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# A META-ANALYSIS OF RATES OF RETURN TO AGRICULTURAL R&D: EX PEDE HERCULEM?

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ABSTRACT

It is widely believed that agricultural research and development (R&D) has yielded sizable dividends for society, more than enough to justify both past investments and increased funding in the future. Yet, in spite of a growing body of evidence that rates of return to public agricultural R&D are very high, there has been a definite slowdown in public funding for agricultural R&D in recent years. Similarly, support for international research is dwindling in the face of seemingly strong evidence that it pays off handsomely. Among the reasons for this decline are greater private funding of agricultural R&D in the developed countries and pressures for increased accountability for the use of public R&D funds. However, the declining support for public-sector agricultural R&D may also reflect increasing skepticism about the evidence that the rate of return to agricultural R&D has been high.

Does the evidence indeed show that the rate of return to agricultural R&D has been high? Past reviews have generally been descriptive in nature, usually ad hoc, and always partial. A more complete study is needed to clarify past evidence so that it can more usefully guide future decisions. *A Meta-Analysis of Rates of Return to Agricultural R&D*, Research Report 113, aims to do just this. It provides a comprehensive assessment of what studies have actually found through a statistical analysis of the entire body of evidence on returns to agricultural R&D since 1953. In doing so, it attempts to answer five key questions of interest to both researchers and policymakers.

1. Has the rate of return to agricultural R&D declined over time?
2. Do the returns to agricultural R&D differ internationally among regions of the world, or between national agricultural research systems and international centers?
3. Does the return to research vary according to its problematic focus, and how does the rate of return to environmental or natural resource research compare with more traditional agricultural production R&D?
4. Does the rate of return vary between basic and more applied research, or between research and extension?
5. Is systematic bias built into the estimates from particular evaluation techniques and estimation details from other aspects of the analysis, or according to who does it?

By investigating these questions through a systematic analysis of the data, the study's findings should be useful to policymakers empowered to make decisions about investments in agricultural R&D.

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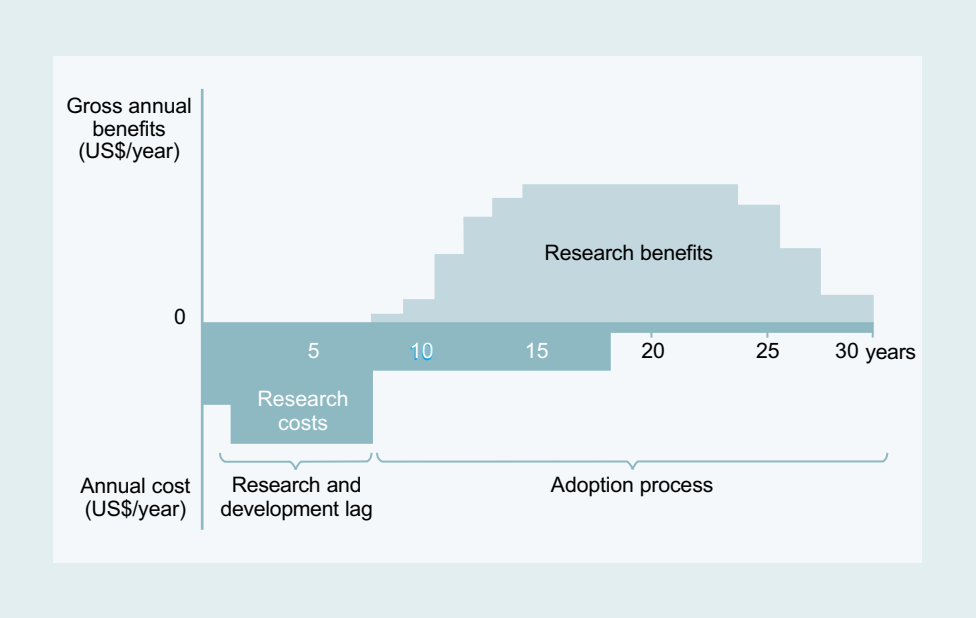
## MEASURING THE IMPACT OF AGRICULTURAL R&D

One of the difficulties in analyzing the evidence is the vast array of economic and non-economic measures that have been used to evaluate the impact of agricultural R&D. This variety reflects different perspectives on the economic and other consequences of a body of research, which in turn are based upon varying beliefs about the underlying purpose of agricultural R&D.

Figure 1
**Flows of research benefits and costs**




Even for successful innovations, R&D can take many years to produce net positive benefits.

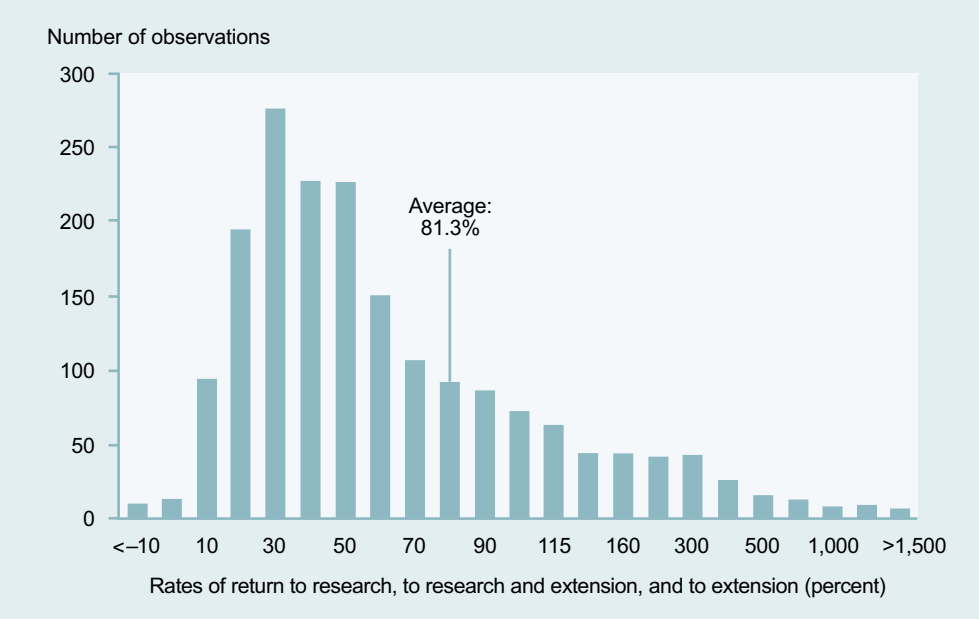
Another difficulty is that estimating benefits is complicated by the lag time between investing in R&D and reaping a return on that investment. Figure 1 shows the timing of benefits and costs from investing in a successful agricultural R&D project that results in a particular innovation. The vertical axis represents the flow of benefits and costs in a particular year, and the horizontal axis represents years after the commencement of the R&D project. Initially, the project involves expenditures without benefits, so during the "gestation" or research lag period the net benefits are negative. Even if the research is successful, leading to a commercial application, there may be further delays including a "development lag" and an "adoption lag." Eventually, the annual flow of net benefits from the adoption of the new technology becomes positive. In some cases the flow of benefits may continue indefinitely, but in others the flow of benefits will eventually decline. The figure thus illustrates the overall flows of net annual benefits over time attributable to a successful R&D project. It represents the sum of benefits across individuals in the society, accruing in each year, relative to the situation if the project had not been undertaken. The lag between investing in R&D and realizing a return on that investment can be quite long, since some inventions are slow to come forth, while others produce rewards more quickly. These lags are a crucial factor in determining the benefits from R&D and may be an important reason why there is underinvestment in R&D.

## WORKING WITH THE EVIDENCE: A META-ANALYSIS OF THE RETURNS TO AGRICULTURAL R&D

This study includes a comprehensive database of literature on returns to research, including both published papers and "gray" literature. Very few studies evaluated returns to basic research or extension; most computed returns to either all types of research (basic and applied) or research and extension. Overwhelmingly, evaluations related to crop research. The original database included 292 publications reporting 1,886 observations. The distribution of the rates of return to research, to research and extension, and to extension for a sample of 1,852 observations is shown in Figure 2.

One feature of the evidence on rates of return is the relatively low signal-to-noise ratio. The rates of return range from small negative numbers to an extreme and implausible rate of more than 700,000 percent per year. Only 21 percent of the data actually fell within the oft-cited 40–60 percent per year range. The wide range reported reflects

Figure 2
**Distribution of rates of return to agricultural R&D**




Only about one-fifth of the observations of rates of return to agricultural R&D fall within the oft-cited 40–60 percent range.

differences in the typical rates of return among different sets of studies—differences among groups such as applied versus basic research, or research on natural resources versus commodities—but also reflects large differences in the reported rate of return within each group. What accounts for the substantial variation in the reported rates of returns? The authors posit a number of factors, grouped into four broad categories:

1. Characteristics of the rate-of-return measures
2. Characteristics of the analysts performing the evaluation
3. Aspects of the research being evaluated
4. Characteristics of the evaluation, including technical estimation details

To understand and compare the influences of these different factors on measured rates of return, the authors meta-analyzed the data. Meta-analysis is essentially an analysis of analyses that allows different data to be compared systematically. Meta-analysts ask two types of questions: (1) Do past studies on the subject tend to show a significant effect of factor X on outcome Y? (2) What is the magnitude of the effect of factor X on outcome Y, based on the evidence from past studies?

To reduce the role of noise in masking the information content of the data, the authors dropped 29 unusually high and low values. A further 664 observations were also dropped because they failed to include information on all of the explanatory variables to be included in the regression model, leaving 1,128. Hence, the number of observations used in the final econometric analysis is smaller than those shown in Figure 2.

## FINDINGS OF THE STUDY

The authors found that higher rates of return tend to be reported when the rate of return:

- is nominal (versus real) and computed using data for the inflationary 1970s
- is ex post (versus ex ante)
- applies to field crops (versus all agriculture)
- is based on an implicit surplus measure rather than econometric derivation
- is based on an econometrically estimated supply shift with a short (versus long) lag

Lower rates of return are reported when:

- the rate of return is for extension only (versus research only)
- both research and extension effects are included (relative to either alone)
- the analyst is employed by a university (versus government)
- the analyst is employed by the private sector (versus government)
- the analyst's employer is not known (versus government)
- the research evaluation is a self-evaluation (rather than an independent evaluation)
- the research is on natural resource issues, rather than agricultural or other topics
- the research scope is for a program (versus a single project)
- the research scope is for one or more institutions (versus a single project)

- the evaluation is published in a refereed journal compared with less formal outlets
- explicit surplus is measured without using either a pivotal or a parallel supply shift
- a longer gestation lag is used

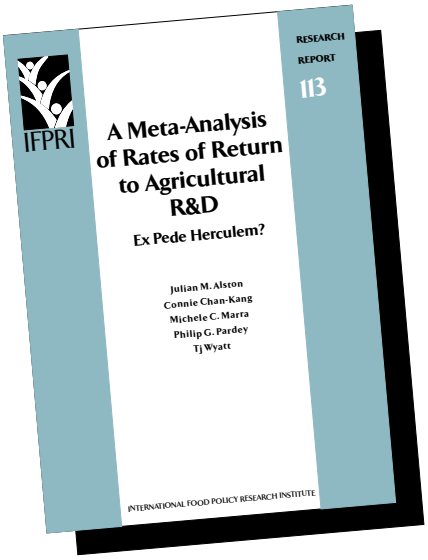
## CONCLUSIONS AND POLICY IMPLICATIONS

The wide range of rates of return to agricultural research found in this study makes it difficult to discern meaningful patterns in the rates of return and to identify the sources of the variation. With regard to the five key questions raised by the study, findings revealed the following:

1. There is no evidence to support the view that the rate of return has declined over time.
2. The rate of return to research may be higher when the research is conducted in more-developed countries.
3. The rate of return to research varies according to problematic focus, in ways that make intuitive sense. In general one would expect that longer production cycles are associated with lower rates of return.
4. A lower rate of return is found in studies that combine research and extension, and especially studies of extension only, compared with studies evaluating research only.
5. Characteristics of the research evaluation itself, particularly the scope of the research being evaluated and choices about lags, were found to have important, plausible systematic effects on the estimated rates of return, and most of these effects are reasonable. In particular, in econometric studies, large rates of return were associated with truncated research lags.

One of the purposes of this study was to determine the information content of the rate-of-return evidence. It found that there is much noise relative to signal, and one should therefore be circumspect in accepting the conventional wisdom concerning the average or indicative ranges of the rates of return and much of the specific evidence. Beyond this, the authors have developed some insights into the sources of variation in the measured rates of return, and insights that should be useful to policymakers who wish to know how to use evidence on rates of return to support R&D investment decisions.






Please send me a copy of *A Meta-Analysis of Rates of Return to Agricultural R&D: Ex Pede Herculem?* by Julian M. Alston, Connie Chan-Kang, Michele C. Marra, Philip G. Pardey, and TJ Wyatt (148 pages).

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