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Resource Allocation in Joint Public-Private Agricultural Research

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Federal technology transfer legislation has encouraged increased collaboration between the public and private sectors, including joint research ventures known as Cooperative Research and Development Agreements (CRADAs). While several economically important technologies have been developed through CRADAs, there is concern that CRADAs may divert public research from its central research missions. This study compares the pattern of research resource allocation for CRADA projects at the U.S. Department of Agriculture with research priorities of public and private intramural agricultural research. The findings suggest that CRADAs have attracted considerable private co-financing of joint research projects, and may have enabled public research to concentrate more resources on research areas where private incentives are relatively weak.

Key Words: agricultural research, CRADA projects, research priorities, technology transfer

During the 1980s, federal lawmakers passed several technology transfer initiatives that sought to better disseminate federal research results of commercial interest (Congressional Research Service; National Academy of the Sciences). Although agriculture was usually not the primary focus of these technology transfer initiatives, the U.S. Department of Agriculture (USDA) responded by strengthening its public-private partnerships in agricultural technology development (Fuglie et al.). A principal mechanism for joint public-private R&D has been the Cooperative Research and Development Agreement (CRADA). In a CRADA, a federal laboratory and an outside cooperator agree to jointly develop and commercialize a technology. CRADAs may also grant intellectual property rights to the cooperator. Since CRADAs were first authorized by Congress in 1986, they have resulted in several economically important technologies, including the anti-cancer drug Taxol, animal vaccines, and various biopesticides (U.S. General Accounting Office; Day and Frisvold).

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Despite these successes, some critics have charged that CRADAs have not been particularly efficient at commercializing technology and may divert public research from its central research missions (Bozeman and Coker; National Academy of the Sciences). However, evaluations of joint public-private research undertakings have been hampered by the lack of detailed, comprehensive data on federal CRADA projects. As a result, previous efforts to examine CRADAs have generally relied on the case study approach (U.S. General Accounting Office; Bozeman and Coker; Day and Frisvold; Cohen and Noll). While case studies can provide useful insights into the operation and management, constraints, and opportunities in CRADAs, they cannot provide a larger macro view of joint public-private research programs. Important questions remain unanswered, particularly how public-private joint research ventures have affected overall public research priorities, and whether these efforts have been successful in drawing in significant private resources and co-financing. Furthermore, previous studies have focused on CRADAs in the energy and health sectors, and none have considered agricultural technology transfer in depth.

In this study, we hypothesize that research activities in CRADAs represent a "middle ground" between public and private interests in research and technology development. To test this hypothesis, we examine the pattern of research resource allocation using data on CRADA projects entered into by the USDA between 1987 and 1995 to examine implicit research priorities in joint public-private research. Using USDA's detailed research classification system, we compare the allocation of public-private research with general mission priorities in public agricultural research and with an indicator of private agricultural research. We also examine the public and cooperator shares of costs incurred in CRADA research for different technology areas and trends in public research resource allocation over time. Implications for federal priorities and funding for agricultural research and technology transfer are discussed.

Technology Transfer and Research Resource Allocation: Hypotheses and Data

Framework of Analysis and Hypotheses

The divergence between the private and social benefits of research is well documented and has been identified as a primary reason for the private sector's pervasive underinvestment in science and technology (Nelson; Ruttan). However, the degree of divergence between private and social returns to research is likely to be uneven across technologies. Research that results in marketable, private goods, and where intellectual property is more easily protected, is likely to provide greater incentives for private investment. In contrast, incentives are limited for technologies that serve more social or nonmarket goals, where results are difficult to patent, or where the risks and uncertainties of successful commercialization are high (Fuglie et al.). Such limited incentives provide the justification for public research programs, such as the

CRADA program. In principle, CRADAs allow public agencies to maximize social good, and private partners to maximize private returns.

We begin by assuming that joint public-private research provides a means of sharing the benefits as well as the costs of R&D. By reducing research costs and assuring the opportunity for exclusive rights to commercial development, CRADAs allow companies to explore a broader range of alternative technologies. CRADAs also offer cooperating firms access to the human scientific capital found within public institutions. Because government scientific knowledge is often more basic in nature than that of private industry, federal scientists can provide expertise private industries may lack. The research effort itself can also give the cooperator useful information for future R&D efforts and technology development, even if a specific technology turns out not to be marketable. Likewise, CRADAs benefit the government by giving its scientists insight into market demand for new technology and industry needs and resources, as well as the information about certain lines of research inquiry. Government research institutions may also benefit from shared license fees and royalties.

For this analysis, we assume that the share of research expenditures allocated among different technology areas reflects the respective priorities of the public and private sectors. We assume that a relatively larger share of private research will be allocated to technologies with a larger private good component. Furthermore, we assume that public research emphasizes areas where potential social benefits are significant but where private research incentives are weak, i.e., where the gaps between social and private returns to research are large. We hypothesize that the allocation of research resources in joint public-private research will reflect a middle ground between the priorities of each partner. For joint public-private research endeavors, we also hypothesize that the private sector will take on a larger share of the research and development costs of technologies with a relatively large private good component. Likewise, for joint research activities with a larger public good component, we expect that the public-sector partner will take on a larger share of the costs of R&D.

Research Classification

Testing these hypotheses requires judgments about the divergence of social and private returns to research among various kinds of technologies. For this purpose we employ the USDA's unique classification systems for its research programs (refer to the appendix). Using this system, agricultural research was grouped into five main technology areas: (*a*) post-harvest utilization of agricultural commodities, (*b*) plant production and protection, (*c*) animal production and health, (*d*) natural resources, and (*e*) human health and nutrition.

We conjecture that the divergence between public and private returns to research will be relatively small for research on post-harvest utilization, plant production and protection, and animal production and health. Conversely, the divergence will be relatively large for research on natural resources and human health and nutrition.

The post-harvest category includes research with many private benefits, such as new uses and processing, as well as research with more public good characteristics, such as food safety and improved quarantine for imported products. Historically, research on new uses and processing technology for agricultural commodities has been dominated by the private sector (Klotz, Fuglie, and Pray). Nevertheless, while new products and processes can often be protected through patents and trademarks, market development of new products can entail substantial commercial risk. For example, large investments in manufacturing scale-up may be required before commercial viability can be determined. New classes of products may also require significant generic advertising to inform consumers of their value. Neither of these types of product development may be patentable, but once completed, they significantly lower the hurdle for other firms to enter the market. Thus there can remain a "public good" component to research on new uses of agricultural commodities.

Private investment in plant and animal research has seen considerable growth over the past several years (Klotz, Fuglie, and Pray). Stronger intellectual property protection and increased market concentration in the plant and animal breeding industries have strengthened private research incentives in these technologies. However, there remain significant gaps in these private research investments. Private incentives for several important components of crop improvement, such as germplasm conservation and "pre-breeding" research, remain weak (Falck-Zepeda and Traxler; Frey). In animal research, private incentives are relatively strong for poultry research but are considerably weaker for large animal improvement (Johnson and Ruttan; Fuglie, Narrod, and Neumeyer).

Divergence between public and private returns to research are probably greatest for natural resource conservation and human health and nutrition. Technologies resulting from this research often have a large "information" component or generate nonmarket benefits with limited incentives for private development and commercialization. Subsidies or regulations may even be necessary for adoption or uses of such technologies. However, these categories are quite broad and may include some technologies that are patentable and have a strong market demand, such as new irrigation methods for improving water use efficiency. So some private interest in these technologies can still be expected.

Research Resource Allocation Data

Using the USDA's research classification system, we estimate the share of total research resources devoted to each of the five technology areas in the USDA's Agricultural Research Service (ARS is USDA's primary in-house research agency) and in the USDA CRADA program. We assume the former reflects USDA's priorities for its perceived mission to provide public goods, while the latter reflects the implicit priorities in USDA's joint public-private research activity.

To identify an indicator of purely private research interests is more problematic. Klotz, Fuglie, and Pray provide estimates for private agricultural research for the seed, animal health, agricultural machinery, agricultural chemicals, and food processing sectors. Unfortunately, these categories do not allow for direct comparison with the USDA classifications. However, the USDA also maintains a small research grant program to the private sector—the Small Business Innovation Research (SBIR) program. The SBIR program receives proposals from small private companies and provides funds for intramural research by those companies. SBIR grants are assigned the same USDA classifications. To the extent that the grant allocations reflect research interests by the private sector, they provide an indicator of private intramural research priorities. Data include all SBIR grants allocated between 1987 and 1995. Although SBIR grants represent only a small component of private agricultural research (approximately $9.1 million in grants in 1996), the composition of successful grant proposals to the SBIR program partly reveals the market demand for agricultural innovations. An important qualification is that SBIR grants are restricted to small firms. Thus the private research interests of sectors where large firms predominate, such as agricultural chemicals and food processing, may be underrepresented.

The estimates of resources devoted to joint public-private research (CRADAs) are derived from a database maintained by the Technology Transfer Office of ARS. Between 1987 and 1995, ARS established 528 CRADAs with nonfederal partners, most of which were for-profit companies (thus referred to as "private"). Detailed financial data are available for only 366 of the 528 CRADA projects. These show total research expenditures by each partner for the project and private contributions to ARS research activities.[1] Therefore, we present research allocation statistics for both the share of CRADA projects (which includes data for all 528 projects) and the share of financial resources (which includes data from only 366 projects).

Results: Resource Allocation and Co-financing of Joint Public-Private Research

The relative shares of research resources allocated to the five technology areas for the public intramural research (ARS expenditures), public-private joint research (CRADA resources), and private intramural research (SBIR grants) are shown in table 1. Note that for private intramural research, the shares allocated to natural resources and human nutrition are much lower than the shares to post-harvest utilization, plant, and animal research areas. Each of the latter three categories received between 23% and 27% of research expenditures, whereas natural resources received only 9.5% and human nutrition less than 1%. Public agricultural research priorities (represented by ARS research), on the other hand, are more evenly distributed among the categories. While the shares allocated to post-harvest uses, plants, and animals are the largest, there is clearly greater interest by the public sector in natural resources (nearly 14% of ARS research) and human nutrition research

[1] For CRADA projects, the private partner may contribute funds for research carried out at the public institution, but the public partner is prohibited by law from contributing funds for research by the private partner.

Table 1. Research Allocation by Public, Public-Private, and Private Research Institutions

Research Category	Public (ARS)	Public-Private (CRADAs)[a] by Agreement	Public-Private (CRADAs)[a] by Resources	Private (SBIR)
	(% of total)			
Natural Resources	13.8	4.4	6.3	9.5
Plants	36.9	32.2	36.5	25.7
Animals	17.6	23.1	17.2	23.0
Post-harvest Utilization of Agricultural Commodities	20.8	37.6	34.6	27.0
Human Nutrition and Well-Being	9.3	1.1	2.7	0.8
General	1.6	1.5	2.7	4.4
Rural Issues	—	—	—	9.6
Total	100%	100%	100%	100%

Notes: ARS = Agricultural Research Service (the USDA's primary in-house research agency); CRADA = ARS joint Cooperative Research and Development Agreement with outside cooperators; SBIR = Small Business Innovation Research grants (private-sector USDA funding).

[a] Based on data from 528 CRADAs initiated by ARS between 1987 and 1995. Detailed financial data on value of research resources were available for only 366 of these projects.

(9.3% of ARS research) compared with the private sector. We believe this reflects a larger divergence between the perceived social and private returns to research in natural resources and human nutrition compared with the other areas.

The allocation of public-private joint research (table 1) generally conforms to our expectations that CRADAs represent a middle ground between public and private interests, but with some important exceptions. The shares of both the number of CRADA projects and total dollars allocated to plant, animal, and human nutrition research lie between those of public intramural research and private intramural research. However, post-harvest utilization research appears to be overrepresented and natural resources research is underrepresented in CRADA activity. Post-harvest research made up 38% of all CRADA projects and 35% of CRADA resources, but only 27% of private intramural research and 21% of ARS research. One explanation may be that the SBIR program does not reflect private-sector interest in post-harvest research because many of the companies most active in post-harvest utilization research are too large to qualify for SBIR grants. Another explanation lies with food safety research, which accounts for 9% of post-harvest CRADA resources. Food safety has received increased attention from policy makers, the media, and the justice system; therefore, new technologies would be of interest to both public and private scientists. Regarding natural resources research, private-sector demand revealed through SBIR grants seems to suggest a larger interest in this type of technology than CRADAs have exploited thus far.

Table 2. Public and Private Contributions to CRADAs by Research Category

Research Category	Public Contributions	Private Contributions (outside cooperators)
	––––––– (% of total)	–––––––
Natural Resources	40.2	59.8
Plants	33.4	66.6
Animals	36.5	63.5
Post-harvest Utilization of Agricultural Commodities	36.6	63.4
Human Nutrition and Well-Being	52.0	48.0
General	37.1	62.9
Total	36.1	63.9

Note: Contributions are based on the value of resources contributed to 366 CRADA agreements entered into by USDA and outside cooperators between 1987 and 1995 (69% of all CRADAs during this period).

Another way to view the allocation of resources in public-private joint research is to examine the share of research that each party finances. In table 2, we show the average public and private shares of research costs in CRADA agreements. These findings conform well to our hypotheses. For joint research on post-harvest utilization, plants, and animals, the private sector financed 63% to 67% of total R&D costs. The private-sector share of the costs of natural resources research was somewhat less at approximately 60%, and for human nutrition research only 48%. It is also significant that for USDA CRADAs on average, the private sector bore 64% of total R&D costs. The relative contributions by USDA and outside collaborators indicate that the private sector plays a substantial role in the CRADA research process.

Finally, we examine whether increased public-private collaboration in USDA's research programs may have been associated with a shift in public research priorities. During the late 1980s and 1990s, attention to private-sector research collaboration increased, not just through CRADAs, but also through exclusive patent licensing, contract research, and other technology transfer mechanisms (Fuglie et al.). According to our "comparative advantage" framework outlined above, greater reliance on public-private cooperation in R&D should enable more public resources to be shifted to areas where private incentives are weakest. Another possibility, however, is that to build political and financial support for public research programs, more public resources may be diverted to areas where private companies show the greatest interest.

Table 3 compares the allocation of ARS research expenditures for the five technology areas in 1986 and 1995. Overall, ARS research allocation was fairly stable over time. Consistent with the comparative advantage view, some public resources were shifted to research on natural resources and human nutrition, areas where market failures severely constrain private research incentives. Also, shares allocated to plant and animal research, areas where private research expanded rapidly over this

Table 3. Allocation of ARS Research Funds, 1986 and 1995

Research Category	1986	1995
	––––––– (% of total) –––––––	
Natural Resources	10.96	13.35
Plants	38.38	37.70
Animals	22.49	17.30
Post-harvest Utilization of Agricultural Commodities	19.47	21.35
Human Nutrition and Well-Being	7.95	9.13
General	0.75	1.17
Total	100%	100%

Source: Adapted from USDA's Current Research Information System (CRIS), *Inventory of Agricultural Research.*

period, declined. But at the same time, the share of public resources devoted to post-harvest utilization increased slightly. This is an area where private incentives are thought to be relatively strong. Post-harvest research also seemed to receive a disproportionately large share of joint public-private research activity (table 2). Increased public-sector attention to post-harvest utilization may reflect not only the interests of food and agro-processing companies, but also pressure from farm groups for technology to expand demand for commodities to counteract low prices. The heightened interest in food safety may be another contributing factor.

Conclusions and Implications

Resource allocation for joint research ventures between the USDA and the private sector appears to reflect a middle ground between public and private priorities. While the private sector on average contributes about two-thirds of the financial resources to CRADAs, the public share is higher for areas where private incentives are relatively low. The pattern of resource allocation among CRADAs also suggests that the USDA may be underutilizing CRADAs for natural resources, and possibly overutilizing CRADAs for new uses of agricultural commodities.

The evidence further suggests that closer R&D cooperation between the USDA and the private sector may have enhanced research efficiency by enabling the public sector to focus more resources on areas where private incentives for research are relatively weak. The overall pattern of research allocation by USDA has remained relatively stable over time. However, USDA research has shifted somewhat in favor of research on natural resources and human nutrition, areas that serve important societal needs and where market failures are most evident. There was also a small shift in public research resources toward post-harvest utilization, an area where private research incentives are thought to be relatively strong. Nevertheless, even these technologies have significant public good components. Public research can concentrate on food safety, quarantine technologies, and basic, pre-commercial research, leaving other applied research and technology development for private research.

The findings and conclusions reported here should be regarded as tentative. Further analysis is needed to understand more clearly the underlying causal factors behind observed trends. Nevertheless, this study represents a significant step forward in identifying broad trends in research resource allocation in joint public-private research.

An important area for future research is a quantitative assessment of the economic returns to alternative models for technology transfer. To date, no systematic study of the economic impact of technologies developed under CRADAs or other new technology transfer instruments has been undertaken. After more than a decade of experience with these mechanisms, it should now be possible to begin measuring and comparing economic outcomes among alternative means of transforming new knowledge into improved goods and services.

References

Bozeman, B., and K. Coker. (1992, May). "Assessing the effectiveness of technology transfer from U.S. government R&D laboratories: The impact of market orientation." *Technovation* 12, 239–255.

Cohen, L., and R. G. Noll. (1995, October 20–22). "The future of the national research labs." Paper presented at National Academy of the Sciences Colloquium on Science, Technology, and the Economy, Irvine, CA.

Congressional Research Service. (1991, July). "Transfer of technology from publicly funded research institutions to the private sector: A report prepared by the Congressional Research Service for the use of the Subcommittee on Oversight and Investigations of the Committee on Energy and Commerce, U.S. House of Representatives." Washington, DC: U.S. Government Printing Office.

Day, K. A., and G. B. Frisvold. (1993, July). "Medical research and genetics resources management: The case of Taxol." *Contemporary Policy Issues* 11, 1–11.

Falck-Zepeda, J., and G. Traxler. (1997, August 5). "Role of federal, state, and private institutions in seed technology generation in the U.S." Paper presented at the Economic Research Service/Farm Foundation Workshop on Agricultural R&D, Rosslyn, VA.

Frey, K. J. (1996). "National plant breeding study, I: Human and financial resources devoted to plant breeding research in the United States in 1994." Special Report No. 98, Agriculture and Home Economics Experiment Station, Iowa State University, Ames.

Fuglie, K., N. Ballenger, K. Day, C. Klotz, M. Ollinger, J. Reilly, U. Vasavada, and J. Yee. (1996, May). "Agricultural research and development: Public and private investments under alternative markets and institutions." Agricultural Economics Report No. 735, U.S. Department of Agriculture, Economic Research Service, Washington, DC.

Fuglie, K. O., C. Narrod, and C. Neumeyer. (2000, forthcoming). "Public and private investments in animal research." In K. O. Fuglie and D. E. Schimmelpfennig (eds.), *Public-Private Collaboration in Agricultural Research: New Institutional Arrangements and Economic Implications.* Ames, IA: Iowa State University Press.

Johnson, N. L., and V. W. Ruttan. (1997, Spring). "The diffusion of livestock breeding technology in the U.S.: Observations on the relationship between technical change and industry structure." *Journal of Agribusiness* 15, 19–35.

Klotz, C., K. Fuglie, and C. Pray. (1995, October). "Private-sector agricultural research expenditures in the United States, 1960–1992." Staff Paper No. 9525, U.S. Department of Agriculture, Economic Research Service, Washington, DC.

National Academy of the Sciences, Committee on Criteria for Federal Support of Research and Development. (1995). *Allocating Federal Funds for Science and Technology*. Washington, DC: National Academy Press.

Nelson, R. R. (1959). "The simple economics of basic scientific research." *Journal of Political Economy* 76, 297–306.

Ruttan, V. W. (1992). *Agricultural Research Policy.* Minneapolis, MN: University of Minnesota Press.

U.S. Department of Agriculture, Agricultural Research Service. (1992). "Technology transfer agreements with the Agricultural Research Service." Unnumbered information bulletin, USDA/ARS, Washington, DC.

U.S. General Accounting Office. (1994, December). "Technology transfers: Benefits of cooperative R&D agreements. Report to the Vice Chairman, Joint Economic Committee." Report No. RCED-95-52, U.S. General Accounting Office, Washington, DC.

Appendix:
The Research Classification System

Since the 1970s, each USDA research project has been assigned to one or more codes under the Current Research Inventory System (CRIS). With this system, examining the allocation of research by detailed topical areas is possible. Intramural (in-house) agricultural research conducted by the Agricultural Research Service (ARS) and SBIR grants to small businesses are all assigned CRIS Research Problem Area codes. In addition to the CRIS system, ARS maintains its own internal system for classifying research, denoted strategic planning codes (STPs). CRADA research projects, for example, are assigned an STP code. To match and compare research allocated within ARS, CRADAs, and to private companies through SBIR grants, we developed a correspondence, or crosswalk, between the CRIS Research Problem Areas and the STP classification system (table A1). While this procedure is straightforward for broad research categories such as the ones used in this study, using more defined research areas increases the risk of measurement error in moving between the two classification systems.

In this study, we report the allocation of research for ARS, CRADAs, and SBIR grants according to the five main STP categories: (*a*) post-harvest utilization of agricultural commodities, (*b*) plant production and protection, (*c*) animal production and health, (*d*) natural resources, and (*e*) human health and nutrition. ARS also used two other STP

Table A1. Classification of Agricultural Research into Major Technology Areas

Major Technology Area	Assignment of STP Codes Used to Classify CRADA Research	Assignment of RPA Codes Used to Classify ARS and SBIR Research
Natural Resources	1.1 Atmosphere and Climate 1.2 Soil 1.3 Water 6.1 Resource Management: Systems and Models	101, 102,[a] 103, 105, 106, 107, 109, 110,[a] 306, 901
Plants	2.1 Plant Production 2.2 Plant Protection 6.2 Plant Production and Protection Systems	102,[a] 111, 112, 201, 202, 204, 205, 206, 207, 208, 209, 214,[a] 301, 302, 304, 305, 307, 308, 309, 314, 318,[a] 706,[a] 905, 906
Animals	3.1 Animal Production 3.2 Protection of Animal and Human Health 6.3 Animal Production Systems	110,[a] 210, 211, 212, 213, 214,[a] 310, 311, 312, 313, 317, 318,[a] 706,[a] 904
Post-harvest Utilization of Agricultural Commodities	4.1 New Uses, New Products 4.2 Safety 4.3 Post-harvest Losses and Quality Changes 4.4 Quality Definition, Grading, and Assessment 6.4 Systems and Models for Conversion and Delivery	401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 501, 503, 512, 604, 701, 702, 704,[a] 707
Human Nutrition and Well-Being	5.1 Human Nutritional Requirements 5.2 Food Composition and Bioavailability 5.3 Nutritional Status and Well-Being 6.5 Human Nutrition Systems and Models	703, 704,[a] 708, 709, 802, 805
Rural Issues		801, 804, 907, 908
General	6.6 General Systems Technologies 8.0 General	104, 113, 114, 203, 315, 316, 502, 506, 508, 509, 601, 603, 902, 903

Notes: STP = Strategic planning codes, defined by the Agricultural Research Service (ARS); CRADA = ARS joint Cooperative Research and Development Agreement with outside cooperators; RPA = Resource Problem Areas, defined by USDA's Current Research Information System (CRIS); SBIR = Small Business Innovation Research grants (private-sector USDA funding).

[a] RPA falls into more than one major technology area. In these cases, research resources in the RPA were split (usually 50/50) between the technology areas.

categories—a systems integration research category and a small, general classification category. Since the subcategories under systems integration correspond to the other main categories (resource systems, plant systems, animal systems, post-harvest systems, nutrition systems, and general systems technologies), we allocated systems research to these other categories. We compute (but do not report) shares for the general research category or a "rural issues research" category used for some SBIR grants.

ARS maintains a database for each CRADA that describes the nature of the research and its timetable, and furnishes a budget of research resources to be contributed by ARS and the outside collaborator.[2] The budget includes the value of monetary and in-kind resources devoted to the project over its lifetime (usually two to four years). ARS provided the authors with a copy of the database describing 528 CRADAs initiated between 1987 and 1995. In the database, most projects were assigned an STP code (those without an STP code were assigned one by the authors). Detailed financial data are available for only 366 (69%) of the 528 CRADAs. Table 1 in the text lists the distribution of CRADA research among the five principal technology areas by the number of projects and by financial resources for the subset of projects with these data. Overall, the two methods show similar results. An advantage of using the financial data is that USDA and outside collaborators' contributions to each project can be identified.

[2] Occasionally, CRADA agreements address more than one project, while some projects involve more than one agreement. For purposes of this analysis, we merged the data by projects.