Research Policy 44 (2015) 610–622

Contents lists available at ScienceDirect

Research Policy

journal homepage: www.elsevier.com/locate/respol

Organizational design of University laboratories: Task allocation and lab performance in Japanese bioscience laboratories

Sotaro Shibayama[a,b,*], Yasunori Baba[a], John P. Walsh[c,d]

[a] University of Tokyo, Research Center for Advanced Science and Technology, 4-6-1 Komaba, Meguro-ku, Tokyo 153-8904, Japan
[b] University of Tokyo, Department of Technology Management for Innovation, 7-3-1 Hongo, Bunky-ku, Tokyo 113-8656, Japan
[c] Georgia Institute of Technology, School of Public Policy, 685 Cherry Street, Atlanta, GA 30332-0345, USA
[d] National Graduate Institute for Policy Studies, 7 Chome-22-1 Roppongi, Minato, Tokyo 106-0032, Japan

ARTICLE INFO

Article history:
Received 18 February 2014
Received in revised form
14 November 2014
Accepted 8 December 2014
Available online 28 January 2015

Keywords:
Laboratory
Task allocation
Organizational design
Scientific productivity
Biology

ABSTRACT

A university laboratory is a fundamental unit of scientific production, but optimizing its organizational design is a formidable task for lab heads, who play potentially conflicting roles of manager, educator, and researcher. Drawing on cross-sectional data from a questionnaire survey and bibliometric data on Japanese biology professors, this study investigates task allocation inside laboratories. Results show a general pattern that lab heads play managerial roles and members (e.g., students) are engaged in labor-intensive tasks (e.g., experiment), while revealing a substantial variation among laboratories. Further examining how this variation is related to lab-level scientific productivity, this study finds that productive task allocation differs by context. In particular, results suggest that significant task overlap across status hierarchies is more productive for basic research, and that rigidly separated task allocation is more productive in applied research. However, optimal task allocation, with regard to scientific productivity, might conflict with other goals of academic organizations, particularly training of future scientists. The paper concludes with a discussion of the policy implications of these findings.

1. Introduction

Since the modern economy relies heavily on scientific production in the academic sector, the organizational design of academic research organizations is a critical agenda for science and technology policy (Etzkowitz and Leydesdorff, 2000; Stephan, 1996). Academic science, especially in natural sciences and engineering, is usually undertaken in laboratories that consist of a lab head (also called principal investigator) and member researchers under his or her supervision. Unlike temporary collaboration, the continuous nature of laboratories allows lab heads with a long-range plan to set research goals, arrange a portfolio of research projects, make investments in facilities, and accumulate and reuse a local knowledge base (Carayol and Matt, 2006; Knorr-Cetina, 1999; Latour and Woolgar, 1979; Owen-Smith, 2001). For these reasons, prior work has suggested that a laboratory is the appropriate unit when analyzing the nature of scientific production (Carayol and Matt, 2006; Latour and Woolgar, 1979).

Studies of the organizational design of laboratories, whether in academia or in industry, date back to the 1950s. Among others, Pelz and Andrews (1966) examined the relationship between scientific production and a series of organizational factors, broadly covering various scientific fields and sectors. Subsequent literature in the sociology of science has further investigated the roles of organizational factors such as communication, coordination, leadership, and organizational prestige in scientific research (e.g., Allison and Long, 1990; Andrews, 1979; Heinze et al., 2009; Hollingsworth and Hollingsworth, 2000; Long and McGinnis, 1981; Zuckermann, 1977). Literature from other disciplinary perspectives has also advanced understanding in specific aspects of organization; for example, the social psychology literature studies creativity and its antecedents (e.g., Amabile, 1996) and the organization management literature examines the motivation of researchers (e.g., Agarwal and Ohyama, 2012; Sauermann and Stephan, 2013).

While these studies have informed how various organizational factors can affect scientific production, they have paid limited attention to a peculiarity of university laboratories. Academic science heavily depends on junior researchers, including students, who are often short of experience and need training (Knorr-Cetina,

* Corresponding author at: University of Tokyo, Research Center for Advanced Science and Technology, 4-6-1 Komaba, Meguro-ku, Tokyo 153-8904, Japan. Tel.: +81 35452 5371; fax: +81 35452 5371.
E-mail address: shibayama@00.alumni.u-tokyo.ac.jp (S. Shibayama).

http://dx.doi.org/10.1016/j.respol.2014.12.003
0048-7333/

1999; Owen-Smith, 2001). Obviously, universities are responsible not only for scientific production but also for education (Hackett, 1990), and thus, lab heads are obliged to train young members, although these two missions of research and education could be in conflict (e.g., Fox, 1992). This is a major challenge for lab heads, who have to organize the lab considering potentially incompatible goals of research and education when deciding on task allocation for the lab head and its members. This division of labor and potentially conflicting relationships between a lab head and members have been noted in a few studies in the sociology of education (e.g., Delamont and Atkinson, 2001; Delamont et al., 1997; Salonius, 2008) but analyses of their implications for scientific production have been limited.

To fill these gaps in the literature, this study examines the organizational design of university laboratories, highlighting the roles of lab heads and members. Investigating task allocation in the lab context requires in-depth understanding of the distinctive activities in lab work. In this regard, prior ethnographies of academic laboratories have illustrated in great detail how academic science operates in one or a few specific laboratories (Knorr-Cetina, 1999; Latour and Woolgar, 1979; Owen-Smith, 2001; Salonius, 2008). Typically, they describe task allocation in academic laboratories as lab heads being the managers, who are busy planning, fund-raising, and supervising members, with members being the workers, concentrating on conducting experiments and other laborious tasks. To advance this simplified model of task allocation, we draw on the above-outlined literature on the organization of research groups (e.g., Hollingsworth and Hollingsworth, 2000; Pelz and Andrews, 1966; Sauermann and Stephan, 2013). In particular, we examine two forms of possible deviation from the typical task allocation: (1) whether lab members should engage not only in labor-intensive tasks but also in upstream tasks, and (2) whether lab heads should engage also in labor-intensive tasks rather than staying away from the bench like a pure manager. We argue that the optimal task allocation depends on context (Cyert and March, 1963; Simon, 1957). In particular, we hypothesize that the pattern of task allocation should be differentiated depending on the orientation of research in terms of being basic vs. applied.

Drawing on interviews with 30 researchers and a questionnaire survey of 396 lab heads from Japanese universities in the field of biology, we first draw a general picture of task allocation in university laboratories. We find it basically consistent with the stylized view of task allocation, but we also observe considerable variation. Second, we examine the effect of task allocation on scientific productivity and its contingency on research orientation. Based on our empirical results, we discuss implications for science policies.

2. Theory and hypothesis

2.1. Social organization of lab work

Research activities in natural sciences are usually undertaken in laboratories that consist of a lab head and some members under the lab head's supervision (e.g., Carayol and Matt, 2006; Latour and Woolgar, 1979; Owen-Smith, 2001). Lab heads are usually professors, and members include students, postdoctoral researchers (postdocs), junior faculty, and technicians. Unlike temporary collaboration, laboratories are characterized by a continuous form of teamwork. Lab heads can pursue relatively long-term goals. They arrange a portfolio of research projects, some of which may be challenging but with potentially great impact and others of which are less novel but with limited risk, so that they can constantly produce at least minimal expected output (Knorr-Cetina, 1999). Laboratories allow division of labor. Particularly in biology, since a project often involves multiple techniques (Knorr-Cetina, 1999; Latour and Woolgar, 1979), coordinating researchers with different expertise is essential. Lab tasks are also vertically divided. Lab heads are usually responsible for setting up the research environment (e.g., funding, equipment, and recruitment) and coordinating a series of projects, while members engage in executing specific projects (Traweek, 1988). In addition, laboratories function as a place of education and training. Young researchers typically consider their lab experience as an opportunity to acquire research techniques, which will prepare them for future employment (Delamont and Atkinson, 2001; Delamont et al., 1997).

In terms of task allocation, prior literature has mainly focused on the role of lab heads and assumed that lab heads are occupied with upstream tasks. In a report on the career design of American life scientists, the National Research Council (1998) mentions that "[a] principal investigator builds a research group by defining the scientific questions to be addressed, specifying the methods to be used, obtaining necessary funding, finding the suitable research environment, and attracting the research personnel. . .. The research personnel in the group usually work on more specific tasks that pertain to the construction of research tools or the acquisition and analysis of data." Similarly, Knorr-Cetina (1999) finds that in the field of molecular biology researchers often stop bench work after becoming lab heads. The role of members, on the other hand, has been relatively understudied. A few studies in the sociology of education, focusing on postgraduate education, have examined the division of labor between lab heads and PhD students (Delamont and Atkinson, 2001; Delamont et al., 1997; Salonius, 2008). Delamont et al. (1997), drawing on ethnographic research in British universities, suggest that lab heads are responsible for identifying research projects and assigning them to students. Becher et al. (1994) also point out that determining research subjects is rarely the responsibility of students. Since mastering technical skills is the most important goal during the student's lab experience (Delamont and Atkinson, 2001), engaging in technical tasks seems to be regarded as the students' primary role.

To further the discussion of task allocation, we distinguish three phases of the research process. In general, scientific research starts from setting a research question and developing a research plan; then, the question is tested by experiments, simulations, and other approaches; and finally, the test results are interpreted and used to advance extant knowledge (Nightingale, 1998). This last phase often raises new questions for future research, and the whole process is repeated. We split this process into two phases: (1) planning, or determining research subjects and hypotheses, and (2) execution, or testing the hypotheses, usually by experiment and data analyses in biology. In addition, we consider the phase of (3) writing scientific papers. Planning and execution are iterated until sufficient results are accumulated that make up a story as a paper. For these three phases, lab ethnographies and the sociology of education literature generally suggest that lab heads are the primary player in planning and members in execution, but they are less clear about task allocation in writing (Delamont and Atkinson, 2001; Knorr-Cetina, 1999; Latour and Woolgar, 1979). Based on these studies, the following section first describes the general features and rationales of task allocation for each phase. Then, we add competing arguments from the literature on the organization of research groups (e.g., Hollingsworth and Hollingsworth, 2000; Pelz and Andrews, 1966; Sauermann and Stephan, 2013).

2.2. Rationales of task allocation

2.2.1. Execution phase

Since biology is strongly driven by empiricism (Bertalanffy et al., 1962), biological research heavily depends on experiments, except for purely computational or theoretical subfields. In the execution phase, researchers attempt to transform some material substances into interpretable information, which often takes