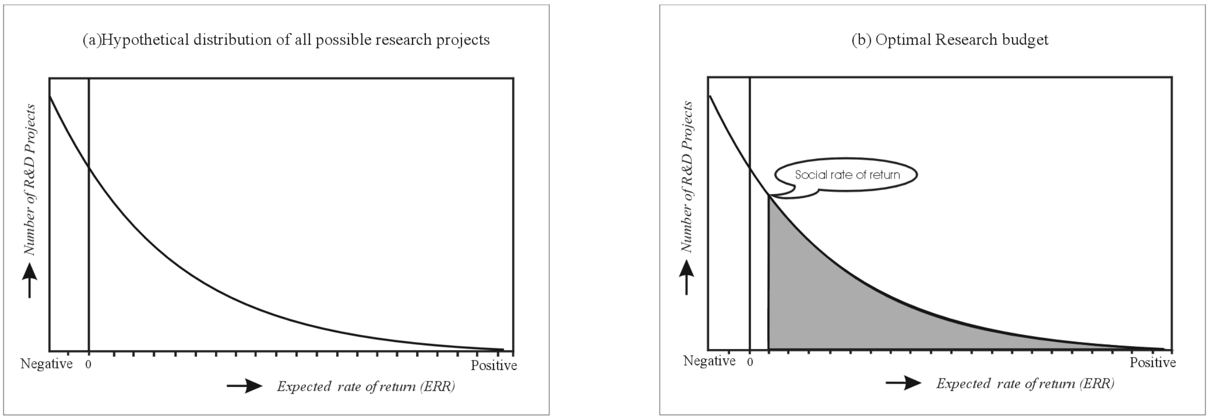

Fig. 2. A model of the economic selection of agricultural R&D projects

The challenge is to estimate the position and slope of the ex ante choice set on the ERR scale. To our knowledge, there are no ex ante studies that have ever tried to attempt this. However, the number of agricultural R&D impact studies that report rates of return is growing steadily. Alston et al (2000) and Evenson (2001), for example, provide recent compilations of such studies. The rates reported by these studies are on average high (40-50%), but spread widely from negative to more than 500%. Using the Alston et al (2000) dataset, we explored whether the reported rate-of-return distribution could provide us with information about the optimal selection of agricultural R&D projects and hence about the ex ante choice set. In order to do so, we had to assume that the ex post rates of return only differ stochastically and not systematically from the ex ante rates of return.

The ex post rate-of-return distributions, as constructed using the available rate of return evidence, do not follow the predicted optimal selection, but tend to have a normal distribution that is lob-sided to the left (figure 3a). We argue that this is because the ex ante selection of agricultural R&D projects is suboptimal for the following two reasons: (1)

imperfect information (expected costs and benefits are know only very partially: R&D investments are inherently risky); and (2) imperfect selection (other criteria than efficiency enter the selection). Hence, projects with a low ERR are selected at the expense of projects with higher ERRs.

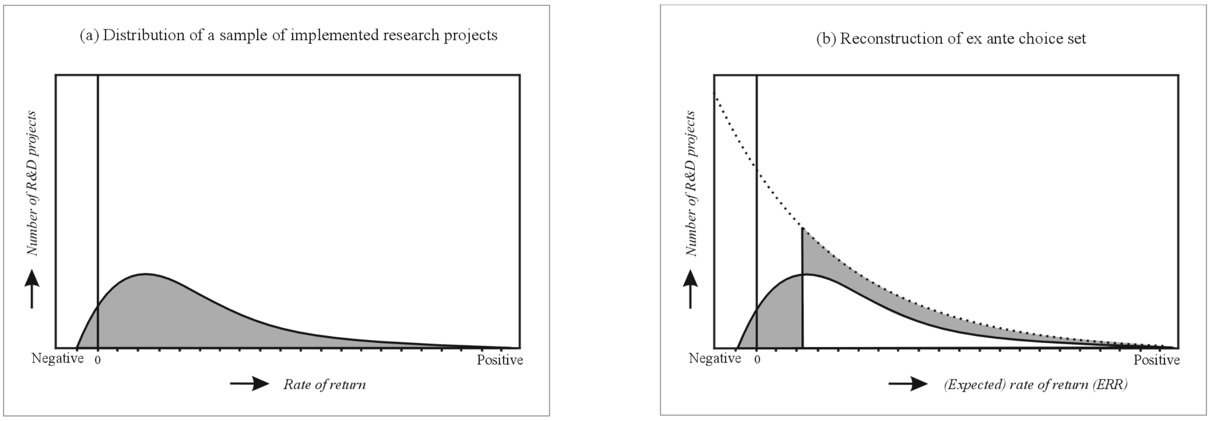

Fig. 3. Reconstruction of the ex ante choice set using the distribution of a representative sample of ex post rates of return

Although the reported distributions do not represent perfect samples,[4] we argue that they still provide information about two important characteristics of the ex ante choice set: (1) The mode of the actual distribution represents the optimal cutoff rate at a given budget; and (2) The right-hand-side slope of the distribution provides a plausible estimate of the slope parameter of the optimal distribution. This can be shown as follows. To reconstruct the ex ante choice set, projects with an ex post rate of return below the mode should be reallocated above the mode. By reallocating the projects proportionally (as is done in figure 3b), one can show mathematically that the slope coefficients of the approximated optimal distribution equals that of the suboptimal one.

Based on the distribution of rates of return reported for agricultural research projects in respectively developed countries and developing countries, the implicit cutoff rate (i.e. the mode of the distribution) for developed countries was estimated at 20% and for developing

[4] The distributions are in particular distorted at the extreme ends. Projects with a very high rate of return are most likely over-represented, while projects with a very low or negative rate of return are under-represented.

countries at 40%. The corresponding exponential slope coefficients yielded -0.0257 and -0.0308 for developed and developing countries, respectively.[5] The two rate-of-return distributions are more-or-less representative for the level of R&D investment that took place during the early 1980s: $4813 million (or 2.03 % of AgGDP) for developed countries and $4409 million (or 0.41% of AgGDP) for developing countries (Pardey, Roseboom, and Anderson, 1994).

With these three variables (cutoff rate, slope coefficient, and investment level) and assuming that all projects have the same size (i.e., budget), the agricultural R&D opportunity curves as depicted in figure 1 can be constructed.

3. A political economy perspective: producers versus producers

One of the criticisms on the rather mechanistic approach to the selection of R&D projects as sketched above is that it is based exclusively on efficiency considerations. It is blind to the initial distribution of assets as well as to who ultimately benefits from the R&D projects selected and implemented. De Janvry, Sadoulet, and Fafchamps (1989) provide a more balanced perspective by introducing transaction costs and collective action concepts into the debate. They show that transaction costs differ across farmers due to differences in assets (land, capital) and that, when this is taken into account, the ERR of a new technology to individual farmers becomes conditional on the distribution of assets.[6] Consequently, there are multiple ex ante choice sets of agricultural R&D projects, which not only differ in content but also in terms of size and composition. This results in a multiplicity of private optima that, in turn, makes collective action to influence choices in R&D so important.

If collective action by large commercial farmers is more effective than that by poor smallholders (as seems to be the case in Latin America), the selection of R&D projects will

[5] In order to avoid that a few very high rate-of-return observations (which we believe are over-represented) could affect the slope coefficient disproportionally, all rates higher than 100% were excluded from the slope coefficient estimation.
[6] Other factors may also play a role, such as geographical location (farmers close to the market face different transaction costs than farmer far away) and education.

be biased towards those that benefit large commercial farmers most. In the terminology of the induced innovation theory (assuming that for large-scale, commercial farmers labor is the relatively scarce factor), the R&D portfolio will be biased towards labor saving technology. However, de Janvry, Sadoulet, and Fafchamps (1989) argue that the bias is also affected by the size of the R&D budget. They find that with a sufficiently large R&D budget the bias will converge to neutrality. This latter finding can be explained as follows. The stronger lobbying by large commercial farmers makes that R&D projects particularly beneficial to them will be selected first, but such projects still have to exceed the social cutoff rate. In the case of very strong lobbying, all R&D projects preferred by large commercial farmers are selected first and only if there is funding left R&D projects preferred by poor smallholders will be selected. The distortion is probably not so extreme in reality, but it is still realistic to assume that some considerable distortion in the selection is present. Hence, the difference between the optimal and suboptimal selection of R&D projects is not only a matter of weak priority setting due to imperfect information and non-economic selection criteria, but also due to lobbying activities of interest groups.

Following this line of reasoning, the consequences of underinvestment in agricultural R&D are not neutral. Poor smallholders will be affected more than large commercial farmers. We acknowledge this bias, but we want to introduce another argument in the discussion. The choice set of profitable R&D projects for large commercial farmers may well be substantially larger than the choice set for poor smallholders. A strictly balanced distribution of R&D resources may look correct from an egalitarian perspective, but can be counterproductive from an efficiency point of view. To illustrate this point, suppose that total agricultural R&D funding is fixed but can be reallocated. We compare the actual allocation with: (a) an egalitarian allocation, which equalizes the percentage of AgGPD invested in R&D between the two groups of countries; and (b) with an efficient allocation, which equalizes the rate of return of the marginal R&D project in both portfolios. The egalitarian allocation would result in an intensity ratio of 0.7% and implicit cutoff rates of 22.6% (point c) and 61.4% (point d) for developing and developed countries respectively (figure 4). The efficient allocation would result in a marginal rate of 31.8% and intensity ratios of 0.53% (point e) and 1.50% (point f) for developing and developed countries respectively.

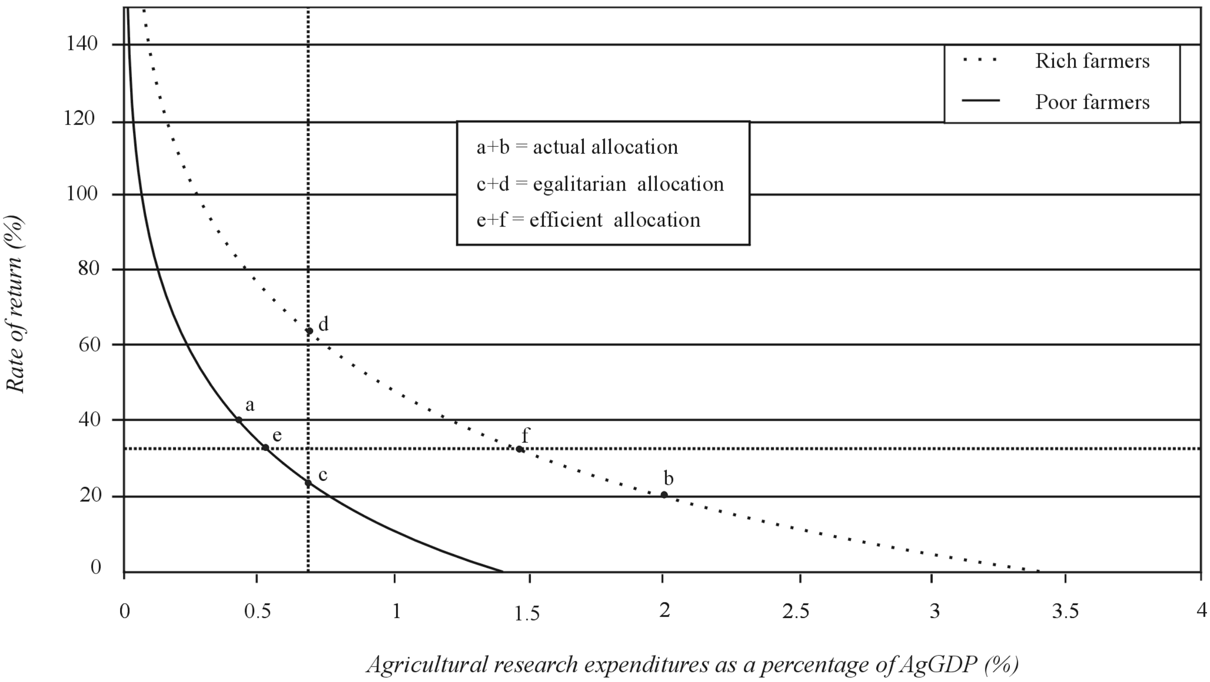

Fig. 4. The egalitarian versus efficient equilibrium in the allocation of R&D resources

The example given above can also be used to represent a dual economy situation in which the developing country curve is more-or-less representative for the position of poor smallholders and the developed country curve for the position of the large commercial farmers. This analogy is warranted because similar to the distinction between developed and developing countries, large commercial farmers in developing countries control more assets, are better educated, more market oriented, and are technologically more dynamic than poor smallholders. In real life, however, the position and shape of the R&D opportunity curves are generally not known. Instead, it is often assumed, usually implicitly, that both groups of farmers are on R&D opportunity curves that are identical in shape and position, although not in content.[7] Hence, a difference in R&D intensity can only be explained in terms of a bias in the selection of agricultural R&D projects.

Assuming two distinctive R&D opportunity curves leads to considerably different conclusions. Still a part of the bias in the R&D portfolio can be attributed to overly strong lobbying by the large commercial farmers that leads to an economically suboptimal outcome, but another (and in this example larger) part of the bias in the R&D portfolio makes economic sense. The R&D investment opportunities are considerably better for large commercial farmers than for poor smallholders and therefore different R&D investment intensities are justified from an efficiency point of view. The model also reveals another fact, namely that strong lobbying by large commercial farmers should not only be explained in terms of better collective action conditions (de Janvry, Sadoulet, and Fafchamps 1989) but also in terms of economic incentives. Settling on the more egalitarian distribution of R&D resources would leave many very profitable R&D projects that target the large commercial farmers unfunded (i.e, all R&D projects with an ERR lower than 61.4%). In contrast, the economic incentive for poor smallholders to lobby for (additional) R&D would be less as the cutoff rate of their preferred portfolio of R&D projects is considerably lower (i.e., 22.6%). In particular, farmers who are not integrated into the market have very little incentive to lobby for R&D as it only leads to untradable surpluses (de Janvry 1985).

4. Introducing a pro-poor policy

The above analysis is rather sobering news for all of those who want to target R&D on the poorest of the poor and at the same time want to subscribe to efficiency. Still, some devices can be conceived to improve poverty targeting. For example, one could argue that an extra dollar earned by a poor farmer should be valued higher than an extra dollar earned by a rich farmer. As shown in figure 5, the model can easily deal with such a correction under the assumption that the cost-benefit structure is the same across all R&D projects (i.e., 5 years of

[7] Hazell and Haddad (2001) discuss extensively the type of research that may benefit poor farmers in particular.

costs followed by 16 years of benefits – see Roseboom 2002a). A premium of 25 cents for every additional dollar earned by a poor farmer shifts the R&D opportunity curve for poor smallholders up. With a fixed R&D budget the new equilibrium cutoff rate settles at 34.4% and the economically optimal agricultural research intensity ratios for poor smallholders and large commercial farmers settle at 0.55% (point g) and 1.40% (point h), respectively.

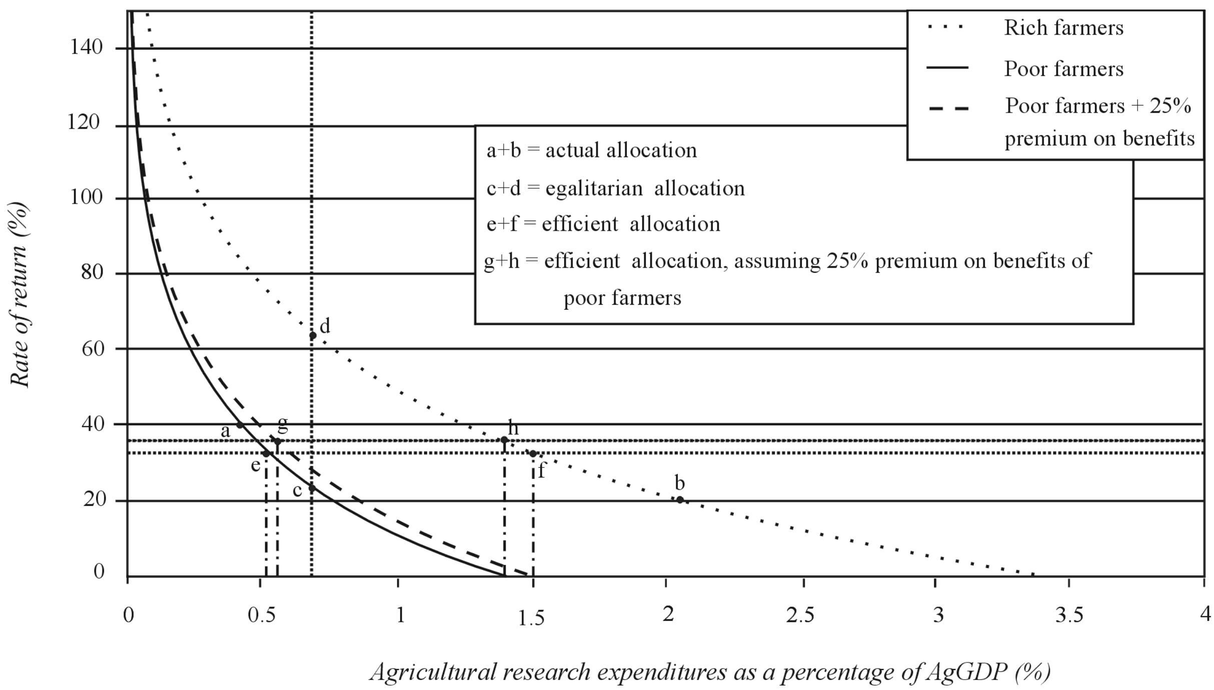

Fig. 5. The welfare effects of introducing a poverty premium on R&D targeting poor farmers

The effect of a poverty premium in this model is very modest, also at higher poverty premiums as shown in table 1. A one-dollar premium for every additional dollar earned by a poor farmer translates itself into a differentiated marginal cutoff rate of 28.1% for R&D projects targeting poor smallholders and 40.3% for R&D projects targeting large commercial

Table 1. Allocation of agricultural R&D funding under different assumptions

	Developed countries/ Rich farmers	Developing countries/ Poor farmers	All
AgGDP (million 1985 PPP$) [a]	237089	1075293	1312381
Actual allocation			
Agricultural R&D expenditures (million 1985 PPP$) [b]	4812.9	4408.7	9221.6

Agricultural research intensity ratio (%) {[b]/[a]}x100	2.03	0.41	0.70
Marginal rate of return (%)	20.0	40.0	
Average rate of return (%)[a] [c]	58.4	72.0	64.9
Net R&D benefits (million 1985 PPP$) {[b]x[c]}/100	2811.6	3172.9	5984.5
Efficiency equilibrium at fixed budget			
Agricultural R&D expenditures (million 1985 PPP$)	3551.4	5670.2	9221.6
Agricultural research intensity ratio (%)	1.50	0.53	0.70
Marginal rate of return (%)	31.8	31.8	
Average rate of return (%)[a]	70.2	63.8	66.3
Net R&D benefits (million 1985 PPP$)	2494.7	3617.6	6112.2
Adjusted efficiency equilibrium: 25% poverty premium			
Agricultural R&D expenditures (million 1985 PPP$)	3323.1	5898.5	9221.6
Agricultural research intensity ratio (%)	1.40	0.55	0.70
Marginal rate of return (%)	34.4	34.4	
Average rate of return (%)[a]	72.8	*62.5*	66.2
Net R&D benefits (million 1985 PPP$)	2420.2	3687.7	6108.0
Adjusted efficiency equilibrium: 50% poverty premium			
Agricultural R&D expenditures (million 1985 PPP$)	3138.8	6082.8	9221.6
Agricultural research intensity ratio (%)	1.32	0.57	0.70
Marginal rate of return (%)	36.6	36.6	
Average rate of return (%)[a]	75.1	*61.5*	66.1
Net R&D benefits (million 1985 PPP$)	2355.8	3742.0	6097.8
Adjusted efficiency equilibrium: 100% poverty premium			
Agricultural R&D expenditures (million 1985 PPP$)	2853.2	6368.3	9221.6
Agricultural research intensity ratio (%)	1.20	0.59	0.70
Marginal rate of return (%)	40.3	40.3	
Average rate of return (%)[a]	78.8	*60.0*	65.8
Net R&D benefits (million 1985 PPP$)	2247.4	3822.9	6070.2

Note: The figures in italics represent the values for the unadjusted R&D opportunity curves and are the relevant values against which to compare the effect of a poverty premium.

[a] Of R&D projects above the marginal rate of return.

farmers. The intrinsic limiting factor in the model is that the total number of profitable R&D projects for poor smallholders is, at least in relative terms, smaller than that for the large commercial farmers. A poverty premium does not alter this fact.

Reallocating R&D funding on the grounds of efficiency would create a net benefit gain of $128 million. Relative to the actual net benefits of $5984 million, this is a rather minor improvement and hence the conclusion that, aside from substantial losses due to poor priority setting, the allocation of R&D resources has not been that far from the economic optimum. The distributional effect, however, is considerable: poor smallholders would gain $445 million (+14%), while large commercial farmers would lose $317 million (-11%).

Another finding is that poverty premiums of 25, 50, and 100 cents create net benefit losses of \$4.3 million, \$14.4 million, and \$42.0 million respectively. Relative to the total net benefits these are minor distortions. The distributional effect is more significant but still rather modest: with poverty premiums of 25, 50, and 100 cents, poor smallholders would gain respectively \$70.2 million, \$124.5 million and \$205.3 million, while large commercial farmers would loose respectively \$74.4 million, \$138.9 million, and \$247.3 million.

The implicit assumption made here is that R&D projects can be clearly differentiated between those that target poor smallholders and those that target large commercial farmers and that there are no negative externalities. Moreover, it is assumed that farmers appropriate all benefits. These are of course oversimplifications. Poverty targeting is getting considerably more complicated when R&D projects have distributional effects that are less clear-cut. For example, an R&D project may lead to a new technology that favors large commercial farmers, has negative externalities for poor smallholders (i.e., lower market prices), but benefits poor consumers. Consequently, each R&D project will be affected differently by a poverty premium. This not only makes it difficult to model the effects of a poverty premium but also to come to general conclusions. It all depends on the (assumed) benefit distribution within a given R&D project.

5. Conclusions

Compared to the actual allocation, a strict efficient allocation of agricultural research resources would have shifted research resources from projects targeting rich farmers (-26%) to poor farmers (+29%) and produced more benefits to poor farmers (+14%) and less to rich farmers (-11%). Total economic welfare would have improved with a modest 2.1%. Hence, the conclusion that elimination of the distortion in research investment allocation has a substantial impact on the distribution of research benefits, but only a modest one on the total amount of research benefits.

The introduction of positive discrimination of research targeting poor farmers resulted, even at a research benefit premium of a 100%, in a rather modest redistribution of income. Rather than shifting the agricultural R&D opportunity curve for poor smallholders artificially, it is more useful to think about policies that could actually shift the curve for poor smallholders outward. What are the factors that hold R&D investment opportunities for poor smallholders back vis-à-vis those for large commercial farmers? Without doubt, the distribution of assets plays a major role and land reform may lead to R&D opportunity curves that are closer to each other and with greater overlap. However, there are also many other factors such as market structure, access to credit, transport facilities, education, health, and political stability that all influence the adoption of new technology positively and help to shift the R&D opportunity curve outward. Rather than pushing technology, it makes more sense trying to pull technology and R&D investment into smallholder agriculture by creating an environment in which innovation can prosper. In situations in which such an environment does not exist or is declining, investment in R&D can do very little.

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