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The dynamics of university units as a multi-level process. Credibility cycles and resource dependencies

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Abstract This paper presents an analysis of resource acquisition and profile development of institutional units within universities. We conceptualize resource acquisition as a two-level nested process, where units compete for external resources based on their credibility, but at the same time are granted faculty positions from the larger units (department) to which they belong. Our model implies that the growth of university units is constrained by the decisions of their parent department on the allocation of professorial positions, which represent the critical resource for most units' activities. In our field of study this allocation is largely based on educational activities, and therefore, units with high scientific credibility are not necessarily able to grow, despite an increasing reliance on external funds. Our paper therefore sheds light on the implications that the dual funding system of European universities has for the development of units, while taking into account the interaction between institutional funding and third-party funding.

Keywords Resource acquisition · Credibility cycles · University governance · Critical resources · Reputation

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Introduction

Since the pioneering work of Latour and Woolgar (Latour and Woolgar 1979), the importance of resource acquisition for the development of research units has been widely recognized (Braun 1998; Weisenburger and Mangematin 1995). The relevance of this topic was heightened by funding reforms characterized by increasing competition and selectivity, as well as by state attempts to steer research through resource allocation, a process that has been labeled as “academic capitalism” (Slaughter and Leslie 1997; Geuna 2001). In this new regime, research units are embedded in a market system and compete for resources from customers who buy research services based on their needs (Slaughter and Rhoades 2004).

However, it is largely disregarded that most units are embedded within larger organizations—universities and Public Research Organizations (PROs)—which control a significant share of funding. The implications remain poorly understood concerning the development of units’ activities on the interaction between institutional embeddedness, and the increasing reliance on external funds.

More specifically, our paper focuses on institutional units within universities below the department level, such as institutes, laboratories or chairs. For these units, the university and department control certain critical resources, including the basic infrastructure, facilities and professorial positions. This is largely an outcome of the dual funding system of European universities, i.e. university funding is provided through two channels: Institutional funding attributed to the university as a whole (mostly as a block grant, and then redistributed internally), and third-party funds acquired by the units directly (Lepori 2011). Despite an increase of third-party funds in previous decades, institutional funding still accounts for the largest portion of university budgets in most European countries, with the exception of the UK (Lepori et al. 2007; Jongbloed and Lepori 2015). This institutional and funding context marks a strong departure from the US, where most of the research funding is based on grants.

The goal of this paper is to develop a model of funding acquisition by university units, which takes into account the interaction between institutional funding and third-party funding.

To this aim, we conceptualize resource acquisition as a two-level nested process, where units compete for external resources based on their scientific credibility (Latour and Woolgar 1979; Joly and Mangematin 1996), while at the same time competing for internal resources within the university, mostly in the form of professorial positions. This second process has a longer time frame and might follow different rules, for example it may be influenced by the university’s strategic priorities and by the extent of educational activities in the field.

Our model borrows ideas developed in previous work on research units (Crow and Bozeman 1998), which we specify and adapt to the context of universities. This concerns: (a) the notion that units might display different profiles of activities (Larédo and Mustar 2000; Braam and Van den Besselaar 2010), particularly the balance between education and research; (b) the idea that resource acquisition is based on credibility cycles (Latour and Woolgar 1979), but these differ depending on the unit’s profile and on the audience providing resources (Joly and Mangematin 1996); and (c) the notion that resources are not always substitutable, but some resources are critical and constrain the unit’s development (Coronini and Mangematin 1999).

We provide empirical evidence from a sample of 20 university units in the field of communication sciences within different Swiss universities. In this field, education plays a central role, but there is an important component of basic research funded by public agencies, as well as of contract research funded by public and private organizations, such as the Federal Office of Communication and (media) companies (Lepori and Probst 2009). Therefore, we observe a diversity of profiles and resource acquisition strategies between units, as well as within the same department. We hold quantitative data on resources, activities, and outputs for a 5-year period, which is integrated with qualitative information on university and unit strategies (Probst et al. 2011). This allows us to analyze differences between units in the activity profiles and resourcing.

The relevance of this work is threefold. First, we propose and empirically test a realistic model of the development of university units, which takes into account their embeddedness and resource dependency. Second, through this model, we are also able to conceptualize the impact of strategic choices at the university and departmental level on the development of units and their interaction with external resources. Third, and more generally, we advance the understanding of the impact of institutional configurations of funding systems on the development of research at the unit level.

Theoretical framework

Resource dependencies and credibility cycles

Our framework is grounded in three concepts developed by the literature on public research laboratories, i.e. the activity profiles framework (Larédo and Mustar 2000), the credibility cycles in the acquisition of resources (Latour and Woolgar 1979) and the notion of critical resources (Coronini and Mangematin 1999).

- (a) The concept of *activity profiles* was developed to characterize productive patterns of research units in terms of their involvement in different types of activities (Larédo and Mustar 2000). It builds on empirical evidence of the diversity of units (Joly and Mangematin 1996) and moves beyond the dichotomy between public (science-oriented) units and private (innovation-oriented) units (Crow and Bozeman 1987), to provide a systematic framework to characterize diversity in the mix of activities.

To operationalize profiles, this approach identifies the main contexts of usage of research and the related types of activities and outputs. Dimensions can then be measured through quantitative indicators in order to compare units and to follow the evolution of profiles over time (Braam and Van den Besselaar 2014).

In a previous work, this approach was adopted to examine institutional units in Swiss communication sciences; profiles have been operationalized in terms of dimensions—distinguishing between science production, training, education, public and private transfer—and measured through a set of indicators. We were therefore able to display a large diversity of profiles, distinguishing between research and education-oriented units (Probst et al. 2011; Buhmann et al. 2015). Beyond these results, the specific focus of this paper will be on the change of profiles over time and on their association with resourcing.

- (b) *Critical resources* Activity profiles also reflect the combination of resources used to perform activities (Carayol and Matt 2004). Units are typically multi-functional and combine different production factors, such as personnel or infrastructure, in order to

produce a set of outputs, including scientific publications, training of researchers, teaching, reports and other applied outputs (Schmoch and Schubert 2009).

Some resources are critical in the sense that they constrain the engagement of other resources and cannot be readily expanded or replaced (Coronini and Mangematin 1999). For example, a technical facility might be essential to readily expanded or replaced (Coronini and Mangematin 1999). For example, a technical facility might be essential to conduct an experiment: in this situation, if the facility cannot be expanded, additional financial resources or personnel would not be useful. Resource dependency theory suggests that units try to secure the critical resources for their survival, thereby reducing the level of uncertainty (Pfeffer and Salancik 1978). If a resource becomes scarce, units will seek alternatives. For example, when faced with budgetary cuts within universities, they will try to increase the amount of third-party funds.

The non-substitutability of resources implies that there are limits to this process, as universities might control some resources that are critical and constrain the acquisition and productive use of external funds. For example, in natural sciences, units might have access to a large number of research grants, but need a large investment on a technical facility, which can only be provided by their institution. Alternatively, funding agencies might condition grants for junior researchers to the availability of permanent positions for principal investigators funded by the university. These examples demonstrate how funding sources are interconnected and how, in a differentiated funding environment, some actors control specific types of resources, which are required in order to access other resources.

- (c) The notion of *credibility cycles* (Latour and Woolgar 1979) expresses the idea that the acquisition of resources is not based directly on the quality of outputs, but rather on credibility. This means that the link between output quality and the acquisition of resources is then indirect: Units accumulate credibility when they perform well, which can then be reinvested into the acquisition of resources—a mechanism that leads to cumulative effects showing how scientific reward and resources are distributed (Merton 1968). Credibility works as capital, which stabilizes the interaction between funders and performers who are faced with uncertainty regarding the actual level of quality (White 2002).

While different types of credibility can be distinguished and associated with different audiences (Larédo and Mustar 2000; Joly and Mangematin 1996)—for example the scientific community, the public sector, private companies, students and their families—we focus in this paper on the role of *scientific credibility*. Scientific credibility refers to the recognition by peers and can be measured through scientific output and citations; it is expected to play an important role for science-oriented external research funds, like those from research councils.

Therefore, the units' activity profiles also indirectly express how units have positioned themselves in terms of resource acquisition by accumulating different types of credibility and constructing stable linkages with the audiences that provide specific resources. While this process is dynamic, empirical studies display that profiles are characterized by stability and that changes tend to occur during specific events, such as the replacement of the director or a major organizational restructuring (Braam and Van den Besselaar 2010).

Profiles and resource acquisition in university institutes

We specify a model of resourcing for university units that draws on three dimensions, i.e. the activities performed, the resources required to perform those activities, and the available funding channels and actors controlling them (Fig. 1).

Most university units engage in three main types of activities, i.e. education (at different levels: bachelor and master, as well as postgraduate), scientific production and the training of researchers (publications, PhD theses), and transfer activities to the public and private sector (Probst et al. 2011). Particularly in the social sciences, with the large number of students, education represents a core mission. The centrality of education is also emphasized by its importance in the funding system of universities in many European countries, including Switzerland, where large shares of institutional resources (also for research) are based on the number of students (CHEPS 2010).

Within the available resources, units are—in principle—free to develop research and to acquire external funds for that purpose. On the contrary, decisions concerning educational activities are more complex, as in most cases, the set-up and design of curricula is organized at the department level, while units provide the courses corresponding to their specialization area.

To perform activities and produce outputs, units mostly rely on different types of human resources, while other resources – such as technical facilities or data—play a more limited role in the social sciences and humanities. We suggest a division of human resources into two groups to distinguish between enrollment procedures and contractual conditions (Probst et al. 2011).

The hiring of professors is based on structured procedures that require a formal decision to open a position in a specific area; since most of these positions are tenured, they represent a long-term investment. Essentially, this process takes place at the department and university level. New positions are opened either in cases of leave or retirement of

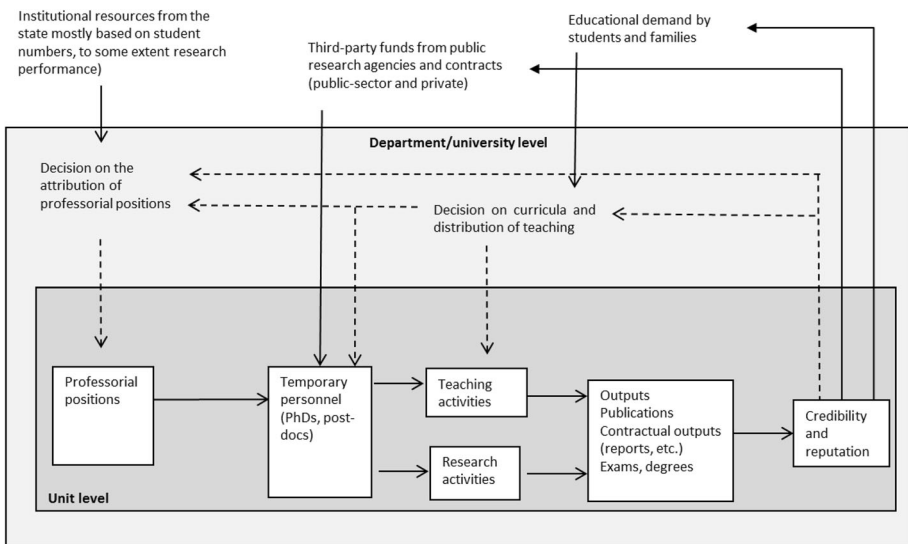


Fig. 1 A multi-level model of resource acquisition and activities

current professors, or when the department or faculty decides to strategically reinforce a unit and/or a subject domain. From the perspective of units, professorial positions represent the most critical resource: they hold most of the scientific credibility and are required to engage in most of the activities—teaching is mostly provided by professors or at least requires their supervision, while most grant applications require the endorsement of a professor.

Other staff includes PhD students and post-doctoral researchers, as well as lecturers and some support staff who are mostly hired with temporary contracts. The ability to hire non-professorial staff on a permanent basis is more and more limited in European universities. When resources are available, temporary staff can be hired directly by units with a simpler procedure, which does not require the direct involvement of the department.

The funding of units can be divided into two streams: institutional funding provided by the university from the general budget and third-party funds acquired directly by the unit. The former mainly originates from the general state allocation to universities, as well as to a more limited extent from student fees. Third-party funds are provided by public research funding agencies, such as the national research council, by public and private organizations and by companies and students for postgraduate education. At the unit level, there might be large variations in the relative importance of the two streams. At the university level however, institutional resources account for about two-thirds of total funding in most European universities (Jongbloed and Lepori 2015).

Institutional funding and third-party funds differ in their allocation criteria, in the resources allocated to units and in the actors controlling the funding decision. A large share of institutional funds is used for professorial positions, which are usually long-term. Institutional funding also includes funding for junior staff, for example teaching assistants and PhD positions attached to chairs, core technical facilities (such as computing facilities) and the coverage of general running costs. On the contrary, most third-party funds are for hiring research personnel (mostly at the junior level) and research costs. Unlike in the US, in the European context institutional funding also covers part of the general costs generated by external projects, as overhead rates are usually not sufficient to cover all project costs (Jongbloed and Lepori 2015). Since they are largely bound by long-term commitments, institutional funds have a continuous nature (despite attempts to move beyond purely incremental budgets; Moll and Hoque 2011), while third-party funds are in principle more short-term and subject to fluctuations.

Institutional funding is usually allocated through some kind of political process at the university and department level. The decisions in this process might be influenced by quantitative indicators—such as the number of students and the acquisition of third-party funds, and the university's strategic priorities (Lepori et al. 2013) as well as by the bargaining power of units (Pfeffer and Salancik 1974). Third-party funds are allocated largely through competitive evaluation procedures, where the credibility of the applicant plays a central role (Viner et al. 2006).

Model and predictions

Based on these dimensions, we conceptualize the development of university units as the outcome of a two-level process (Fig. 1).

On the one hand, units are engaged in credibility cycles concerning their research and educational activities. Unit results are manifested in scientific publications, contractual deliverables, and degrees. These cycles are associated with specific audiences: the academic community in the field, external audiences, as well as students and their families.

The educational cycle is only partially controlled by the units themselves, since teaching volume is largely dependent on departmental decisions. Acquired resources can be directly employed for hiring additional staff to perform research and education.

In this process, units can leverage their credibility in order to acquire external funds, and if they are successful, they accumulate further credibility. However, at some levels, the expansion of research funded through external sources will be constrained by the amount of professorial positions. Alternatively, units may invest in teaching activities in order to receive additional resources from their department, but their freedom to do so will be constrained by departmental decisions.

On the other hand, a distinct cycle is responsible for the allocation of professorial positions. This cycle takes place in the medium term (5–10 years) and is based on decisions at the departmental level, which might take into account different criteria depending on the local conditions. In this regard, three allocation scenarios can be distinguished that have different implications on unit profiles and development.

In the first scenario, the replacement of professorial positions or newly available positions is attributed selectively to those units that manage to acquire external funds. In this model, cumulative processes are fully at work and a close association between a unit's credibility and its size (in terms of both professorial and non-professorial staff) is to be expected.

In the second scenario, the allocation of professorial positions follows the demand for education (as expressed for example by the number of enrolled students). Departments expand the educational offer in domains with high demand and, accordingly, allocate professorial positions to units in that domain. In this model, a close association can be expected between the volume of education and the number of professorial positions in a unit.

In the third scenario, decisions on the allocation of professorial positions do not take into account external resourcing, but are based on political bargaining within departments and are largely incremental, with retiring professors being replaced within the same domain. In this scenario, no association is expected between professorial positions and other characteristics of units, such as the volume of education and research, and the level of credibility. Units might still be able to hire non-professorial staff from external funding, but this process will eventually reach a ceiling.

In reality, we expect to observe a mix of these scenarios. A resource-dependency perspective suggests that the prevalence of each model will be influenced by the way the state allocates institutional funds to the university, as universities will try to secure their resource basis (Salancik and Pfeffer 1974), and allocation of resources within universities tends to mimic the national allocation model (Moll and Hoque 2011; Lepori et al. 2013).

Data and methods

We provide illustrative evidence of the model on a sample of 20 units in communication sciences within seven Swiss higher education institutions. For these units, we hold a rich set of data on the composition of personnel, teaching activities, acquisition of external funds, scientific publications, and doctorates. Data have been collected every year from 2009 to 2013, mostly from official university sources pulled from the unit's websites and from individuals within the units (Probst et al. 2011). In order to maintain anonymity, the units will be designated with numbers.

Quantitative data

Human resources

We measure human resources in terms of full time equivalent positions (FTE) of staff employed by the unit for the considered year. We consider *total staff* employed, *professorial* and *non-professorial* staff. The former includes ordinary, associated, and assistant professors; in the Swiss system, these positions are tenured and permanent (with the partial exception of assistant professors).

Educational activities

We measure educational activities through the number of *teaching hours* delivered by staff belonging to the unit, separately at the bachelor and master level. This is a suitable measure as it takes into account the contribution of each unit to curricula organized at the departmental level. We complement this information with the number of bachelor and master theses supervised by members of the unit's as a measure of the subject importance in the curricula and the effort for supervision. Data on the number of students are available only at the faculty or department level, while the breakdown at the unit level would be problematic. In order to tally teaching hours for individual units, data was collected by coding the university course books.

Research output

We measure the research output of the units by counting the number of publications, including academic journal publications, books and book chapters. The inclusion of books is critical given their importance in the social sciences and humanities (Hicks 2004), and the important internal differences in publication cultures between subdomains of the field of Communication Science (Lauf 2005). This justifies our choice of using simple (un-weighted) counts of publications.

Funding acquisition

We hold data on the acquisition of external funds, divided between funds from public research agencies (mostly the academic-oriented research council) and contract funds from public and private bodies. The latter have a more applied and policy-oriented character. In order to limit fluctuations, external funds have been distributed over the whole duration of projects.

We do not hold figures on the total budget of units, but we compute a gross estimation by counting a cost of 200,000 Swiss francs (CHF) per year per FTE of professorial staff and of 100,000 CHF per year per FTE of non-professorial staff, based on the average salaries in Swiss universities. We add 50 % to this amount as additional costs for travel and infrastructure, a reasonable estimate for social sciences. We then compute the share of third-party funds based on the total budget.

Scientific credibility

We use the number of citations in Google Scholar for professors and senior staff in each unit as a measure of scientific credibility. Most of this information can be retrieved from the individual's Google Scholar profiles. When missing, data have been computed by hand based on publication lists. Despite some methodological limitations, Google Scholar is preferred since it provides a broader coverage of non-journal sources, and therefore is better at covering the subfields of communication oriented towards humanities (Bornmann et al. 2016). As a cumulative credibility measure, we use the total number of citations of the members of a unit *in the current year* during the previous 5 years.

Data are complete for 17 out of 20 units. The three units with missing data will accordingly be dropped in some of the analyses performed.

Empirical strategy

Our empirical strategy takes into account some of the limitations of the data, particularly the limited number of observations and the rather short time frame, which does not allow us to fully investigate the long-term process associated with the allocation of professorial positions.

In a first step, we perform a descriptive cross-sectional analysis using the averages of the variables over 5 years, in order to reduce the volatility of the data (particularly for third-party funds). The goal is to test (cross-sectional) relationships between our variables of interest, particularly between the orientation towards education or research, the composition of human resources, and credibility.

To this aim, we run a factor analysis by using four measures of educational activity (teaching hours and number of theses separate for the bachelor and master level) and five measures of research activity (total publications, PhD students and graduates, funds from funding agencies and contracts). Two large factors can be identified: factor 1 accounts for 47 % of the total variance (eigenvalue: 4.195) and, in the rotated components matrix (Varimax rotation), loads on PhD students (0.860), PhD graduates (0.648), publications (0.880), research agency (0.871) and contract funds (0.772), as well as to teaching hours at the master level (0.628). Factor 2 accounts for 23 % of total variance (eigenvalue 2.058) and loads on teaching hours at the bachelor (0.680) and master level (0.651), bachelor theses (0.822) and master theses (0.807), as well as on PhD students (0.438). Factor 1 can therefore interpreted as a measure of *research orientation* and factor 2 of *educational orientation*, with master students, and to a lesser extent, PhD students loading on both factors.

In a second step, we provide descriptive evidence of changes in the units' activities and resourcing over the 5-year period (2009–2013).

As a third step, we exploit panel data to perform regressions on our variables of interests. Even if the number of observations and the time period are limited, regressions provide some quantitative support to the descriptive analysis. Since the model suggests that professorial staff is dependent on the acquisition of external funds and teaching activities, we first perform a regression with FTEs of non-professorial staff as the dependent variable, and project funds and teaching hours as the independent variables. Second, our model suggests that, at least in the time frame considered, the amount of professorial staff should be considered as given, since its allocation is more long term. Therefore, we run a regression to ascertain whether the endowment of professorial staff and unit credibility is

Table 1 Organizational structure of the field

University	A	B	C	D	E	F	G
Faculty	Social and economic sciences	Economics	None (university is composed by largely independent institutes)	Communication sciences	Social and economic sciences	Faculty of philosophy	No faculty level
Department	Social science		Institute of media and communication	None (communication is a self-standing faculty)	Department of communication	Institute of communication	Applied Linguistics'
Total units considered in the analysis	3	5	5	6	6	8	3
Units	1	1	1	8	6	2	1
Total students in COM (2013)	0	60	0	739	559	1127	901
Bachelor level	Bachelor in social minor in communication	No	Individual courses within university masters	Bachelor in communication	Bachelor in communication (major and minor)	Bachelor in communication (major and minor)	Bachelor in communication
Master level	None	Master in communication	Individual courses within university masters	Different masters (by unit or joint)	Master in communication	Master in communication	Master in communication

associated with the level of acquisition of external funds (focusing specifically on the credibility-based research agency funds) and with the amount of teaching hours. Ultimately we are interested both in cross-sectional (between units) and longitudinal (within units) variance; therefore, we run random effects models using clustered standard errors.

Results

The context of Swiss communication sciences

The field of communication sciences in Switzerland has a long tradition—particularly its subdomain of journalism studies—but witnessed a very rapid growth starting in the late 1980s. This expansion was fueled by an increasing demand for education, students increased from below 200 in 1995 to more than 2000 in 2015, and the subsequent expansion of educational offers. Before the year 2000, communication sciences was mostly a side subject within social sciences curricula. Currently four universities offer a full bachelor curriculum, with more universities offering specialized masters (see Table 1). A similar expansion took place for research: for example the number of PhD students increased from less than 10 in the 1990s, to its current rate of about 150. Research also broadened in terms of subject topics, with the emergence of new topics driven by high societal demand, such as public opinion studies, health communication, and electronic communication (Buhmann et al. 2015).

The organization of the units is highly diverse (Table 1). This is a result of differences between universities in their structure and rules due to the federal organization of higher education (Lepori 2007). Our common unit of analysis will be the lower organizational level (what we refer to as units). In German-speaking universities these units are typically *chairs*, organized around a full professor, while in some universities they are labeled as *institutes* and might have more than one professor. In the larger universities, these units are embedded in middle-level structures called departments or institutes, which represent the whole field of communication within the university. The highest level is composed of large disciplinary faculties (for example social sciences and economics). There are however variations: in one university there is no department level and communication is a stand-alone faculty, while another university, given its specialized nature, is composed of largely independent institutes.

Throughout the paper, we will consistently refer to *units* as our main level of analysis and to *faculty/departments* for the higher levels.

Our sample is composed of 20 units, 16 cover the entire period (2009–2013), whereas two were created in 2013 and two have been merged into a new unit during this period. These units belong to seven universities, with the number of units by university ranging from seven to one (Table 1).

Units cover specific subjects within the field of communication and enjoy a high level of autonomy in their activities, particularly concerning research. The situation for teaching is slightly different: as shown in Table 1, the management of the bachelor curriculum takes place at the higher institutional level (mostly what we would call “department”); masters are more focused, and therefore there is more flexibility for units. But in all cases, the decision to offer a master is made at the department/faculty level, based also on the number of students. Within the resources available, faculties/departments are free to offer curricula, as there is no national-level accreditation and no selection of students.

The funding system of Swiss universities can be characterized by a weak level of competitiveness: the share of third-party funds is around 25 % of the total budget and institutional funds have a large component of historical and/or negotiated resources; the formula component (based on students and third-party funding) is limited. The internal allocation process is therefore largely political while indicators, such as the number of students or the acquisition of external funds, are mostly used for negotiation purposes. The main process is the allocation of chairs, as it determines the allocation of the largest part of the budget (in the social sciences, about 70 % of the total costs in 2014 were composed by personnel costs). Planning of the chairs, particularly the replacement of retiring professors is a key competence of the faculties and is a central element of university strategic planning in Swiss universities (Fumasoli and Lepori 2011).

Comparing units: a cross-sectional view

Table 2 provides descriptive information on the sample, using the average by unit for the years 2009–2013. These data display the level of heterogeneity concerning the size and activities of the units. In terms of personnel, the smallest unit was created in 2013 through the hiring of a new professor, while the largest employed five professors and slightly less than 20 FTEs of staff.

A first characterization can be based on the number of professors: eight units represent a pure chair model, i.e. with a single professor, three units display an institute model (3–4 professors), and the remaining fall into an intermediate category. These differences display different institutional characteristics between the German-speaking universities, where the chair model prevails, and the Italian-speaking university. Units employ an average of three FTEs of non-professorial staff for each FTE of professorial staff, therefore displaying the rather steep hierarchical structure of personnel.

In terms of volume, bachelor teaching is more prevalent than master teaching—in 2013 there were 1600 students studying at the bachelor level and 700 at the master level in the field of communication in Switzerland. Funds from research agencies (mostly the national

Table 2 Sample descriptive information. Average 2009–2013 (only the years of existence of the unit are considered)

	Mean	SD	Minimum	Median	Maximum
Total staff (FTE)	6.90	5014	0.61	4.09	18.18
Total professorial staff (FTE)	1.78	1.11	0.33	1.57	4.50
Teaching hours bachelor	334.35	448.00	1.60	245.00	2041.00
Teaching hours master	189.28	166.26	–	3.40	94.60
Bachelor theses (N)	10.43	21.83	–	3.40	94.60
Master theses (N)	7.42	7.40	–	6.30	30.00
Research agency funds (CHF)	134,751.58	163,733.83	–	94,788.10	609,014.40
Contract funds (CHF)	78,194.13	91,654.49	–	39,500.00	291,719.40
PhD students	4.79	3.42	–	3.40	11.40
Total publications	10.42	6.16	1.20	10.33	22.40
Credibility	832.13	1049.90	15.20	471.70	4593.20
Share third party funds	0.16	0.13	–	0.14	0.54

research council) are higher than contract funds. Data also confirm the complementary role of third-party funding in resourcing; all units are well below 50 % with the exception of a newly created unit for which the value is not very reliable.

The sample is also characterized by heterogeneity in terms of the volume and orientation of activities; for research funds and teaching hours, the top three units account for 40–50 % of the total volume for the whole sample. Differences in human resource endowments and publication numbers are somewhat lower, as displayed by the ratio between median and standard deviation.

As shown by Fig. 2, most of the units in the field can be considered as balanced, i.e. with a relative research versus educational orientation near the average of the field. Three units display a clear orientation towards research, while three units are oriented towards education. Five of the specialized units are in the same university, suggesting an allocation model that leaves more room for differentiation.

Correlations display preliminary evidence of the association between a unit’s activities and staff composition (Table 1): FTEs of professorial staff is highly correlated with educational orientation, but only weakly to research orientation. Non-professorial staff

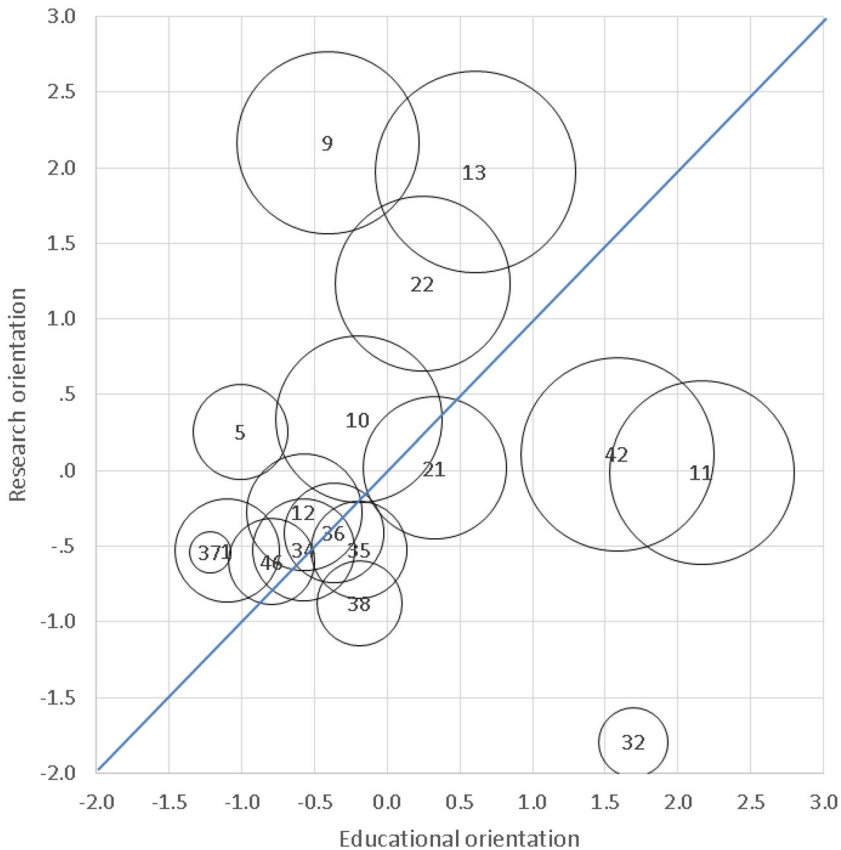


Fig. 2 Characterization of units by educational versus research orientation. Averages of the years in which the unit existed. Three units (3, 20, and 43) are not displayed because of missing data. Bubble size is proportional to full staff, numbers are unit IDs

Table 3 Correlation table (cross-sectional)

	Professorial staff (FTE)	Non professorial staff (FTE)	Research orientation	Educational orientation	Credibility	Credibility normalized	Share third-party funds	Non professorial staff normalized
Professorial staff (FTE)	1	0.802 ^{ab}	0.434	0.716 ^{ab}	0.606 ^{ab}	0.114	-0.262	0.255
Non professorial staff (FTE)	0.802 ^{ab}	1	0.817 ^{ab}	0.484 ^a	0.437	0.123	0.099	0.764 ^{ab}
Research orientation	0.434	0.817 ^{ab}	1	0.000	0.287	0.266	0.404	0.866 ^{ab}
Educational orientation	0.716 ^{ab}	0.484 ^a	0.000	1	0.657 ^{ab}	0.231	-0.412	0.041
Credibility	0.606 ^{ab}	0.437	0.287	0.657 ^{ab}	1	1.731 ^{ab}	-0.136	0.161
Credibility normalized	0.114	0.123	0.266	0.231	0.731 ^{ab}	1	0.291	0.131
Share third-party funds	-0.262	0.099	0.404	-0.412	-0.136	0.291	1	0.434
Non professorial staff normalized	0.255	0.764 ^{ab}	0.866 ^{ab}	0.041	0.161	0.131	0.434	1

^{ab} <0.01, ^a <0.05, N=17-20 depending on the variable

displays an opposite pattern: it is strongly associated with research orientation, but only weakly to educational orientation. Once normalized by professorial staff, non-professorial staff remains only strongly correlated with research orientation. Expectedly, the share of third-party funds is positively correlated with research orientation, but the coefficient is not significant.

Table 3 also shows that a unit’s credibility is strongly associated with the amount of professorial staff, but not with research orientation. Once we normalize credibility by professorial staff, there are no remaining significant correlations with the educational or research orientation of the units.

These results suggest that there are two distinct mechanisms driving unit’s activities and resources. On the one hand, educational activities are closely associated with the amount of professor positions allocated to units, which is also largely associated with the level of credibility. On the other hand, individual units might expand further through the acquisition of external research funds, which allows the hiring of additional non-professorial staff. Accordingly, the research-oriented units have a higher proportion of non-professorial staff.

Table 4 Indicators of change

	Change 2009–2013 (average)	Change 2009–2013 (median)	Variance explained by units fixed effects	Variance explained by units and time fixed effects
Professorial staff FTE	1.19	1.08	0.88	0.89
Non professorial staff FTE	1.16	1.14	0.95	0.95
Total teaching hours	0.99	1.23	0.95	0.95
Teaching hours bachelor	1.02	1.00	0.99	0.99
Teaching hours master	0.94	1.25	0.73	0.74
Total project funds	1.01	0.98	0.86	0.86
Research agency funds	1.42	2.15	0.83	0.85
Contract funds	0.55	0.18	0.61	0.66
PhD students	1.23	1.14	0.85	0.86
Total publications	0.78	0.94	0.68	0.72
Credibility	1.67	1.49	0.93	0.95

Columns 1 and 2 report the ratio between the 2013 scores and 2009 scores, computed for the average of all units, respectively the median (the latter is less sensible to outliers). Columns 3 and 4 report ANOVA decomposition of variance: for example, for professorial staff, 88 % of the variance in the panel is due to time-independent differences between units, a further 1 % to a general time trend (independent from units), and finally, 11 % is due to different time changes by unit

Development over time

As a second step, we investigate patterns in the evolution of units between 2009 and 2013. Table 4 provides two sets of indicators: the change in the average and median characteristics of units and the decomposition of variance.

On average, the units considered saw a slight increase in personnel, both at the professorial level and in total FTEs. Teaching activities also had a slight increase for most units, due to an increase in teaching hours at the master level. Total project funds were stable, but show a strong shift from contract funds to research agency funds: in 2009, project funds were divided almost equally between the two categories, whereas in 2013 research agency funds accounted for three-quarters of the total project funding volume. Most of this change was due to two units (unit 9 and 22), which had the largest volume of contractual research in 2009 and moved to a more balanced composition of project funds.

The number of publications witnessed a small decrease, which should not be over-interpreted given the composite nature of this indicator; credibility strongly increased, but this represents mostly a baseline effect of increasing citations.

The analysis of variance shows the extent to which differences between units remain stable over the time period. High stability characterizes the endowment of human resources (most of the variance in professorial staff is due to a single unit), teaching activities at the bachelor level and, as could be expected due to its cumulative nature, credibility. More changes took place concerning master's teaching and project funds.

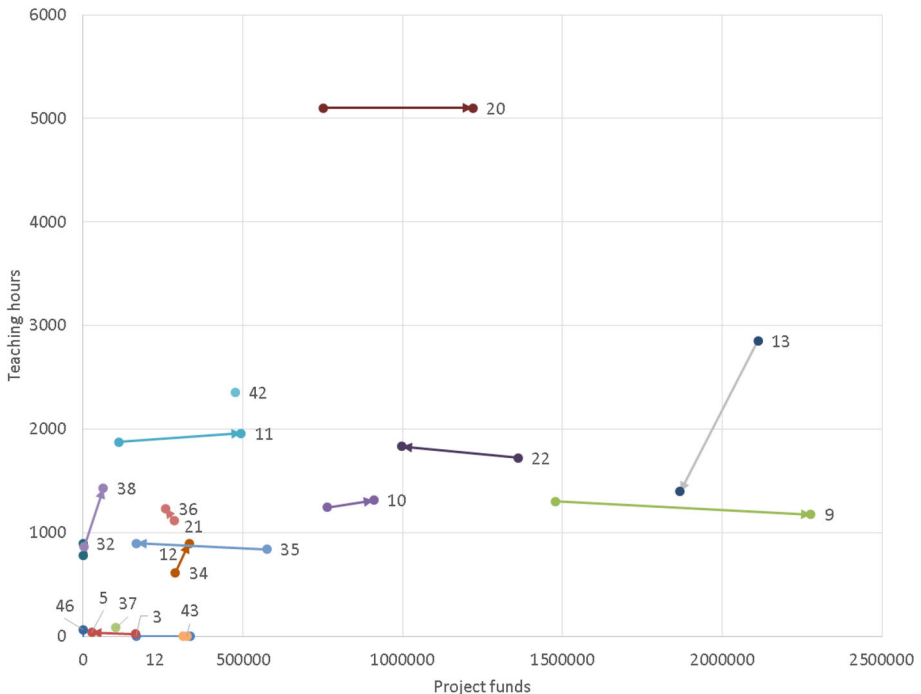


Fig. 3 Trajectories of units, project funds and teaching hours. For each unit, the two points represent the sum of the variables for the years 2009, 2010 and 2011 (divided by two), respectively 2011 (divided by two), 2012 and 2013, with the arrow from the first to the second period. Isolated points are units which did not exist in the whole period

Master’s education displays an implication of the Bologna reform: at the bachelor level, communication sciences offers a generic bachelor, with stable content over time, while master’s programs are more specialized in specific subfields (such as journalism, corporate communication or political communication). On the one hand, this generates room for units to expand their offerings based on specific competences. On the other hand, specialized master’s programs are more susceptible to changes in educational demand and might be closed when there are too few students.

Variance in project funds can also be expected, given their short-term nature and the limited size of the units in our sample (in some cases amounts refer to a single project, and therefore, short-term variations are quite strong). Nevertheless, there are lasting differences between units that remain stable over the considered period.

Figure 3 displays trajectories of units between the first half of the considered period (2009–2011) and the second half (2011–2013), to remove short-term variations for two main indicators, i.e. total teaching hours and total project funds.

Expectedly, we observe more changes in project funds than in teaching hours, given the high stability of teaching at the bachelor level. Units display different patterns, some of them increasing the amount of project funds, some having a sizeable decrease. A comparison with Fig. 2 displays no clear association with educational versus research orientation, as displayed by contrasting tendencies between units 9, 13, and 22.

As shown by Fig. 4, data do not display evidence of an association between the level of research agency funds or its development over time and the units’ credibility level.

A careful look at the data reveals very divergent paths between units. Unit 9 seems to be in a credibility accumulation process, where scientific credibility increases, thus fostering

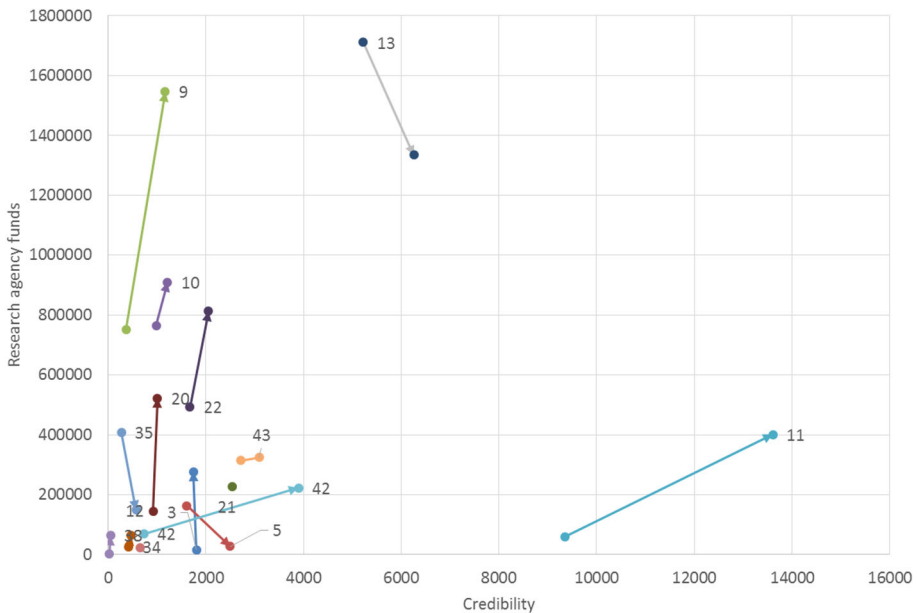


Fig. 4 Trajectories of units, credibility, and research agency funds. For each unit, the two points represent the sum of variables for the years 2009, 2010 and 2011 (divided by two), respectively 2011 (divided by two), 2012 and 2013, with the arrow from the first to the second period. Isolated points are units that did not exist during the entire period

the acquisition of research funds—the increase in credibility allowed this unit to replace contract funds with research agency funds. Unit 13 seems to have reached a ceiling related to the number of professorial positions: even if credibility continues to increase, the acquisition of external funds remains stable. On the contrary, unit 11 displays the highest (and still increasing) level of credibility among all units, but the amount of research funds only slightly exceeds the median of the entire sample.

Of course, these results may partially be due to the small size of the sample and to some limitations of the credibility measure considered (particularly the dependency of citation counts by the subfield considered). But, at least they show that there is no straightforward relationship between the level of scientific credibility and the acquisition of external funds.

Activities, resources and staff

As a last step, we conduct a quantitative analysis of the development over time of human resources, as well as relationships with activities and credibility.

As expected, professorial positions display a limited dynamic: total FTEs increased from 26.81 to 33.88. Among the 20 units considered, 13 had no change in their professorial staff, but some replacements of retiring staff. Two units lost one position, four units received one additional position, while one unit (unit 11) received four additional professors. This unit is strongly oriented towards education and covers the bulk of education in the concerned department; its reinforcement could therefore be considered as strategic at the departmental level.

Interestingly, there is not more variability concerning non-professorial staff. Among the largest units (with more than 5 FTEs of non-professorial staff), only unit 11 had a strong increase in staff numbers, which can be associated with the increasing number of professors, while change in the other units was limited. There is slightly more variance in the smaller units, particularly in those who were in the build-up phase at the beginning of the period considered.

As shown by Table 5, differences in the endowment of non-professorial staff between units are strongly associated with the amount of project funds and teaching hours by units; the same variables also explain about one-third of the change in FTEs of non-professorial

Table 5 Panel regressions for non-professorial staff

FTE non professor									
	Coef.	SE	<i>p</i>	Coef.	SE	<i>p</i>	Coef.	SE	<i>p</i>
Cons	3.849	0.690	0.000	2.778	0.790	0.000	1.502	0.546	0.006
Project funds (×100'000)	0.614	0.131	0.000				0.593	0.096	0.000
Teaching hours ×100				0.516	0.045	0.000	0.505	0.048	0.004
Rsquare (within)	0.177			0.336			0.180		
Rsquare (between)	0.635			0.655			0.880		
Observations	84.000			74.000			74.000		
Groups	20.000			18.000			18.000		

Linear regression panel model, random effects with robust standard errors. Within Rsquare shows the percentage of variance explained by units over time, whereas between Rsquare shows the percentage of variance explained across units (cross-sectional)

Table 6 Panel regressions for funds and teaching hours

	Research agency funds ($\times 100,000$)				Total teaching hours ($\times 100$)								
	Coef.	SE	p		Coef.	SE	p						
Cons	0.608	0.266	0.023	0.331	0.298	0.267	0.267	2.864	1.358	0.035	4.121	1.579	0.009
Professorial staff FTE	0.428	0.228	0.000	0.464	0.144	0.001	0.001	1.347	0.833	0.106	1.102	0.766	0.150
Credibility normalized ($\times 1,000$)				0.513	0.511	0.315	0.315				-1.690	1.292	0.191
Rsquare (within)	0.061			0.060				0.053			0.115		
Rsquare (between)	0.063			0.101				0.677			0.643		
Observations	84,000			80,000				74,000			74,000		
Groups	20,000			18,000				18,000			18,000		

Linear regression panel model, random effects with robust standard errors. Within Rsquare shows the percentage of variance explained by units over time, whereas between Rsquare shows the percentage of variance explained across units (cross-sectional)

staff over time. This supports the hypothesis that the hiring of non-professorial staff is a short-term equilibrium process associated with a unit's activities (and related resources from third parties and from the university for education).

The results for the regressions on research agency funds and teaching hours are less clear (Table 6). For the former, FTEs of professorial staff is significant, but explains a very low share of the variance, while credibility is not significant. This suggests that the acquisition of funds is related to other factors, such as the subject domain of the units or individual strategies of the heads of units. For teaching hours, the amount of professorial staff explains a large share of variance between units, but the coefficient is not statistically significant (in the robust specification of the model), hence the effect needs to be confirmed. The coefficient of credibility is negative, but not significant.

Discussion and conclusions

The goal of this study was to investigate the relationships between resource acquisition and patterns of activities, while also taking into account two characteristics of university units: their multifunctional character, i.e. their engagement in both research and teaching, and the dual funding system composed of institutional allocation (controlled by the university) and third-party funds (acquired based on the units' credibility).

The data we have gathered provides empirical evidence on some key elements of the model. Units are indeed involved in two distinct resource cycles, one internal, mostly associated with education, and one external, mostly associated with research activities. Junior staff can be hired from both sources, and therefore, units can acquire additional resources, both by expanding their educational activities or by expanding externally funded research (based on their scientific credibility).

However, the critical resource for unit activities—i.e. professorial positions—can only be acquired through the internal resource cycle which, according to our data, is more oriented to education than to research. Allocating professorial positions based on education is a rational choice for departments in the field. Arguably, this is because of two reasons: first, the resources controlled by departments are mostly based on education; second, since professorial positions are long-term, their allocation to research-oriented units would imply that these units become independent from departments. This behavior is therefore consistent with the common attempts of departments to avoid that their institutes become too autonomous (a frequently claimed consequence of the increase of external funds; Pfeffer and Salancik 1978; Bleiklie et al. 2015).

The implication is that *university institutes do not necessarily reinvest their scientific credibility in the acquisition of external funds*. When they have the option to expand their educational offerings (for example thanks to a growing number of students in their domain), this might be preferable, as it is more likely to lead to the acquisition of additional professorial positions. There might be some reasons for institutes to expand their volume of research activities, e.g., the aim to become more independent or grow despite having small numbers of students.

Our argument is however that such strategic decisions will lead to strong variations in the relationships between credibility and the acquisition of external resources, a pattern consistent with our data.

Admittedly our study displays a few limitations, which should be taken into account when interpreting the results. First, the sample is rather small and heterogeneous, limiting

the statistical power of the analysis. Second, most processes we deal with are endogenous, and therefore we cannot make strong claims on causality—but this might be less of a concern since they are mostly focusing on behavioral patterns. Finally, more in-depth evidence on the trajectory and behavior of units from qualitative data would support our findings and provide a more in-depth understanding of the underlying processes.

Despite these limitations, we believe our study provides important insights on the impact of the configuration of public funding on strategic decisions and activity profiles of university units. Indeed, it is well known that institutional configurations have a deep impact on a unit's activities (Crow and Bozeman 1998), but this phenomenon has been less studied in the case of university units (see Verbree et al. 2015). To our knowledge, the connection with the configuration of funding streams, and particularly with dual university funding, has rarely been made.

The relevance is both theoretical and practical. At the theoretical level, we advanced the conceptualization of the profiling of units by taking into account their double dependency on the institution they belong to and external resources. While previous work has taken into account the heterogeneity of external funds and their allocation modes (Joly and Mangematin 1996), it is even more important to address the implications of this duality between institutional and third-party funds, as it characterizes the largest part of the public research system in European countries (Lepori et al. 2007). In this context, the assumption that resources are substitutable—and therefore units can switch from institutional to external funds—is not warranted, particularly when units are embedded within organizations that control critical resources, such as infrastructure or long-term positions.

In this respect, we point to two directions for further investigation: first, through a more in-depth examination using qualitative information from the strategic decision-making of units and how it is associated with the structure of the resource space; second, an extension of the analysis by systematically comparing different institutional settings and funding systems. A further important extension would be to move beyond the purely incentive-based framework adopted in this paper to a more refined understanding of behavioral mechanisms accounting for differences in the unit's responses to external pressures, for example investigating the presence of intrinsic motivations to perform research or the role of normative pressures and of the imitation of the most successful units.

At the practical level, our analysis highlights the risk that wrong expectations might be derived from incorrect assumptions and modeling. First, in the specific setting we are considering, it is not a given that hiring highly reputed researchers as professors will lead to an increase in the research volume and acquisition of external funds, since, once appointed, they are embedded in a setting and incentive system, which might alter their behavior. In this respect, the fact that European universities are mostly funded through a state allocation comprised of a large historical component (Jongbloed and Lepori 2015) leads to a very different resourcing and power dynamic than in US universities.

Second, research policies tend to focus on changing the volume of funding by streams, implicitly assuming that resources are fully substitutable. Our analysis indicates however that this may not be warranted: simply increasing the amount of third-party funding when their acquisition and use is constrained by professorial positions, whose number does not grow and whose allocation remains largely incremental, may lead to non-optimal results. In other words, the negative effects of increasing external funds on university research remarked by the literature (Laudel 2006) might be due more to the lack of consideration of interdependencies and of the different characteristics of resources needed by units than to shifts in funding composition alone.

From a policy perspective, it is therefore relevant to ask under which conditions the interaction between institutional and external funding might work differently, and when the incentives to acquire external funds may be more effective. Different settings can be envisaged, however with divergent implications. A system similar to the US, where project funds cover the full costs and where private donations also fund professorial positions, could allow high credibility units to expand their volume of research further; such units would become more autonomous and powerful in respect to their departments, as already known from earlier studies of resource dependency (Pfeffer and Salancik 1974), but entail the risk that research is increasingly driven by external interests to the university. An alternative, which broadly corresponds to the UK system, would be to create incentives for departments to develop their research through a highly competitive allocation of institutional funding, therefore aligning the incentive systems of departments and units. This is likely to lead to a concentration of research-oriented institutes in the selected institutions and departments, since they would enjoy different growth conditions depending on where they are situated.

These remarks emphasize how changes in public funding policies should be embedded in a broader institutional design of the whole regulation system of research.

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