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Understanding knowledge disclosure of bioscientists

More than a question of contextual and organizational ambidexterity?

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Abstract

This paper focuses the extent to which university scientists integrate scientific excellence and industry relevance in their knowledge disclosure. Universities are increasingly expected to be entrepreneurial and to fulfill the traditional missions of teaching and research and to transfer the knowledge and commercialize it. The paper reports on four case studies that analyze practices of knowledge disclosure of university scientists in biotechnology research units. We relate those practices to the contextual ambidexterity of university scientists with the organizational ambidexterity of research units. We build on longitudinal empirical data, gathered between October 2005 and November 2008 at two research universities in the Netherlands and two in the United Kingdom.

Keywords: scientific excellence and relevance, ambidexterity, knowledge commercialization, knowledge disclosure, biotechnology

Introduction

Universities play an increasingly important role in knowledge-based economies. Traditionally, universities were expected to educate students and contribute to 'basic' research, which could be freely used by society. In the last decades, however, they have been expected to contribute more substantially and directly to economic competitiveness (e.g. Zaharia and Gilbert, 2005), referred to as their "third function" or "third mission" (Etzkowitz, 2003). The entrepreneurial university has emerged as an 'ideal-type' in most countries, with universities focusing on patenting, licensing and spin-offs. In a sense, universities become academic research enterprises, with university scientists behaving more like entrepreneurs (Mirowski and Van Horn, 2005).

More than any other technology, entrepreneurship in life sciences has become the centre of attention to policy-makers, university administrators and the biotechnology industry. Both academics and policy-makers assume that scientific quality and entrepreneurial activities complement each other in life sciences (Owen-Smith and Powell, 2003; Jong, 2009). They assume that scientific excellence leads to entrepreneurial activity, and that 'relevant research' will lead to better science.

The technology-transfer literature focuses on academic research commercialization, specifically on the entrepreneurship process and incentive structures (Rothermael et al., 2006). Several studies examine motivation for scientists, barriers to the transfer process and the availability of organizational resources like technology transfer offices, venture capital and a strong knowledge base (e.g. Debackere and Veugelers, 2005; Etzkowitz and Leydesdorff, 1997; Murray, 2004; Owen-Smith and Powell, 2001; Di Gregorio and Shane, 2003; Siegel et al., 2003). Many of these studies assume that universities worldwide are converging to the 'one-size-fits-all' entrepreneurial university type which embraces both scientific excellence with entrepreneurial relevance.

Others, however, have criticized this 'one-size-fits-all perception' of the entrepreneurial university (e.g. Etzkowitz, 1998; Nelson, 2004; Litan et al., 2007; van der Steen et al., 2010). They argue that universities increasingly find tension between research commercialization and traditional teaching and scientific research (Chang et al., 2009). Universities also need to adapt to constantly changing policy and funding environment, where pressure to perform is coupled with a quasi-market element of competitive public funding. Some authors argue that this performance and relevance-driven environment can even harm scientific excellence and limit scientific progress by 'privatizing' the scientific commons—the *anti-commons effect* (e.g. Nelson, 2004; Raisch and Birkinshaw 2008; Van Looy et al, 2004; Thursby and Thursby, 2005). We argue that universities facing uncertain resources and policy imperatives for research

commercialization respond as ambidextrous organizations, pursuing both research excellence and research commercialization to diversify their resource base (Leisyte and Enders, 2011, Leisyte, van der Steen and Enders, 2008). Organizational ambidexterity in this context refers to a university's ability to efficiently pursue teaching and research excellence while also adapting to and exploring the "third" mission (Chang et al, 2009: 937). However, how well compliance rhetoric for a balance between exploration and exploitation in a university as an organization matches reality as well as to extent to which individual university researchers internalize this balance is still questionable (Chang et al, 2009; Birkinshaw and Gibson, 2004).

One of our main assumptions is that the individual university scientist is at the center of knowledge transfer and entrepreneurial activity. Therefore, our research focuses on the university research unit consisting of scientists who are motivated by personal and institutional incentives (Bercovitz and Feldman, 2005, p.180). Bercovitz and Feldman (2009) argue that realizing adaptive and explorative initiatives for an entrepreneurial university largely depend on the acceptance of change by the individual scientists. Scientists need to engage in the new third mission, trading off traditional—teaching and scientific research—with entrepreneurial activities. So realizing the entrepreneurial university rests on whether individual scientists adopt new routines and modify behavior (Whelan-Berry et al., 2003; Bercovitz and Feldman, 2009).

University scientists balance their time between teaching, pure research and research commercialization. The contextual ambidexterity concept may be helpful in understanding what norms and practices are employed by university scientists. By contextual ambidexterity, we mean the capacity of scientists to align and adapt to their organizational environment (Gibson and Birkinshaw, 2004; Chang et al, 2009). In our case, this would mean to what extent scientist carry out their research and, at the same time, commercialize the results. Our main aim is thus to understand to extent to which—and how—university scientists integrate scientific excellence and industry relevance in their practices of knowledge disclosure in life science research units. We employ a broad definition of knowledge disclosure to include both scientific and more 'relevant to industry' or applied research practices of university scientists. Moreover, we expect that scientists disclose their knowledge in many different ways, through scientific or commercial practices. We define knowledge disclosure as the process where technological knowledge is created, accumulated and disseminated through interactive learning among multiple actors (Jensen and Scheraga, 1998; OECD, 1999).

Given the above, the central focus of this paper is to understand how scientists respond to the organizational ambidexterity in their research unit. In particular, we aim to understand how and

to what extent do university life scientists deal with their contextual ambidexterity, that is, how do they integrate scientific excellence and industry relevance in their practices of knowledge disclosure. The third question is how the contextual ambidexterity compares across the units of different academic credibility in life sciences. In particular, we will explore the co-existence between the norm of communalism and the proprietary research as embodied in the life scientists knowledge disclosure practices.

The paper is organized as follows. Section 2 presents the conceptual underpinnings of the paper to understand the practices of university scientists. Section 3 discusses the methodology and presents the four cases. Section 4 presents the analysis of the four cases in terms of the scientific and entrepreneurial norms, and how they correspond to their knowledge disclosure practices of university scientists in the four research units. Finally, section 5 concludes with a discussion.

Organizational and contextual ambidexterity in entrepreneurial university – norms and practices

Higher education and research enterprise governance have been changing with the rise of the audit culture in Europe (Ezzamel and Reed, 2008; Whitley, 1997). Alternative forms of control are increasingly used, such as output control and performance monitoring (De Boer, Enders and Leisyte, 2007; Pollitt and Bouckaert, 2004; Teelken, Boersma and Groenewegen, 2009). In such a context, beside the usual communication within their scientific community, university scientists interact with a large variety of actors, such as university management and external research sponsors, such as research councils, ministries, industrial firms, and foundations. Norms of the academic community mix with those of the corporate world, governmental regulation and university management. On the one hand, increasing performance imperatives come from university management, national research evaluations and auditing of various kinds. On the other hand, society calls for relevant research and value creation for the knowledge economy.

Organizational ambidexterity in universities

As seen from organizational theory, norms from different actors can pose conflicting demands between exploration (search, variation and discovery) and exploitation (refinement, selection, implementation) in organizations, March (1991) emphasizes that these activities are inseparable for organizational learning and success. The balance between the two activities simultaneously can be understood as organizational ambidexterity (Gibson & Birkinshaw, 2004). Organizational ambidexterity at universities can be understood as the balance between its different ‘missions’, such as teaching, research and knowledge commercialisation.

Entrepreneurial universities (Clark 1998, Etzkowitz 1983) are perceived to epitomize these diverse functions and, in this sense, can be seen as ambidextrous organizations, which face increasingly dynamic and competitive environments. They serve various needs: students, academic researchers, larger academic communities, industry and society at large.

These environments are shaped by government regulation, external funding agencies, rules and criteria set by private industrial sponsors, organizational structures as well as rules governing the research management at a university. Paramount to understanding the rules governing research management at the university level are the profile of the university, the institutionalization of technology transfer office in the university, university personnel policies and partnerships with industry.

In response to the diversity of demands, universities develop ambidextrous organizational units to compete, such as, for example, interdisciplinary research institutes or research centers. These units help balance alignment and adaptability. Ideally, these organizational units have formal and informal rules, standard operating procedures and norms that balance the two types of activities (Bercovitz and Feldman 2006, p. 176) For example, certain units, such as university departments may be more focused on teaching and basic research, while within the same university, research centers and institutes may have specific missions for research commercialization. The formal rules of promotion in such a university for university departments thus may be based on the performance in teaching and research, while the rules to measure performance of research centers maybe more oriented towards research commercialization, such as attracting industrial funding or technology transfer. Organizational ambidexterity may also be observed also within a unit which is supposed to combine different missions and activities at the same time. In such a case, the formal rules for academic staff may include allocating a certain percentage of time for teaching, for research and for research commercialization.. Similarly, standard performance reviews may involve some criteria which ask for publications in high impact journals, attendance in conferences and at the same time, call for contract research and consultancy with industry. Furthermore the organizational ambidexterity of the research units may be understood by looking at the research funding sources of research units (industry and other external private sponsors vis-à-vis public research funding).

Contextual ambidexterity of individual university scientist

The sociology of science demonstrates that university scientists are very much aligned to the scientific community—alignment to the organization comes second (Knorr-Cetina; 1999; Clark. 1983). As Merton states: “The ethos of science is that affectively toned complex of values and norms which is held to be binding to the man of science” (1968, p. 605). Thus the response of

university scientists to the conflicting demands from their organizational context will be mediated by their own internalized organizational rules and scientific norms as well as an individual's ability to both explore and exploit. At the individual scientist's level, contextual ambidexterity comes into play (Raisch and Birkinshaw 2008). Among other competing norms and rules, scientists balance between the norms of communalism and proprietary research. They need to divide the time between research production and research commercialization (Chang et al. 2009), their roles need to be relatively flexible and they need to have more general skills. We argue that organizational ambidexterity and contextual ambidexterity of an individual university scientist are interdependent, resulting in strategic responses and mutual learning. For example, the strategic response of a scientist to organizational demands will depend on their level of contextual ambidexterity. When a university scientist is averse or unable to pursue research commercialization, the response to demands for commercialization will be symbolic. Furthermore, depending on the academic standing of university scientists and the inherent power they may have due to their academic credibility and high public funding resource base, university scientists can influence the organization towards more exploration or exploitation, thus influencing the ambidexterity of the organization.

An important underlying dimension of the contextual ambidexterity for scientists is the balance between the norms of the traditional academic community as well as the norms of the utilitarian and proprietary research. The academic credibility based on the Mertonian norms— such as communalism, universalism, disinterestedness, originality and skepticism (CUDOS) traditionally has been the key prerequisite for an academic career.¹ As Ziman puts it, “Public contributions to knowledge are rewarded by communal recognition in the form of citations, honorific titles, prizes, and, above all, academic employment.” (1994, p.178)

Despite the criticism of these norms (Shapin 2008; Ziman 1994) and their limitations, we still believe they are useful to understand the knowledge disclosure practices of individual scientists. The community of science is ruled by a reward system that facilitates the production of public knowledge. The system is based on priority of discovery and reputation. Peer review builds academic reputations, where discovery is the main commodity in the reward structure that governs science (Merton, 1973; Whitley, 1984). The traditional knowledge disclosure channels

¹ Communalism means a collective enterprise where research results are shared at the earliest opportunity. Universalism refers to inclusion in science; the enterprise is open to all competent persons regardless of nationality, religion or race. Disinterestedness refers to impartiality of the scientists in presenting the research results. Originality deals with the novelty, where the copying of previous work is unacceptable. Finally, the norm of skepticisms implies the critical scrutiny and testing of the research claims. The reputational career of a university scientist is built on these norms according to Merton (1973).

in science are publications in different forms: articles, books, and peer-reviewed papers presented in conferences.

A more utilitarian perspective on the economic potential of academic research has gained ground among university scientists (Bercovitz & Feldmann 2006; Bercovitz 2008). In fact, some see a shift from disinterested research towards more professional norms coming from the corporate spirit of non-academic R&D; namely proprietary, local, authoritarian, commissioned and expert work (PLACE) (Ziman, 1994). The reward structure adheres to the corporate spirit, where the scientific enterprise contributes to the organizational mission. Scientists pursue organizational careers rather than the individual ones. Some authors suggest that entrepreneurial university scientists behave according to norms traditionally associated with industrial researchers (Shapin 2008). At first glance, the corporatism underlying the organizational principles of PLACE is difficult to reconcile with the CUDOS since the profitability of the research results trump the communalism of science and the idea of contributing to the public good. However, depending on the field these two types of norms may be coexisting, that is the contextual ambidexterity maybe really high. Life sciences seem to be a good example of such a field.

The characteristics of life scientists

Evidence suggests some scientific fields and technologies are more prone to application and proprietary knowledge disclosure, and are therefore more relevant to industry than others (Bercovitz and Feldmann 2006). In particular, university life scientists have been at the forefront of entrepreneurial activities, such as patenting and spin-off creation (Tijssen et al. 1996; Tijssen, 2004; Owen-Smith and Powell 2003; Ebers and Powell 2007). It may largely be because the basic science in biotechnology is so close to application. Ziman argues that the progress in basic science in biotechnology was running ahead of the R&D capacity of industrial firms, which opened up “risky but attractive commercial opportunities for academic molecular biologists backed by venture capital” (Ziman, 1994, p. 200) to create their own small spin-off companies and to commercialize their research results.

Proprietary knowledge in biotechnology is not a foreign concept. The search for research results that can be turned into intellectual property, with a legal owner with the right to demand payment for its use, has been commonplace in this field. Thus the scientific information is not only the public good which is universal, but also potentially a marketable commodity which is local and proprietary. However, as Ziman (1994) states, the gains from intellectual property rights are highly speculative, since 99% of what researchers discover is ‘worthless in commercial terms’ (p. 184). Occasional blockbusters attract the attention of university managers and motivate them to stay in the competitive and very expensive game (Geiger and Sa, 2008).

The main reason for focusing on biotechnology research units is that in biotechnology, high prestige research and entrepreneurial activities (measured in terms of productivity or university start-ups) are expected to increasingly go together (Powell and Owen-Smith, 1998; Blumenthal, et al., 1996). This field would then be interesting to study, since contextual ambidexterity of individual university scientists would be rather high.

University entrepreneurship in biotechnology has become the centre of attention to policy-makers, university administrators as well as pharmaceutical and biotechnology industries. There are two parallel explanations. First, the process of drug discovery is undergoing dramatic changes. For example, in the US since 2002, small biotechnology companies have become the major source of Federal Drug Agency approved drugs based on molecular entities (Van der Steen et al, 2010; Wong, 2007). Here, the large pharmaceutical companies acquire a different role in the development of new medicines. At the same time, in the past decades, universities have become more active in patenting and commercializing their scientific discoveries, in particular in the biotechnology-related disciplines (Kneller, 2007).

Therefore, it is unsurprising that in biotechnology; a high level of connectivity exists between universities and companies (Zucker et al., 2002; Stuart et al., 2007). Close and broad formal and informal relations exist between university and biotechnology firms, for instance, in co-authorships between university and industrial researchers (Owen-Smith and Powell, 2001; Gittelman and Kogut, 2003) as well as combined university and firm appointments. According to Stuart et al. (2007), half of all biotechnology firms have been founded by university scientists. Many of these scientists maintained academic appointments after the spin-off formation.

The academic norm of communalism will be explored by looking at traditional scientific knowledge disclosure practices. In particular, we will look at the traditional scientific knowledge disclosure practices, such as publication of research results in journals, books and conferences. While looking for the PLACE norms, we will look at the entrepreneurial knowledge disclosure practices of patenting, spin-off creation, contract and consultancy work as well as co-publication with industry that aim at applied research results and development following the proprietary norms of research.

Methods and data

Selection of the cases

The empirical data comes from documentary evidence as well as interviews with the four biotechnology research units in four universities. The selection of the cases is based on theoretical sampling of basic research units in research universities in the Netherlands and in

England. In order to account for high level of organizational ambidexterity, the chosen universities all have medical hospitals and have the third mission indicated in their mission statements. As noted by Mowery and Ziedonis (2002) universities with medical university hospitals account for the majority of university invention disclosures.

Contrasting research units were selected to account for the different research excellence. We assume that the reputation of a research unit is based on its quality, which may influence knowledge-disclosure behavior. We distinguish between ‘high achievers’ and ‘middle achievers’ among the research units using evaluations from the RAE and Dutch visitations to account for the different levels of perceived quality as indicated in Table 1.

Table 1. The cases

Field of research	England	The Netherlands
Life sciences	Case A (strong case)	Case C (strong case)
	Case B (weak case)	Case D (weak case)

In our study, the unit of analysis will be research units within departments, institutes or research centres that have their own administrative, physical, and academic existence. These research units have their own organisational behaviour and are supposed to act on the basis of the unit’s interests and those of its individual members. They mostly perform research, and teaching activities do not amount to more than 30% of the scientists’ portfolios.

The data collection involved multiple sources under the rationale of triangulation (Yin, 2003). The study used documents, literature, and semi-structured interviews. The documents and the literature address the period since the 1980s. The interviews took place in October 2005 – January 2006 and were repeated in March-November 2008 in the Netherlands and England to increase the robustness of findings. In total 66 interviews were conducted with researchers, university managers, and policy-makers.

Conceptualization of organizational and contextual ambidexterity of research units

The selected research units are interdisciplinary, where different sub-groups are formed according to different projects, although the group as a whole works in the same over-arching topic. All have some involvement in research commercialization activities. The four research units differ in the area of specialization. All research units have PhD students and post-docs

working for the professors in the laboratories, with the group leader being a professor. The number of professors per research unit ranges from two to fifteen (see Table 2). All research units work in partnership with other universities and industry, although to a different extent according to their emphasis on basic and applied research.

The English research units have different resources and different academic reputation according to the results of external research assessment. Moreover, the lower performing unit B experienced a sharp research funding decrease. This unit is also going to be restructured and integrated in one department, and academics have to increase their teaching responsibilities. Unit A, by contrast, due to the improvement of the research assessment score in 2001, received more funding. New posts were created, the building refurbished and new equipment installed. Teaching loads were reduced, with 70% of time going to research. Research in both units was mainly funded from external sources such as the private charities, research councils, industry as well as the European Union.

In the Netherlands, research unit D is in a more favourable position in terms of resources than unit C. Unit D is a part of a bigger research network and its leader has received a big national project that provides funds for upgrading equipment. Moreover, their university has a special fund for multidisciplinary projects, which provides funding for the unit. Unit C is in a different situation, although it does not struggle financially, though the university as a whole is under financial strain. Due to the financial problems in the school, C cannot hire new staff, although the unit itself is self-sustainable from external funding sources, such as research council grants. The basic university funding is reported to have decreased around 20%, while the contract research funding has increased. This includes NWO, European Union external funds as well as contract research with industrial partners.

Table 2. Characteristics of the English and Dutch biotechnology research units (2005)

	Funding of the Department/Institute	Size of the research unit	Specialisation
Case A	High (€6 M in 2000 and increased since then)	38 FTE, 15 professors, 19 postdocs Staff stable	Protein crystallography
Case B	Low (€2 M in 1999/ 2000 – decreased since then)	14 FTE, 6 professors, 20 postdocs Staff reduced	Biosensors
Case C	High (€10 M in 2005)	14 FTE, 2 professors, 8 postdocs, Staff reduced	Functional genomics

Case D	High (€12 M in 2004)	24 FTE, 10 professors, 12 postdocs, Staff stable	Proteomics
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The university environment for the four research units differs in terms of their entrepreneurial culture and the structural promotion of entrepreneurial activities.

Case A's university is regional which has traditionally been good in life science research. It has hired an external company to facilitate patenting processes and licensing agreements. The university promotes itself as a leader of innovation in the region. Their office of technology partnerships facilitates university-industry collaboration. The website shows the exchanges taking place between university scientists and company CEOs in different clubs, with a shortlist of services that the university provides for local companies. The university management established a new post at the senior management level (research directors) to encourage interdisciplinary dialogue between different departments and foster scientific inventions. Case A concentrates mainly on basic research and during the interviews did not report much on the interaction with the IP processes or working with the technology partnership office.

Case B is located in a university which is geared more towards applied sciences and has a technology-transfer culture. It is located centrally in terms of life-science research with numerous hospitals and companies in the neighborhood. The IP and corporate partnership offices are active in promoting a dialogue between university scientists and companies. This is visible from different seminars, trainings and programs organized by the university. The university has a special seed-funding capital program as well as business development and training facilities at the university level. They provide fellowships for staff and students to work with companies. On their website, they showcase their spin-off companies and the long-term university-industry agreements.

In the case of C, the university has been reorganizing in 2005-2008 with the increasing layers of research management. The technology transfer office has a broad portfolio, ranging from facilitating contact with companies, European grant writing, and technology transfer. Compared to the English universities, it has a less professional website and fewer programs on offer. Little information on the patenting and licensing procedures is provided. The office mainly participates in the national tech transfer promotion schemes, such as tax incentives for small and medium enterprises and different regional grants. It sees itself as a liaison between university scientists, regional and national authorities as well as industry. The university has prepared a report on the need for relevance and innovation in research. The regional location of the university means they are tapping into the regional innovation funding from the EU and the

national government. At the same time, there is limited critical mass in life sciences research in the region.

In the other Dutch case D, the university has also undergone structural changes in its management, agglomerating their departments into bigger schools and increasing the layers of management in 2005. The university website does not contain information on the technology transfer or corporate partnerships office. However, its annual reviews state that the university holding company is responsible for intellectual property and technology transfer at the university. The university has science incubator and opened a brand new facility in 2004. As in the case of C, it actively participates in national programs and initiatives promoting innovation and collaboration with industry. The central geographical location of the university is helpful for close collaboration with the key biotechnology companies in the Netherlands.

Empirical findings

Biotechnology scientists from our case studies disclose their knowledge of different audiences, such as the scientific community and industry. In our case studies, external research assessments encourage peer reviewed articles to be the dominant channel of knowledge disclosure. Most of their research is funded either by research councils, the European Union, charities or industry, and they largely influence the choice of the knowledge-disclosure medium and the type of research carried out. Academics enumerated publications, patents, spin-offs, contracts with industry, external governmental grants, conference papers, reviews, participation in committees, consultancy services and invitations to speak as their outputs. The key idea behind producing them is to contribute to the researcher's standing in the academic community, get funding as well as contribute to the country's economy at large. B and C work more on the 'applied side' than A and D, as perceived by the researchers themselves.

Scientific norms and practices of scientists in the research units

Irrespective of the differences in the basic and applied research portfolios, for the studied research units, journal articles are the dominant medium of knowledge disclosure. There is a strong internal drive to publish with group leaders, deans and heads of departments explicitly encouraging academics. A junior from research unit C notes that they are evaluated once per year, and that a positive evaluation depends on publishing two articles per year. A usual instrument to encourage researchers to publish is to stimulate conference attendance. The D group leader encourages this also because it enhances the unit's visibility. A usual routine for biotechnology units is to collaborate widely, while aiming to publish in top journals. Furthermore, scientists mention external funding bodies that increasingly look at the number of publications when deciding on project funding. The emphasis is laid on publications in high-

rated journals, which is perceived as a new phenomenon, as noted by a professor from research unit A: "I suppose if you look back thirty years nobody would have bothered so much. But it was a different world 30 years ago." Journal articles help build credibility both within the scientific community of life scientists and for external funding bodies, such as research councils (types and numbers of publications are important to obtain research council's grants).

The push to publish means a strong emphasis on scientific journals instead of books or popular articles and reviews. Articles in highly rated journals are basically all that count. Researchers in both groups are very conscious about citation indexes and the impact factors of journals. They are not interested in "wasting time and effort" on writing books or book chapters, unless it concerns "a very prestigious series". The C leader expresses how he is quite selective about what to publish:

I don't like [writing books] anymore I must say because they are not in Netline, in Putnet. So you don't get your citation indexes from that and I get quite a lot of invitations for books but I'm very hesitant to take them. Only when they are very famous book series such as 'Methods in Enzymology' or something, then yes, but not for just another microbiology book. I usually don't do that anymore. It's too much effort, it takes your time and I can make a review when I have time for a journal; I also prefer that.

The major norms of biotechnology research units are to assure the continuity of the research lines of the academics' preference and to build credibility through publishing in high-impact international journals. Publishing in journals also proves performance to management. This translates into routine publishing, where both quality and quantity matter.

To meet targets, researchers follow various publishing routines. The obvious one is to publish management's required number of publications as well as need to increase their reputation in the scientific community: "that is my strategy and that is the only strategy to survive, as far as I can see". The common behavior of research units is to target quality journals, while not forgetting about quantity. Besides quality they consider how fashionable the topic is and the likelihood research will be published in top international journals. Impact factors are all important, as the research unit leader from A notes:

Publications are essential and it's also clear that those publications have to have an impact on the field and therefore most people know that they need to get into the journals which are the most widely read and cited. It's important for their own work to be reviewed in journals where they are going to have a high impact.

Citation indexes are considered, as this is one of the researcher's evaluation criteria. The major value behind journals with a high citation index is that they further transmit scientific knowledge because they are widely read among the scientific community. A professor from C exemplifies this fact:

If it is a very big step and very novel, new [research], you have got 'Nature' [to publish in]. After that it is really building on research that you can publish in other magazines. But getting into Nature is not the final goal ... it's all about getting cited. You can make a big/high claim/research and nobody will read it. If you make it a bit less high profile, everybody will use it and put it in their reading cabinet. Citations, that's what makes you further scientific knowledge.

Furthermore, all research units were concerned about the continuity of funding so that they could continue to build their academic credibility and lines of research. So, they followed certain routines to offset the lack of continuity. They combined short-term outputs and themes into a long-term theme and more substantial outputs. For example, in A the head of the group indicated that they manage to get grants one after the other so they can maintain longer term research that leads to bigger projects and credibility within that area. This is shared by the senior researchers in B who find it difficult to maintain continuity. The B leader notes that researchers are creative about maintaining lines of research and the stable production of outputs. Other respondents from D also stress the need to balance short-term outputs with the long-term research programme. In this case, the research unit manages to get grants on a regular basis, so they can maintain credibility in a particular area. The group leader of D notes:

The kind of work is the same but the specific subject you're studying within the micro organism ... might vary, although I try to also get of course continuation in that like anti-microbes. We have done that for 20 years already and some metabolic regulation, we also try to do that for longer term. Of course if you want to be recognized in the field you have to have some long-term show. Project with one theme for once and then ended and doing something else is not ideal. But sometimes it happens.

In contrast, C is less concerned about balancing short and long-term projects. They are positive about three-year contracts and think producing journal publications is enough. However, the professors in this unit also maintain a 'red line' in their research, which means they work on the same over-arching research topic and try to ensure continuity by building on short-term outputs. In all units, however, academics are concerned that their PhD students graduate on time and get 'publishable' results. Thus, produced PhD theses have strong value. The completion rates of PhDs (see Table 3) are important for the funding and reputation of the research units.

Entrepreneurial norms and practices of university scientists

Both Dutch and English biotechnology research units are keen to collaborate with industry through consultancy services as well as collaborative research projects (using the shared facilities or company-funded PhD students). This is particularly apparent in the units that carried out more applied research, such as B and C. Certain external funding bodies, such as the EU or research councils, tend to favor 'relevant' research. This is perceived by life scientists as a push for researchers to think about the applicability of their research. For

example, a researcher from research unit A admits that he would be more likely to get funding if he would go for applied research project and likes the idea of doing that:

'I think the funding bodies would like us to do more applied research. I'll be happy to do more applied research, I just can't currently see in many avenues where I can take my work. I would be quite happy to do a little more applied research I just currently struggling to see what that will work and be able to do that. I feel that I'm more likely to get research funding going that way as well. And to be fairer might be more stimulating. I'd might actually enjoy it.'

The group leader of B noted that different funding bodies would fund different types of research. For instance, the Department of Health, the Department Trade and Industry in England and the European Union would fund more applied research. The research unit with less academic credibility and resources opts for more applied type of research.

In the Netherlands, a junior in C draws attention to the relevance of their research and relates this to their cooperation with industry, which is partly subsidized by the Ministry of Economic Affairs: "The relevance comes from the fact that we obtain quite some money from industry. We do want to implement our research data...so there is the relevance". At the same time, although D is more oriented towards basic research, relevance is important. For example, if a choice must be made about the 'relevance' of research, then a professor from D goes for it:

If you have to decide to work on a protein that is involved in a very important disease or a protein which is equally interesting but involved in degradation of metabolising yeast, then you choose for the one that has medical relevance. Maybe the project itself is not that interesting but the potential impact is better, so then you decide on that project. In that respect it influences your research.

The applicability of knowledge is a good and serious criterion in selecting research projects according to this professor. At the same time, he recognizes that this cannot always be the leading criterion because keeping the major basic research lines intact is also important. A balancing act, in which basic and applied research project call for priority, is the result.

Patents are mentioned as an important channel of knowledge disclosure by all research units but are perceived as less rewarding than articles. For them, patenting procedures are time consuming while providing negligible benefits. They can even be counterproductive for academic credibility building. Time lags due to patenting can have serious effects, as shown by a C junior researcher who had to wait for one year to have his PhD published because of the patenting procedure:

If you go for a patent then there is a delay. For instance, when I finished my thesis I had this nice booklet but there was interest in patenting. One had been patented the second year already, so that was out, there is one year protection, twelve months at least, so there was an interest and that was filed at the

moment I finished my thesis. But that meant I had to wait for one year. Ok, I had a job and could continue, but the booklet is there for a year just waiting for defense. It was not allowed to be made public.

Patenting offices at the universities are supposed to support the academics, but many researchers question the added value of these offices. Basically, academics argue that the patenting offices do not provide many incentives for patenting. Researchers are also concerned about the very low success rates of patents. A junior respondent from C refers to an EU regulation that bans patents in a certain molecular genomics areas. Additional problems with patents come from competition for patent, since large companies may crowd out certain areas in the field which may be patentable, as experienced by a junior researcher. This competition even further reduces the possible success of patenting processes for life sciences at universities:

'In my case, I filed two and got one patented with is the basis for the whole company thing. What was interesting with that is that we had some other ideas about things a few years ago which we didn't patent and now that area has been completely patented to hell as it where.... Whereas these days a lot of big companies are just blankly patented that they have no idea what they wanted to do with it, which doesn't leave much room for trying who wants actually to do something. So somebody may have patented something without really thinking about what it is was that they were doing. And then somebody else would come along, any university will come along, oh, this would be really good to send somewhere and finally will find out that they can't do anything with it.'

Despite the hesitations, researchers in B and C are aware that patents may be useful for their career since they count as publications on their CVs and can bring added value even though they are outside their core activity. Nevertheless, they prefer to publish a journal article and not waste too much energy on patents. This creates some tensions with central management, since they would like to see a growing number of patents for the university.

In sum, scientists in our case studies largely ignore and challenge the call for getting more patents, thus the ambidextrous demands from their management, especially in the Netherlands. The strategy used by researchers their contextual ambidexterity is to keep on the productivity in the area of publications and occasionally to patent at the periphery of their portfolios if this does not imply too much risk taking in terms of timing to produce research results in the public domain. Life scientists in the studied research units are hardly willing to go down this road of 'commercialization' and 'entrepreneurship'.

In terms of spin-off companies, a few of interviewed scientists tried to establish their own companies and some of them succeeded. The active ones were found in the English case studies. The key concern, however, of these entrepreneurial scientists was not being able to disclose their knowledge arising from the work in the spin-off company. This opinion was particularly

shared among the junior scientists who were anxious about a gap in publications during the time when they need to publish to establish themselves in the scientific community. In their view, joining a spin-off was not advisable for junior university scientists.

Conclusions

The central question of this paper was how and to what extent do university life scientists deal with their contextual ambidexterity. We aimed to provide an empirical contribution to this discussion, focusing on the actual practices of university scientists within an 'entrepreneurial university'. Our main aim was to understand how scientists respond to the organizational ambidexterity in their research unit. In particular, we aimed to understand how do they integrate scientific excellence and industry relevance in their practices of knowledge disclosure and how the contextual ambidexterity compares across the biotechnology units of different academic credibility.

Based on the evidence from biotechnology research units, scientific and entrepreneurial activities paint a mixed picture. Irrespective of their academic reputation and the amount of research outputs, the major tendency is to adhere to the scientific norm of communalism. Researchers in all of the cases are keen to publish journal articles and are very aware of the scientific value of knowledge disclosure to the academic community. High impact journals are most important. In addition, scientific knowledge disclosure practices are encouraged and maintained by the university management, such as appraisals, external evaluations call for quality and quantity of the research publications. Finally, the national institutional context is very important in promoting certain practices. For example, in the UK, the results of the external evaluations are directly linked to the funding levels of the Funding Council. In both countries, the competitive grant bidding of the research councils generally means that academics need a good publication record. Thus, the academic values of communalism are reinforced by the institutional context, such as the community of science, university management as well as external public funding bodies. Therefore, the contextual ambidexterity in the studied research units is not strongly reinforced by the institutional environment despite the fact that universities claim to be active in their third mission and they do have academic hospitals. In the studied research units the norm of communalism embodied in the traditional academic publishing activities remains dominant as it is an important performance criterion not only within the academic community, but also for receiving institutional and external grant funding as well as being positively evaluated for performance at the studied universities.

On the other hand, a mixed picture emerges when we consider the entrepreneurial activities of the research units. All collaborate with industry to a different extent and are aware of the

importance of industry funding for their survival. Increasingly, their budgets depend on external third-stream funding, and commercialization is encouraged by university managers. Researchers with a high academic reputation maintain more basic research because they obtain funding from the major research council and university funding (first- and second-money streams). Thus life scientist's contextual ambidexterity is manifested not only through performance reviews of knowledge disclosure practices but also through demands for external funding, and in cases of lower credibility, this means more contract research with industry and consultancy. At the same time, to fit the priorities of the external funders, they try to be 'relevant' in their topic selection and also through entrepreneurial initiatives of creating spin-off companies and patenting. In the cases of lower research reputation, we can see more applied research activity taking place, and the external funding is a mixture of project grants and industry funding. This is especially true in the case of English research unit B. Their researchers are entrepreneurial in patenting, creating spin-offs and working with the industry and hospitals on a contract basis. Thus the contextual ambidexterity is really high in the cases of lower academic credibility and their response to ambidextrous organizational environment is more compliant compared to the units which have high credibility.

In general, the research units wish to invest their time in credible outputs for the scientific community. Additionally, patents and work in spin-off companies can be a lock-in for researchers who want to make their results public as soon as possible. All of them think that patents hardly pay off in terms of costs and benefits. Tensions also emerge from ambivalent signals and partly contradictory expectations that the research units face. On the one hand, external research evaluations and funding streams are based on expectations of academic excellence. On the other hand, the research groups experience a growing rhetoric of 'relevance' that does not really pay off in terms of reputation and funding in the academic community.

Discussion

In our four cases, we can see that most biotechnology research units are predominantly using traditional scientific channels of knowledge disclosure and adhere to the scientific norms of knowledge production. We can see that cases A and C have medium organizational ambidexterity. Although they actively publish in journals, they are also collaborate with industry on contract research, patenting, and financing their PhD students. Both units have similar types of activities, the major difference between them being the sources of funding. Unit C has a higher proportion of industrial funding, while A has more basic funding from research councils. Cases B and D look more entrepreneurial in their knowledge disclosure practices. The English research unit B and Dutch unit D have somewhat lower production of journal articles than their

counterparts in their countries, but are more active in commercial knowledge disclosure and interaction with industry. They are active in patenting, creating spin-offs and especially with contract research with a variety of companies and hospitals. They have a high proportion of industrial and project funding from hospitals and industrial companies.

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